Journal of Population Economics (2025) 38:66
https://doi.org/10.1007/s00148-025-01123-1

ORIGINAL PAPER

Health drain: the effect of internal migration on regional disparities in healthcare costs

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Received: 30 June 2023 / Accepted: 18 August 2025

Abstract
Internal migration can increase regional disparities in healthcare costs between economically disadvantaged and more prosperous regions in the same country. Persons who move to more prosperous regions tend to be young and healthy while persons who move to or remain in economically disadvantaged regions are on average older and sicker. In this study, we propose a novel framework that allows estimating the effect of internal migration and resulting changes in population composition on average healthcare costs in different regions. Our framework refines a "move people back" approach by adjusting for place effects. Based on data for the entire population of the Netherlands, we show that internal migration during the 1998–2018 period increased average healthcare costs in economically disadvantaged provinces by up to 3.4%, and it explains 29.3% of regional variation in healthcare costs.

Keywords Internal migration · Regional variation in health · Regional variation in healthcare costs · Move people back approach

JEL Classification I14 · H51 · R23

Responsible editor: Xi Chen

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Published online: 01 September 2025

1 Introduction

Internal migrants who move between regions in the same country are often young and highly educated, and they tend to move to regions that provide better economic opportunities (Greenwood 1997; Dahl 2002; Diamond 2016; Couture and Handbury 2020; Iammarino et al. 2019; Jia et al. 2023; Bernard 2017; Bryan and Morten 2019). Many countries experience a brain drain away from economically disadvantaged regions, such as Northern England, Southern Italy, East Germany, or West Virginia and Mississippi in the United States, to prosperous urban centers and their surroundings. Such a brain drain can be accompanied by a *health drain* if persons who move to more prosperous regions tend to be young and healthy while persons who move to or remain in economically disadvantaged regions are on average older and sicker. Thus, internal migration can increase average healthcare costs in economically disadvantaged regions, and it can decrease average healthcare costs in destination regions. In turn, disparities in health can contribute to increasing regional economic disparities in many countries, and they provide challenges for healthcare systems in regions of origin.[1] Therefore, it is important to understand the relationship between internal migration and regional disparities in healthcare costs.

In our study, we propose a novel framework that allows examining how internal migration affects average healthcare costs in different regions through a change in population composition. We implement this framework based on administrative data for the entire population of the Netherlands. The Netherlands faces stark contrasts between a booming Randstad region in the western part of the country, which includes the major cities of Amsterdam, Rotterdam, and The Hague, where average healthcare costs are low, average incomes are high, and the population is growing fast, and a number of provinces at the periphery of the country with higher average healthcare costs, lower average incomes, and a population that is growing slowly or even shrinking. Residents outside the Randstad region exhibit higher mortality rates, less satisfaction with the political system, and lower trust in government.[2] A similar urban-rural or center-periphery divide can be observed in many European Union and other developed countries. The Randstad region attracts many internal migrants from peripheral provinces.

In our framework, we compare average healthcare costs in Dutch provinces based on their current population with counterfactual average healthcare costs in the absence of internal migration. To compute these counterfactuals, we take two steps: First, we assign individuals to provinces where they have lived in the past. Since internal migration changes population composition only slowly, we study internal migration over an extended period of 20 years in our baseline specification. Based on the Dutch population register, we know, for essentially the entire population of the Netherlands

[1] In recent decades, regional disparities have increased in both the European Union and the United States (Ehrlich and Overman 2020). Health is an important component of human capital (Grossman 1972), and poor health can have a substantial negative impact on economic outcomes (O'Donnell et al. 2015).

[2] Mortality rates at the province level are shown in Figure A1 in the online Appendix. Urban-rural differences in political dissatisfaction and trust in the government are documented by Van den Berg and Kok (2021).

in the year 2018, each individual's place of residence in the year 1998 if they were already alive and a resident in the Netherlands that year.

Second, we estimate what healthcare costs of internal migrants would be if they had stayed in their region of origin. To compute what counterfactual healthcare costs of an individual in the year 2018 would have been if she had stayed in the province where she lived in the year 1998, we adjust observed healthcare costs in the year 2018 for estimated place effects. Place effects refer to the combined effect of local conditions on healthcare costs, e.g., due to regional differences in physician practice style, access to care, or living conditions. We estimate place effects for each province in the Netherlands by following individuals over time who move between provinces.[3] Our approach estimates a partial equilibrium effect. We account for the effect of internal migration on average healthcare costs in each province that results from changes in population composition, but our analysis does not consider for example the effect of internal migration on location decisions of medical providers.[4]

We find that internal migration increases average healthcare costs included in the basic health insurance package for provinces in the periphery by up to 3.4%, and it decreases average healthcare costs for provinces in the Randstad region by up to 3.7%. Internal migration exacerbates regional inequality in healthcare costs. We find that 29.3% of the difference in average healthcare costs between provinces in the year 2018 can be attributed to the effects of changes in population composition due to internal migration between the years 1998 and 2018. Our results are robust to a wide range of alternative specifications. Furthermore, we show in a decomposition analysis that our findings can mostly be attributed to selective migration: in peripheral provinces, healthcare costs are substantially higher for in-migrants than for out-migrants, while in Randstad provinces healthcare costs are substantially lower for in-migrants than for out-migrants. Finally, we show that effect sizes remain sizable even after adjusting healthcare costs for differences in either demographics or risk scores. Thus, differences in age and gender or in risk scores can only partially, but not fully, account for the effect of internal migration on regional differences in healthcare costs.

Our study relates to the literature on causes of regional variation in healthcare costs (Skinner 2011; OECD 2014). A large literature studies the role of supply-side factors such as physician practice style (Phelps 2000; Cutler et al. 2019; Molitor 2018). Some of these studies focus on the Netherlands (Westert and Groenewegen 1999; Douven et al. 2015). However, several recent studies demonstrate, based on a movers approach, that patient characteristics can also explain a large share of regional variation in healthcare costs and use for various countries. This share is 50% for healthcare use of Medicare patients in the United States (Finkelstein et al. 2016) and for healthcare use in Norway (Godøy and Huitfeldt 2020), 70% for healthcare costs in the Netherlands (Moura et al. 2019), and 90% for outpatient care in Germany (Salm

[3] The movers approach to separate environmental effects from individual effects was first developed by Abowd et al. (1999) in the context of firms and workers. Our empirical specification to estimate place effects closely follows Finkelstein et al. (2016) who estimate place effects in healthcare use for Medicare patients in the United States and Moura et al. (2019) who estimate place effects in healthcare costs for provinces in the Netherlands.

[4] In a robustness check, we explore the importance of spillover effects of movers on stayers.

and Wübker 2020).[5] The possible role of internal migration is typically not emphasized in the literature on causes of regional variation in healthcare costs.

Our study makes two main contributions to the literature. In terms of content, we show that internal migration and resulting changes in population composition can lead to a substantial increase in average healthcare costs in economically disadvantaged regions. In the Netherlands, internal migration can explain around 29.3% of regional variation in healthcare costs. This is to the best of our knowledge a new result that has not been shown before, neither for the Netherlands nor for any other country.

Our second main contribution is methodological. Our study combines a “move people back” approach (Darlington-Pollock and Peters 2021) with a movers approach to estimate place effects (Finkelstein et al. 2016, 2021; Deryugina and Molitor 2020; Johnson and Taylor 2019; Atella et al. 2019). Many studies examine how moving decisions, for example, from rural to urban areas, depend on health (Verheij et al. 1998; Van Lenthe et al. 2007; Tunstall et al. 2014; Dunn et al. 2014; Dijkstra et al. 2015; Vaalavuo and Sihvola 2021; Holmager et al. 2021; Westphal 2016). In contrast to these studies that test whether health differs between movers and non-movers, the “move people back” approach allows quantifying the effect of internal migration on average healthcare costs in regions. In our study we refine the “move people back” approach by adjusting outcomes for individuals who have moved to a different region for place effects that we estimate based on a movers approach.

Our findings have important policy implications. Traditional explanations of regional variation in healthcare costs, such as differences in physician practice style, access to care, or patient beliefs, suggest that regional variation in healthcare is at least potentially inefficient (Skinner 2011). However, if internal migration causes differences in average healthcare costs across regions, then such differences can be justified. Our study finds that internal migration reduces healthcare costs in wealthy regions, and it increases healthcare costs in poorer regions. This finding can justify above-average healthcare costs in poorer regions. In fact, healthcare costs in economically disadvantaged regions could even be too low if the allocation of healthcare resources does not sufficiently account for changes in population composition that result from internal migration.[6]

This study proceeds as follows. Section 2 describes the institutional setting. Section 3 presents our data and descriptive evidence. Methods are explained in Sect. 4, and in Sect. 5, we show our estimation results. Section 6 concludes.

2 Institutional setting

The Netherlands have a system of managed competition in healthcare markets (a description of the Dutch healthcare system can be found in Kroneman et al. 2016). Residents of the Netherlands are obliged to purchase a basic health insurance pack-

[5] These shares refer to the combined effect of all observed and unobserved individual characteristics that don’t change when patients move to a different region.

[6] In the European Union, net migration rates are negatively correlated with life expectancy across regions. In Table A1 in the online Appendix, we show for NUTS-2 regions in the European Union for the period 2010 to 2018 that life expectancy and net migration rates are positively correlated, even after controlling for country and year fixed-effects.

age from one of several competing health insurers. The contents of the basic health insurance package are set by law. It includes care by general practitioners and medical specialists, hospital care, pharmaceuticals, mental health care, and medical devices such as protheses and wheelchairs. In addition to the basic health insurance package, individuals can purchase supplementary insurance, e.g., for dental care. In our study, we focus on care included in the basic package.

Health insurance is paid for by a combination of income-dependent employer contributions and insurance premiums paid by individuals, in about equal parts.[7] For the basic health insurance package, health insurers have to accept all applicants, and insurance premiums are community rated. Thus, they do not depend on the health of insurance holders.[8] Individuals have the option to change their insurance contract at the beginning of each year.

Importantly for our study, individuals keep their health insurance contract if they move to a different province. All health insurers operate nationally, even though their market shares differs widely across regions.[9] Insurers negotiate with care providers about prices, quality, and quantity of care, within the framework set by law.

The Netherlands has a risk adjustment scheme that compensates health insurers for differences in their risk pools. Compensation is based on risk scores that are assigned to each individual. Among other factors, risk scores depend on neighborhood characteristics such as the share of immigrants from non-Western countries, urbanization rate, and the average distance to a general practitioner.[10] Yet, this regional component of the risk score is directed primarily at compensating for additional healthcare needs in poor neighborhoods in large cities, and it is not explicitly focused on compensating for additional healthcare needs in peripheral regions that result from internal migration.[11]

3 Data and descriptive statistics

We use administrative data provided by Statistics Netherlands (CBS). Our data combine information on healthcare costs, current and past places of residence, demographic characteristics, education, and predictors of risk scores including pharmaceutical use, income, and neighborhood characteristics. These data are assembled by Statistics Netherlands from various sources.[12]

7 Insurance premiums for children under the age of 18 are paid by the government.

8 Group discounts of up to 10% are allowed.

9 The map depicted in Figure A2 in the online Appendix shows for each region the health insurer with the highest market share.

10 Variables in the Dutch risk adjustment scheme are described in more detail in Section B1 in the online Appendix.

11 By the measures included in the risk score, neighborhood characteristics for poor villages in peripheral regions and for wealthy suburbs of large cities tend to be similar.

12 Data on individual healthcare expenditures included in the basic healthcare insurance package is obtained from Vektis, a private firm commissioned by the Dutch government to assemble information from health insurers. Data on current and past places of residence and basic personal characteristics come from the personal records database maintained by municipalities. Information on household income is provided by the tax administration. Information on education degrees is collected from various education registers and a series of professional population surveys.

In our baseline analysis, we restrict our data to individuals who reside in the Netherlands at the beginning of both the years 1998 and 2018. This allows us to examine the effects of changes in population composition due to internal migration over a 20-year period. The year 1998 is one of the first years for which the population register in the Netherlands is (almost) complete, and 2018 is the last year in our data set. The population of the Netherlands in the year 2018 was about 17.2 million. After excluding individuals with missing information on either healthcare costs, place of residence, or predictors of risk scores, we are left with around 17 million observations. Furthermore, since we are looking at individuals who reside in the Netherlands in both the years 1998 and 2018, we exclude around 4.8 million individuals who were either not born before the year 1998 or immigrated to the Netherlands after the year 1998, which leaves us with an analysis sample of around 12.2 million observations. A detailed description of data availability is presented in Table A2 in the online Appendix.

The main outcome variable in our analysis is annual healthcare costs of an individual for care that is covered by the basic health insurance package.[13] In a robustness check, we employ individual risk scores as an alternative outcome variable. In computing risk scores, we emulate the Dutch risk equalization scheme in the year 2015, as described by McGuire and Van Kleef (2018) and Layton et al. (2018), and we follow the Dutch risk equalization scheme as closely as possible with the available data.[14]

Throughout our analysis, we define regions by provinces. This reflects our focus on internal migration as opposed to residential mobility. Internal migration refers to moves over a longer distance within the same country. The Netherlands has 12 provinces with populations ranging from 380,000 to 3.7 million in the year 2018.[15] Provinces strongly differ in terms of average income. Economically disadvantaged provinces tend to be at the periphery of the country far away from Amsterdam, while the wealthiest provinces are in the Randstad region close to Amsterdam.[16] We know the province of residence for the entire population of the Netherlands at each point of time based on the personal records database.[17] In our baseline analysis, we define movers as individuals whose province of residence on the first day of the year 1998 was different from their province of residence on the first day of the year 2018. Our definition of movers includes individuals who move at least once in the period between 1998 to 2018, and it does not include individuals who move back to the province where they were residing at the beginning of the year 1998. According to our definition, there are around 1.6 million movers in our sample. We denote the remaining population in our sample as stayers.

[13] Healthcare costs include both care paid by insurers and deductible payments made by patients.

[14] Section B1 in the online Appendix describes our computation of risk scores in detail.

[15] The share of employees who live and work in the same province is 78% in the year 2018 (own calculation based on CBS data).

[16] In the year 2018, average personal income was highest in the province of Utrecht (Euro 37,627) and lowest in the province of Groningen (Euro 29,046). See Figure A3 in the online Appendix for a map of where provinces are located.

[17] When a person changes her address of residence, she has to notify the municipality. If a person fails to notify the municipality about a change of address, then the municipality can impose a penalty. Registration is also necessary to obtain various municipal services such as parking permits.

Table 1 presents summary statistics separately for movers, stayers, and the entire sample.[18] Healthcare costs are on average 27.1% lower for movers than for stayers, and risk scores are on average 26.8% lower. This indicates that movers are on average healthier than stayers. The table also shows that compared to stayers, movers are on average younger and better educated. Moreover, they are more likely to have work as main source of income, and they have higher average household incomes. However, movers are less likely to own their home.[19]

The maps displayed in Fig. 1 show regional variation in average healthcare costs (panel a) and average risk scores (panel b) across provinces in the year 2018. In addition to provinces, the maps show only one city, Amsterdam. Provinces in the Randstad region that are close to Amsterdam tend to have lower healthcare costs, whereas provinces in peripheral regions far away from Amsterdam and the Randstad region tend to have higher healthcare costs. Average healthcare costs in Limburg, a province in the South-Eastern corner of the Netherlands, are 23.7% higher than in Flevoland, a province directly to the East of Amsterdam.[20] Figure A3 in the online Appendix presents a map of the Netherlands that shows the names and location of all provinces. Lower healthcare costs in more prosperous provinces reflect that geographical access to healthcare services is relatively equal in the Netherlands in international comparison (OECD 2017). Average healthcare costs and risk scores are closely correlated across provinces.[21]

The maps presented in Fig. 2 show population growth rates and internal migration balances across provinces. Panel a shows population growth rates over the period 1998–2018 across provinces. Population tends to grow fast in provinces in the Randstad region close to Amsterdam, and it tends to grow slowly or, in the case of Limburg, even decline in peripheral provinces. Panel b shows net in-migration rates over the period from 1998 to 2018 as a share of the population in the year 1998. Patterns for population growth rates and internal migration balances tend to be similar.[22] Provinces in the Randstad region close to Amsterdam tend to have positive internal migration

[18] Table A3 in the online Appendix shows summary statistics for the analysis sample (as in Table 1), the sample we use for estimating place effects, and the overall population. Summary statistics for all three samples refer to the year 2018. We find that the sample used for estimation place effects looks very similar to the overall population. However, individuals in the analysis sample are on average older and have higher healthcare expenditures than the overall population. This reflects that children as well as recent immigrants are omitted from the analysis sample.

[19] We do not know the motives of movers in our sample. However, according to a representative survey of the Dutch population in the year 2021, the most common reasons to move house are changes in household composition (27%), a better home or location (21%), and employment (7%). Only 4% say that they move for health or care needs (Stuart-Fox et al. 2022).

[20] Correlations between average healthcare costs of provinces in the year 2018 and average healthcare costs of provinces in previous years are shown in Table A4 in the online Appendix.

[21] Figure A4 in the online Appendix plots average risk scores against average healthcare costs across provinces. The R-squared is 0.961. Figure A1 in the online Appendix shows regional variation in mortality rates (deaths per 1000 individuals) at the province level for the year 2018. Provinces with higher average healthcare costs (and risk scores) tend to have higher mortality rates.

[22] One exception is the province of Zuid-Holland to the South of Amsterdam, which combines fast population growth, a negative internal migration balance, and a strongly positive external migration balance.

Table 1 Summary statistics

Variable	Movers		Stayers		Full sample	
	Mean	(Std. Dev.)	Mean	(Std. Dev.)	Mean	(Std. Dev.)
Healthcare cost	2290.72	(7672.57)	3141.24	(9153.51)	3027.87	(8974.90)
Risk score	0.90	(1.53)	1.23	(1.91)	1.19	(1.87)
Age	44.18	(15.97)	53.70	(18.03)	52.43	(18.06)
Female	0.52	(0.50)	0.51	(0.50)	0.51	(0.50)
Household size	2.53	(1.36)	2.50	(1.28)	2.51	(1.29)
Household income	52,721.83	(72,003.53)	49,023.12	(62,158.32)	49,516.13	(63,571.18)
Main source of income						
Employment and self employment	0.79	(0.41)	0.63	(0.48)	0.65	(0.48)
Social benefits	0.07	(0.26)	0.08	(0.26)	0.08	(0.26)
Pensions	0.13	(0.33)	0.29	(0.45)	0.27	(0.44)
Students grant	0.01	(0.11)	0.00	(0.04)	0.00	(0.05)
Capital income	0.01	(0.08)	0.01	(0.08)	0.01	(0.08)
Home ownership						
Own house	0.61	(0.49)	0.67	(0.47)	0.66	(0.48)
Rent without housing allowance	0.27	(0.44)	0.20	(0.40)	0.21	(0.41)
Rent with housing allowance	0.10	(0.31)	0.12	(0.32)	0.12	(0.32)
Institutional	0.02	(0.13)	0.02	(0.13)	0.02	(0.13)
Education level						
Basic education	0.03	(0.18)	0.08	(0.27)	0.07	(0.26)
Vocational training	0.39	(0.49)	0.58	(0.49)	0.55	(0.50)
College degree	0.57	(0.50)	0.34	(0.47)	0.38	(0.49)
Number of observations	1,620,679		10,538,240		12,158,919	

Note: Values are for the year 2018. Sample includes individuals whose data are available for both the years 1998 and 2018. Healthcare costs and household incomes are in Euros. Female, source of income, house ownership, and education level are binary indicators. Education level is not known for 5,107,546 individuals

balances, e.g., more people are moving in than moving out, while provinces in peripheral regions tend to have negative migration balances, e.g., more people are moving out than moving in.

4 Methods

To assess the effect of changes in population composition due to internal migration on average healthcare costs of provinces, we compare actual average healthcare costs in provinces based on their 2018 population with counterfactual average healthcare costs in the same provinces based on their 1998 population. We denote the effect of internal migration during the 1998 to 2018 period for province j by TE_j. This effect can be written as the difference between a factual and a counterfactual average outcome:

$$TE_j = \bar{y}_j^F - \bar{y}_j^{CF} \tag{1}$$

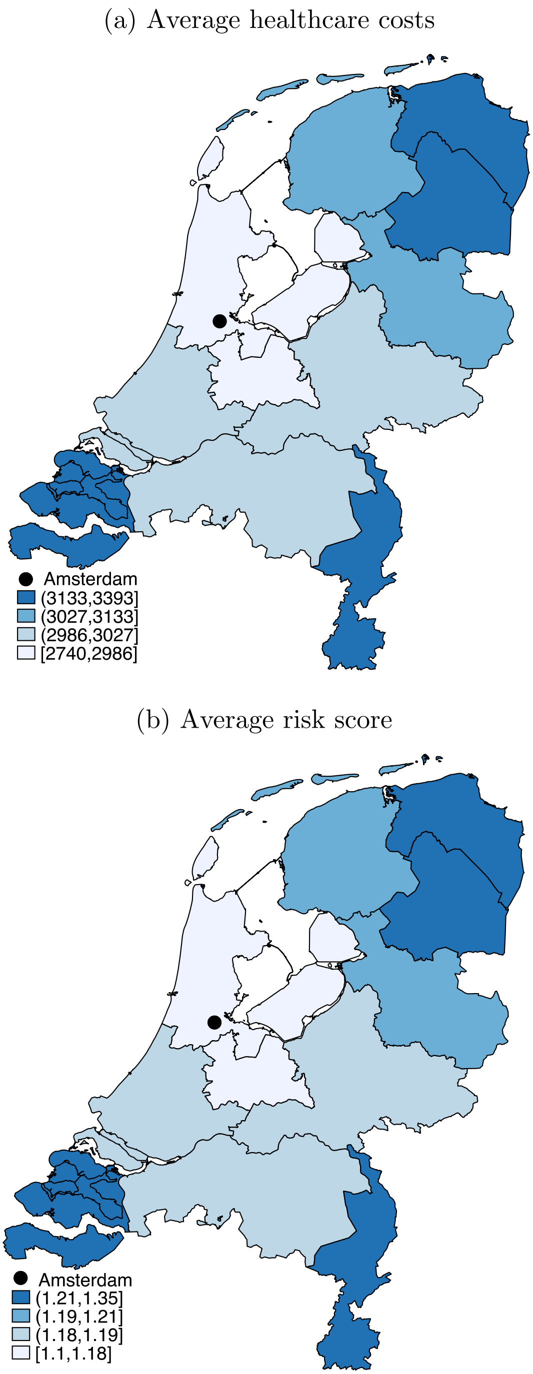

Fig. 1 Regional variation in healthcare costs and risk scores in 2018. Note: The sample has 12.2 million observations. Values are for the year 2018. Healthcare costs are in Euros

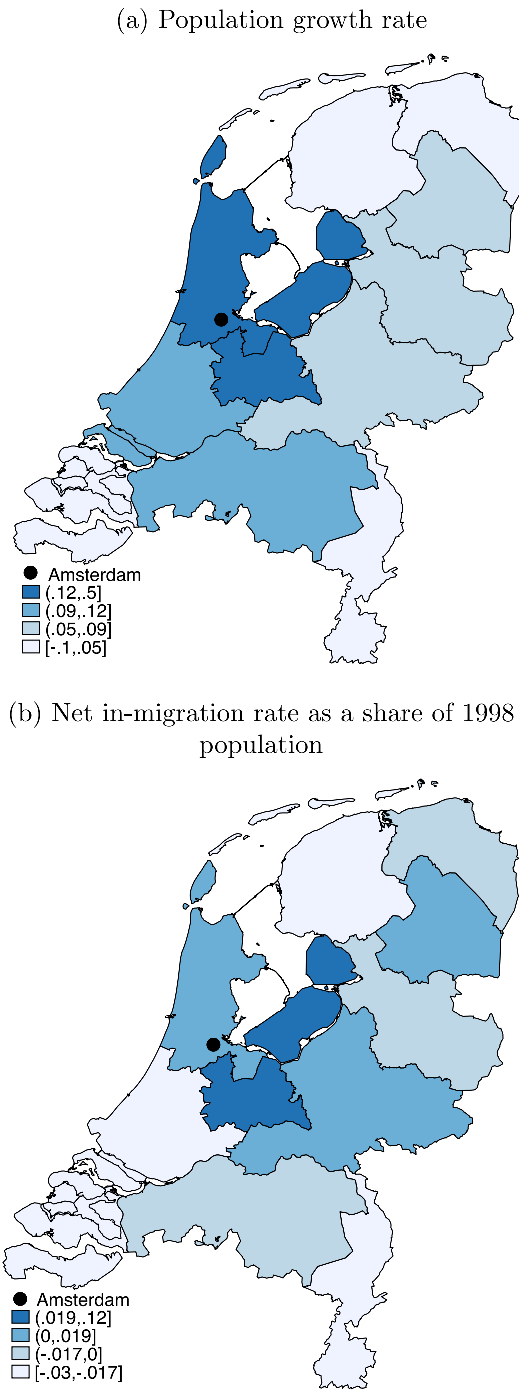

Fig. 2 Population growth rate and net in-migration rate over the period 1998 to 2018. Note: In **a**, growth rates are for the entire population. In **b**, the number of observations is 12.2 million

Here, $\bar{y}_j^F$ is the average of the outcome variable, healthcare costs, in the year 2018 for the population that resided in province j on the first day of the year 2018, or formally

$$\bar{y}_j^F = \frac{1}{N_{j,2018}} \sum_i y_{i,2018} I_{j,2018} \tag{2}$$

where $N_{j,2018}$ is the population of province j on the first day of the year 2018, $y_{i,2018}$ is healthcare costs of individual i in the year 2018, and $I_{j,2018}$ is a binary indicator that takes the value one if individual i lives in province j on the first day of the year 2018. We can calculate $\bar{y}_j^F$ directly from our data.

Likewise, $\bar{y}_j^{CF}$ denotes counterfactual average healthcare costs in the year 2018 for the population that resided in province j on the first day of the year 1998, or formally

$$\bar{y}_j^{CF} = \frac{1}{N_{j,1998}} \sum_i y_{i,2018}^{CF} I_{j,1998} \tag{3}$$

where $N_{j,1998}$ is the population of province j on the first day of the year 1998, $y_{i,2018}^{CF}$ denotes counterfactual healthcare costs of individual i in the year 2018 if she had stayed in the province where she lived at the beginning of the year 1998, and $I_{j,1998}$ is a binary indicator that takes the value one if individual i lived in province j on the first day of the year 1998. To obtain $I_{j,1998}$ for all individuals i, we assign movers to the province in which they have resided on the first day of the year 1998. For stayers, their provinces of residence in the years 1998 and 2018 are the same.

To compute $y_{i,2018}^{CF}$, we need to take the effect of local conditions on healthcare costs into account. Imagine a person who moved from Limburg to Flevoland. Then, this move might have affected her healthcare costs by exposing her to a different practice style of local physicians, different access to medical facilities, and different health due to, for example, more local air pollution or better economic opportunities. Thus, the same person would incur different healthcare costs if she lived in a different province.

We refer to the combined effect of local conditions on healthcare costs as place effects, and we denote γ_j as the place effect for province j. In order to compute counterfactual healthcare costs $y_{i,2018}^{CF}$ for individual i, we need to adjust for place effects:

$$y_{i,2018}^{\mathrm{CF}} = y_{i,2018}(1 + \gamma_o - \gamma_d) \tag{4}$$

Here, $y_{i,2018}$ is the healthcare cost of individual i in year 2018. We denote the province of origin, where i lived on the first day of the year 1998 as $j = o$, and the province of destination, where i lives on the first day of the year 2018 as $j = d$. Outcome $y_{i,2018}$ depends on the place effect for province d, the individual's current place of residence. However, for estimating what the outcome variable for an individual would have been if she had stayed in her province of origin, we need to adjust the outcome variable by subtracting the place effect of the province of destination (γ_d) and adding the place effect of the province of origin (γ_o). For example, for a person who moved from Limburg to Flevoland, we need to subtract the place effect for Flevoland, and we need to add the place effect for Limburg. For stayers, d and o are the same. Note that place effects in Eq. 4 refer to place effects in the year 2018, not to place effects for example in the year of move.

Place effects cannot be directly observed. We estimate place effects using an empirical approach previously employed by Finkelstein et al. (2016); Moura et al. (2019) based on following persons who migrate across regions. We specify the linear model

$$\log(y_{it}) = \alpha_i + \gamma_j + \lambda_t + X_{it}\beta + \zeta_{t-\tau_i} + \varepsilon_{it} \tag{5}$$

and we estimate parameters by fixed-effects estimation. y_{it} is healthcare costs of individual i in year t, where $t \in [2010, ..., 2018]$. We add 1 to healthcare costs inside the logarithm operator since some individuals incur zero healthcare cost in a given year.[23] Individual fixed-effects (α_i) account for unobserved individual characteristics that do not change over time and are not affected by moving to a different province. Province fixed-effects (γ_j) represent place effects that affect all individuals living in province j. The province of residence j is defined as the province where an individual resides on the first day of year t. λ_t are year fixed-effects. Individual characteristics (X_{it}) include age and gender.[24] $\zeta_{t-\tau_i}$ are indicators for the year relative to the year of move, e.g., 4+ years before the move, 3 years before the move, 2 years before the move, 1 year after the move, 2 years after the move, 3 years after the move, and 4+ years after the move, where τ_i is the year in which individual i moved from one province to another. These indicators account for the direct impact of moving on outcome variables. For non-movers, the relative year of move is set to zero. The error term ε_{it} includes time-varying unobserved individual characteristics. In our estimation, we account for robust standard errors, clustered at the individual level.

We can separately identify individual fixed-effects (α_i) and place effects (γ_j) because of the presence of movers in our sample. Only for movers, we observe the same individual in two different provinces. Place effects measure how healthcare costs change if individuals move to a different province. The log specification of healthcare costs in Eq. 5 implies that α_i and γ_j shift healthcare costs proportionally. Thus, we assume that place effects shift healthcare costs by the same factor for all individuals.[25] We also assume that γ_j are constant over time,[26]

In order to obtain unbiased estimates of place effects γ_j, the exogeneity assumption below must be satisfied:

$$E(\varepsilon_{it}|\gamma_j, \lambda_t, X_{it}, \zeta_{t-\tau_i}) = 0 \tag{6}$$

[23] A total of 515,153 out of 41.3 million observations (1.2%) have zero healthcare costs.

[24] Age is categorized in bins of 5 years. Gender and age interaction terms are included to account for non-linear effects of age, separately for men and women.

[25] We relax this assumption in robustness checks presented in Section 5.2.

[26] We use place effects for movers in the period between the years 2010 and 2018 to estimate the place effect in Eq. 4 which refers to the year 2018. We relax this assumption in a robustness check presented in Section 5.2.

Thus, ε_{it}, the time-varying individual-specific error term, must be mean-independent of all covariates. We discuss the exogeneity assumption and explore the robustness of our results in Sect. 5.2.

The sample used for estimating Eq. 5 is not the same as shown in Table 1. We use a panel data set with annual observations for the period 2010 to 2018.[27] The sample consists of all movers and a 25% random sample of non-movers among the individuals who reside in the Netherlands in a given year with information on healthcare costs and province of residence.[28] Our estimation sample consists of 41.3 million observations.

Table 2 shows estimates of place effects γ_j and their standard deviation for healthcare costs. Noord-Brabant, the province with the lowest place effect, serves as the reference category. Provinces in the Randstad area close to Amsterdam (Flevoland, Noord-Holland, Utrecht, and Zuid-Holland) have higher place effects than provinces in peripheral regions. Flevoland has the highest place effect of 0.101, which implies that moving from Noord-Brabant, the reference category, to Flevoland increases healthcare costs by 10.1%. It is remarkable that place effects tend to be highest for provinces with low average healthcare costs.[29] One possible explanation for this finding is that people in Randstad provinces tend to be very healthy, but conditional on their health, they receive more healthcare services than people in peripheral provinces. Randstad provinces have a higher density of hospitals, and place effects are positively correlated with the number of hospitals within 10 km. Furthermore, place effects are negatively correlated with demand. Place effects are lower for provinces with a higher average age and a higher share of persons age 60.[30] It is possible that the presence of many elderly persons puts pressure on healthcare resources that are available for everyone in the region. This could explain why provinces in the periphery with a larger share of older people have both higher average healthcare costs and lower place effects.

5 Results

5.1 Effects on healthcare costs

Figure 3 presents results for our baseline analysis on healthcare costs. The horizontal axis in the figure represents average healthcare costs per person for care included in the basic health insurance package in the year 2018. The vertical axis shows the effect of internal migration during the 1998 to 2018 period on average healthcare costs in

[27] 2010 is the first year for which individual healthcare costs are available in our data. We adjust healthcare costs for inflation with 2018 as the base year, using the inflation adjustment deflator for healthcare costs in the Netherlands provided by EUROSTAT.

[28] The definition of movers for estimating Eq. 5 is different from the definition of movers in Table 1. In the sample for estimating place effects, movers are defined as persons who change their province of residence exactly once during the estimation period. Movers who change their province of residence more than once are omitted from the sample, as in Finkelstein et al. (2016); Moura et al. (2019). We also omit observations for movers in the year of the move from our sample.

[29] Average healthcare costs of provinces are shown in Table 3.

[30] In Table A5 in the online Appendix, we show correlations between place effects and a wide range of local characteristics including the number of hospitals within 10 km, the average age in a province, and the share of persons above age 60.

Table 2 Place effects for provinces

Province	Place effects for log healthcare cost
Drenthe	0.027
	(0.008)
Flevoland	0.101
	(0.007)
Friesland	0.038
	(0.007)
Gelderland	0.007
	(0.005)
Groningen	0.021
	(0.007)
Limburg	0.041
	(0.006)
Noord-Brabant	-
	-
Noord-Holland	0.060
	(0.005)
Overijssel	0.034
	(0.006)
Utrecht	0.060
	(0.005)
Zeeland	0.055
	(0.008)
Zuid-Holland	0.068
	(0.005)

Note: Estimates of province fixed-effects (γ_j) in Eq. 5 using logarithm of (healthcare cost +1) as outcome variable. Robust standard errors, clustered at the individual level, in parenthesis. The lowest value of place effects is chosen as the base category for the regression. In this regression, the province of Noord-Brabant is the base category. The number of observations is 41.3 million

the year 2018, computed based on Eq. 1. The dots shown in the scatterplot represent the 12 provinces of the Netherlands and one dot for the entire country.

Internal migration tends to increase average healthcare costs in provinces in the periphery of the Netherlands, and it tends to decrease average healthcare costs in provinces in the Randstad region. The province with the highest positive effect on the vertical axis is Zeeland, a province in the periphery of the Netherlands. Average healthcare costs in Zeeland in the year 2018 are Euro 107.95 (or 3.4% of total costs) higher than they would have been based on its 1998 population. The province with the strongest negative effect is Utrecht, a province in the Randstad region. Average healthcare costs in Utrecht in the year 2018 are Euro 106.58 (or 3.7% of total costs) lower than they would have been based on its 1998 population. At the national level, the effect of internal migration on healthcare costs is slightly negative and very close to zero.[31]

[31] Effect sizes and their standard deviations for all 12 provinces and the entire country are presented in Table 3.

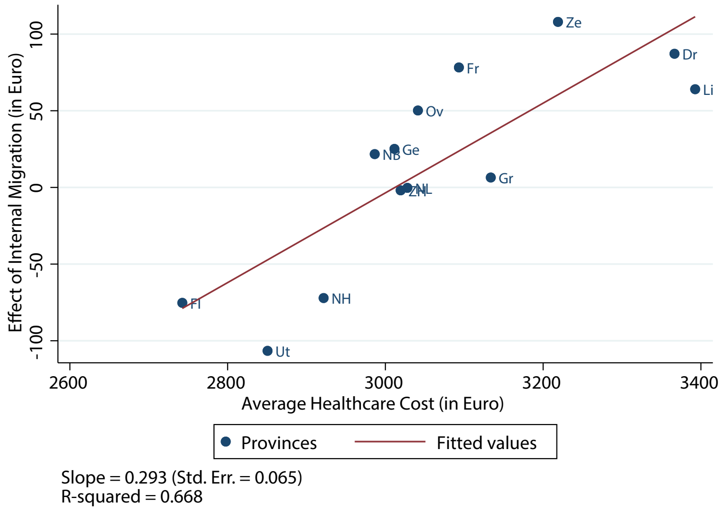

Fig. 3 Baseline results for healthcare costs. Note: The number of observations is 12.2 million. Average healthcare cost is based on the year 2018. Dr, Drenthe; Fl, Flevoland; Fr, Friesland; Ge, Gelderland; Gr, Groningen; Li, Limburg; NB, Noord-Brabant; NH, Noord-Holland; NL, Netherlands; Ov, Overijssel; Ut, Utrecht; Ze, Zeeland; ZH, Zuid-Holland

Internal migration increases regional inequality in healthcare costs. If we fit a regression line through the dots for provinces in Fig. 3, the resulting slope parameter is 0.293.[32] Thus, for a province with Euro 100 higher average healthcare costs, the predicted effect of internal migration increases by Euro 29.30. Hence, 29.3% of the difference in average healthcare costs between provinces in the year 2018 can be attributed to changes in population composition due to internal migration between the years 1998 and 2018. The slope of the regression line is significantly different from zero at the 1% level,[33] and the R-squared of the regression line is 0.668, indicating a close fit between average healthcare costs and the effects of internal migration on healthcare costs across provinces.[34]

32 In computing parameters for the regression line, we do not take the dot for the entire country into account, neither in Fig. 3 nor in other figures.

33 When computing standard errors for the slope parameter of the regression line, we need to take into account that the effect of internal migration for each province is an estimate and thus a random variable. Therefore, we correct standard errors based on a method suggested by Hanushek (1974). The method is explained in Section B2 in the online Appendix. Standard errors with and without correcting for the randomness of the effect of internal migration are almost the same. This holds for all results presented in this study. Critical values for determining statistical significance are based on a t-distribution with 10 degrees of freedom.

34 In Figure A5 in the online Appendix, we fit a quadratic function to model the relationship between average healthcare costs at the province level and the effect of internal migration. The coefficient for the quadratic term is not statistically significant at the 5% level, which gives support for the linear function shown in Fig. 3.

5.2 Robustness

In this subsection, we discuss whether the assumptions underlying our empirical approach are plausible and whether our results are robust to alternative specifications of our empirical model. Specifically, we first discuss the exogeneity assumption, and next, we present results for an event-study analysis. Then, we explore the robustness of our results to alternative specifications for estimating place effects, i.e., heterogeneous place effects. Subsequently, we examine the effects of internal migration during a shorter time period, between the years 2010 and 2018, and we explore for this shorter time period whether our results are sensitive to the inclusion of spillover effects of internal migration on stayers. Finally, we present results for risk scores as alternative outcome variable. We find that our results are robust to all alternative specifications.

Exogeneity assumption

In order to obtain unbiased estimates of place effects, the exogeneity assumption stated in Eq. 6 must be satisfied. Thus, the time-varying individual-specific error term must be mean independent of all covariates, including province fixed-effects, year fixed-effects, age, gender, and year relative to the year of move. This exogeneity assumption is not violated if movers are healthier than stayers or if healthy people tend to move to specific provinces, as long as unobserved individual-specific health (or other unobserved individual-specific determinants of healthcare costs) are constant over time. Furthermore, since we account for the year relative to the year of move in Eq. 5, the exogeneity assumption is not violated if pre-move or post-move time trends differ between movers and stayers, as long as these time trends do not depend on the specific provinces of origin or destination.

However, the exogeneity assumption can be violated if the decision to move from (or to) a specific province is correlated with changes in unobserved individual-specific characteristics, e.g., if persons with declining health are more (or less) likely to move from (or to) a specific province. Thus, we cannot account for pre-move trends that differ between movers to and from specific provinces. In order to examine whether such different pre-trends affect our estimation results, we apply several robustness checks. In a first robustness check, we compare outcome variables after the move with outcomes alternatively 1, 2, or 3 years before the move,[35] In this way, we examine whether our results are robust to the point of time at which we measure pre-move outcomes. Results are shown in Figure A6 panels a to c in the online Appendix, and they are similar to the baseline specification.

In a second robustness check, we estimate alternative specifications where we restrict data for movers to observations within a time window of 1, 2, or 3 years around the year of move. If we restrict data to a shorter time window around the year of move, then observations dating from many years before the move will not be considered in our estimation, and province-specific pre-trends will have less influence on our estimates of place effects. Results are shown in Figure A6 panels d to f in the online Appendix, and they are also similar to the baseline specification.

[35] The estimation equation for these specifications is identical to Eq. 5, but we restrict the sample for movers to all periods after the move and alternatively 1, 2, or 3 years before the move.

Event study

As a further robustness check whether pre-trends differ between movers who move to and from different provinces we conduct an event-study approach. In this approach, we follow individuals over time who move between provinces, and we relate their healthcare costs to the difference in average healthcare costs between their province of destination and province of origin, both for years before and after the move. Our empirical specification follows Finkelstein et al. (2016) who also pursue an event study approach in addition to estimating place effects. Our estimation equation is

$$\log(y_{it}) = \alpha_i + \sum_{r=-6}^{6} \delta_i I_r \theta_r + \lambda_t + X_{it}\beta + \zeta_r + \varepsilon_{it} \tag{7}$$

and we estimate parameters by fixed-effects estimation. δ_i is the difference between the log of average healthcare costs in the destination region and the log of average healthcare costs in the region of origin. I_r are indicators for years relative to year of move where $r = t - \tau_i$. θ_r are the coefficients of interest. We normalize the coefficient for the year before the move to 0 ($\theta_{-1} = 0$). ζ_r are indicators for years around the year of move for $r \in [-6, -5, ..., -2, 1, ..., 6]$. Other variables are as defined in Eq. 5.

We show the results of our event-study approach in Figure A7 in the online Appendix. We find no significant pre-trends for years before the move, which suggests that healthcare costs before the move follow the same time trend both for individuals who in the future will move to a province with higher average costs and for individuals who in the future will move to a province with lower average costs. This finding provides further evidence in favor of the mean independence assumption in Eq. 6. In addition, we find that estimation coefficients are quite stable from around 3 years after the move.[36]

Heterogeneous place effects

In Eq. 5, we assume that place effects are identical for all individuals in the same province. However, it is possible that place effects differ, for example between young and old people or between persons with and without a chronic health condition. For example, if patients with chronic health conditions receive more intensive treatment in one province compared to other provinces, then this does not necessarily imply

[36] Negative coefficients in post-move periods in Figure A7 in the online Appendix imply that patients who move to provinces with higher average healthcare costs face decreased individual healthcare costs. This is in line with the results on place effects shown in Table 2 and discussed in Sect. 4. Our event-study coefficient differs in sign from the coefficient in Moura et al. (2019) who also use an event-study approach based on Dutch data. The difference between the coefficients can be explained by several factors. For the event-study analysis, our study period ranges from 2010 to 2018 instead of 2006 to 2013 in Moura et al. (2019). Our definition of healthcare costs includes mental healthcare, in contrast to Moura et al. (2019). And in our study, the sample of movers is larger due to more accurate information on places of residence. We identify movers based on the personal records database administered by municipalities while Moura et al. (2019) use information from health insurers.

that patients without chronic health conditions also receive more intensive treatment in this province. In order to test whether our results are robust to specifications with heterogeneous place effects, we estimate the following model that adds an interaction term between place effects and a group indicator to Eq. 5:

$$y_{it} = \alpha_i + \gamma_j + \mu_j \times G_i + \lambda_t + X_{it}\beta + \zeta_{t-\tau_i} + \varepsilon_{it} \tag{8}$$

Variables are defined in the same way as in Eq. 5. The only addition is an interaction term between place effects and a group indicator ($\mu_j \times G_i$). G_i is a binary indicator whether individual i belongs to a specific group. In separate regression G_i stands alternatively for (1) persons above age 50 in the year 2018, (2) persons with above median healthcare costs in the year 2010 (or the first year that they are in our data) relative to their province of residence in this year, and (3) persons with chronic health conditions based on the use of pharmaceuticals in the year before the move. We estimate group-specific place effects, and we use these group-specific place effects to compute counterfactual outcomes for movers according to Eq. 4. Scatter plots showing the effect of internal migration on healthcare costs allowing for heterogeneous place effects are presented in Figure A6 panels g to i in the online Appendix. Results are similar to the baseline specification.

Direction of move

Place effects might differ not only between groups in the population, but they can also depend on the direction of move and the specific combination of the province of origin and the province of destination. For example, persons who move from Limburg to Flevoland might be different from persons who move from Flevoland to Limburg, and their corresponding place effects might also differ. We extend the model presented in Eq. 5 by including indicators for specific combinations of provinces of origin and destination:

$$y_{it} = \alpha_i + \gamma_{od} + \lambda_t + X_{it}\beta + \zeta_{t-\tau_i} + \varepsilon_{it} \tag{9}$$

Here, γ_{od} is a binary indicator that takes value 1 after individual i has moved from province o to province d. Other variables are defined as in Eq. 5. Using estimated values of γ_{od}, we adjust healthcare costs for movers similar to Eq. 4, and we compute the effect of internal migration on average healthcare costs in all provinces.[37] We present these results in panel (j) of Figure A6 in the online Appendix. Results are similar to the baseline specification.

Movers in different sub-periods

In the baseline specification, we employ all persons who move to a different province between the years 2010 and 2018 to estimate place effects for the year 2018 that we insert in Eq. 4. In a robustness check, we estimate place effects only based on persons who move to a different province in the year 2015 or later and thus close to the year

[37] Equation 4 is replaced by $y^{\mathrm{CF}}_{i,2018} = y_{i,2018}(1 - \gamma_{od})$.

2018. Results are shown in Figure A6 panel k in the online Appendix, and they are similar to the baseline specification. Furthermore, in panel l of Figure A6 in the online Appendix, we show results when we estimate place effects for movers during the 2010-2013 period. Results are similar to the baseline specification.

Place effects from Moura et al. (2019)

The coefficient of our event-study analysis in Figure A7 in the online Appendix differs in sign from results by Moura et al. (2019) who also apply an event-study approach based on Dutch data, but for an earlier study period and a different sample of movers. We explore how our results change if we use place effects that we estimate based on the event-study coefficient in Moura et al. (2019).[38] Based on these estimated place effects we re-estimate our baseline results. The results are shown in Figure A6 (m) in the online Appendix. The slope coefficient is now 0.238 instead of 0.293 in our baseline specification in Fig. 3. Thus, while using completely different place effects changes our coefficient, the main results are still qualitatively comparable.

Healthcare costs in levels

As an additional robustness check, we estimate Eq. 5 using the level of healthcare costs instead of the logarithm of healthcare costs as the outcome variable. Instead of assuming that place effects shift healthcare costs proportionally by a constant factor, we now assume that place effects shift healthcare costs by a constant amount.[39] A scatter plot using these estimates is shown in Figure A6 panel n in the online Appendix. Results are similar to the baseline specification.

Migration during shorter period

Next, we examine the effect of internal migration during a shorter period, between the years 2010 and 2018, on average healthcare costs of provinces. Hence, we assign movers to the province where they resided at the beginning of the year 2010, the first year for which individual healthcare costs are available in our data. Fewer persons move between provinces during a shorter time period, and hence we expect that effect sizes are smaller if we study migration during a shorter time period. This is also what we find in panel o of Figure A6 in the online Appendix. Otherwise, our results show similar patterns for internal migration during the 2010–2018 and the 1998–2018 periods. For both periods, internal migration tends to increase healthcare costs in peripheral provinces, and it tends to decrease healthcare costs in Randstad provinces.

38 Specifically, we compute $\gamma_j = (\bar{y}_j/\bar{y}_{min} - 1) * 0.274$, where γ_j is the estimated place effect for province j, $\bar{y}_j$ is average healthcare cost in province j, and $\bar{y}_{min}$ is the lowest average healthcare cost among all provinces. The ratio $\bar{y}_j/\bar{y}_{min}$ is computed based on the information in Figure 1 in Moura et al. (2019). 0.274 is the estimated event-study coefficient in Moura et al. (2019) for their baseline specification. The formula above is derived from Equation (3) in Finkelstein et al. (2016). γ_j for the reference category, the province with the lowest γ_j, is set to 0.

39 For this specification, we replace Eq. 4 by $y^{\mathrm{CF}}_{i,2018} = y_{i,2018} + \gamma_o - \gamma_d$.

Spillover effects on stayers

Our research question focuses on the effect of changes in population composition due to internal migration on average healthcare costs of provinces. This does not include spillover effects of migration on the local population of stayers.[40]

However, we explore in a robustness check whether our results are sensitive to the inclusion of spillover effects from internal migration. For this, we examine the effect of internal migration during the 2010–2018 period since individual healthcare costs are available in our data only starting from the year 2010. We start with regressing changes in average healthcare costs of stayers during the 2010 to 2018 period across provinces on net in-migration rates of provinces as a share of their 2010 population. Results are shown in Figure A8 in the online Appendix. There is only a weak and insignificant negative correlation between net internal in-migration rates and changes in healthcare costs of stayers across provinces.[41]

In the next step, we adjust healthcare costs of stayers in each province based on the changes predicted by the fitted regression line in Figure A8 in the online Appendix. Results are shown in Figure A6 panel p in the online Appendix. Results are overall similar to the baseline specification for the short migration period in panel o. This suggests that our results are robust even if we account for the correlation between changes in healthcare costs of stayers and net internal migration balances.

Effects on risk scores

As a final robustness check, we use risk scores as alternative outcome variable.[42] Panel q in Figure A6 presents results for risk scores which are similar to results for healthcare costs shown in Fig. 3. Internal migration tends to increase risk scores in peripheral provinces, and it tends to decrease risk scores in Randstad provinces. 28.7% of regional variation in risk scores across provinces in the year 2018 can be attributed to internal migration during the 1998-2018 period.

Summary of robustness checks

In summary, our results are remarkably robust to alternative specifications. For example, slope coefficients of fitted regression lines for specifications that examine the effect of internal migration during the 1998 to 2018 period (panels a to n of Figure A6 in the online Appendix) range from 0.238 to 0.300, which is similar to the slope

40 For example, Aygün et al. (2021); Giuntella et al. (2018) estimate spillover effects of external migration on the native population.

41 In further robustness checks, we regress changes in average healthcare costs of stayers during the 2010 to 2018 period across provinces on net in-migration rates for specific groups such as individuals under age 50, individuals age 50+, men, women, and registered healthcare professionals. Results are shown in Table A6 in the Online Appendix. All estimation coefficients are small and not significantly different from zero.

42 Risk scores can be seen as a proxy for health. Health has many dimensions which are often difficult to quantify. Risk scores combine elements of health such as chronic health conditions with information on factors that are closely correlated with health such as age and socio-economic conditions.

coefficient in the baseline specification of 0.293. Thus, different approaches to estimate place effects have limited impact on our results. Smaller effect sizes for internal migration during the 2010 to 2018 period do not imply a lack of robustness, but a weaker response to a smaller dose of the treatment.

5.3 Decomposition analysis

Next, we examine the underlying mechanisms why internal migration affects average healthcare costs in provinces. There can be two possible mechanisms: (1) Movers are on average healthier than stayers, as seen in Table 1. Therefore, net in-migration tends to decrease average healthcare costs in a province, while net out-migration tends to increase average healthcare costs. (2) There can be selective migration: in some provinces, in-migrants have lower average healthcare costs than out-migrants, while in other provinces, in-migrants have higher average healthcare costs than out-migrants.

Formally, we can decompose the total effect of internal migration into the effect of net in-migration and the effect of selective migration based on the equation below:

$$\bar{y}_j^F - \bar{y}_j^{CF} = \frac{N_j^{\text{IN}} - N_j^{\text{OUT}}}{N_{j,1998}}(\bar{y}_j^{\text{IN}} - \bar{y}_j^F) + \frac{N_j^{\text{OUT}}}{N_{j,1998}}(\bar{y}_j^{\text{IN}} - \bar{y}_j^{\text{OUT,CF}}) \qquad (10)$$

where $\bar{y}_j^F - \bar{y}_j^{CF}$ is the total effect of internal migration on healthcare costs in province j, as in Eq. 1. N_j^{IN} is the number of persons who move into province j from another province during the period from the year 1998 to 2018. N_j^{OUT} is the number of persons who move out of province j to another province during the period from the year 1998 to 2018. $N_{j,1998}$ is the population in province j in the year 1998. $\bar{y}_j^{\text{IN}}$ are average healthcare costs in the year 2018 of in-migrants in province j. $\bar{y}_j^{\text{OUT,CF}}$ are average healthcare costs in the year 2018 of out-migrants out of province j. Healthcare costs of out-migrants are adjusted according to Eq. 4.

The first summand in Eq. 10 is the net in-migration rate times the difference in average costs between in-migrants and the full population. We denote this term as the effect of net in-migration. The second summand in Eq. 10 is the out-migration rate times the difference between the average healthcare costs of in-migrants and the adjusted average healthcare costs of out-migrants. We denote this term as the effect of selective migration.

Table 3 shows average healthcare costs, the total effect of internal migration, the effect of net in-migration, and the effect of selective migration for all 12 provinces. The effect of selective migration tends to dominate the effect of net in-migration. For example, for the province with the largest positive total effect, Zeeland, the total effect is Euro 107.95, of which Euro 103.21 can be attributed to the effect of selective migration and Euro 4.74 Euro to the effect of net in-migration. For the province with the strongest negative total effect, Utrecht, the total effect is minus Euro 106.58, of which minus Euro 72.64 can be attributed to the effect of selective migration, and

Table 3 Decomposition analysis for healthcare cost

Province	Average healthcare cost (2018)	Total Effect (Std. Dev.)	Effect of net in-migration (Std. Dev.)	Effect of selective migration (Std. Dev.)
Drenthe	3366.50	87.16 (0.001)	−9.20 (-)	96.36 (0.001)
Flevoland	2742.53	−75.29 (0.002)	−33.93 (-)	−41.35 (0.002)
Friesland	3093.20	78.23 (0.001)	7.71 (-)	70.53 (0.001)
Gelderland	3011.47	25.11 (0.001)	−3.69 (-)	28.80 (0.001)
Groningen	3133.60	6.45 (0.001)	1.16 (-)	5.29 (0.001)
Limburg	3392.72	64.04 (0.001)	24.66 (-)	39.38 (0.001)
Noord-Brabant	2986.49	21.72 (0.001)	0.75 (-)	20.98 (0.001)
Noord-Holland	2921.68	−72.14 (0.001)	−12.31 (-)	−59.83 (0.001)
Overijssel	3041.24	50.17 (0.001)	4.27 (-)	45.90 (0.001)
Utrecht	2850.63	−106.58(0.001)	−33.94 (-)	−72.64 (0.001)
Zeeland	3218.80	107.95 (0.001)	4.74 (-)	103.21 (0.001)
Zuid-Holland	3019.34	−1.92 (0.001)	16.82 (-)	−18.74 (0.001)
Netherlands	3027.87	−0.29 (0.001)	0 (-)	−0.29 (0.001)

Note: Values are in Euros. The standard deviation for the total effect is the same as that of the effect of selective migration because only the effect of selective migration is a random variable. The effect of net in-migration is not a random variable. The sample includes 12.2 million observations

minus Euro 33.94 can be attributed to the effect of net in-migration. Compared to effect sizes, their standard deviations tend to be very small.[43]

Figure 4 provides more evidence on selective migration. The horizontal axis in the figure represents average healthcare costs in the year 2018. The vertical axis shows the difference in average healthcare costs in the year 2018 between in-migrants and out-migrants, $\bar{y}_j^{\text{IN}} - \bar{y}_j^{\text{OUT,CF}}$, for persons who moved to another province during the 1998 to 2018 period. The dots shown in the scatterplot represent the 12 provinces of the Netherlands plus one dot for the entire country. Figure 4 shows that $\bar{y}_j^{\text{IN}} - \bar{y}_j^{\text{OUT,CF}}$ tends to be positive for provinces with above-average healthcare costs, and it tends to be negative for provinces with below average healthcare costs. Selection effects can be very large. For example, for Zeeland average healthcare costs are Euro 691.68 higher for in-migrants than for out-migrants. In contrast, for Noord-Holland, average healthcare costs are Euro 491.21 lower for in-migrants than for out-migrants.[44]

In summary, the results of our decomposition analysis suggest that selective migration of high-cost individuals into provinces with high average healthcare costs and of low-cost individuals into provinces with low average healthcare costs is the main

[43] TE_j is a linear combination of observed variables and estimated place effects for the province of origin and the provinces of destination, $\hat{\gamma}_o$ and the $\hat{\gamma}_d$'s. Thus, the variance of TE_j is a linear combination of the variance of $\hat{\gamma}_o$, the variances of the $\hat{\gamma}_d$'s, and their covariances. We weight the $\hat{\gamma}_d$'s according to the number of movers out of province o who migrated into province d. The standard deviation of the effect of selective migration is the same as the standard deviation of TE_j, and the effect of net in-migration is not a random variable.

[44] Numbers are presented in Table A7 in the online Appendix.

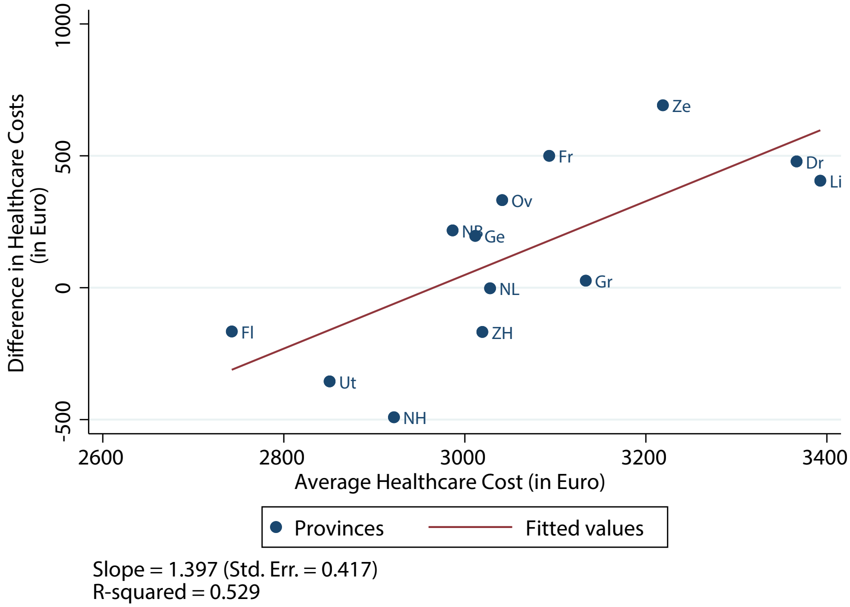

Fig. 4 Difference in healthcare costs between in-migrants and out-migrants by province. Note: The vertical axis shows the difference between average healthcare costs of in-migrants and adjusted average healthcare costs of out-migrants. The sample includes 1,620,679 observations. Dr, Drenthe; Fl, Flevoland; Fr, Friesland; Ge, Gelderland; Gr, Groningen; Li, Limburg; NB, Noord-Brabant; NH, Noord-Holland; NL, Netherlands; Ov, Overijssel; Ut, Utrecht; Ze, Zeeland; ZH, Zuid-Holland

mechanism behind the effect of internal migration on regional inequality in healthcare costs.

5.4 Adjusting healthcare costs for demographics and risk scores

Finally, we assess to what degree the effects of internal migration can be explained by demographics, e.g., the age and gender of movers to different provinces, and by risk scores. For this purpose, we adjust healthcare costs either for age and gender, or for differences in risk scores, and we estimate the effect of internal migration on adjusted healthcare costs. To obtain adjusted healthcare costs we use residuals from regressing individual healthcare costs on either (1) indicators for 5-year age bins interacted with gender or (2) risk scores. We then repeat our analysis based on these adjusted healthcare costs as outcome variable.[45]

[45] Formally, we replace Eq. 4 by $y^{CF}_{i,2018} = (\bar{y}^F + \hat{\epsilon}_{i,2018})(1 + \hat{\gamma}_o - \hat{\gamma}_d)$, where $\bar{y}^F$ is the national average of healthcare costs in the year 2018, $\hat{\epsilon}_{i,2018}$ is a residual from regressing individual healthcare costs $y_{i,2018}$ on either (1) indicators for 5-year age bins interacted with gender or (2) risk scores, and other variables are as defined in Sect. 4. Place effects are the same both in the analysis with adjusted healthcare costs and with unadjusted healthcare costs.

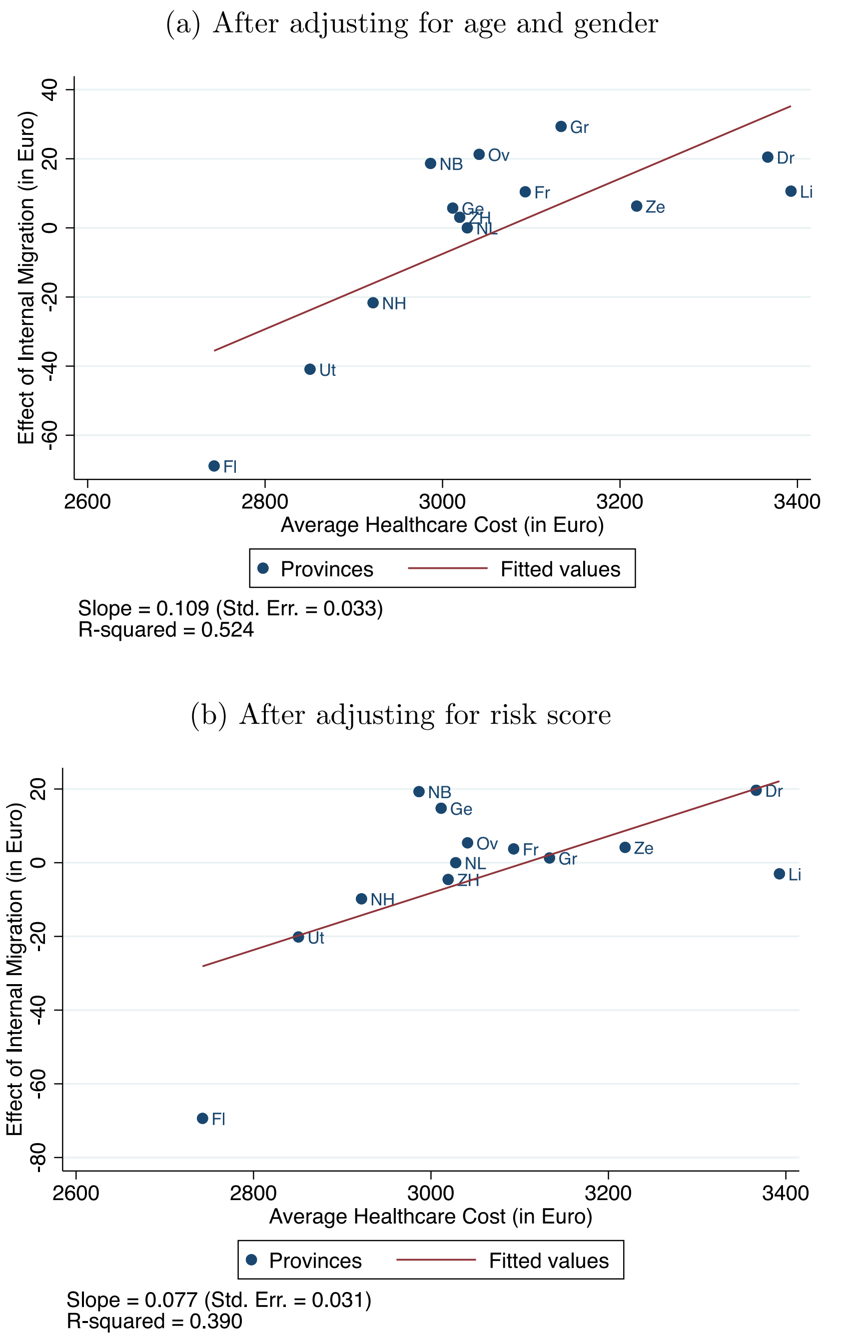

Fig. 5 Effect of internal migration during the 1998 to 2018 period on healthcare costs after adjusting for demographics and risk score. Note: The sample includes 12.2 million observations. Dr, Drenthe; Fl, Flevoland; Fr, Friesland; Ge, Gelderland; Gr, Groningen; Li, Limburg; NB, Noord-Brabant; NH, Noord-Holland; NL, Netherlands; Ov, Overijssel; Ut, Utrecht; Ze, Zeeland; ZH, Zuid-Holland

Figure 5 presents the effects of internal migration during the 1998–2018 period on adjusted healthcare costs. Panel a shows results after adjusting healthcare costs for age and gender. The slope coefficient of the fitted regression line is 0.109 which is significantly different from zero at the 1% level. Thus, the share of variation in healthcare costs across provinces that can be attributed to internal migration over the 1998 to 2018 period is 10.9% after adjusting healthcare costs for demographics, compared to 29.3% for unadjusted healthcare costs (see Fig. 3). Hence, demographics can explain around 62.8% of the effect of internal migration on regional variation in healthcare costs, whereas the remaining is explained by individual characteristics of movers other than age and gender.

Figure 5b shows results after adjusting healthcare costs for risk scores. Even after adjusting for risk scores, internal migration tends to increase healthcare costs in provinces with above-average healthcare costs, and it tends to decrease healthcare costs in provinces with below average healthcare costs.[46] The slope coefficient of the fitted regression line is 0.077 which is significantly different from zero at the 5% level.

Our findings have implications for healthcare financing. Our baseline results presented in Fig. 3 show the additional costs resulting from internal migration that an insurer (or other payer) would incur for the coverage of an average person in a given province if there would be no risk adjustment scheme. Our results shown in Fig. 5 demonstrate that these costs are still positive and substantial for several provinces, even after adjusting healthcare costs for demographics or risk sores. Thus, internal migration can lead to changes in average healthcare costs at the province level that are not compensated even in the presence of a basic (panel a) or elaborate risk adjustment scheme (panel b).[47]

6 Conclusion

Large regional disparities in health and healthcare costs are well documented in many countries, but the underlying causes why such disparities arise are still not fully understood. In this study, we show, for the case of the Netherlands, that internal migration and resulting changes in population composition can explain a substantial share of this variation. This is a new explanation that, to the best of our knowledge, has not been provided before.

We compute the effect of internal migration on average healthcare costs in Dutch provinces by comparing actual outcomes with counterfactual outcomes if there had been no internal migration over the past 20 years. To compute counterfactual outcomes, we assign persons to provinces where they have lived 20 years ago, and we estimate what healthcare costs of movers would have been if they had stayed in their province

[46] Effect sizes for each province of the results shown in Fig. 5 are also presented in Table A8 in the online Appendix.

[47] Since, due to data limitations, the risk scores used in our study are not exactly the same as the risk scores in the Dutch risk adjustment scheme, we cannot make statements about the effects of internal migration on uncompensated healthcare costs under the current risk adjustment scheme in the Netherlands. Yet, the analysis presented in this subsection provides a framework of how effects of internal migration that are not yet compensated by the risk adjustment scheme can be calculated.

of origin by adjusting their outcomes for place effects. We estimate place effects based on a movers approach.

We find that internal migration increases average healthcare costs for economically disadvantaged provinces in the periphery by up to 3.4%, and it decreases average healthcare costs for prosperous provinces in the highly urbanized Randstad region by up to 3.7%. These effects can mainly be attributed to selective migration: in peripheral provinces, healthcare costs are substantially higher for in-migrants than for out-migrants, while in Randstad provinces, healthcare costs are substantially lower for in-migrants than for out-migrants. Internal migration during the 1998–2018 period explains 29.3% of regional variation in healthcare costs. Finally, we find that effect sizes remain sizable even after we adjust healthcare costs for demographics or risk scores. Our results are robust to alternative specifications.

Our study has important policy implications. Internal migration increases healthcare costs in economically disadvantaged provinces in the Netherlands. Addressing demand for healthcare services in such regions imposes challenges. Equipment, facilities, and personnel need to be procured, and funding for healthcare services needs to be provided.

While our study focuses on the Netherlands, the patterns we document might be equally or even more important in other countries. Many countries experience a brain drain away from economically disadvantaged regions, which are often rural, peripheral, or home to declining industries, to prosperous urban centers and their surroundings. Our results show that internal migration and resulting changes in population composition can have a noticeable impact on average healthcare costs in economically disadvantaged regions, and they highlight the importance of addressing healthcare needs in disadvantaged regions even if average healthcare costs in such regions are already above the national average.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00148-025-01123-1.

Acknowledgements We are grateful for helpful comments and suggestions by editor Xi Chen, three anonymous reviewers, Padmaja Ayyagari, Pierre Thomas Leger, Nikolaus Schweizer, Johannes Spinnewijn, Christel van Dijk, Arthur van Soest, and Anthony Wray as well as seminar and conference participants at University of Duisburg-Essen, University of Groningen, Strathclyde University, Tilburg University, Netherlands Econometrics Study Group Meeting in Groningen, Conference on Economics Growth and Development organized by Indian Statistical Institute, Winter School organized by Delhi School of Economics, Lowlands Health Economic Study Group Conference in Rotterdam, Essen Health Conference, American Society of Health Economists Conference in St. Louis, and the Meeting of the Health Economics Committee of the German Economic Association in Wuppertal. We gratefully acknowledge funding from the Leibniz Society through the Leibniz Science Campus Ruhr on “Healthcare challenges in regions with declining and ageing populations.” We thank Statistics Netherlands (CBS) for providing non-public microdata.

Data availability The study is based on non-public microdata from Statistics Netherlands (CBS). Statistics Netherlands provides access to the data used in this study under some conditions. All STATA code that we have used for the empirical analysis is available from the authors. Data are stored at Statistics Netherlands.

Declarations

Conflict of interest The authors declare no competing interests.

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