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Health Inequality and the Intergenerational Transmissions of Health: Descriptive Evidence from the U.S. and Europe

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ABSTRACT

This paper explores the relationship between cross-sectional health inequality in a population and the strength of intergenerational transmissions of health. Using data from 28 countries from the SHARE, ELSA, and HRS surveys (N = 103,061), we estimate intergenerational correlations and educational inequalities in chronic health conditions for the age 50+ population. We then evaluate the relationship between health inequality and intergenerational transmissions of health by estimating their between-country correlation. We find that societies in which health disparities are wider also tend to have stronger intergenerational transmissions of health. We also find that both the degree of health inequality and intergenerational transmission are stronger in wealthy and more developed countries. Drawing on the theory of fundamental causes, we argue that this pattern relates to institutional and contextual mechanisms that alter how individuals can leverage resources to gain health advantages.

Health Inequality and the Intergenerational Transmissions of Health: Descriptive Evidence from the U.S. and Europe

Socioeconomic inequality in health is a persistent feature of many societies. It is present in rich and poor countries alike, across virtually all ages, and manifests itself across a wide range of conditions (Semyonov, Lewin-Epstein and Maskileyson 2013; Van Doorslaer et al. 1997; Van Ourti, Van Doorslaer and Koolman 2009). Individual health can be viewed as being determined by one's (or one's parents') ability to manage insults to health through, for example, accessing proper nutrition, clean water, adequate housing, sufficient health care, and managing stress, as well as by exogenous factors, such as environmental contamination, epidemiological conditions, or formal and informal institutions. Socioeconomic health differentials may therefore emerge and be sustained when groups of individuals have different capacities to mobilize resources, such as money, social networks, and prestige, that can be used to offset threats to poor health (Link and Phelan 1995).

In recent years, a growing body of evidence has suggested that intergenerational health transmissions, whether they be in the form of knowledge, attitudes, behaviors, or genetic endowments, may also be important determinants of health. Studies across a range of disciplines have found intergenerational associations for a diverse set of health outcomes, attitudes, and behaviors, such as longevity (Herskind et al. 1996), BMI (Dolton and Xiao 2017), obesity (Danielzik et al. 2002; Lake, Power and Cole 1997; Whitaker et al. 2010), smoking (Schori, Hofmann and Abel 2014; Sherman et al. 2009), chronic health conditions, like asthma, hay fever, migraines, and diabetes (Thompson 2014), diet and dietary knowledge (Rimal 2003), coronary heart disease (Sundquist et al. 2011), and depression (Garber and Cole 2010; Hammen, Shih and Brennan 2004). It is therefore plausible that socioeconomic inequalities in health may not emerge

solely through intragenerational mechanisms, but additionally through the conscious and unconscious transmission of characteristics and behaviors that can provide health advantages for offspring. Despite this growing body of evidence, there is currently no research examining how intergenerational health transmissions may relate to socioeconomic inequalities in health.

The goal of the present study is to analyze the relationship between health inequality and intergenerational transmissions in health for populations aged 50+ in Europe and North America. Our study contributes to the literature by being the first to demonstrate an empirical link between health inequality and intergenerational transmissions of health. Drawing upon the theory of fundamental causes (Link and Phelan 1995; Phelan, Link and Tehranifar 2010), which seeks to explain why socioeconomic inequalities emerge and persist, we argue below that health inequality should be positively correlated with the degree to which health is transmitted across generations. This is because the same mechanisms that allow health inequalities to emerge should also enhance the importance of the behaviors, attitudes, or other resources that individuals inherit as inputs for their own health. We test this hypothesis using data on 28 countries from the Survey of Health, Aging, and Retirement in Europe (SHARE), the English Longitudinal Study of Aging (ELSA), and the Health and Retirement Study (HRS) for the United States. First, we estimate intergenerational health correlations between respondents and their parents and then estimate educational differences in health for the respondents. We then analyze the relationship between health inequality and intergenerational transmissions of health by estimating their between-country correlations.

Background

Fundamental causes, health inequality, and intergenerational transmissions of health

In order to understand the connection between health inequality and intergenerational health transmissions, we must first consider why socioeconomic differences in health emerge. Link and Phelan (1995) famously put forward the theory of fundamental causes, which sought to explain persistent socioeconomic inequality in mortality. According to the theory, a fundamental social cause of health inequality meets four criteria (Phelan et al. 2010). First, it influences multiple disease outcomes, and not just a singular condition. Second, it affects these outcomes via multiple mechanisms. Third, it involves the ability to use resources to either avoid or manage illness. Finally, a fundamental social cause's influence on inequality is perpetuated as mechanisms linking social status to health change over time. The intuition behind the theory of fundamental causes is that, even as disease environments change and medical knowledge evolves, individuals who have greater access to resources, including money, prestige, social networks, and power, can more effectively leverage those resources to minimize exposure to illness and to manage existing illness. Here, resources may be used for the sake of gaining a health advantage deliberately, such as through purchasing gym memberships or more comprehensive health insurance, but also unintentionally, such as by choosing to live in a more well-to-do neighborhood where community norms happen to promote healthier lifestyles, for example, through the collective exploitation of political clout to limit noise pollution, crime, or maintain particular property standards.

Central to the theory of fundamental causes is the idea that health inequalities will exist if, and only if, resources can be effectively used to gain health advantages. That is, the ability to mobilize resources is constrained by technological and institutional contexts. For conditions

where little etiological knowledge or few effective interventions are available, socioeconomic status will impart little to no advantage in health (Phelan et al. 2004). It is only once effective interventions are known and available that socioeconomic status should become a significant determinant of health. Evidence has shown, for example, that socioeconomic status was positively related to blood cholesterol and LDL prior to the introduction of statins, but once they became available to the general population, cholesterol levels became inversely related to one's socioeconomic status (Chang and Lauderdale 2009).

A corollary of this proposition is that contextual constraints which limit the extent to which resources can be leveraged for gaining health advantages will also limit socioeconomic inequality in health. Here, we use 'contextual constraints' in a broad sense. For example, they may refer to formal institutional arrangements that explicitly limit how individuals may use their resources, such as the universal provision of health insurance or the enforcement of housing standards. But there may also be constraints that indirectly limit an individual's likelihood of using their resources to this end. For instance, if a given society has a broad cultural acceptance of smoking or drinking, individuals with higher socioeconomic status may not necessarily want to avoid these risk factors, despite having a disproportionate ability to do so. Likewise, contextual conditions that negatively influence basic inputs to health, such as air pollution from poorly regulated car emissions or harmful additives in food, will hinder individuals' ability to gain a health advantage for outcomes directly impacted by those inputs, regardless of their socioeconomic status. As a result, the degree to which individuals can or will use their resources to mitigate health insults may vary according to the context in which they live. A study of colorectal mortality in the US, for instance, showed that socioeconomic status was less strongly related to mortality in states that were more open to the diffusion of information (i.e. more

readily adopted new policies), implying that socioeconomic status provided less of a health advantage when medical information was more widely available (Wang et al. 2012). Thus, there is evidence that contextual factors which limit the ability to leverage resources to gain a health advantage may consequently reduce health inequalities.

Until now, we have only discussed how *individual* resources influence one's own health. However, individual health may also be influenced by resources that are acquired via one's parents (Freese and Lutfey 2011). These transmitted resources can take one of three forms: those that are randomly transmitted (i.e. genetic predisposition), those that are non-randomly, unintentionally transmitted (e.g. adoption of observed behaviors and attitudes), and those that are intentionally transmitted (e.g. knowledge sharing and financial bequests). Note that while genetic predispositions are likely transmitted regardless of the socioeconomic status attained by an individual's parents, the transmission of behaviors, attitudes, and/or knowledge plausibly correlates with parents' education, income, etc. Thus, intergenerational correlations in health can be driven by several factors including direct transmission of health (e.g. genetic predispositions), transmission of socioeconomic status (which in turn produces good health for the respective generations), and transmission of health-inducing attitudes, behaviors, and knowledge that may produce positive health outcomes in children regardless of their socioeconomic status. As an example, a recent analysis examined socioeconomic differentials in vaccine knowledge and uptake during the rollout of the human papillomavirus (HPV) vaccine in 2006 in the US. The authors found that parents with higher socioeconomic status were more likely to be knowledgeable about the vaccine, were more likely to receive a physician's recommendation for the vaccine, and their children were more likely to be vaccinated against HPV (Polonijo and Carpiano 2013). Evidence from outside the US suggests that inequalities in the uptake of this

preventative intervention are not purely due to inequalities in financial resources. A study of Danish teenage girls also showed that, despite the universal availability of no-cost vaccinations, those with mothers who had only basic education, low disposable income, or who had immigrated to Denmark had substantially lower odds of receiving the HPV vaccine (Slåttelid Schreiber et al. 2015). The rollout of the HPV vaccine serves as a modern example illustrating the spillover effects of socioeconomic status, as the children who benefited from their parents' socioeconomic status will have substantially lower rates of short-term morbidity and also lower rates of the various forms of cancer related to HPV much later in life, and these health advantages will have been gained through little to no intentional action of their own.

In sum, we argue that the types and amount of resources an individual has at their disposal, whether those resources are acquired or inherited, will strongly influence their own health outcomes. The relative importance of these resources for influencing one's health, however, will be contingent upon individuals' ability to leverage their resources, which itself will depend on the specific cultural and institutional context in which the individual is embedded. The present study is situated at the intersection of these features of fundamental cause theory. Our primary goal is to examine whether the strength of intergenerational transmissions in health correlates with socioeconomic inequalities in health. Based on the above discussion, we hypothesize that populations in which socioeconomic health inequalities are wider will also have stronger intergenerational transmissions of health. We will test this hypothesis by estimating the degree of health inequality and the intergenerational transmission of health in a society, and then calculating their correlation coefficient to see if the two are positively correlated (described below). It is important to note here that our measure of health transmissions only serves as a measure of the degree of similarity in health between generations, but cannot distinguish through

which transmission mechanisms that similarity originated (e.g. transmissions of genes, socioeconomic status, behaviors, etc.). Therefore, our measure of health transmissions refers to the totality of all inputs from resources that produce health for the parental generation and also affect the health of the next generation, whether directly or indirectly.

Hypotheses

Our primary hypothesis is based on the assumption that societies in which resources can be leveraged to a greater extent to, for example, gain access to better quality health care, healthier neighborhoods, or less stressful jobs, will exhibit more health inequality and also be societies in which the knowledge, behaviors, attitudes, wealth, or social networks that children receive from their parents can be used to gain a health advantage for themselves. If there are contextual or institutional mechanisms that dampen the effectiveness of such resources, however, we would expect that individuals' health would be more likely to resemble their cohorts' (who have had more similar health opportunities) and less likely to resemble their parents' (whose intergenerational transmissions could not be as effectively exploited). Thus, we expect that greater levels of health inequality should be positively correlated with the strength of intergenerational transmissions in health.

Furthermore, in support of our primary hypothesis, we also expect the degree of both intergenerational transmissions and health inequality to vary depending on the country context. We hypothesize that societies with stronger exogenous influences on health (e.g. infectious disease burden or the level of air pollution) will also exhibit less health inequality and weaker intergenerational transmissions. We expect to observe this relationship for two reasons. First, the exogenous influences may serve as barriers towards individuals utilizing resources to offset

threats to health, and therefore will limit health disparities and the importance of intergenerational transmissions. Second, as described in detail below, our health measures are based on mortality (for the parents' generation) and chronic health conditions (for the children's generation) which both tend to manifest later in life. Thus, weaker exogenous negative inputs to health may increase overall longevity and allow more time for health disparities to emerge and to widen. We test this hypothesis by examining whether intergenerational transmissions and health inequalities are inversely correlated with population wealth and country development, which we measure by GDP per capita.

Data and methods

Data

In this study we use data on individuals aged 50 and older from the following 28 countries: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, England, Estonia, Finland, France, Germany, Greece, Hungary, Israel, Italy, Latvia, Lithuania, Luxembourg, Malta, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, and the United States. The harmonized data come from the Health and Retirement Study (HRS), which covers the United States, the English Longitudinal Study of Ageing (ELSA), and the Survey of Health, Ageing and Retirement in Europe (SHARE). Both ELSA and SHARE were modelled after HRS, making the three surveys highly comparable (Börsch-Supan et al. 2013; Steptoe et al. 2012). The surveys follow random samples of individuals aged 50+ over time and measure characteristics pertaining to health, economics, and family dynamics, and basic demographics. In addition to the sample respondents, the surveys also collect information on their spouses, and some information on their children and parents as well. The focal individuals in our study are the survey respondents and any spouses 50 years or older. The intergenerational aspect of our analysis will

refer to the health transmission between the parents of the survey respondents (or spouses) and the focal individuals themselves, because the surveys only collected information on the health of parents, but not on the children of the respondents.

We restricted our analysis to data from the latest possible wave, corresponding to the years 2016-2017 (wave 13 for HRS (2016), wave eight for ELSA (2016/2017), and wave seven for SHARE (2017)). We chose these waves because they contain the most recent information and provide the greatest number of countries for a comparative analysis, as SHARE added eight countries to the survey in wave seven. In total, our analysis includes data on 103,061 individuals (SHARE: 74,929, ELSA: 7,223, and HRS: 20,909). We apply the weights recommended by the data providers to our descriptive and regression analysis to account for non-random sampling designs (Bergmann et al. 2019; Health and Retirement Study 2002; NatCen Social Research 2018).

Respondent Health Measures

In this study we measure health using indicators of chronic health conditions (see Table 1 for observations and summary statistics of measures by country). For each of five chronic conditions (high blood pressure, stroke, diabetes, chronic lung disease, and cancer), respondents were asked if a doctor had ever diagnosed them with it. To construct our health measure, we calculate the total number of chronic conditions each individual report having been diagnosed with, ranging from zero to five. We consider this to be the most objective of our measures, since it measures serious health insults and requires a diagnosis by a doctor rather than self-evaluation. Furthermore, previous studies have also used chronic health conditions as a valid health measure (e.g. Currie and Stabile 2003; Leopold 2018). Nevertheless, this measure has some

shortcomings. First, it is possible that there are differential diagnostic patterns between the countries considered in our analysis. Second, we combine a series of chronic conditions that may have heterogeneous causes and be more or less likely to affect certain socioeconomic groups. We made this decision weighing the trade-off of gaining precision in our health measure from combining several chronic conditions while also potentially confounding mechanisms leading to each individual condition. Third, because this measure is self-reported, it is also possible that individual respondents may misreport being diagnosed with any of these conditions. Some studies have shown that misreporting of self-reported chronic conditions varies inversely with individuals' level of education and therefore self-reported measures tend to underestimate socioeconomic health disparities (Kriegsman et al. 1996; Mackenbach, Looman and Van der Meer 1996; Okura et al. 2004; Wu, Li and Ke 2000). This finding is not universal, however (see e.g., Glymour and Avendano 2009; Merkin et al. 2007; Stavrou et al. 2011). We therefore suspect that, even if self-reported chronic conditions are not perfectly reported, our estimates of health inequality derived from the self-reported data should at least represent a lower bound for the true health disparities in a population.

- Table 1 about here -

Parental health

In addition to respondent health measures, our analysis also requires information on their parents' health to assess intergenerational health transmissions. The only health information available about the parents in data is their longevity and respondent-rated parent health. The latter, however, is only measured for living parents, so using this measure risks introducing

considerable survivorship bias. Rather, we use parental longevity, a somewhat cruder, but more objective measure of parental health, which has also been used in previous studies (e.g. Atkins et al. 2016). We measured parental longevity as a dummy variable indicating if at least one of the respondents' parents survived until at least age 75. This choice of threshold was meant to approximate life expectancy for the countries we analyze and is also consistent with the standard age threshold used when calculating Years of Potential Life Lost, which is a general indicator of premature mortality used by the OECD (OECD 2020). Later in the study we check the robustness of our results by imposing various age thresholds to parental mortality and demonstrate that our findings are not dependent on this assumption.

Socioeconomic status measure

We operationalize socioeconomic status in terms of respondents' education, as this information is available and comparable for all countries and does not suffer from an overly high non-response rate compared to other indicators, like those pertaining to income or wealth (De Luca and Rosetti 2019). Education is coded according to the ISCED-97 scale in all the 26 countries in SHARE. HRS uses a US-specific scale and ELSA uses a UK-specific scale. However, both HRS and ELSA record whether respondents have completed a tertiary education or not, making the final education coding strictly comparable between all countries. For our analysis, educational attainment was treated as a binary variable with a value of one if the respondent has completed a tertiary education and a value of zero otherwise.

Contextual measures

Following the theory of fundamental causes, we expect that contexts that impart higher risks of exogenous insults to health through, for example, poorer quality of housing, lower standards for clean drinking water, or a less developed health care sector, will exhibit a lower level of health disparities and weaker intergenerational transmissions, because these inputs will limit how individual resources can or will be used while also acting as an equalizer, imparting health insults more or less regardless of socioeconomic status. To approximate the development status and population wealth of each country, we use the log GDP per capita (PPP), which is adjusted for the local cost of living (World Bank 2019).

To best approximate the context in which the individuals' health was formed (rather than the survey context where the respondents were aged 50+), we measure log GDP per capita (PPP) in 1995, which is the earliest measurement point available for the widest range of countries. We also ran the analysis using each country's current GDP rather than the retrospective measure, which did not alter our results substantively (available upon request). To reiterate, we expect the magnitude of both health inequality and transmissions to be *larger* in wealthy and more developed contexts (i.e. high GDP) since these contexts may also be characterized by weaker negative exogenous inputs to health and a higher level of longevity, thus allowing individuals to leverage their own resources to a larger extent.

Methods

For each country in our data, we estimate two quantities using ordinary least squares regression. We estimate health disparities by regressing the individual's number of chronic health conditions on a dummy measuring whether they have attained tertiary education or not and on the individual's age. This simple estimate can be interpreted as the raw health disparity between high

educated individuals and their less educated counterparts in a given country. Previous studies have also estimated health inequality by comparing health between education groups (e.g. Mackenbach et al. 2008; Reeves and Mackenbach 2019), although some research suggests that estimation of health inequality could be sensitive to what socioeconomic measure is applied (Galobardes et al. 2007; Geyer et al. 2006). We chose this measure of health inequality over more conventional measures (such as the GINI coefficient) for three main reasons: First, one of the mechanisms behind the theory of fundamental causes is that individuals leverage resources to improve their health and we aim to capture that process by estimating the disparity between SES groups rather than the overall dispersion of health. Second, we believe that SES differences have a more straightforward interpretation, which makes cross-country comparison more intuitive. Third, while dispersion measures such as the GINI coefficient depend mechanically on the overall level of health in a country, the same is not true for socioeconomic disparities. One might suspect that the SES disparities co-vary systematically with the share of high-SES individuals in a country, which would make it a poor measure of health inequality. However, we show as a robustness checks that the two do not share a statistically significant correlation.

Having estimated health disparities, we next estimate intergenerational transmissions of health by regressing the number of chronic health conditions on a dummy measuring whether at least one parent survived to the age of 75 and on the individual's age. This estimate can be interpreted as the health disparity between individuals with healthy versus non-healthy parents. Previous studies (e.g. Atkins et al. 2016) use a similar approach to document disparities between groups in cardiovascular outcomes.

When estimating either health inequality or intergenerational health transmission, each regression also controls for the age of the respondent in order to adjust for differences in age

distributions between countries and misreporting of chronic diseases, which tends to increase with age (Kriegsman et al. 1996; Okura et al. 2004; Wu et al. 2000). Because we estimate our models separately for each country, the models implicitly control for country-level fixed effects and thus control for all shared factors within a country.

We report both the estimate of health inequality and of intergenerational transmissions such that a larger positive value corresponds to individuals with high education and long-living parents having fewer chronic health conditions and thus better health than their counterparts. By running these regressions, we obtain estimates of health inequality and intergenerational transmissions of health for each country. In the next section, we estimate the correlation between health inequality and intergenerational health transmissions and show the relationship between these two values graphically.

Results

Main analyses

In this section, we first present the results from the individual models predicting health inequalities and intergenerational transmissions in Figure 1, and then present the relationship between the two (descriptive statistics by country can be found in Table 1). Starting with the underlying models, the estimates of health inequality ranged from -0.05 in Romania to 0.27 in the Czech Republic. Thus, panel (a) of Figure 1 shows that, in the Czech Republic, individuals with a tertiary education had 0.27 fewer chronic health conditions than those with less than a tertiary education. These estimates do not differ substantially from previous comparative studies of health inequality (e.g. Mackenbach et al. 2008), especially considering the differences in populations and health measures used across studies. Our estimates of intergenerational health transmissions varied from -0.02 in Greece to 0.29 in the Czech Republic. Taking the Czech

Republic as an example, panel (b) of Figure 1 therefore suggests that individuals who had at least one parent survive beyond age 75 had 0.29 fewer chronic health conditions than those whose parents had died before reaching age 75. From these two models it is apparent that there is much variation in the extent to which socioeconomic status is correlated with individual health and also in the degree to which individuals' health resembles that of their parents. Some countries, like Romania and Slovakia, had fairly little socioeconomic inequality in health, while others, like the United States and the Czech Republic, had substantially larger health inequalities. Likewise, individual and parental health were virtually uncorrelated in Estonia and Greece, but showed modest correlations in the United States, Malta, and the Czech Republic.

When we plot the two series of estimates against one another, an interesting picture emerges (Figure 2). There is a sizeable positive correlation ($\rho = 0.553$, $p = 0.002$) between health inequality and intergenerational transmissions of health across the 28 countries in our sample. The reader should note that each country observation is visually scaled to reflect its population size, but all countries have equal weight when calculating the correlation coefficients. The figure shows that countries with higher levels of health inequality also tend to be characterized by greater intergenerational transmissions of health. In other words, individual health tends to more strongly resemble parental health in countries where education is a stronger determinant of an individual's health.

- Figure 2 about here -

As described above, one corollary of the theory of fundamental causes is that health inequality (as well as intergenerational transmissions of health) should be more pronounced in contexts where individuals have greater opportunities to use their resources (whether acquired

through education or transmitted by parents) to gain health advantages. We test this hypothesis by proxying exogenous threats to health using log GDP per capita (PPP) from 1995 (Figure 3).

- Figure 3 about here -

The results from this exercise revealed some important insights. First, health inequality in a population was positively correlated with the log GDP per capita (ρ = 0.464, p = 0.013). That is, populations and countries that are, on average, healthier and more developed also tend to have wider disparities in health between tertiary and non-tertiary educated individuals, supporting the hypothesis that health inequalities will be larger when there are fewer contextual barriers to good health. This finding is consistent with a recent study on individuals from 29 countries aged 24-75 years, which also found that socioeconomic inequalities in self-rated health increased with GDP per capita (Präg, Mills and Wittek 2016). Second, we find that intergenerational transmissions are also positively correlated with log GDP per capita (ρ = 0.36, p = 0.06). To our knowledge, no previous research links the degree of intergenerational transmission of health to country-level characteristics. Although it is beyond our data and methods to firmly conclude any causal links, these associations are consistent with the theory that contexts which provide more opportunities for individuals to leverage their resources for health advantages and have fewer exogenous threats to health, in this case countries characterized by larger GDP per capita, also pave the road for a steeper educational gradient in health and stronger intergenerational transmissions.

Supplementary Analyses

In addition to our main analysis, we performed a series of robustness checks to ensure that our results are stable across different selections of countries and various definitions of

intergenerational transmissions. First, to ensure that none of our results are driven by one specific country, we recalculated the correlation between the intergenerational transmission of health and health inequality for all countries but one, changing the omitted country at each iteration, across the entire list of countries. Thus, in Figure 4 the first column represents the correlation in the sample when only the Czech Republic is excluded, the second when only the United States is excluded, and so on. The results showed that the Czech Republic and the United States both contribute substantially to the overall positive correlation between intergenerational transmissions and health inequality but cannot solely explain it. When the Czech Republic or the United States was excluded, the correlation coefficient dropped to 0.46 and 0.47, respectively, and retained its significance ($p = 0.017$ and 0.012, respectively). Excluding any other country had a much smaller influence on the overall correlation, leaving it between 0.55 and 0.63. Although the correlations are somewhat sensitive to leaving out individual countries, some volatility is to be expected given the number of countries, and we consider the underlying patterns robust.

Second, we check the robustness of our results by changing the age threshold of a 'healthy' parent. The main results defined parental health in terms of their survival beyond age 75. Admittedly, this was a somewhat arbitrary choice. We re-estimated the correlation between health inequality and transmissions for all parental age thresholds from 73 years to 77 years, and for at least one parent surviving past the 50^{th}, 66^{th}, and 75^{th} percentile of their country (percentiles derived from data). We present these results in Figure 5 and conclude that although results vary somewhat by age threshold, the overall positive correlation is robust, falling between 0.403 and 0.637.

Finally, we analyze the extent to which out measure of health inequality, the SES disparity in chronic conditions, reflects the underlying distribution of education. Figure 6 shows our measure of health inequality as a function of the share of tertiary educated in the country. Although the correlation is positive (ρ = 0.228), it is not statistically significant at any conventional levels (p = 0.242) and we conclude that the between-country patterns we observe in health inequality are not mainly driven by population differences in level of education. Based on the abovementioned sensitivity analyses, we consider our findings robust to omitting individual countries, defining health of parents across a range of thresholds, whether general or country-specific, and are not driven by between-country differences in level of education.

Discussion

In this study, we used data on 28 countries from Europe and North America to examine the relationship between health inequality, intergenerational health transmissions, and country GDP. Drawing on the theory of fundamental causes, we argued that societies which have wider socioeconomic disparities in health will also exhibit a greater degree of similarity in health across generations, and our results supported this hypothesis. We also showed that both the level of health inequality and the extent to which health is transmitted across generations is dependent upon contextual factors that influence the degree to which resources can be used to gain health advantages, both being more pronounced in wealthy countries.

In our view, there are several plausible interpretations of our findings. One interpretation is that institutional and technological contexts may not only influence the degree of contemporary health inequality but may also reinforce health inequality over the long-term as well. That is, when contexts allow individuals to have competitive health advantages in one generation, those same advantages can be transmitted, either consciously or unconsciously, to

subsequent generations, and therefore reinforce health inequalities in subsequent generations. For example, in a context in which health care is not universally available, individuals with greater resources will be more able to afford quality care, leading to cross-sectional health inequalities. But they may also bolster future health inequalities by allowing an individual to provide annual checkups for their children, advising their older children on how to navigate the healthcare system, and how to find better health insurance plans later in life. Thus, just one contextual factor (in this case, market-based health insurance) can lead to both wider health inequalities and a stronger intergenerational correlation in health.

There are, of course, other possible interpretations of our findings. There may be background factors that are correlated with both intergenerational transmissions and health inequality that would lead to the same correlation observed here. One plausible candidate relates to the so-called 'Great Gatsby Curve' (Corak 2013), which shows that income inequality is negatively correlated with income mobility. As we discuss above, our estimate of intergenerational transmissions captures all factors in the parental generation that produce health for parents and for children, including potentially the transmission of socioeconomic status. It is well documented that (a) child health is correlated with child socioeconomic status, (b) child socioeconomic status is correlated with parents' socioeconomic status, and (c) parents' health is correlated with parents' socioeconomic status. Thus, our measures of both inequality and transmissions could potentially be second-order effects of the transmission of socioeconomic status. However, we argue that there are many likely mechanisms through which parents transmit health to children outside of the transmission of education, genetic predispositions being the most salient.

We also believe our study has several important strengths. First, this was the first study to our knowledge to demonstrate a link between intergenerational health transmissions and health inequality. Drawing upon the large literature on socioeconomic health inequalities and the growing body of work demonstrating the importance of intergenerational transmissions of health, this study was able to illustrate the potentially important contribution of intergenerational influences on the existence and perpetuation of societal health inequalities. A second important strength of our study was that it addressed this research gap from an international perspective. Using data from highly comparable surveys from Europe and the United States allowed us not just to evaluate whether there is a correlation between intergenerational health transmissions and health inequality, but also if this relationship covaries with particular characteristics of a society, which is crucial for understanding the potential mechanisms underlying the relationship. Third, our study used various measures of health and different age thresholds for intergenerational health transmissions, allowing us to demonstrate that the findings presented here appear to represent a general phenomenon and are not confined to a certain definition of health in either generation.

In spite of these strengths, there are several limitations worth mentioning. First, our study was descriptive in nature, and although there is a theoretical mechanism which may causally link health inequality to intergenerational health transmissions, the results presented here cannot be interpreted as such. Second, due to data limitations, our study relied on fairly crude measures of parental health and all health measures for individuals and their parents were self-reported. Ideally, all of our health measures would have been collected by a third party to avoid any potential differences in reporting between socioeconomic groups and countries. For parents, it would have also been preferable to have multiple health measures that were directly comparable

to those for respondents and at varying points over the life course to more directly estimate intergenerational transmissions of health. Third, our study was unable to speak to the precise mechanisms leading to intergenerational health transmissions. While we speculate that parents are likely to transmit health-influencing behaviors, attitudes, knowledge, genetic predispositions, or social or economic resources, we could not identify what exactly is transmitted across generations that leads to similar health outcomes. To this end, it would have been ideal to also have information on parents' socioeconomic backgrounds, as this could allow us to disentangle whether our results are primarily being driven by a transmission of socioeconomic background. If this were the case, we would have a better understanding of the pathways through which the correlation between health inequality and transmissions emerges. Finally, our study was limited to Western countries in the Northern hemisphere and our conclusions may not necessarily extend to, for example, developing countries or even wealthy countries in East Asia.

We believe the findings of our study offer several promising avenues for future research. For example, it would be useful to know the extent to which changes within a particular context can alter both health inequality and the transmission of health simultaneously, as this can inform both policy and our theoretical understanding of the mechanisms linking the two. Many of the countries included in our study have undergone dramatic institutional and economic changes during the respondents' lives. It would be interesting to know, for instance, how shifts away from socialism in the former Eastern Bloc states in our study would have impacted the extent and kinds of intergenerational transmissions in health after the system change. Similarly, it would also be valuable to have more detailed work examining socioeconomic differences in the kinds of health-related behaviors, attitudes, or resources that are transmitted across generations and how they correlate with socioeconomic differences in health. It is important that we understand

these details, as the results of this paper suggest that the causes of health inequalities may not just be rooted in one generation, but, if contextual conditions permit, may also be transmitted across generations.

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Tables and figures

Table 1: Descriptive statistics

Country	Obs.	Chronic Conditions	Parental Health	Tertiary education	GDP / Capita (PPP)
		Mean (sd)	Mean (sd)	Mean (sd)	$
Austria	3171	0.68 (0.79)	0.83 (0.38)	0.27 (0.44)	23660
Belgium	4835	0.62 (0.76)	0.87 (0.34)	0.37 (0.48)	22532
Bulgaria	1994	0.75 (0.74)	0.70 (0.46)	0.18 (0.39)	7683
Croatia	2371	0.77 (0.80)	0.78 (0.41)	0.14 (0.35)	7951
Cyprus	1195	0.68 (0.77)	0.92 (0.28)	0.17 (0.37)	17070
Czech Republic	4185	0.86 (0.86)	0.80 (0.40)	0.14 (0.35)	13753
Denmark	3202	0.57 (0.73)	0.87 (0.34)	0.45 (0.50)	22661
England*	7223	0.66 (0.80)	0.84 (0.37)	0.16 (0.36)	20434
Estonia	5059	0.72 (0.79)	0.78 (0.41)	0.24 (0.43)	6284
Finland	1971	0.80 (0.86)	0.87 (0.34)	0.41 (0.49)	19558
France	3286	0.55 (0.72)	0.87 (0.34)	0.26 (0.44)	20745
Germany	3785	0.79 (0.83)	0.84 (0.37)	0.30 (0.46)	23581
Greece	3032	0.68 (0.76)	0.85 (0.36)	0.20 (0.40)	15409
Hungary	1528	0.89 (0.83)	0.67 (0.47)	0.14 (0.35)	9177
Israel	2109	0.67 (0.84)	0.82 (0.38)	0.41 (0.49)	19890
Italy	4509	0.63 (0.74)	0.87 (0.33)	0.08 (0.27)	22286
Latvia	1705	0.66 (0.79)	0.78 (0.41)	0.24 (0.43)	5508
Lithuania	1975	0.82 (0.83)	0.81 (0.39)	0.33 (0.47)	5924
Luxembourg	1238	0.61 (0.76)	0.85 (0.36)	0.23 (0.42)	39636
Malta	1240	0.70 (0.76)	0.82 (0.39)	0.07 (0.26)	12916
Poland	4625	0.78 (0.84)	0.81 (0.40)	0.11 (0.31)	7665
Romania	2035	0.67 (0.74)	0.74 (0.44)	0.05 (0.22)	5421
Slovakia	1972	0.44 (0.65)	0.73 (0.44)	0.10 (0.30)	8648
Slovenia	3675	0.70 (0.77)	0.80 (0.40)	0.17 (0.38)	13556
Spain	4670	0.69 (0.79)	0.85 (0.36)	0.12 (0.33)	16218
Sweden	3180	0.59 (0.73)	0.91 (0.29)	0.37 (0.48)	22815

Switzerland	2382	0.45 (0.68)	0.88 (0.32)	0.19 (0.39)	29902
United States	20909	1.07 (0.97)	0.85 (0.36)	0.32 (0.47)	28691

Note: *Chronic conditions* are defined as the number of chronic conditions (i.e. high blood pressure, stroke, diabetes, chronic lung disease, and cancer) a respondent reported having been diagnosed with by a doctor. *Parental health* consists of a dummy variable with a value of 1 if at least one of the respondents' parents survived until at least age 75 and a value of 0 otherwise. *Educational attainment* consists of a dummy variable with a value of 1 if the respondent has completed a tertiary education and a value of 0 otherwise. *GDP/Capita (PPP)* is the countries' gross domestic product, measured in 1995 (World Bank (2019).

*For GDP per capita, the values for England represent the values for the United Kingdom.

Figure 1: Health inequality and intergenerational transmission of health by country

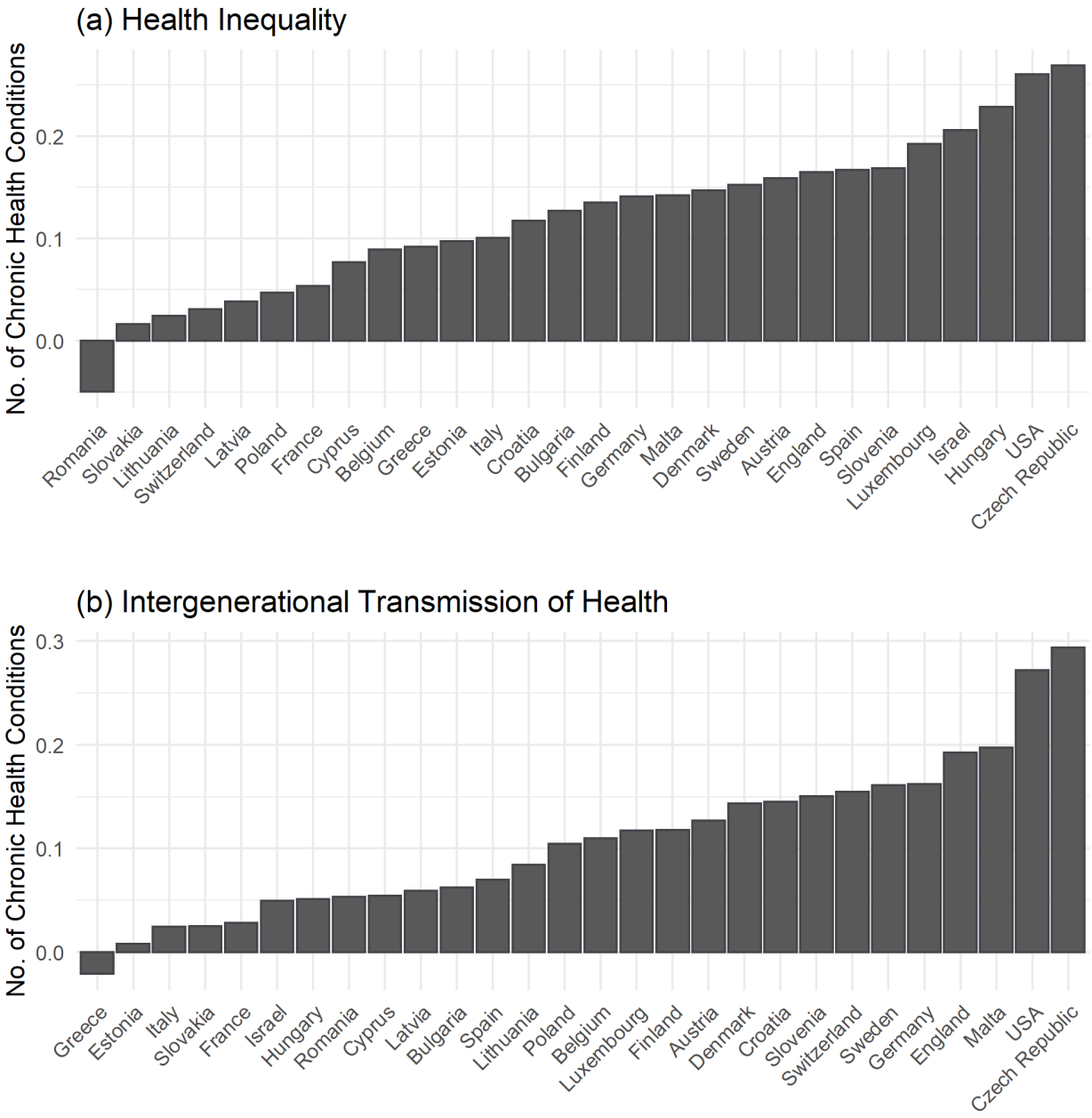

Fig. 1 Health inequality is the difference in number of chronic health conditions reported between individuals with tertiary vs. non-tertiary education. Intergenerational transmission of health is the difference in number of chronic health conditions reported between individuals who had at least one parent live past the age of 75 and those who did not. Both sets of estimates have been adjusted for the age of the respondent and weighted as per the recommendations from the data suppliers.

Figure 2: The relationship between health inequality and intergenerational transmissions of health for 28 countries

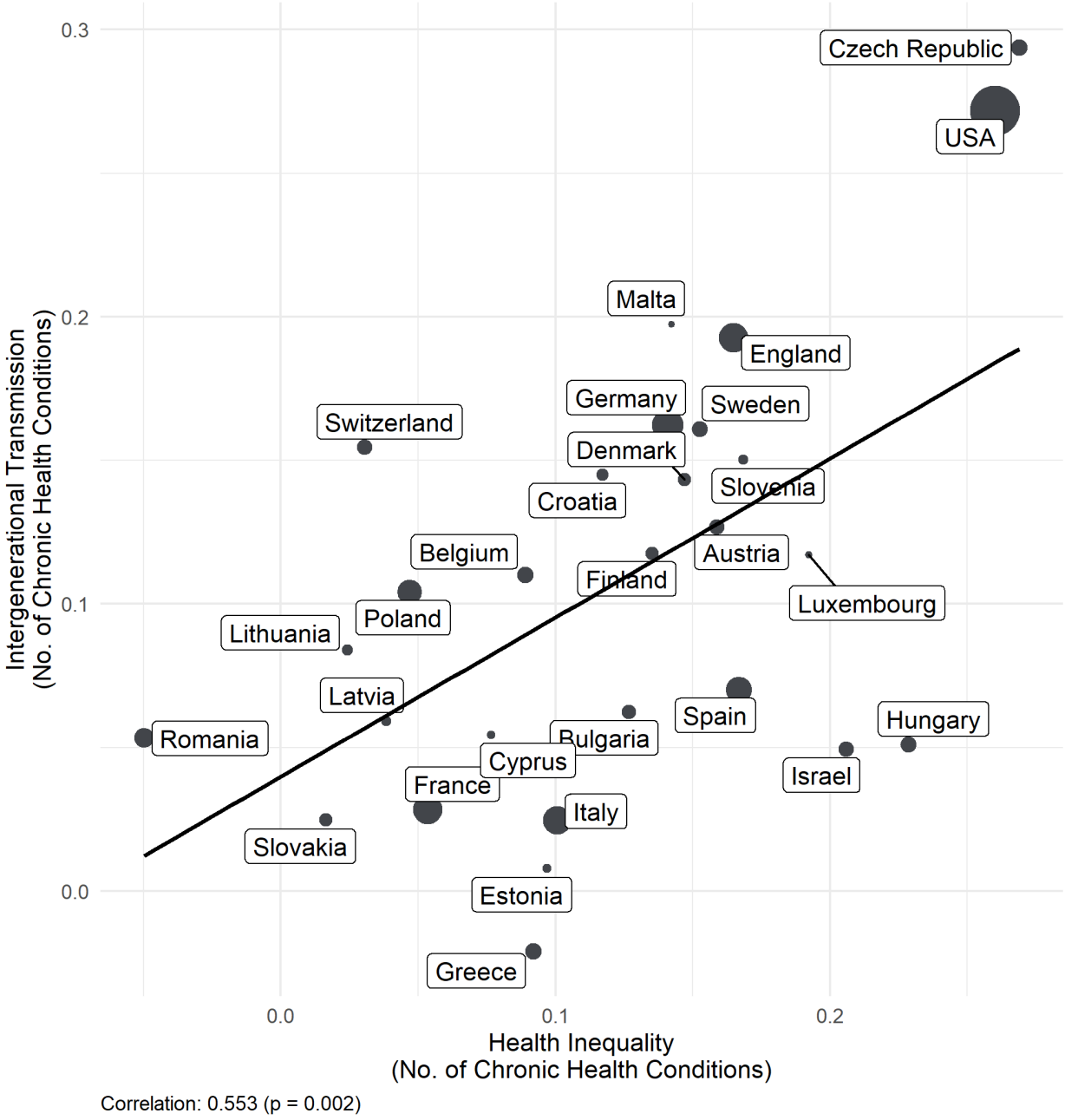

Fig. 2 Health inequality is the difference in number of chronic health conditions reported between individuals with tertiary vs. non-tertiary education. Intergenerational transmission of health is the difference in number of chronic health conditions reported between individuals who had at least one parent live past the age of 75 and those who did not. Both sets of estimates have been adjusted for the age of the respondent and weighted as per the recommendations from the data suppliers.

Figure 3: The relationship between health inequality/transmissions and GDP per capita

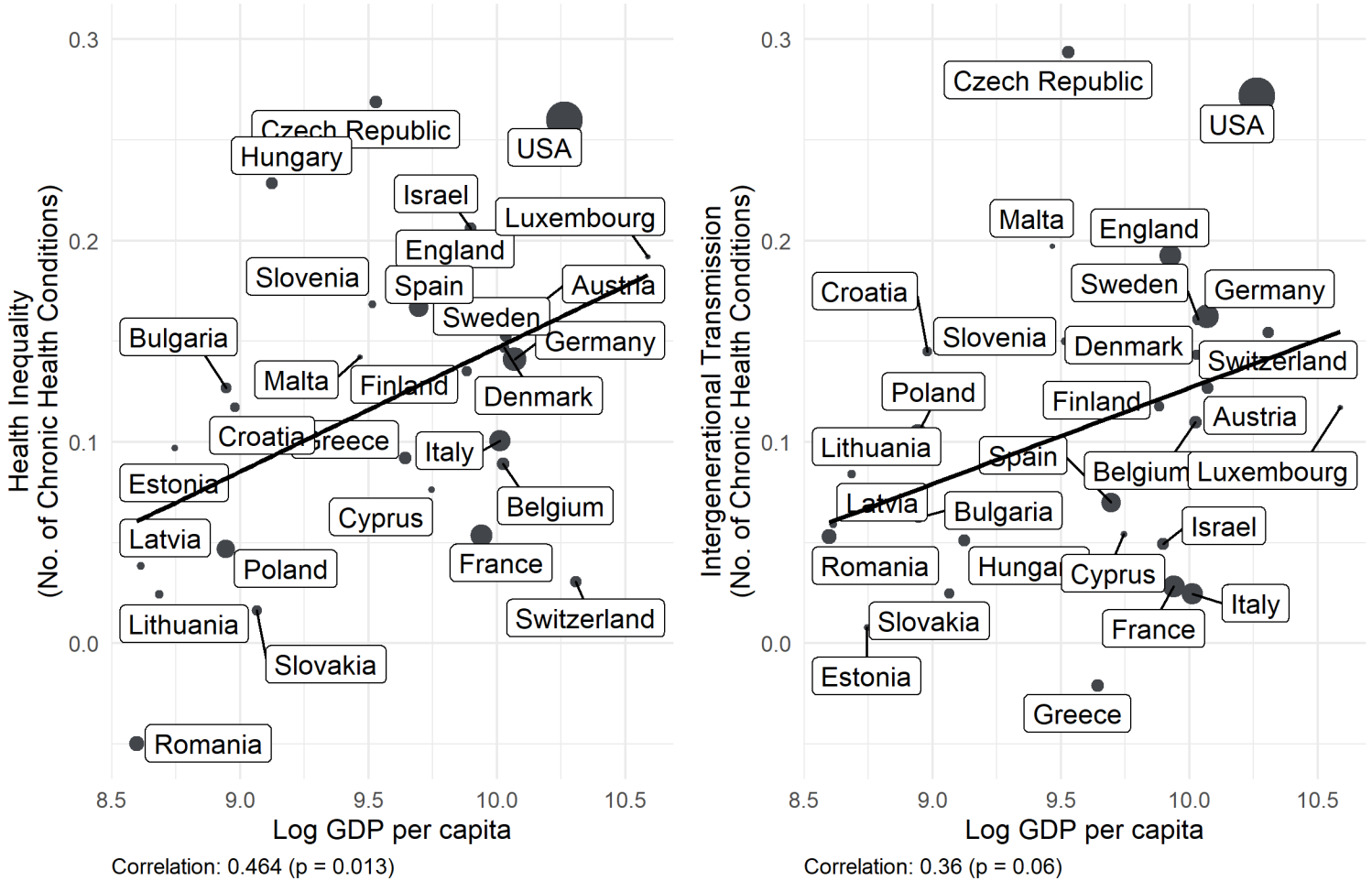

Fig. 3 Health inequality is the difference in number of chronic health conditions between individuals with tertiary vs. non-tertiary education. Intergenerational transmission of health is the difference in number of chronic health conditions between individuals who had at least one parent live past the age of 75 and those who did not. All estimates have been adjusted for the age of the respondent and weighted as per the recommendations from the data suppliers. Information on GDP per capita (PPP) was obtained from the World Bank (2019).

Figure 4: Correlations between inequality and transmissions when excluding single countries

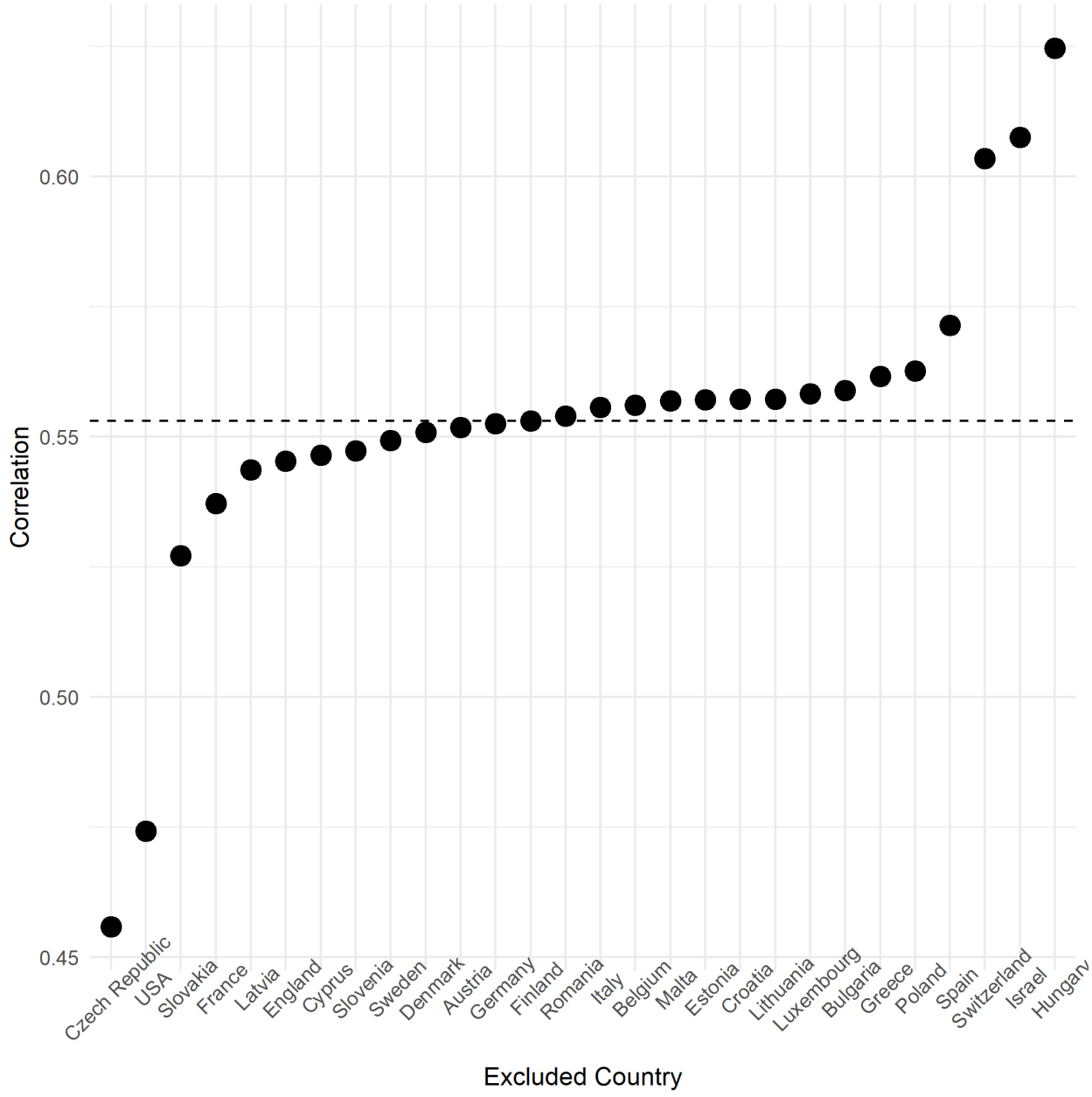

Fig. 4 Figures represent the correlation between health inequality and intergenerational transmission of health when excluding a given country. Health inequality is the difference in number of chronic health conditions reported between individuals with tertiary vs. non-tertiary education. Intergenerational transmission of health is the difference in number of chronic health conditions reported between individuals who had at least one parent live past the age of 75 and those who did not. All estimates have been adjusted for the age of the respondent and weighted as per the recommendations from the data suppliers. The dashed line marks the correlation coefficient when excluding no countries, 0.553.

Figure 5: Correlations between inequality and transmissions across definitions of parents' good health

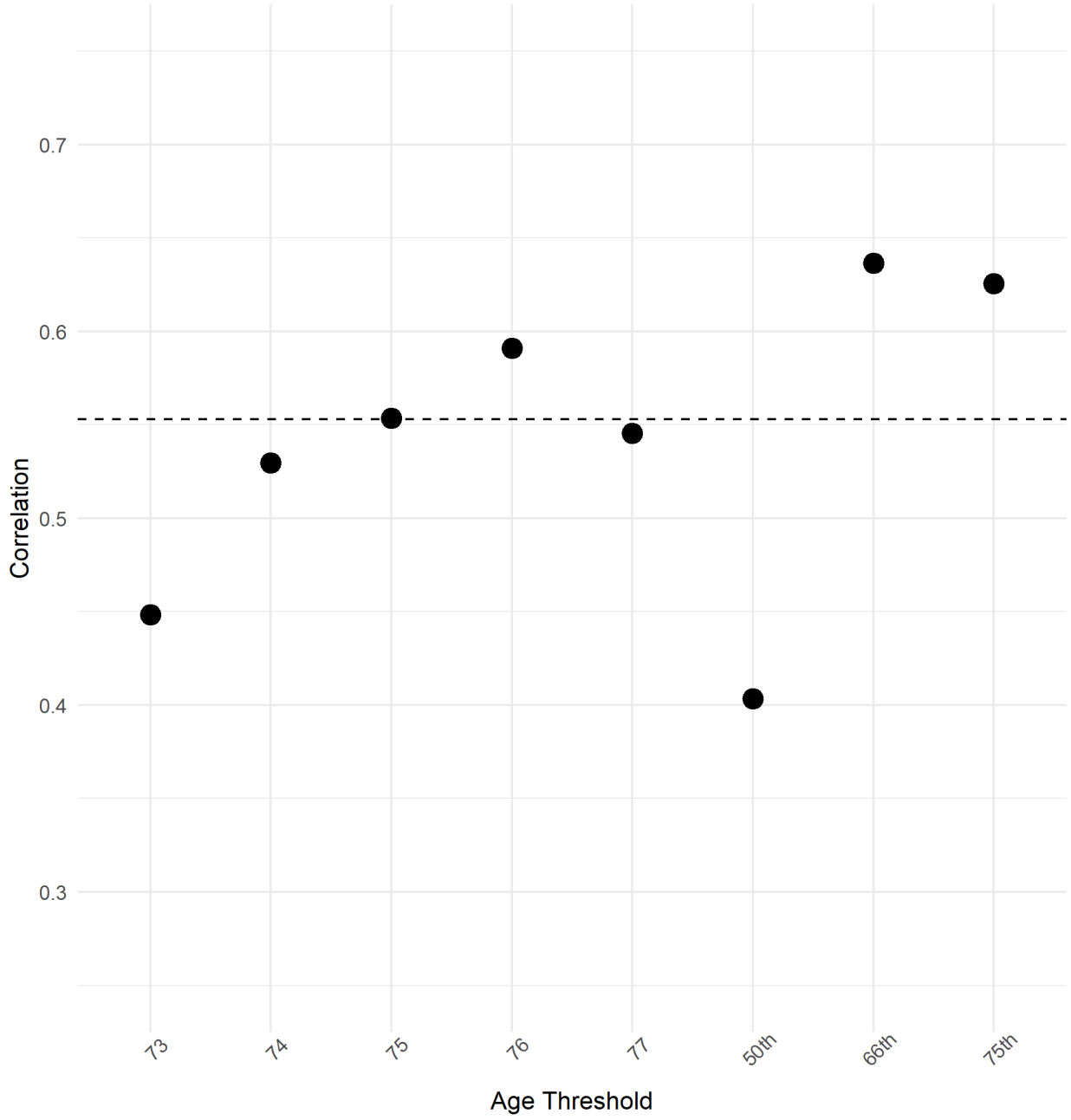

Fig. 5 The figures represent the correlation between health inequality and intergenerational transmission of health at various age thresholds that defines the health of parents. Health inequality is the difference in number of chronic health conditions reported between individuals with tertiary vs. non-tertiary education. Intergenerational transmission of health is the difference in number of chronic health conditions reported between individuals who had at least one parent live past the given age threshold and those who did not. All estimates have been adjusted for the age of the respondent and weighted as per the recommendations from the data suppliers. The percentile-based age thresholds (50^{th}, 66^{th}, and 75^{th}) are derived from data for each country. The dashed line marks the correlation coefficient when using our preferred age threshold of 75 years (0.553).

Figure 6: Health Inequality and the Share of High Educated Individuals

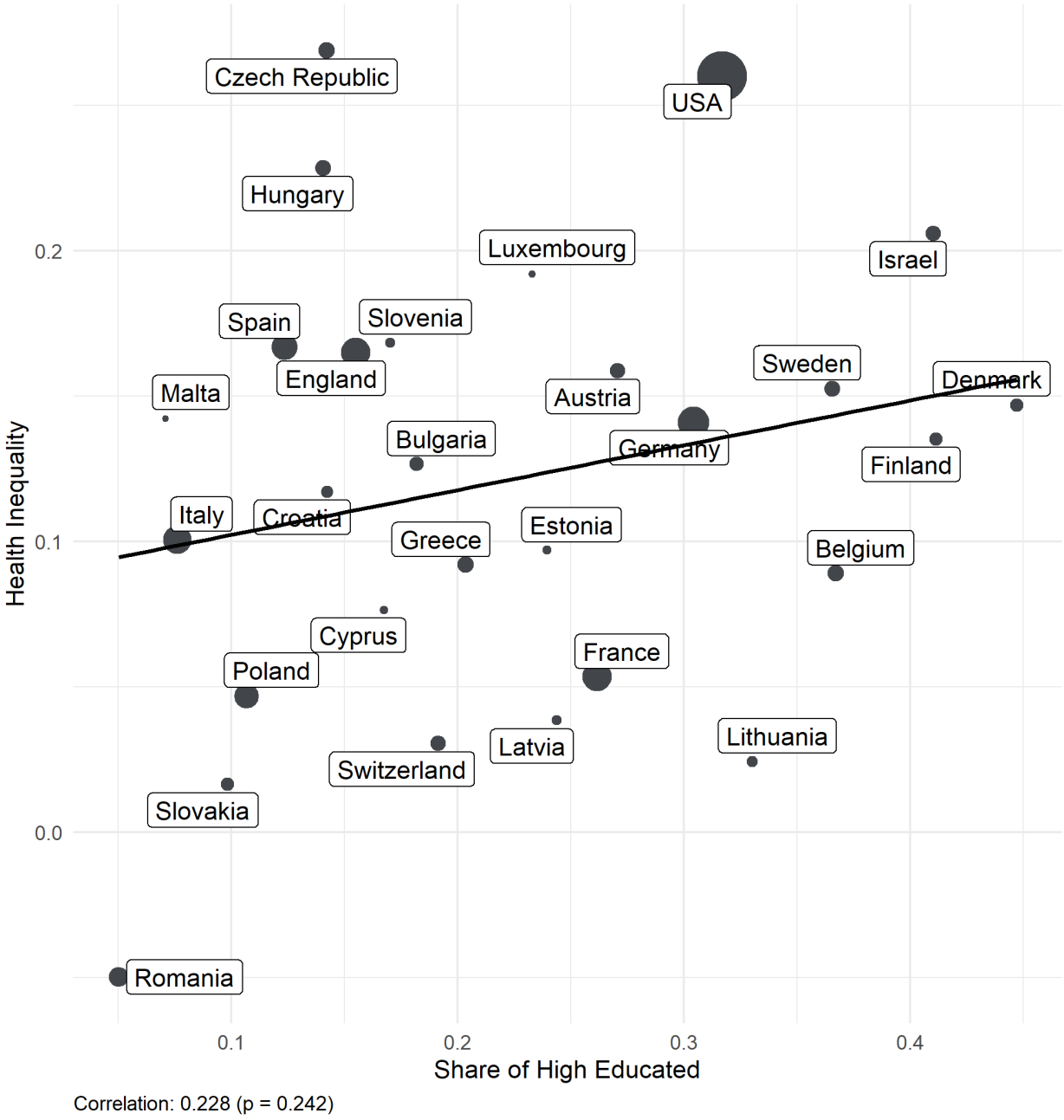

Fig. 6 Health inequality is the difference in the health measure between individuals with tertiary vs. non-tertiary education, adjusted for the age of the respondent. Share of high educated is the share of individuals in each country with a tertiary education. All estimates have been weighted as per the recommendations from the data suppliers.