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Long-Distance Migration and Mortality in Sweden: Testing the Salmon Bias and Healthy Migrant Hypotheses

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ABSTRACT

International migrants often have lower mortality rates than the native populations in their new host countries. Several explanations have been proposed, but in the absence of data covering the entire life courses of migrants both before and after each migration event, it is difficult to assess the validity of different explanations. In the present study, we apply hazard regressions to Swedish register data to study the mortality of long-distance migrants from Northern to Southern Sweden as well as the mortality of return migrants to the North. In this way, we can study a situation that at least partly resembles that of international migration while still having access to data covering the full demographic biographies of all migrants. This allows us to test the relative roles of salmon bias and healthy migrant status in observed mortality rates of long-distance migrants. We find no mortality differentials between residents in northern and southern Sweden, and no evidence of a selection of healthy migrants from the North to the South. In contrast, we provide clear evidence of 'salmon effects' in terms of elevated mortality of the return migrants to northern Sweden, which are produced when migrants return to their place of origin in relation to subsequent death. © 2016 The Authors. *Population, Space and Place*. Published by John Wiley & Sons, Ltd.

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INTRODUCTION

The demographic study of migrants often produces different 'paradoxes'; this happens when observed demographic rates for migrant populations fail to conform to expectations. This is often the case in fertility research (e.g. Frank & Heuveline, 2005 on the unexpectedly high fertility of Mexican third-generation migrants in the US) as well as mortality research (e.g. Palloni & Arias, 2004 on the unexpectedly low mortality of Hispanics in the US). In this study, we use a research design based on longitudinal analyses of domestic migration and mortality in Sweden to address the mechanisms behind one of these paradoxes. The aim is to detect and distinguish between two mechanisms thought to be responsible for the often unexpectedly low mortality of migrants: (1) the primary, healthy migrant effect and (2) the secondary, unhealthy return migrant, or 'salmon effect' in mortality.

Sometimes, paradoxes in migration research stem from the methodological difficulties of studying migrant populations and the need for data that accurately cover dimensions of both space and time. In the case of international migration, this involves not only the standard demographic consideration of proper time-to-event data but also the need to consider data that stretch over several geographical areas or countries. In reality, however, most data sources are collected in one given country only, and the demographic indicators for migrants living in that country easily become distorted. This happens if the demographic outcomes of migrants occur more (or less) often in the country that can be observed than in the migrants' countries of origin or any subsequent destination. For example, the demographic literature identifies migration effects in measures of fertility, manifested in artificially elevated fertility rates of immigrants, which are produced when childbearing more often occurs subsequent to migration than before it (Andersson, 2004; Milewski, 2006; Parrado, 2011). The mortality literature points at suggested salmon effects, which are produced by situations when migrants opt to return to their country of origin in cases of poor health or in anticipation of death (Abraído-Lanza *et al.*, 1999). This pattern would produce reduced mortality rates for immigrants in the host country, where the data on migrants are collected. In our study, we aim to address the mechanisms behind any such salmon effects in migrant mortality. Based on analyses of Swedish register data, we study the mortality of long-distance domestic migrants in Sweden; to some extent, this resembles a situation of international migration, but it allows us to assess the complete demographic biographies of migrants and stayers alike.

PREVIOUS RESEARCH

A stream of recent research has focused on the Hispanic mortality paradox in the US, as expressed in lower mortality of Hispanics than of Non-Hispanic Whites, despite the former group's imminent socio-economic disadvantages (for a review of the state of current research in the US, see Markides & Eschbach, 2005, 2011; for related research on morbidity, see Riosmena *et al.*, 2013). Similar patterns have been observed for immigrant populations across Europe (e.g. Anson, 2004, and Deboosere & Gadeyne, 2005, for Belgium; Uitenbroek & Verhoeff, 2002, for the Netherlands; Razum *et al.*, 1998, and Kibele *et al.*, 2008, for Germany; Courbage & Khlat, 1996, for France; Wallace & Kulu, 2014a, for the UK) as well as in other countries (e.g. Hajat *et al.*, 2010 for New Zealand). Salmon effects may have produced these patterns of reduced migrant mortality, but there are at least two competing mechanisms that may also contribute to these patterns: those of (i) selective immigration of healthy migrants or immigrants with healthy lifestyles (e.g. Deboosere & Gadeyne, 2005) and (ii) the underreporting or misreporting of emigration and return-migration events (cf. Weitoft *et al.*, 1999; Kibele *et al.*, 2008; Wallace & Kulu, 2014a). Migrants are more likely to report their immigration to their new country than their emigration or subsequent return migration. Such patterns of underreporting also contribute to the distortion of observed demographic rates. As the population at risk in a given country becomes inflated and the reports of vital events (deaths, births, civil status changes) instead occur in another country, the observed demographic rates of any population with high levels of undocumented outmigration or return migration will be depressed.

The testing of these competing hypotheses has not been entirely successful, mainly because of the lack of data that span both time and space. Turra and Elo (2008) note that longitudinal surveys following individuals in and out of a host country are needed to explore the role of migration for mortality and other demographic processes. Such surveys are rarely available and hardly large enough to detect differentials in mortality. Register data may be more suitable for mortality research but are bound to be restricted to one specific country context. Thus, they are not entirely suitable for studies of international migration. However, they may be used to look at salmon effects and other migration effects that may occur *within* the country where the data are recorded. Existing research on domestic migration and mortality tends to focus on short-distance migration among the elderly and its effects on recorded mortality rates (e.g. Kibele & Janssen, 2013; see also Boyle, 2004). An even larger body of research, carried out by epidemiologists and health geographers, focuses on how poor health relates to patterns in domestic migration, including that of domestic return migration (Boyle & Norman, 2009; Wallace & Kulu, 2014b; Lu & Qin, 2014). For example, the short-distance migration of elderly people is often directed to areas with nursing homes (Litwak & Longino, 1987), which in turn produces distorted patterns of local morbidity. While long-distance and working-age migrants are often found to be relatively healthy, the opposite tends to hold for short-distance and elderly migrants (Bentham, 1988; Boyle *et al.*, 2002; Boyle, 2004). Evidently, differentials in migration patterns by people's health status help produce some of the differences that are observed in morbidity between regions and local areas (Brimblecombe *et al.*, 2000; Boyle *et al.*, 2002; Norman *et al.*, 2005; Connolly *et al.*, 2007).

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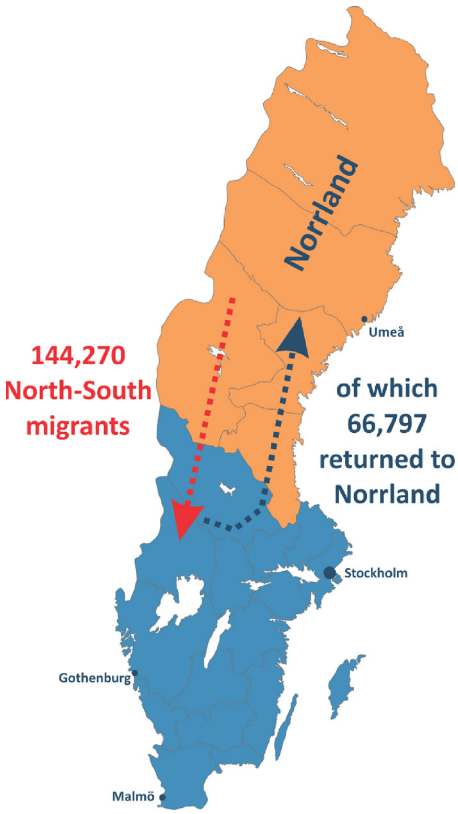
STUDY CONTEXT AND STUDY DESIGN

In this study, we exploit Swedish register data to detect possible salmon and healthy migrant effects in the mortality of long-distance migrants within the country. Sweden is a fairly large country in terms of geography, at least by European standards, and by focusing on the long-distance migrants from northern to southern Sweden, we can study a migration situation that to some extent resembles that of international migration. This allows us to detect and distinguish between any healthy migrant and salmon effects in migrant mortality. As Swedish registers cover the entire resident population of the country and its vital events with a high degree of accuracy, issues of underreporting migration and mortality events are virtually non-existent.

Our study thus provides a direct test of the two main hypotheses of interest. To this end, we use individual-level register data that track the demographic trajectories of all individuals living in Sweden from the late 1960s through 2007. We study the mortality of migrants from northern to southern Sweden, and that of return migrants to northern Sweden (Fig. 1). The sparsely populated, forested northern part of Sweden, called *Norrland*, is a region characterised by considerable outmigration during the entire period we study. Although it covers 59% of Sweden's surface, it only has about 14% of its inhabitants (cf. Öberg & Springfeld, 1991). In our study, we follow all individuals born in Norrland in 1954 onwards, for whom the Swedish registers contain monthly data on place of residence from the age of 16, and observe how the mortality patterns of migrants from Norrland compare with those of the remaining population.

We address several questions to detect any primary healthy migrant effects: Do migrants from Norrland to southern Sweden have lower



Note: Norrland includes the five northern counties of Sweden: Norrbotten, Västerbotten, Jämtland, Västernorrland and Gävleborg.

Figure 1. Sweden with Norrland, number of migrants.

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mortality than the general population of Norrland? Do they have lower mortality than the population of southern Sweden? In order to detect any secondary unhealthy return migrant, or salmon, effect in mortality, we ask whether return migrants to Norrland have higher mortality than those who stay in southern Sweden. We also address the impact of possible confounders by studying whether patterns differ by population sub-groups in terms of their marital and socio-economic status. All analyses are carried out separately for women and men.

DATA AND METHODS

We apply a longitudinal approach, using Swedish population registers and hazard regression/event-history techniques to examine the role of migration in mortality. The baseline hazard $h_0(t)$ is modelled as a function of age. The baseline is assumed to follow a Gompertz distribution, defined as $h_0(t) = \exp(\gamma t)\exp(\beta_0)$ where γ and β are ancillary parameters that control the shape of the baseline hazard. The Gompertz parametrisation has been widely used by demographers to model human mortality data.

The data stem from the Sweden in Time: Activities and Relations (STAR) collection of registers, administered by the Stockholm University Demography Unit and the Swedish Institute for Social Research and stored at Statistics Sweden. Swedish population registers are a source of detailed and highly accurate demographic information with a very low percentage of missing data. The information analysed for every individual comprises histories of vital demographic events, such as those of migration and death, which are covered with the accuracy of a month. The analyses also include a variety of background information such as place of birth (time-constant) and time-varying histories of place of residence, marital status, and educational attainment. Individuals are censored at any first emigration from Sweden.

The base population of our study consists of all people aged 16 and older who were living in the country at the beginning of 1990. We include only those with no prior emigration from or immigration to Sweden, and for whom complete domestic migration histories were available. The first year for which we have access to full domestic migration histories is 1970; thus, those who turned 16 in 1970 are the oldest cohort in our data. The first year of follow-up is 1990, as this is the earliest year for which we have annual background data on educational attainment. In 1990, the oldest individuals turned 36. New individuals enter the study the month they turn 16 during 1990–2007. All individuals are followed until death, censoring due to emigration, or 31 December 2007, whichever comes first.

In 2007, the last year for which we have data, the oldest individuals turned 53. Consequently, our study is targeted mainly at people of working age. For our purposes, this is not necessarily a disadvantage: it makes the age structure of our study population resemble that of a typical international migrant population in Sweden. The total study population amounts to 1,871,000 Swedish-born women and 1,976,000 Swedish-born men. Of these, 144,270 were born in Norrland and had moved to other parts of Sweden, and 66,797 of these migrants had returned to and again lived in Norrland for some time during our study period.

Information on marital status and highest educational attainment are recorded annually. The education information is grouped into three categories, each corresponding to one or several levels of the International Standard Classification of Education (ISCED). The lowest category corresponds to individuals who attended primary school or lower secondary school (ISCED codes 0–2). This category also includes those few individuals for whom education is unknown. Individuals without educational information comprise about 0.6% of the total person-time at risk, of which the majority can be attributed to individuals aged 16–18 who did not have an educational level assigned at that early age. The intermediate level consists of people who received upper secondary education or advanced vocational training (ISCED codes 3–4). Individuals with tertiary education are assigned to the highest category (ISCED codes 5–7).

To address our hypotheses, we study the relative mortality of the following groups: (1) people born in Norrland who remained there, (2) people born and living in southern Sweden, (3) People born in Norrland who migrated from Norrland to southern Sweden, and (4) people born in Norrland who migrated from Norrland and returned to northern Sweden. People who

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continue to migrate between the two regions are categorised according to their time-varying current place of residence. Foreign-born people are excluded from the analyses. All analyses are carried out separately for women and men and include controls for age. To test the healthy migrant hypothesis, we compare the mortality of migrants from Norrland to southern Sweden (group 3) with those who were born in and remained in Norrland (group 1) or southern Sweden (group 2). If the healthy migrant hypothesis holds, we expect individuals who had made a long-distance move (group 3) to have lower mortality than any of the other two groups. To address the salmon bias hypothesis, we compare the mortality of those who migrated from Norrland to southern Sweden and subsequently returned to Norrland (group 4) with all other groups. If the hypothesis holds, we expect migrants who returned to Norrland to have elevated mortality. Additional analyses involve controls for the role of marital status and educational attainment, as well the study of possible mortality differentials by the duration since any recorded migration.

RESULTS

Table 1 shows descriptive statistics in terms of time at risk and crude mortality rates for women and men in different categories of the variables we have constructed. Differences in mortality between different migration and civil status categories largely reflect differences in age composition between population sub-groups. Mortality rates for men are about twice as high as those for women. The standardised associations between region of residence, migratory history, and mortality are shown in Table 2: Table 2a shows the mortality risks for women, and Table 2b for men. Each table includes four hazard regression models and provides the relative risk of death for each category of included variables as compared with a reference group within the same variable. The ancillary parameters that control the shape of the Gompertz baseline hazard, the *constant* and *gamma*, are provided for each model at the bottom of the table.

Model 1 shows the effect of our main independent variable of interest – *region of*

Table 1. Distribution of time at risk for Swedish-born women ($N = 1{,}871{,}308$) and men ($N = 1{,}975{,}514$).

	Women			Men		
	Person-time (in years)	Number of deaths	Rate (per 1,000 years)	Person-time (in years)	Number of deaths	Rate (per 1,000 years)
Region of residence						
Stable in Norrland	1,863,589	941	0.50	2,152,115	2,091	0.97
Stable in other parts of Sweden	21,602,998	11,073	0.51	22,868,385	21,791	0.95
Movers from Norrland	779,299	453	0.58	695,299	749	1.08
Movers returning to Norrland	345,372	245	0.71	284,531	433	1.52
Missing information	4,068	1	0.25	5,975	0	0.00
Marital status						
Never married	15,906,863	7,285	0.05	19,035,672	18,909	0.99
Married	7,601,050	3,841	0.51	6,304,394	4,082	0.65
Separated	1,431,132	1,668	1.17	1,060,859	2,433	2.29
Widowed	56,270	96	1.71	18,443	54	2.93
Missing information	8,553	12	1.40	7,508	28	3.73
Highest achieved education						
Low (or missing)	4,785,859	4,195	0.88	6,038,953	9,658	1.60
Medium	12,835,238	6,114	0.48	13,939,322	12,602	0.90
High	7,382,770	2,593	0.35	6,448,602	3,246	0.50
Total	25,003,867	12,902	0.52	26,426,877	25,506	0.97

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Table 2. Relative risk of death, by region of residence and migrant status in Sweden, 1990–2007.

	Model 1		Model 2		Model 3		Model 4	
	RR	SE	RR	SE	RR	SE	RR	SE
(a) Swedish-born women: main effects								
Region of residence								
Stable in Norrland	1.00	(0.0340)	1.01	(0.0343)	1.00	(0.0339)	1.00	(0.0341)
Stable in other parts of Sweden	1		1		1		1	
Movers from Norrland	0.97	(0.0463)	1.10*	(0.0529)	0.95	(0.0454)	1.08	(0.0517)
Movers returning to Norrland	1.12	(0.0723)	1.26***	(0.0813)	1.09	(0.0707)	1.23**	(0.0792)
Highest achieved education								
Low			2.55***	(0.0515)			2.48***	(0.0502)
Medium			1				1	
High			0.64***	(0.0151)			0.66***	(0.0156)
Marital status								
Never married					1.80***	(0.0386)	1.72***	(0.0369)
Married					1		1	
Divorced					1.91***	(0.0562)	1.69***	(0.0499)
Widowed					2.30***	(0.2380)	1.97***	(0.2030)
Constant	0.000000132		0.000000090		0.000000065		0.000000047	
Gamma	0.0001913		0.0002120		0.0002157		0.0002343	
(b) Swedish-born men: main effects								
Region of residence								
Stable in Norrland	1.03	(0.0234)	1.02	(0.0233)	1.00	(0.0229)	1.00	(0.0229)
Stable in other parts of Sweden	1		1		1		1	
Movers from Norrland	0.98	(0.0363)	1.18***	(0.0439)	0.97	(0.0361)	1.15***	(0.0430)
Movers returning to Norrland	1.35***	(0.0654)	1.56***	(0.0760)	1.32***	(0.0642)	1.52***	(0.0736)
Highest achieved education								
Low			2.06***	(0.0280)			2.02***	(0.0274)
Medium			1				1	
High			0.50***	(0.0099)			0.54***	(0.0106)
Marital status								
Never married					2.74***	(0.0498)	2.54***	(0.0463)
Married					1		1	
Divorced					3.02***	(0.0776)	2.65***	(0.0682)
Widowed					3.35***	(0.4590)	3.01***	(0.4120)
Constant	0.000000499		0.000000382		0.000000140		0.000000121	
Gamma	0.0001376		0.0001524		0.0001762		0.0001857	

Models also include missing categories.
RR, relative risk; SE, standard error.
*$p < 0.05$,
**$p < 0.01$,
***$p < 0.001$.

residence – on the risk of mortality when only age is controlled for. The reference group consists of those who were born and remained in southern Sweden. The patterns of relative differences in age-standardised mortality are very similar for women and men. Individuals who remained in Norrland and primary migrants from Norrland to southern Sweden experienced mortality that was very similar to that of people born and resident in southern Sweden. In contrast, the model reveals elevated mortality for individuals who had returned to Norrland: the relative risks that can be ascribed to any salmon effects in mortality are 1.12 for women and 1.35 for men.

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However, this excess risk is only statistically significant for men.

In models 2–4, we examine whether the patterns in model 1 stem from differences in the composition of migrants according to their educational level and marital status. Model 2 adds control for *highest achieved education* in each month of observation. The reference group consists of those with medium education. As expected, we find that the higher the educational level, the lower the mortality; however, our main interest is whether including the control for this variable modifies the estimates for *region of residence*. This is indeed the case. Adding this control produces elevated mortality for primary migrants to southern Sweden, as well as higher excess risks of mortality for return migrants to Norrland. This holds for women as well as men. Evidently, long-distance movers tend to be more highly educated than stayers, and we need to

Table 3. Relative risk of death, by region of residence and migrant status in Sweden, 1990–2007 (Swedish-born women and men: main effects and interactions).

	Women				Men			
	Model 5		Model 6		Model 5		Model 6	
	RR	SE	RR	SE	RR	SE	RR	SE
Region of residence								
Stable in Norrland	0.97	(0.0456)	1.05	(0.0652)	0.98	(0.0299)	1.02	(0.0606)
Stable in other parts of Sweden	1		1		1		1	
Movers from Norrland	1.16*	(0.0806)	1.16	(0.0985)	1.23***	(0.0640)	1.11	(0.0976)
Movers returning to Norrland	1.23*	(0.1140)	1.43**	(0.1580)	1.51***	(0.0992)	1.26	(0.1610)
Highest achieved education								
Low	2.47***	(0.0530)	2.48***	(0.0502)	2.01***	(0.0291)	2.02***	(0.0274)
Medium	1		1		1		1	
High	0.67***	(0.0168)	0.66***	(0.0155)	0.54***	(0.0115)	0.54***	(0.0106)
Marital status								
Married	1		1		1		1	
Unmarried	1.71***	(0.0345)	1.74***	(0.0373)	2.56***	(0.0454)	2.55***	(0.0482)
Interactions								
Low education + stable in Norrland	1.15	(0.0871)			1.03	(0.0514)		
High education + stable in Norrland	0.98	(0.0960)			1.06	(0.0845)		
Low education + movers from Norrland	0.95	(0.1150)			0.99	(0.0867)		
High education + movers from Norrland	0.82	(0.0924)			0.78*	(0.0750)		
Low education + returning to Norrland	0.81	(0.1440)			1.15	(0.1300)		
High education + returning to Norrland	1.13	(0.1640)			0.84	(0.1120)		
Unmarried + stable in Norrland			0.94	(0.0693)			0.97	(0.0621)
Unmarried + movers from Norrland			0.90	(0.0921)			1.05	(0.1010)
Unmarried + returning to Norrland			0.80	(0.1090)			1.25	(0.1730)
Constant	0.000000047		0.000000047		0.000000119		0.000000119	
Gamma	0.0002343		0.0002343		0.0001869		0.0001869	

Models also include missing categories.
RR, relative risk; SE, standard error.
*$p < 0.05$,
**$p < 0.01$,
***$p < 0.001$.

control for this pattern in order to obtain an accurate picture of how migration itself relates to mortality. When the control is added, we find that female migrants to southern Sweden have 10% higher mortality than stayers in this region and that male migrants from Norrland to southern Sweden have 18% higher mortality. The excess mortality of return migrants to Norrland increases to 26% for women and 56% for men.

Model 3 adds control for *marital status* instead. Married individuals – who make up the reference group – experience the lowest mortality, with risks of death being about twice as high for the different categories of unmarried women and about three times as high for the different categories of unmarried men. Our main concern, however, is whether including marital status affects the estimates for *region of residence*. It turns out that this is not the case; the estimates for this variable are only slightly different in model 3 than in model 1. Finally, in model 4, we include controls for *marital status* and *highest achieved education* simultaneously; the results in this model are very similar to those in model 2.

In a final step of our modelling, we add interaction parameters for the different combinations of our main variable of interest and *education* and *marital status*, respectively. This serves the purpose of detecting whether any primary healthy migrant or secondary salmon effect in mortality comes out more or less strongly for any particular educational or marital status category. Table 3 shows the results from these models for women and men, separately. Model 5 adds interaction parameters for different combinations of educational level and region of residence; model 6 adds similar parameters for the different combinations of region of residence and the status of being unmarried. Only one interaction parameter (for men) turns out statistically significant at the conventional 5% level, and the patterns of relative risks for our main variable of interest largely remain intact when this complexity is added to the model. However, a few interesting patterns of interaction can still be observed. Highly educated primary migrants from Norrland to southern Sweden seem to have somewhat lower mortality than what the main effects of high education and being a mover from Norrland would otherwise predict (relative risk = 0.82 for women and 0.78 for men). The interaction between marital status and region of residence produces no significant parameters but still suggests that unmarried return-migrant men have even higher mortality than what the main effects of being unmarried and a return migrant to Norrland would predict. The opposite may hold for women. The incorporation of this interaction into the model leads to a somewhat stronger main effect of being a return migrant for women, but a weaker main effect for men. A further inspection of patterns in interactions reveals gradients in parameters that seem to appear different for return-migrant women and men. While disadvantaged return-migrant men (unmarried men and men with low education) seem to be exposed to even higher mortality than what each of the different factors considered would predict, we find that similarly disadvantaged women have somewhat lower mortality than otherwise predicted. We tested additional models that also included variables with categories for different durations since last previous migration. Contrary to our expectations, we did not find any meaningful patterns or changes in patterns of associations with this variable added.

CONCLUSIONS AND DISCUSSION

In our mortality study, we relied on a research design based on high-quality longitudinal data on domestic migration between northern and southern Sweden and the mortality of migrants in this country. The purpose was to detect and distinguish between any primary, healthy migrant effects in mortality and those related to secondary, unhealthy return migration, or salmon effects in migrant mortality. To some extent, the focus on long-distance domestic migration resembles that of international migration, but it allows us to avoid the bias in mortality estimates that would stem from the non-reporting of deaths occurring outside the geographical area we are able to study.

The main contribution of our study is that we find clear evidence of the otherwise so elusive salmon effects in mortality: we find elevated mortality in working-age return migrants to northern Sweden. This holds for women and men alike, and patterns remain intact once we add controls for educational attainment and marital status. In contrast, we find no evidence

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of primary healthy migrant effects in the mortality of migrants from northern to southern Sweden. When we control for the relatively high educational level of long-distance migrants, we rather find that the migrants to southern Sweden are selected in terms of higher mortality than that of the non-migrant population. In general, patterns in relative mortality are very similar for women and men, but the excess mortality of migrants in general and return migrants in particular appears somewhat stronger for men than for women. For both sexes, it is important to control for the composition of migrants in terms of their educational attainment in order to derive accurate estimates of the association between migration and mortality. A deeper look at various interaction effects between our variables at hand suggests that salmon effects in mortality are stronger for low-educated and unmarried men than for men who belong to more advantaged socio-demographic categories in terms of mortality.

The question remains as to what extent our findings are specific to the context we study, and to what extent they can be generalised to other contexts and migration types. There is a great deal of previous research, but precious little empirical evidence of true salmon effects in migrant mortality. In many cases, this absence of evidence may be related to the fact that most previous research has had to rely on indirect evidence on the mortality of emigrants and return migrants. The study that most resembles ours in terms of research design is that of Wallace and Kulu (2014b), which examined the health status of migrants between Scotland and England in the UK. The socio-demographic differentials between Scotland and England highly resemble those of northern and southern Sweden. Wallace and Kulu find evidence of healthy migrants from Scotland to England, but no evidence of salmon effects in terms of poor health among the return migrants to Scotland. However, their study was limited by the relatively small number of observations in the 2% sample at their disposal from the 1991 UK census, and by the absence of longitudinal data based on that census. To get at true salmon effects in mortality, it is necessary to analyse longitudinal data covering both of the demographic careers that are presumed to be interrelated, that is, those of migration and mortality.

In their discussion of the absence of support for the salmon bias hypothesis, Wallace and Kulu refer to the similarity in contexts in the two parts of the UK. They note that both countries operate under the same healthcare system and that there may not be much cultural importance attached to reaching the end of life in a person's region of birth. In our study, we find clear support for the salmon bias hypothesis, but the same arguments certainly also hold for Sweden and the two regions we study. The very term salmon effect in mortality implies that there is an intention among migrants to move home in anticipation of death. This may not be an entirely plausible pattern of behaviour in terms of domestic migration within a relatively homogenous welfare state like Sweden. Return migration to Norrland may not be motivated by the anticipation of one's own death but may instead be related to a poor life situation in general. Differentials in living conditions between migrants, stayers, and return migrants may still produce mortality differentials like those observed in our study, but we may want to find another term to describe these differentials than that of salmon effects in mortality. In the case of international migration, the salmon term may appear more relevant; nonetheless, it may turn out to be controversial for this life situation as well (e.g. Razum *et al*., 1998; Khlat & Darmon, 2003).

Our study has many strengths, but also some limitations. As noted, previous research has produced no (or conflicting) evidence of salmon effects in mortality, and we note that this may be related to the lack of appropriate longitudinal and geographical data for studying these associations. With our research design and the availability of longitudinal data covering the necessary aspects of both space and time, we were able to demonstrate the existence of elevated mortality in long-distance return migrants in Sweden. Our data are not perfect: there may also be some underreporting of domestic migration events in Sweden. However, for our purpose, this is no real cause for concern, as any underreporting would be reflected in the numerators and denominators of mortality rates alike. The underreporting of emigration and return migration is otherwise often mentioned as a key factor in producing mortality rates for immigrants that are implausibly low (Weitoft *et al*., 1999; Kibele *et al*., 2008). Our study

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suggests that such underreporting of migration events cannot explain all evidence of immigrant sub-mortality and that other factors are at play as well, including those of salmon effects in migrant mortality.

There are also some shortcomings in our study design. Evidently, we are not able to follow international migrants from the time they leave Sweden and are thus not able to study salmon effects in the mortality of international migrants. In addition, our data do not cover all age groups of residents in Sweden. For future research, it would be worthwhile to analyse linked register data from Sweden and neighbouring Finland (Saarela & Scott, 2015) in order to study the mortality of migrants between two neighbouring but quite different countries of residence. A better consideration of old-age mortality, as well as geographical data on the availability of family and kin networks of migrants and non-migrants (Pettersson & Malmberg, 2009; Kolk, 2016), would also offer better insight into the nature of any salmon effects in migrant mortality.

The main contribution of our study was to underline the importance of access to longitudinal data and sound demographic techniques when studying the demographic behaviour of migrants in particular and issues related to population, space, and place in general. In our study, we focused on salmon effects in mortality, which are produced when migration and mortality are interrelated and linked across space and time. Similar 'migration effects' in fertility occur when migration and fertility careers are interrelated, which often produces unexpected patterns in the recorded fertility of international migrants (e.g. Andersson, 2004; Milewski, 2006; Parrado, 2011). In cases when the analyst lacks data that stretch over all dimensions of space and time, immigrant mortality rates may turn out unrealistically low and immigrant fertility unrealistically high. We hope our study will raise the awareness of the need to better assess the role of migration effects in demographic indicators of migrant populations.

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