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The "Hispanic mortality paradox" revisited: Meta-analysis and meta-regression of life-course differentials in Latin American and Caribbean immigrants' mortality

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ABSTRACT

The literature on immigrant health has repeatedly reported the paradoxical finding, where immigrants from Latin American countries to OECD countries appear to enjoy better health and greater longevity, compared with the local population in the host country. However, no previous meta-analysis has examined this effect focusing specifically on immigrants from Latin America (rather than Hispanic ethnicity) and we still do not know enough about the factors that may moderate the relationship between immigration and mortality. We conducted meta-analyses and meta-regressions to examine 123 all-cause mortality risk estimates and 54 cardiovascular mortality risk estimates from 28 publications, providing data on almost 800 million people. The overall results showed that the mean rate ratio (RR) for immigrants vs. controls was 0.92 (95% CI, 0.84–1.01) for all-cause mortality and 0.73 (CI, 0.67–0.80) for cardiovascular mortality. While the overall results suggest no immigrant mortality advantage, studies that used only native born persons as controls did find a significant all-cause mortality advantage (RR, 0.86; 95% CI, 0.76–0.97). Furthermore, we found that the relative risk of mortality largely depends on life course stages. While the mortality advantage is apparent for working-age immigrants, it is not significant for older-age immigrants and the effect is reversed for children and adolescents.

1. Introduction

A large body of studies has suggested that immigrants may be healthier and experience lower mortality rates than non-immigrants in their country of origin and native-born residents in their country of destination. More specifically, many have reported a "Hispanic mortality paradox,"[1] where immigrants from Latin America and Caribbean countries to various Western countries enjoy similar or better health outcomes and lower mortality rates compared with local populations in host countries. This phenomenon has been documented in the United States (Fang et al., 1996; Palloni and Arias, 2003, 2004), Australia (Young, 1986), and various Western European countries (Khlat and Darmon, 2003; Klinthall and Lindstrom, 2011; Mackenbach et al., 2005; Regidor et al., 2009). In addition, studies from Canada (DesMeules et al., 2005), the Netherlands (Mackenbach et al., 2005; Stirbu et al., 2006), and the United Kingdom (Balarajan and Bulusu, 1990; Marmot et al., 1984a; Wild et al., 2007) found lower mortalty rates for Caribbean migrants compared to the native-born populations in these receiving countries. Caribbean immigrants to these countries are racially/ethincally diverse and include, in addition to Hispanics, individuals of Afro-Caribbean, Asian Indian, and Chinese descent (Cervantes-Rodriguez et al., 2009; Foner, 1998; Lindsay, 2001). As such, the Hispanic mortality paradox may extend to non-Hispanic migrants from Latin America and the Caribbean.

The apparent immigrant mortality advantage is paradoxical for a

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[1] The literature often uses Latin American and Hispanic interchangeably. Both terms are socially constructed ethnic labels used to designate individuals of either of Spanish descent or from Latin America and the Caribbean. Latin Americans have diverse national origins, cultures, and racial backgrounds (Rodriguez, Saenz and Menjivar, 2008). We use the "Hispanic mortality paradox" when referring to the literature that directly employed this term. The present study, in contrast, looks only at immigrants from Latin America and the Caribbean.

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number of reasons. First, most Latin American and Caribbean immigrants to Western countries tend to originate from less developed countries, where they were likely to grow up in an environment with higher health risks (for example, due to the quality of water or the presence of toxic elements in food) compared with the native population in developed nations (Davey-Smith et al., 2000; Klinthall and Lindstrom, 2011). Second, lower socioeconomic status has often been linked to poorer health, greater morbidity, and a higher risk of mortality. Immigrants in general, and Latin American and Caribbean immigrants more specifically, tend to have a lower socioeconomic status. Language barriers can also create difficulties in accessing high-status employment and adequate healthcare. It is therefore surprising that they would nevertheless enjoy lower mortality rates (Abraido-Lanza et al., 1999; Klinthall and Lindstrom, 2011). Finally, from a stress perspective, immigration may be detrimental to health because it may be associated with a culture shock and with greater physical distances from family and friend support networks (Guillot et al., 2011; Popham and Boyle, 2011).

While multiple studies have documented the immigrant mortality paradox, questions still abound regarding the validity of the data on which such studies rely and the pervasiveness of the phenomenon across various geographical locales, different racial/ethnic groups, and sociodemographic characteristics. Indeed, some studies have reported a lack of association or even a reverse association between immigration from Latin American and Caribbean countries and mortality risks (Maxwell and Harding, 1998; Rosenwaike, 1987; Stirbu et al., 2006; Uitenbroek and Verhoeff, 2002). Such contrasting results suggest the need for a meta-analysis that may help in assessing the current state of knowledge.

While a number of narrative literature reviews have been performed on this subject (e.g. Markides and Eschbach, 2005; Palloni and Morenoff, 2001; Vang et al., 2015), we are unaware of any quantitative meta-analysis that examined the relationship between Latin American and Caribbean immigration to OECD countries and mortality. Former meta-analyses in this field have looked at the relationship of immigration with suicide rates (Voracek and Loibl, 2008) and of Chinese immigration to the West with coronary heart disease (Jin et al., 2015). Closer to the design of the current study, Ruiz et al. (2013) conducted the first quantitative meta-analysis of the Hispanic mortality paradox. They compared Hispanics in the United States (both immigrants and non-immigrants) to other racial groups and found a 17.5% lower mortality rate for the Hispanic population.

In the current study, we extend these research efforts in three important ways. First, we focus on immigrants from Latin America and the Caribbean rather than Hispanics as an ethnic group, as we believe that the process of immigration itself needs to be isolated from other demographic population characteristics. Moreover, by examining Latin American and Caribbean migrants, we can assess whether the Hispanic mortality advantage is applicable to ethnically diverse migrant populations from the region. Second, we examine immigration to multiple Western countries, rather than only to the United States, seeking to test whether immigrants' mortality risks differ by host country. Finally, and importantly, we use sub-group meta-analyses and meta-regression techniques to explore moderating factors in the relationship between immigration and mortality. DesMeules et al. (2005) note that current research on the health of immigrant subgroups tends to be piecemeal, with individual studies often reporting on only one or a few sub-groups at a time (e.g. a specific age group of immigrants residing in a specific locale).

Meta-analysis and meta-regression techniques allow us to leverage recurring differences between the sampling frames already examined in a large range of existing studies. This analytic design therefore enables direct tests of multiple potential mediating and moderating factors. In addition to country of origin and destination, we are therefore able to assess basic demographic moderators, such as age and gender. Importantly, our analytic strategy allows us to compare different studies in terms of their choice of comparison group and whether they utilized national mortality records. Importantly, we find that such study design characteristics often explain why some previous research has reported an immigrant mortality advantage, while others report weak or non-existing relationships.

2. The immigrant mortality paradox: theoretical explanations

The literature offers a few prominent explanations for the commonly-reported “Hispanic mortality advantage.” We extend these explanations to address the Latin American and Caribbean immigrant mortality advantage. According to Abraido-Lanza et al. (1999), these explanations may be divided into two broad categories. The first category assumes that the lower mortality rates do not reflect actual differences in health and mortality, but rather are the result of data artifacts, such as reporting bias, and migratory factors such as selective in- and out-migration. The second class of explanations proposes that study findings may in fact reflect an actual difference in health and mortality rates between immigrants and native-born populations. For these, health/mortality differences results from variations between immigrants and non-immigrants in factors such as genetic racial resilience, nutrition, health behaviors, and social support networks. We elaborate on each of these approaches below.

Palloni and Arias (2004) efficiently summarize the major problems related to reporting and data bias that may lead to an illusion of an immigrant mortality advantage. They suggest three likely data artifacts that may produce the appearance of an advantage: (1) problems in ethnic identification on death certificates, (2) misreporting of ages (some immigrants tend to overstate their age, leading to a depression of mortality rates in older ages), and (3) the mismatching of records, leading to downward biases in mortality rates.

Another mechanism that may explain immigrants' health and mortality advantages is the selective nature of international migration. Selection can occur at the individual and at the state level (Vang et al., 2015). At the individual level, scholars have suggested two main hypotheses, the “healthy migrant effect” for initial migration and “Salmon Bias” for return migration. The former postulates that individuals who are healthy and can withstand the journey are more likely to migrate (Palloni and Arias, 2004; Sorlie et al., 1993; Kimbro, 2009). The latter suggests that some foreign-born individuals return to their country of origin following morbidity, which artificially lowers mortality rates (Abraido-Lanza et al., 1999; Turra and Elo, 2008). As for state-level selection, many receiving countries impose selective admission policies for immigrants, which generally favor individuals with host language proficiency, higher education, professional skills, and good health (Chiswick et al., 2008; Gushulak, 2007; Llacer et al., 2007).

While data bias and selective migration explanations seem quite plausible, some scholars have argued that the immigrant mortality advantage cannot be fully accounted for by these tendencies (Palloni and Arias, 2004; Razum et al., 2000). They suggest that the mortality advantage for Latin American and Caribbean immigrants may also be the result of various factors that differentiate immigrants from host-country natives. These factors may include genetic racial resilience (Abraido-Lanza et al., 1999; Ruiz et al., 2013; Voracek and Loibl, 2008) and various social and cultural characteristics (Palloni and Arias, 2004).

One factor closely related to health outcomes and longevity is diet and nutrition. Some scholars have suggested that Latin American and Caribbean immigrants bring with them healthier eating habits, which they maintain, at least initially, in the new country (Gordon-Larsen et al., 2003; Perez-Escamilla and Putnik, 2007). Others have emphasized health behaviors and life style as a major differentiating factor, with some evidence suggesting that immigrants are more likely to lead a healthier lifestyle and less likely to engage in risky practices such as smoking, alcohol use, and drug consumption, relative to native-born populations (Haynes et al., 1990; Lizarzaburu and Palinkas, 2003; Singh and Siahpush, 2002; Kimbro, 2009). Furthermore, while better nutrition and better health habits are important for individuals' general health, they are likely to be particularly beneficial in preventing the onset of chronic diseases, including cardiovascular diseases (Bazzano et al., 2003; Kris-Etherton et al., 2002; Lakier, 1992).

A third explanation for the immigrant mortality advantage may be greater availability of social support and social cohesion. The cultural norms of immigrants may prescribe tighter and closer family relationships and obligations, as well as a greater likelihood of living with extended families that are able to offer emotional and instrumental support (Palloni and Arias, 2004). Immigrants are also more likely to live in immigrant and/or ethnic enclaves, which potentially offer greater social cohesion and support, some protection against racism, and more opportunities to participate in communal activities (Halpern and Nazroo, 2000; Hovey, 1999; King and Locke, 1987; Nazroo, 2003). These characteristics are important, as both social support and social participation are associated with lower mortality rates (Shor and Roelfs, 2013a, 2013b). Furthermore, social support and social cohesion may be particularly important for immigrants having to cope with the challenges of a new country, language and culture (Finch and Vega, 2003; Wong et al., 2007).

We argue that these theoretical mechanisms, developed primarily for explaining the Hispanic mortality advantage (e.g., selection, social support and cohesion, diet and nutrition), are not exclusive to Hispanic migrants. Non-Hispanic migrants from Latin America and the Caribbean may also be positively selected for migration, follow healthier diets than native-born populations in receiving countries, and benefit from close ethnic ties. For instance, Afro-Caribbean migrants who settled in England consumed more fruits and green vegetables than the native-born white British population (Sharmat et al., 1999). Likewise, the diets of Surinamese migrants in the Netherlands were higher in overall quality than the diets of ethnic Dutch residents (Nicolaou, 2009). Hence, the proposed mechanisms that underpin the Hispanic mortality advantage may also be found in other non-Hispanic migrant populations from Latin America and the Caribbean, suggesting a broader migrant mortality advantage.

3. Moderating factors in the immigration-mortality association

The immigration literature suggests substantial heterogeneity in the immigration-mortality association stemming from differences in demographic characteristics, including age, gender, country and region of origin, and host country. Below we outline the theoretical relevance for some of these main factors and the rationale for their inclusion in our analyses.

3.1. Age

While most studies report an immigrant mortality advantage, many of these examine only working-age adults or fail to present analyses differentiated by age groups. However, both theory and empirical findings highlight the importance of adopting a life-course perspective when thinking about the immigrant mortality advantage. Specifically, the literature offers a possible distinction between three groups of immigrants: children and adolescents, working-age immigrants, and older immigrants who migrated after retirement age (Vang et al., 2017).

First, the underlying conditions and experiences for children and adolescents who immigrate to a new country may be different from those of adults. For example, one of the prominent explanations for immigrants' mortality advantage is that they have better nutrition and a healthier lifestyle (e.g. lower cigarette and drug consumption; see Lizarzaburu and Palinkas, 2003; Kimbro, 2009). If that is indeed the case, such nutrition and lifestyle habits are likely to be more entrenched in adult immigrants, who spent their formative years in a culture that teaches and values these qualities. Conversely, individuals who immigrated as children and adolescents were more likely acculturated into the norms of the host culture and therefore more likely to adopt unhealthy habits from their new society. These habits may include greater use of tobacco and other drugs, unhealthy dietary practices, and less physical exercise, all behaviors that are associated with worse health in general and cardiovascular disease more specifically (Gushulak and MacPherson, 2006; Regidor et al., 2009).

Selection processes are also less likely to be a major factor for individuals who immigrated at a young age. In determining immigration policies, countries usually focus on the health and skills of parents, rather than their children (Vang et al., 2017). Furthermore, individuals who immigrated at a very young age are less likely to maintain strong social ties to their country of origin and less likely to be fluent in the language of the origin country given that they spent their formative years being socialized in the receiving country (Portes and Rumbaut, 1990; Rumbaut, 2004). They are therefore also less likely to migrate back (as adults) when they are sick.

The empirical findings regarding a possible health and mortality advantage among children and adolescents are also inconclusive. While some studies report better health for immigrant children (Beiser, 2005; Maximova et al., 2011), others found that those who immigrated at a young age have worse health and a higher mortality risk (Klinthall and Lindstrom, 2011; Quon et al., 2012; Rosenwaike, 1987; Uitenbroek and Verhoeff, 2002). Vang et al. (2017) suggest that immigrant children do not consistently enjoy better health when compared to their contemporaries in the new country.

On the other end of the age spectrum, older immigrants (above retirement age) may also have unique conditions and experiences that set them apart from younger people. First, older immigrants may be more likely to enjoy the benefits that come with years of better-balanced nutrition and a healthier lifestyle. When combined with the likely advantages of a Western-country's healthcare system, they may therefore show greater resiliency to various diseases, in particular those associated with unhealthy nutrition, such as cardiovascular diseases. As for selection processes, individuals who immigrated at an older age may maintain stronger social ties and be better acquainted with healthcare opportunities at their country of origin. Consequently, the Salmon Bias, mentioned earlier, may be more applicable to them, as they would be more likely and able to migrate back when they are sick. If that is the case, we should see mortality rates at older ages that are lower, and consequently a more advantageous effect for elderly immigrants compared with other age groups (Palloni and Arias, 2004).

Indeed, some studies found that the mortality advantage is significant for older individuals (Balarajan and Bulusu, 1990; Rosenwaike, 1987) and others have even suggested a stronger mortality advantage among older individuals compared with younger ones (Klinthall and Lindstrom, 2011). However, once again the literature is inconclusive, as other studies report no significant mortality advantage (Wild et al., 2007) or even a mortality disadvantage (Fang et al., 1996) for older immigrants.

3.2. Gender

Previous research suggests a few areas where immigrant women's health-related experiences may be different from those of men. According to the literature, women may enjoy a smaller migrant mortality advantage than men for a number of reasons. First, research shows that the migration process—including reasons for migration, type of migration, and post-migration integration trajectories—differs by gender (Gorman et al., 2010). For instance, men typically migrate at a younger age (Kanaiaupuni, 2000), which may contribute to a healthier profile.

The gendered nature of migration also means that female migrants may be exposed to different health risks during migration (Zimmerman et al., 2011). Pre-migration risks for female migrants might include greater exposure to gender violence, lower socioeconomic status, a greater burden of infectious diseases, and less access to basic rights and healthcare services (Llacer et al., 2007). As such, women's pre-departure health status may be less optimal than men's because of social, environmental and other factors (Gushulak and MacPherson, 2011). During migration, women may be especially susceptible to sex trafficking and sexual abuse, particularly if the migration is irregular or clandestine (Farley et al., 2004; Zimmerman et al., 2011). Post-migration risks may include a greater propensity to adopt risky behaviors than when in their countries of origin and less access to medical care relative to men (Gorman et al., 2010).

To the extent that women migrants are disprortionately concentrated in domestic/care-giving employment, they may also bear a greater burden of health-related risks (e.g., abuse, loneliness) associated with such low-skilled jobs (Benach et al., 2011; Holroyd et al., 2001). In addition, reproductive-age migrant women are vulnerable to poor maternal health, as obstetric and gynecological health access may be limited in receiving countries, owing to language and other cultural barriers (Gagnon et al., 2009, 2013).

3.3. Country of origin

Another factor that may mediate the mortality advantage for various Latin American and Caribbean immigrants is their country of origin. A number of elements may play a significant role here. First, some scholars have suggested that migrants from relatively less developed countries, such as some of the Caribbean and Central American countries like Guatemala, Nicaragua, Haiti, and Jamaica, grew up in an environment with greater health risks, including exposure to pollution or worse healthcare and preventive care early on in life. This fact may put them on a disadvantageous life-course trajectory compared with migrants who grew up in more affluent countries, such as Argentina, Chile, and Uruguay (Klinthall and Lindstrom, 2011). According to this logic, greater exposure to stress and disease load, combined with worse healthcare and preventive care during the first years of life, may increase the risk of morbidity and mortality in later life (Bengtsson and Brostrom, 2009; Bengtsson and Lindstrom, 2000; Bengtsson and Mineau, 2009).

Geographical distance between the country of origin and the country of destination may also be an important mediating factor. Distance may be especially important for selection processes. First, it may influence the healthy migrant effect (Jasso et al., 2004). Immigration between relatively adjacent countries, such as the United States and Mexico, tends to be more common and employment-driven. According to some, such migration is less likely to be positively selected for health, and thus also less likely to produce a healthy migrant effect (Klinthall and Lindstrom, 2011; Ringback-Weitoft et al., 1998). Moreover, geographical distance may also determine the likelihood of return migration (leading to Salmon Bias). Migrants from geographically distant countries may be less likely to migrate back (permanently or temporarily) when they are sick, as return migration may be more costly (Borjas and Bratsberg, 1996; Gonzalez-Ferrer et al., 2014). Return migration is therefore more likely to occur when the country of origin is geographically close to the country of destination. These two phenomena generate two diverging predictions. While attenuated selection effects may reduce the immigrant mortality advantage for immigrants from geographically proximate countries, greater return-migration rates among these same immigrants may artificially increase their apparent mortality advantage.

3.4. Country of destination

Differences in attitudes toward immigration in receiving countries may affect the overall integration of immigrants (or lack thereof), as well as the degree to which immigrants feel welcomed. With regard to pro- or anti-immigrant sentiment, countries with an ethos of multiculturalism and embracing immigration, such as Canada or Sweden (Multiculturalism Policy Index, 2010), may be relatively more welcoming, which may help in reducing stress and feelings of alienation that are often associated with moving to a new country. Indeed, the 2014 Migrant Integration Policy Index shows that countries that officially adopt multiculturalism (such as Canada, Australia, and Sweden) score higher in terms of migrant-friendly integration policies than countries such as the US, UK and France (Huddleston et al., 2015). Immigrants in the former countries may have better prospects for socioeconomic integration, which in turn, improves their health. Another potentially important element is language, for which it is again important to look at the interaction between country of origin and country of destination. For Latin American and Caribbean immigrants who speak Spanish, integration may be facilitated because of a shared language with native-born populations (such as when migrating to Spain).

A third element that may be important in receiving countries is their healthcare and welfare systems. Scandinavian countries, for example, are famous for their advanced welfare state and accessible and affordable healthcare systems. Some researchers have suggested that an accessible healthcare system is particularly important for migrant populations, as such systems may help in decreasing ethnic disparities in health and mortality (Cooper et al., 1998; Essen et al., 2002; Stirbu et al., 2006). Finally, official immigration policies and the type of immigrants who enter the country, whether by design or due to circumstances, may also make a difference. For example, some countries, such as Sweden, Norway, Switzerland, and Canada, are more likely to accept refugees, political dissidents, and victims of natural catastrophes. Others, however, give preference primarily to individuals who immigrate for economic reasons (e.g. Spain and the United States). The latter individuals are more likely to exhibit the healthy immigrant effect, and so immigrants in the latter set of countries may show a stronger immigrant mortality advantage (Klinthall and Lindstrom, 2011).

4. Data and methods

4.1. Search strategy and inclusion criteria

We conducted a search for studies of mortality among immigrants using keyword searches of bibliographic databases, complimented by (for all identified articles) title searches in the bibliographies, lists of citing publications, and lists of "similar" publications (from Web of Science and Google Scholar). We performed searches iteratively until the point where we could no longer identify additional publications. We also conducted additional searches for unpublished dissertations and other unpublished work. We completed the literature search in 2016. At the end of the search process, we identified 276 candidate publications (see Fig. 1).

The two lead authors determined publication eligibility. Of the 276 candidate publications, 137 were fully coded and publications were tracked throughout the process using spreadsheets (See Appendix for full list of variables for which data were sought). Fig. 1 summarizes the number of publications considered at each step of the search process. Twenty-eight of these 137 coded publications were deemed eligible for the present study. A publication was included in the study if it (1) clearly compared a group of international immigrants from Latin America or the Caribbean to a control group in an OECD destination country; (2) had all-cause mortality or cardiovascular mortality as the outcome of interest; (3) reported a measure of statistical significance (see below and Appendix 1 for additional details); (4) reported an effect size in the form of a rate ratio (or provided information sufficient to convert the results to rate ratio format; see again Appendix 1 for additional details on conversion); and (5) reported effect estimates not already reported by another study.

The 28 publications that satisfied all of the conditions mentioned above included 123 effect estimates (rate ratios) for our analysis of all-cause mortality and 54 effect estimates for our analysis of cardiovascular mortality. Table 1 provides summary details on the full set of studies included in our analysis.

4.2. Statistical methods

We used both meta-analysis and meta-regression techniques. A meta-analysis is a quantitative synthesis of the literature. It takes a large number of effect estimate from different studies and calculates an overall average effect estimate, weighted by the inverse of the effect estimate's variance. A meta-regression analysis complements the meta-analysis, and is similar in essence to a weighted linear regression. In a meta-regression, the dependent variable is the size of the effect estimates from individual studies, and the predictors are the characteristics of these studies (e.g. sample size, age of participants, or location) that might influence the magnitude of the effect (for more information, please see Hogans et al., 2017; Roelfs et al., 2010; Roelfs et al., 2013; Roelfs et al., 2015; Shor et al., 2012; Shor and Roelfs, 2015). Thus, a meta-regression may help us determine not only whether immigrants tend to live longer than the control group, but also whether, for example, this effect is significantly stronger for men or for women.

The type of effect estimate varied between the studies in our sample, necessitating the conversion of odds ratios and hazard ratios into a common metric (rate ratios; abbreviated as RR from this point forward). We converted all non-RR point estimates into RRs (the most frequently reported type). We used the standard errors reported in the publications to calculate the inverse variance weights. When not reported by the original study, we calculated standard errors using (1) confidence intervals, (2) t statistics, (3) χ^2 statistics, (4) exact p-values, or (5) the midpoint of the p-value range.

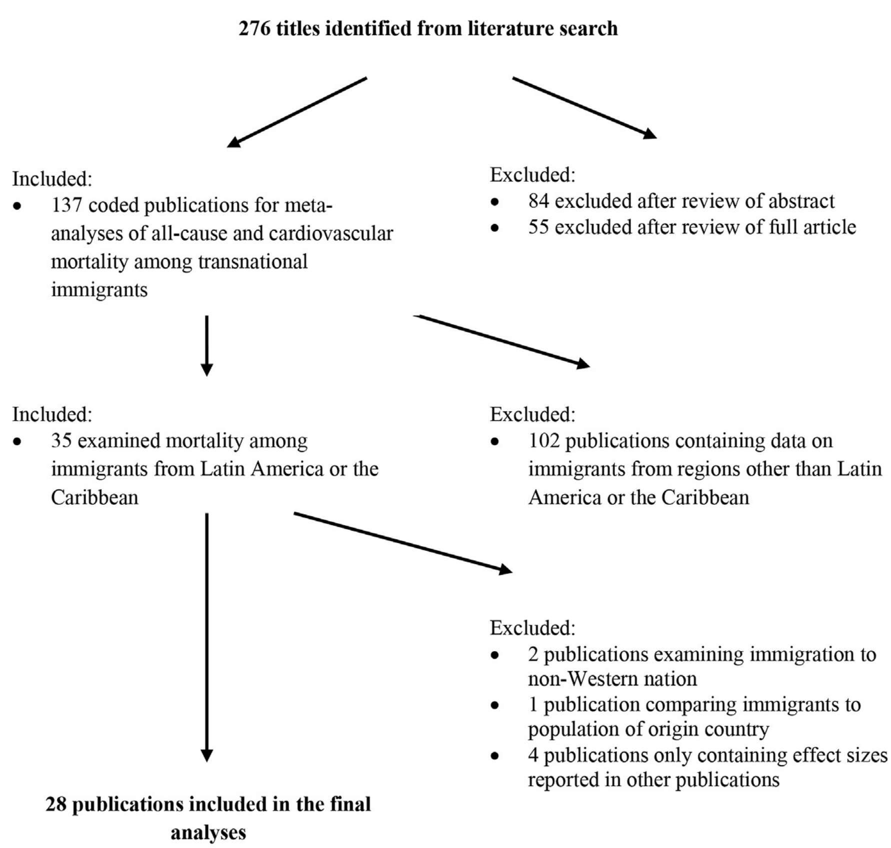

Fig. 1. Search strategy and yield.

Table 1
Studies included in the analyses.

Publication	Cause of Death	Country/Region of Origin	Destination Country	Years	Sample Size	# RRs	Mean RR
Balarajan and Bulusu 1990	All cause	Caribbean	United Kingdom	1981–1983	26,154,693	16	0.92
DesMeules et al., 2005	All cause	Caribbean	Canada	1980–1998	369,936	2	0.41
	Cardiovascular					2	0.39
Fang et al., 1996	All cause	Caribbean	United States	1990–1992	2,624,668	12	0.84
	Cardiovascular					12	0.66
Maxwell and Harding 1998	All cause	Caribbean	United Kingdom	1991–1993	15,018,619	2	0.94
Iribarren et al., 2009	All cause	Caribbean	United States	1964–1973	177,750	1	0.76
		Mexico				1	0.95
	Cardiovascular	Caribbean				1	0.66
		Mexico				1	0.88
Klinthall and Lindstrom 2011	All cause	Chile	Sweden	1980–2001	18,673	2	0.42
	Cardiovascular					2	0.47
Lariscy et al., 2015	Cardiovascular	Mexico	United States	1986–2006	61,586	6	0.70
Mackenbach et al., 2005	All cause	Antilles and Aruba	Netherlands	1995–2000	15,448,000	1	0.21
		Surinam				1	0.33
Marmot et al., 1984a, 1984b	All cause	Caribbean	United Kingdom	1971–1972	48,707,471	2	1.05
	Cardiovascular					2	0.67
Maxwell and Harding 1998	All cause	Caribbean	United Kingdom	1991–1993	32,271,472	1	1.04
Okrainec et al., 2015	Cardiovascular	Caribbean	Canada	2005–2012	175,414	2	0.73
Omariba et al., 2014	Cardiovascular	Caribbean	Canada	1991–2006	2,734,835	2	0.64
Palloni and Arias 2004	All cause	Cuba	United States	1989–1997	39,013	2	0.92
		Mexico				2	0.72
		Puerto Rico				2	0.92
Rafnsson et al., 2013	Cardiovascular	Caribbean	Netherlands	1996–2006	6,718,862	1	1.01
			United Kingdom	1999–2003	26,900,388	1	0.83
Regidor et al., 2008	All cause	America, South	Spain	2000–2004	5,423,000	1	0.81
	Cardiovascular					1	0.70
Regidor et al., 2009	Cardiovascular	America, Central	Spain	2001–2005	54,077	2	0.84
		Caribbean				2	1.20
Rosenwaike 1987	All cause	Cuba	United States	1980–1981	229,469,000	16	0.93
		Mexico				16	0.96
		Puerto Rico				16	1.17
Shai and Rosenwaike 1987	Cardiovascular	Puerto Rico	United States	1980–1981	3,005,072	2	1.02
Singh et al., 2013	Cardiovascular	Mexico	United States	1999–2001	198,140,541	1	0.57
Stirbu et al., 2006	All cause	Antilles and Aruba	Netherlands	1995–2000	15,448,000	2	1.25
		Surinam				2	1.31
	Cardiovascular	Antilles and Aruba				2	0.94
		Surinam				2	1.34
Turra and Elo, 2008	All cause	Puerto Rico	United States	1995–2000	21,600,000	2	1.18
Uitenbroek and Verhoeff 2002	All cause	Caribbean	Netherlands	1994–2000	731,289	4	1.41
Wallace and Kulu 2014	Cardiovascular	Jamaica	United Kingdom	1971–2001	48,707,471	2	1.00
Wei et al., 1996	All cause	Mexico	United States	1979–1993	3735	3	0.79
Wild and McKeigue 1997	Cardiovascular	Caribbean	United Kingdom	1991–1992	31,704,859	6	0.60
Wild et al., 2007	All cause	Caribbean	United Kingdom	2001–2003	52,041,916	8	1.07
	Cardiovascular					2	0.84
Woo 2007	All cause	Mexico	United States	1998–2002	20,568	2	0.68
Young 1986	All cause	Argentina	Australia	1981–1982	14,695,000	1	0.50
		Chile				2	0.43
		Uruguay				1	0.71

All analyses were calculated by maximum likelihood using a random effects model and matrix macros provided by Lipsey and Wilson (2001) and using Stata. Both Q-tests and I^2 tests were used to assess the presence and magnitude of heterogeneity in the data (Huedo-Medina et al., 2006). We examined the danger of selection bias using a funnel plot of the log RRs against effect estimate weights. Funnel plot asymmetry was tested using Egger's test (Egger and Davey-Smith, 1998) and Peters' test (Moreno et al., 2009).

Following our discussion of the theoretically-important moderators of the immigrant-health association (see literature review), we used multiple focal covariates in the analyses. We included (1) the mean age of a study's sample at baseline (divided by 10); (2) the proportion of a study's sample that was male; (3) immigrants' country of origin (when known); (4) immigrants' region of origin within Latin America or the Caribbean; and (5) immigrants' country of destination.

Because a subset of the literature discussed the possibility that data artifacts confound the immigrant-mortality association (see Palloni and Arias, 2004; Ruiz et al., 2013), we also examined the effects of study-design variables on the size of the effect. We chose these covariates based on both theoretical justifications and data availability. Most important among these covariates was the composition of the comparison group in a given study. While some studies compared immigrants with native-born controls, others compared immigrants to the general population in the destination country. Since the general population consists primarily of native-born persons, studies that use this control group still produce informative results, as these studies tend to analyze entire populations rather than small samples. However, because the general population also includes immigrants, the difference between immigrant and control groups is likely to be attenuated to some degree. This, in turn, will result in RRs that are closer to 1.00 (the null value for a ratio). In addition, studies that used a general population as the control group were also less likely to use national registers to assess mortality during follow-up (record linkage). Finally, these same studies were also much less likely to report precise standard errors because they focused on entire populations. While we chose to include studies using general population controls in our analyses, we monitored closely differences between these studies and those that used only non-immigrants as controls.

5. Results

Table 2 provides descriptive statistics on 123 mortality risk estimates for all-cause mortality and 54 mortality risk estimates for cardiovascular mortality included in this study (containing data on nearly 800 million people). We obtained data from 28 studies published between 1984 and 2015, covering 9 countries of origin in South-America, Central America and the Caribbean and 7 destination countries in North America, Western Europe, and Australia (see full details on all countries in the table). Both males and females are well-represented in the dataset, as are all age groups. The age range for the sample was 2–95 for the all-cause mortality analysis. While most RRs came from studies comparing immigrants to the general population, about one third of RRs compared immigrants to the native-born population.

Table 3 presents the results of our meta-analyses for both all-cause mortality and cardiovascular mortality, in addition to number of RRs and heterogeneity *Q*-tests. Our overall results do not offer support for the healthy immigrant hypothesis for all-cause mortality (RR, 0.92; 95% CI, 0.84–1.01). However, among studies that compared immigrants to native-born controls, there was a 14% lower all-cause mortality risk for the immigrant group (RR, 0.86; CI 0.76–0.97). The overall findings for cardiovascular mortality showed a 27% lower risk for immigrants (RR, 0.73; CI 0.67–0.80), and the effect was significant regardless of the type of control group. As we explained earlier, studies that used native-born persons as the control group also tended to use record linkage and report standard errors. The results shown at the bottom of Table 3 confirm an immigrant mortality advantage among these studies.

Table 3 also presents results disaggregated by various subgroups. First, we found that age is a central moderating factor in the immigration-mortality relationship. In particular, and in line

Table 2
Descriptive statistics.

Variable	All-cause Mortality (n = 123)		Cardiovascular Mortality (n = 54)	
	Range	Mean (SD) or %	Range	Mean (SD) or %
Mean age of sample (years)	2 to 95	49.2 (21.7)	32 to 95	53.8 (15.8)
Sex of sample				
Male		49.6%		44.4%
Female		47.2%		42.6%
Both sexes		3.4%		13.0%
Country of origin				
Argentina		0.8%		
Antilles and Aruba		2.4%		3.7%
Chile		3.3%		3.7%
Cuba		14.6%		
Jamaica				3.7%
Mexico		19.5%		14.8%
Puerto Rico		16.3%		3.7%
Surinam [b]		2.4%		3.7%
Uruguay [b]		0.8%		
Multiple nations [c]		39.8%		66.7%
Region of origin				
South America		8.1%		9.3%
Central America		19.5%		18.5%
Caribbean		72.4%		72.2%
Destination country				
Australia		3.3%		
Canada		1.6%		11.1%
Netherlands		8.1%		9.3%
Spain		0.8%		9.3%
Sweden		1.6%		3.7%
United Kingdom		23.6%		24.1%
United States		61.0%		42.6%
Sample size	343 to 35.9M	8.3M (8.7M)	1540 to 15.4M	6.8M (21.4M)
Number of control variables	0 to 34	1.4 (4.4)	0 to 8	1.7 (1.9)
Baseline start year	1964 to 2001	1984.7 (7.7)	1964 to 2005	1989.0 (9.7)
Follow-up duration (years)	0.5 to 21.5	3.6 (3.4)	0.5 to 21.5	5.1 (5.6)
Comparison group (in destination country)				
General population		67.5%		25.9%
Non-immigrant population		32.5%		74.1%
Record linkage methods used [a]				
Immigrant group		19.5%		51.9%
Non-immigrant group		17.9%		48.1%
Standard error imputed		63.4%		29.6%

[a] Survival status at end of follow up verified by making a positive match between baseline data and national death records.
[b] Excluded from models examining country of origin due to collinearity with destination country variables.
[c] Excluded from models examining country of origin due to missing information.

Table 3
Meta-analyses of the relative all-cause and cardiovascular mortality risk for immigrants vs. non-immigrants.[a]

	All-cause mortality			Cardiovascular mortality		
	RR (95% CI)	Number of RRs	*p*-value from *Q*-test [b]	RR (95% CI)	Number of RRs	*p*-value from *Q*-test [b]
All available data	0.92 (0.84–1.01)	123	<0.001	**0.73 (0.67–0.80)**	54	<0.001
By comparison group						
Non-immigrants only	**0.86 (0.76–0.97)**	40	0.031	**0.77 (0.68–0.86)**	40	0.517
General population	0.95 (0.88–1.03)	83	0.879	**0.65 (0.53–0.79)**	14	0.476
By mean age of sample						
0 to 19	**1.27 (1.06–1.53)**	16	0.923	Omitted [c]	0	NA
20 to 44	**0.89 (0.79–1.00)**	38	<0.001	**0.63 (0.53–0.76)**	17	0.074
45 to 64	**0.86 (0.77–0.96)**	41	0.989	**0.75 (0.65–0.86)**	27	0.779
65 +	0.91 (0.80–1.04)	28	0.999	0.86 (0.68–1.08)	10	0.691
By sex of sample						
Female	0.95 (0.87–1.03)	58	0.940	**0.81 (0.69–0.96)**	23	0.502
Male	0.95 (0.87–1.03)	61	0.033	**0.65 (0.56–0.77)**	24	0.487
By country of origin						
Argentina	Omitted [c]	0	NA	Omitted [c]	0	NA
Antilles and Aruba	0.69 (0.46–1.04)	3	<0.001	0.91 (0.68–1.23)	2	0.299
Chile	**0.47 (0.29–0.77)**	4	0.239	0.50 (0.18–1.41)	2	0.767
Cuba	0.92 (0.78–1.10)	18	0.513	Omitted [c]	0	NA
Jamaica	Omitted [b]	0	NA	1.00 (0.81–1.23)	2	0.008
Mexico	0.91 (0.77–1.06)	24	0.964	**0.72 (0.63–0.82)**	8	0.840
Puerto Rico	1.15 (0.97–1.35)	20	0.956	1.02 (0.83–1.26)	2	0.609
Surinam	0.83 (0.55–1.24)	3	0.007	**1.33 (1.10–1.61)**	2	0.194
Uruguay	Omitted [c]	0	NA	Omitted [c]	0	NA
By region of origin						
South America	**0.66 (0.51–0.86)**	10	0.038	1.01 (0.69–1.50)	5	0.417
Central America	0.91 (0.77–1.06)	24	0.965	**0.73 (0.56–0.94)**	10	0.992
Caribbean	0.96 (0.88–1.03)	89	0.403	**0.71 (0.63–0.80)**	39	0.175
By destination country						
Australia	**0.54 (0.37–0.82)**	4	0.255	Omitted [c]	0	NA
Canada	**0.41 (0.25–0.66)**	2	0.999	**0.57 (0.44–0.74)**	6	0.577
Netherlands	0.91 (0.73–1.15)	10	<0.001	1.11 (0.82–1.50)	5	0.768
Spain	Omitted [c]	0	NA	Omitted [c]	1	NA
Sweden	**0.46 (0.21–0.99)**	2	0.307	0.50 (0.16–1.53)	2	0.781
United Kingdom	0.97 (0.85–1.10)	29	0.999	**0.71 (0.59–0.86)**	13	0.522
United States	0.96 (0.88–1.04)	75	0.605	**0.70 (0.61–0.81)**	23	0.148
By number of control variables						
No controls	0.93 (0.84–1.02)	61	0.094	0.80 (0.63–1.00)	12	0.963
1 control	0.92 (0.83–1.03)	47	0.752	**0.67 (0.59–0.77)**	28	0.067
2 + controls	0.90 (0.74–1.11)	15	0.752	0.83 (0.67–1.02)	14	0.853
By whether record linkage methods were used [d]						
Immigrant group						
Yes	**0.75 (0.64–0.88)**	24	0.012	**0.78 (0.67–0.91)**	28	0.795
No	0.96 (0.90–1.04)	99	0.872	**0.69 (0.59–0.79)**	26	0.232
Non-immigrant group						
Yes	**0.81 (0.68–0.96)**	22	0.045	**0.83 (0.72–0.97)**	26	0.961
No	0.95 (0.88–1.02)	101	0.752	**0.66 (0.56–0.75)**	28	0.102
By standard error estimation						
Non-estimated SE only	**0.85 (0.75–0.95)**	45	0.049	**0.76 (0.75–0.78)**	38	<0.001
Estimated SE only	0.96 (0.89–1.05)	78	0.875	**0.69 (0.66–0.71)**	16	<0.001

Rate ratios that are significant at the 95% level are in bold.
[a] All meta-analyses calculated by maximum likelihood using a random effects model.
[b] Cochrane's *Q*-test assesses whether the effect estimates were homogeneous; *p*-value < .05 indicates a significant degree of heterogeneity.
[c] No meta-analysis could be produced because there was no effect size or one effect size for the sub-group.
[d] Survival status at end of follow up verified by making a positive match between baseline data and national death records.

with our preliminary expectations, we found differences between both the direction of the relationships and the size of the effect for (1) children and adolescents, (2) working-age immigrants, and (3) older immigrants. Individuals who were younger than 20 had a *higher* risk of early all-cause mortality compared with the controls in the destination country (RR, 1.27; CI, 1.06–1.53). Conversely, working-age immigrants (20–64) did in fact enjoy a mortality advantage. For individuals between the ages of 20 and 44 the mean RR was 0.89 (CI, 0.79–1.00) and for individuals between the ages of 45 and 64 the mean RR was 0.86 (CI, 0.77–0.96). Finally, we found no significant difference between immigrants and controls for those 65 years old or over. Supplemental meta-regression analyses (see Appendix 2) were consistent with these findings. The immigrant advantage for working-age persons was also present in our analysis of cardiovascular mortality (here we had no data for the youngest age group).

As for gender, we found no support for the hypothesis about a significant difference between men and women for all-cause mortality (see Table 3 and Appendix 2). However, the results do show a significant difference between the size of the effect for men and for women for cardiovascular mortality. Male immigrants enjoy a greater cardiovascular mortality advantage over the local population of about 35% (RR, 0.65; 95% CI, 0.56–0.77), although female immigrants also enjoy a significant advantage of about 19% (RR, 0.81:CI, 0.69–0.96).

Next, we disaggregated the analysis by countries and sub-regions of origin and by destination country. For all-cause mortality, the healthy immigrant effect was significant only for immigrants from Chile. For cardiovascular mortality, we found a lower risk for immigrants from Mexico, but a higher risk for those coming from Surinam. Immigrants from South America had a lower risk for all-cause mortality, while those coming from Central America and the Caribbean had a lower risk for cardiovascular mortality. Nevertheless, the results shown in Appendix 2 demonstrate that almost none of the differences between different countries and regions were statistically significant. We also examined differences between immigrants and controls in various OECD destination countries. The results show an immigrant mortality advantage in Australia, Canada, and Sweden for all-cause mortality, and in Canada, the United Kingdom, and the United States for cardiovascular mortality. However, once again, our meta-regression analyses (Appendix 2) showed very few significant differences between various destination countries.

5.1. Robustness checks

Cochrane's Q-tests for data heterogeneity presented in Table 3 indicated low levels of residual heterogeneity when using random-effects models. Additionally, one of the major concerns in meta-analysis research is the tendency of scholars and academic outlets to avoid reporting non-significant findings, otherwise known as "the file drawer effect" (Berman and Parker, 2002; Egger and Davey-Smith, 1998; Rosenthal, 1991). This tendency may lead to a misestimation of the mean RR. Figs. 2 and 3 present a funnel plot of the log RRs against sample size for all-cause and cardiovascular mortality respectively. For the all-cause mortality analysis, some sampling variability was visible in the funnel plot of the log RRs versus weights (see Fig. 2) and funnel plot asymmetry was confirmed using Eggers' test ($p < 0.001$). However, Peters' test for funnel plot asymmetry in heterogeneous data showed that heterogeneity was not likely a major problem in the final analyses ($p = 0.989$). For the cardiovascular mortality analysis, low levels of sampling variability were present in the funnel plot (see Fig. 3) and funnel plot symmetry was confirmed using Eggers' test ($p = 0.052$) and Peters' test ($p = 0.435$).

When funnel plot asymmetry is present, one should be especially careful in interpreting mean RRs that are relatively close to 1.00, even when these are significant. Since this is the case in the present analysis to some degree, publication bias may be an issue here. Fig. 2 is somewhat asymmetric around the mean, suggesting that there may be some missing higher-weight publications with a negative relationship (Egger's test confirmed this possibility). If such studies exist and could be included in the analysis, the expanded analysis would produce an immigrant mortality advantage that would be stronger than what we found. We should therefore treat with caution the non-significant results reported in the tables, especially those where confidence intervals are close to 1.00.

6. Limitations

A limitation for our study is the lack of data on immigrant mortality among specific racial/ethic groups. We chose to focus on the mortality risks of Latin American and Caribbean immigrants rather than individuals of Hispanic descent. This allowed us to assess whether the well-documented (ethnic) Hispanic mortality advantage applies to immigrants from Latin America and the Caribbean. However, the racial/ethnic diversity of Latin American and Caribbean migrants also poses some challenges because existing racial/ethnic health disparities in both origin and destination countries may moderate the healthy immigrant effect for some sub-groups, such Afro-Caribbean or Amerindian immigrants.

The destination country effects in Table 3 suggest that—at least with respect to Afro-Caribbean migrants—the inclusion of black migrants did not substantially change the results. If we assume that Afro-Caribbean migrants have a greater burden of morbidity and mortality than non-black migrants, then we would instead expect to see significantly higher RRs for the United Kingdom, the Netherlands, and Canada, since these are destination countries where the Caribbean migrant population is predominantly black

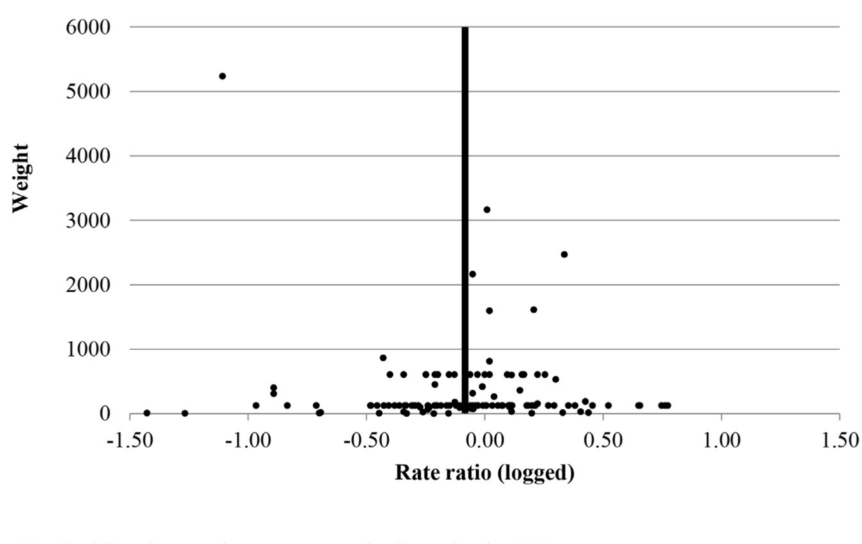

Fig. 2. Funnel plot of rate ratios (logged) versus effect estimate weight for studies of all-cause mortality (n = 123 rate ratios).

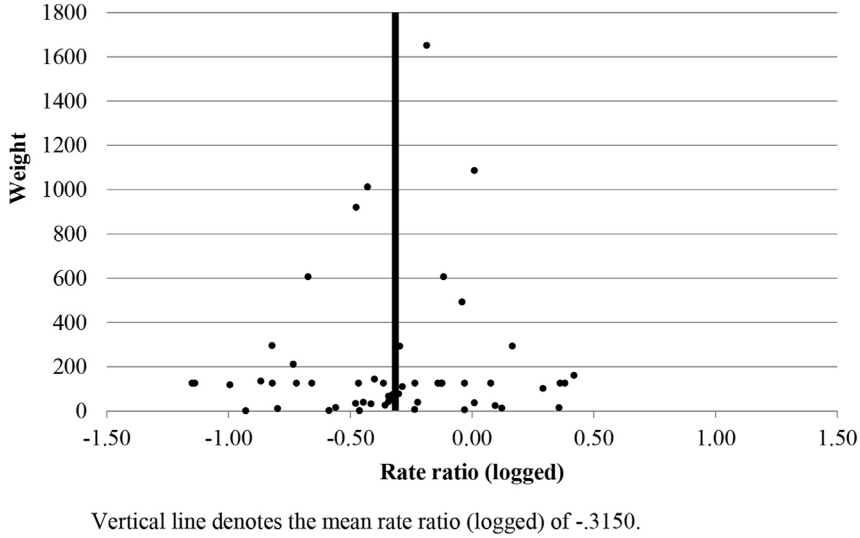

Fig. 3. Funnel plot of rate ratios (logged) versus effect estimate weight for studies of cardiovascular mortality (n = 54 rate ratios).

(Foner, 1998; Lindsay, 2001). Yet, Table 3 shows that all-cause mortality risks were not statistically significant for the UK and the Netherlands. The results for cardiovascular mortality tell a similar story of either non-statistically-significant differential risk (Netherlands) or even a lower mortality risk (United Kingdom). In Canada, Caribbean migrants actually have lower all-cause and cardiovascular mortality than the controls.

Likewise, country-of-origin effects do not suggest that the presence of black Caribbean migrants affected the results. Risks for all-cause mortality were not statistically higher for migrants from Antilles and Aruba or from Surinam (countries with large Afro-Caribbean populations; see Cervantes-Rodriguez et al., 2009). Surinamese migrants do have a higher risk of cardiovascular mortality. However, it is not clear why this higher risk only appeared for cardiovascular mortality and only for Surinamese migrants. Future studies that include the race/ethnicity of Latin American and Caribbean migrants may explain how race/ethnicity interacts with origin and destination country contexts to alter mortality.

7. Discussion and conclusion

We conducted a meta-analysis and meta-regression of the relationship between immigration from Latin America and the Caribbean to OECD countries and mortality rates (both all cause and cardiovascular). While our overall results appear to offer mixed support for the immigrant mortality-advantage hypothesis, analyses of studies that used only native-born controls showed significant results for both all-cause and cardiovascular mortality. Our publication-bias analysis further suggests that if a bias indeed exists, it is toward null findings. Therefore, we may conclude than there is indeed an immigrant mortality advantage.

Beyond the overall effect, a closer look at the results of our subgroup meta-analyses reveals important variations. In particular, age emerges as a key moderating variable, to which future studies must pay closer attention. Working-age immigrants (ages 20 to 64) appear to enjoy greater survival prospects compared to controls, an effect that is even stronger for cardiovascular mortality. This advantage, however, does not exist for immigrants older than 65. Furthermore, the effect actually reverses among children or adolescents. For this age group (2–19), immigration was actually associated with a greater risk of mortality when compared to controls in the host country.

One possible reason for the mortality disadvantage of immigrant children and adolescents is selection. First, children and adolescents are less likely to be subjected to careful selection processes by host countries, as countries tend to pay greater attention to the skills and health condition of the adults in the family (Vang et al., 2017). It is therefore possible that children have less of a healthy immigrant advantage compared with adults. Furthermore, immigrant children and adolescents who become seriously ill may not necessarily return to their countries of origin (Salmon Bias) because parents are the ones who typically make the decision to return (Dustmann, 2003). Although immigrant children returnees are common in some migrant populations (e.g., Mexican immigrants; see Zuniga and Hamann, 2015), parents may be less willing to return to Latin American and Caribbean countries where healthcare access and services for their children may be more limited. As such, a less healthy profile, coupled with lower return rates, may result in higher mortality rates for migrant children and adolescents compared to their native-born counterparts.

Beyond selection processes, the mortality disadvantage of immigrant children may also result from childhood-related vulnerabilities. Compared with adults, children are more vulnerable to environmental health risks and may have a harder time adjusting to new health hazards when moving to a new country (Stillman et al., 2012). After all, most of these children moved from the global South to the global North, having to adjust to new climates and nutritional environments, which may pose unique health challenges. Finally, acculturation may also play an important role in children's mortality disadvantage. To the extent that acculturation negatively influences dietary habits and health behaviors of immigrants, children may be especially vulnerable. Immigrant children, particularly those who migrated at very young ages, are more likely to adopt the norms of the host society (Portes and Rumbaut, 1990; Rumbaut, 2004). As such, they may adopt behaviors such as an unhealthy diet, less physical exercise, and greater consumption of tobacco and other drugs. When coupled with lower socioeconomic status and potentially-reduced access to healthcare services, these disadvantages may increase vulnerability. Our findings thus call for paying greater attention to the migration process and the pre- and post-migration risks that immigrant children face.

As for differences in country of origin and country of destination, Latin American and Caribbean immigrants to Canada, Sweden and Australia enjoyed a relatively large advantage (close to or even greater than 50% reduction in all-cause mortality risk), compared with controls. Further research on such “immigration-friendly” countries, where integration policies are favorable and anti-immigrant sentiment is relatively low, is needed to establish whether they indeed offer immigrants greater health and longevity prospects.

Finally, our results offer mixed support for the Salmon Bias Hypothesis (Abraido-Lanza et al., 1999), stating that one of the main elements behind the mortality advantage for immigrants is a bias in documentation; sick individuals return to their country of origin to end their lives there. According to this hypothesis, we would expect immigrants from countries that are geographically proximate to destination country (such as Mexico for immigrants to the US) to be more likely to return when sick, producing a seemingly greater mortality advantage. On the one hand, we found that immigrants from South America, the most distant geographical sub-region among the ones examined in our study, enjoyed a relative all-cause mortality advantage. In addition, the fact that we did not find a significant mortality advantage for the oldest age group (65 and above) is also problematic for the return-migration hypothesis, as this is the group where Salmon Bias was expected to be most evident. On the other hand, we did find a cardiovascular mortality advantage for immigrants from the most geographically-proximate regions (Central America and the Caribbean), but not from South America.

In conclusion, we conducted the first meta-analysis focusing specifically on immigrants from Latin America (rather than Hispanic ethnicity). Our analyses suggest that studies that carefully compared immigrants' mortality to that of native-born persons found a significant all-cause and cardiovascular mortality advantage for these immigrants. Furthermore, the age of immigrants emerges as a key moderating factor in these analyses, with immigrant children and youth being particularly susceptible to early mortality risks, calling for greater attention to this particular age group and its health. Future research on immigrant health and mortality should therefore try to move beyond general comparisons of immigrants and native-born persons, and instead explore in greater depth variations in relative mortality for multiple sub-populations.

Appendix 1. Additional information

Section 1: Variables for which data were sought

1) Author names; 2) author genders; 3) publication date; 4) publication title; 5) place of publication; 6) ethnicity of immigrant and non-immigrant groups; 7) nation and region of origin for immigrant group; 8) geographic destination for immigrants; 9) comparison group used (e.g. non-immigrants in nation of origin or non-immigrants in destination nation); 10) whether the comparison group was the general population (i.e. consisted primarily – but not solely – of non-immigrants); 11) percent of the sample that was male; 12) minimum age; 13) maximum age; 14) mean age; 14) name of data source used; 15) baseline start date (day, month, year); 16) baseline end date (day, month, year); 17) follow-up end date (day month, year); 18) maximum follow-up duration; 19) average follow-up duration; 20) information on timing of immigration relative to baseline start date; 21) information on the structure of the follow-up period (e.g. were there any gaps between the end of baseline and the beginning of follow-up?); 22) statistical technique used; 23) cause of death (all-cause or cardiovascular); 24) whether death record linkage was used; 25) total number of persons analyzed in the publication; 26) total number of persons analyzed for the specific effect size; 27) number of persons in the immigrant and non-immigrants groups; 28) number of deaths in the immigrant and non-immigrant groups; 29) death rates in the immigrant and non-immigrant groups 30) effect size; 31) confidence interval; 32) standard error; 33) t-statistic; 34) Chi-square statistic; 35) minimum and maximum p-values; 36) full list of control variables used; 37) date of data extraction; 38) subjective quality rating; 39) number of citations received by publication according to Web of Science and Google Scholar; and 40) 5-year impact factor for place of publication.

Section 2: Additional information on the conversion of odds ratios and hazard ratios to rate ratios

All non-rate-ratio point estimates were converted to RRs (the most frequently reported type) using one of the following equations:

$$RR = \frac{OR}{(1-r)+(r*OR)}$$

or

$$RR = \frac{1-e^{HR\times ln(1-r)}}{r}$$

where RR is the relative risk, OR is the odds ratio, HR is the hazard ratio, and r is the death rate for the reference (i.e. non-immigrant) group.

When not reported in the individual studies, death rates were obtained from the *Human Mortality Database* (University of California-Berkeley and Max Planck Institute for Demographic Research, 2011). The underlying death rate was calculated such that the result would be matched to a particular study in terms of the nation from which the sample was drawn, the year in which the study was conducted, and the sex and age of the respondents.

Section 3: Additional information on the estimation of standard errors

When the original study did not report a standard error or a test of significance from which a standard error could be calculated, we used an estimate of the standard error (studies were retained rather than eliminated because of the large sample sizes present, often an entire population). Missing standard errors were estimated using mean substitution, where means were calculated separately for each destination nation in the analysis. We tested the robustness of our estimation procedure by comparing our reported results against results where we both scaled the standard errors down and scaled them up. The results we reported did not substantively differ from these alternatives, suggesting that the estimation of standard errors did not inflate or deflate the final results.

Appendix 2. Multivariate meta-regression analyses predicting the magnitude of the effect of immigration on all-cause and cardiovascular mortality [1]

	All-cause mortality		Cardiovascular mortality [2]
	With Country of origin	With region of origin	
Constant	0.00 (0.00–0.00)	2.18 (0.55–8.67)	0.86 (0.09–8.17)
Mean age at baseline (decades)	**85.63 (6.14–1204.08)**	0.76 (0.55–1.06)	1.08 (0.56–2.13)
Mean age (decades), squared	**0.73 (0.55–0.96)**	1.02 (0.99–1.06)	0.99 (0.94–1.05)
Proportion of sample that is male	0.94 (0.77–1.14)	0.98 (0.73–1.31)	**0.77 (0.62–0.96)**
Country of origin [3] (Reference = Mexico)			
Antilles and Aruba	0.84 (0.63–1.10)	…	…
Chile	0.84 (0.46–1.52)	…	…
Cuba	1.31 (0.90–1.91)	…	…
Puerto Rico	1.34 (0.91–1.96)	…	…
Region of origin (Reference = Caribbean)			
South America	…	1.12 (0.57–2.20)	1.08 (0.70–1.67)
Central America	…	0.76 (0.42–1.38)	1.09 (0.65–1.87)
Country of destination (Reference = USA)			
Australia	1.43 (0.39–5.19)	0.51 (0.19–1.33)	…
Canada	···	**0.41 (0.20–0.85)**	0.79 (0.43–1.44)
Netherlands	**5.64 (1.01–31.7)**	0.76 (0.36–1.62)	1.62 (0.84–3.11)
Spain	···	0.73 (0.20–2.66)	1.65 (0.79–3.43)
Sweden	**0.26 (0.10–0.68)**	0.43 (0.13–1.38)	0.49 (0.12–2.01)
United Kingdom	···	1.02 (0.54–1.93)	1.35 (0.65–2.79)
Sample size (logged)	1.06 (0.89–1.27)	1.00 (0.92–1.08)	0.96 (0.87–1.05)
Number of control variables	1.02 (1.00–1.05)	1.00 (0.98–1.03)	1.06 (0.95–1.20)
Study age (decades)	**2.69 (1.89–3.80)**	0.99 (0.75–1.30)	1.04 (0.89–1.21)
Number of RRs included in meta-regression	74	123	54

RRs that are significant at the 95% level are in bold.
[1] All meta-regressions calculated by maximum likelihood using a random effects model. Numbers reported are the exponentiated regression coefficient (95% confidence interval). Results statistically significant at the 0.05 level are bolded.
[2] No model could be produced to examine the association between country of origin and cardiovascular mortality due to the low number of cases available.
[3] Effect estimates based on respondents from multiple nations were excluded from analysis. Because Argentina, Jamaica, Surinam, and Uruguay were always combined with one or more other nations, they were part of this set of excluded effect estimates.
[4] Excluded due to high collinearity.

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