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Life expectancy inequalities in Hungary over 25 years: The role of avoidable deaths

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Using mortality registers and administrative data on income and population, we develop new evidence on the magnitude of life expectancy inequality in Hungary and the scope for health policy in mitigating this. We document considerable inequalities in life expectancy at age 45 across settlement-level income groups, and show that these inequalities have increased between 1991–96 and 2011–16 for both men and women. We show that avoidable deaths play a large role in life expectancy inequality. Income-related inequalities in health behaviours, access to care, and healthcare use are all closely linked to the inequality in life expectancy.

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Keywords: life expectancy; income inequality; administrative data; avoidable death; health behaviours; healthcare access; healthcare use; Hungary

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Introduction

Lower-income individuals experience higher mortality and lower life expectancy, even in developed countries with universal or near-universal access to high-quality healthcare. Is there scope for health policy interventions to mitigate these inequalities? In this paper, we use detailed mortality register data, census data, and administrative data from Hungary to shed light on this question. We begin by constructing life expectancy measures at age 45 by sex and age for each settlement in Hungary using a national mortality register and population data spanning the period 1991–2016. By settlement we mean a village or town, or a district of the capital city. Using data on the causes of mortality, we are able to estimate life expectancy separately based on avoidable deaths and unavoidable deaths, as well as for all-cause mortality. To track changes in life expectancy and inequality, we estimate life expectancy measures for three different periods, 1991–96, 2001–06, and 2011–16. We provide evidence on inequalities in a rich set of health-related indicators linked to life expectancy, covering health behaviours, access to healthcare, and healthcare spending.

Our work contributes to the literature on inequalities in health and in life expectancy. The international literature has found that socio-economic status is positively correlated with health and life expectancy. This association is statistically strong and substantively large, and has been documented across a variety of developed countries and time periods. Among many others, see Chetty et al. (2016) for the United States (US), Case and Deaton (2020) also for the US but with a historical perspective, Currie et al. (2020) for France, Kinge et al. (2019) for Norway, Stanistreet et al. (1999) for the United Kingdom, Tarkiainen et al. (2013) for Finland, Marmot (2005) for a worldwide comparison, and Mackenbach et al. (2008, 2018, 2019) for European comparisons.

In this paper, we focus on Hungary: an interesting case because the country went through major economic and social changes during the last 30 years, but access to healthcare remained universal. The finding that despite major economic restructuring and changes in the ways the country's welfare state operates, inequalities in life expectancy have persisted and even widened is not an obvious one. It highlights that structural transformations that lead to overall improvements in average well-being may be accompanied by widening inequalities in important outcomes.

The related literature in Hungary has focused largely on educational level as a proxy for socio-economic status, mortality as a measure of health, and broader geographic regions, and has found similar patterns as seen in other developed countries (Klinger 2001, 2003; Kovács and Bálint 2014; Bálint and Németh 2018; Kovács and Bálint 2018). For a systematic review of the literature on the socio-economic determinants of mortality in Hungary, see Scheiring, Irdam, et al. (2018). Unemployment, regional labour market shocks, regional differences in privatization, and foreign investment have all been associated with mortality inequality (Juhász et al. 2010; Uzzoli 2011; Nagy et al. 2012, 2014; Azarova et al. 2017; Scheiring, Stefler, et al. 2018). It is also important to note that inequality in life expectancy by educational level in Hungary is among the highest in the European Union member states (Mackenbach et al. 2008, 2018). However, in the Central and Eastern European region, the inequality in mortality is not unique to Hungary. For a review of the Eastern European context, see Scheiring et al. (2019), who found based on a review of the literature that inequality and unemployment were among the leading factors contributing to the post-socialist mortality crisis. Case and Deaton (2020, p. 108) compared the 'long-standing misery' of the Eastern European countries with the deaths of despair due to suicide, alcohol, and drug abuse among less educated, white Americans.

Our contributions to the established literature are empirical. First, we document patterns over a 25-year period and show that while life expectancy at age 45 increased overall, socio-economic inequalities also increased (particularly among women), despite large shifts in Hungary's economy and society. Second, owing to our detailed data, we are able to estimate life expectancy at the settlement level and to group settlements according to average income. This is important because income is a good composite indicator of social differences; in addition, it is comparable across space and time. Third, using detailed mortality registers, we separately study the contributions of avoidable and non-avoidable deaths to inequality and show that at least half of the inequality is due to avoidable causes of death. Fourth, we study the relationships between inequality in life expectancy and 27 measures of health behaviours, access to healthcare, and healthcare use. These health-related indicators mediate the relationship between income and life expectancy. While it is not possible to identify the causal relationships between each of the 27 indicators and life expectancy, we show in a unified framework how much these wide-ranging health-related indicators vary with income. By doing so, we highlight the scope for health policy in reducing life expectancy inequality. Health policy could mitigate the inequalities in life expectancy by encouraging improvements in health behaviours (e.g. via education and information campaigns), ensuring better access to care (e.g. filling vacant general practitioner (GP) posts; providing better transport to healthcare units), and ensuring timely use of diagnostic and curative healthcare services among the poor.

An important and unresolved question in the literature is what can explain the persistent inequalities in health and life expectancy in countries with universal access to healthcare (Mackenbach et al. 2008; Bambra 2011). While health inequalities are generally high in Eastern Europe, there are also persistent and substantial inequalities in mortality in the Nordic countries and other European countries with advanced welfare states (Mackenbach 2017). Our empirical findings suggest that inequalities in health behaviours, access to care, and healthcare use all contribute to these puzzling patterns, which cannot be explained by a single underlying mechanism. Our results are in line with the predictions and findings of Phelan et al. (2004) that for more preventable causes of death, socio-economic status is more strongly associated with mortality than for less preventable ones. The increasing inequality in life expectancy suggests that poorer individuals lag further and further behind when both the economy and healthcare technology improve. According to Wise (2003), differential risk and access are the two central mechanisms of disparity creation; and when interventions are of high efficacy then differences in access dominate the differences in outcomes. Deaton (2002) argued that new techniques and knowledge can generate a gradient, even when none previously existed. He pointed out the possibility that widening gradients may be 'related to life-saving bursts of technical progress' (p. 18). Phelan and Link (2005) provided evidence that social disparities emerge when new health-enhancing information or technology is developed. They documented how social gradients have increased in those diseases that have become more preventable or treatable. Glied and Lleras-Muney (2008) demonstrated that improvements in health technologies tend to increase disparities in health across educational groups because education enhances the ability to exploit technological advances. Our empirical findings on disparities in healthcare access and use are in line with the observations of Deaton (2002), Wise (2003), Phelan and Link (2005), and Glied and Lleras-Muney (2008).

The remainder of this paper proceeds as follows. The 'Methods' section describes the data used in this study and summarizes our analysis. We then present our results, and finally, discuss our findings and limitations, before concluding the paper.

Methods

Data and sample

Mortality, income, and population data. We use unique mortality register data from the Hungarian Central Statistical Office (HCSO); these cover all deaths in Hungary between 1991 and 2016, providing information on the age, sex, and settlement of residence of the deceased, as well as cause of death. Based on the cause of death, we can separate non-avoidable and avoidable (preventable and amenable) mortality. A death can be considered as amenable if it could have been avoided through optimal quality healthcare. The concept of preventable deaths is broader and includes deaths that could have been avoided by public health interventions focusing on wider determinants of public health (European Statistical Office 2019).

Age- and sex-specific population data at the settlement level also come from the HCSO. We use these data to calculate life expectancy and settlement-level per capita income. We define income as the settlement-level average annual taxable domestic income per capita, and use this measure as a proxy for the household-level per capita income. To calculate the per capita measure, we divide the total settlement-level current annual taxable income (measured in the HCSO's 'T-STAR' municipal statistical system) by the settlement-level population. We measure all income in 2016 terms.

Health-related indicators. We use a rich set of additional health-related data to understand which indicators of health behaviours, healthcare access, and healthcare use are associated with life expectancy inequalities. Our focus on health-related indicators is motivated by the goal of understanding whether health and social policy interventions could mitigate income inequalities in life expectancy.

The list of general practices with and without vacant GP posts comes from the National Health Insurance Fund Administration (NHIFA) of Hungary. Using 2016 data, we calculate the share of general practices with vacant GP posts for each settlement.

We use measures of annual social security health spending on inpatient care, outpatient care, and prescription drugs, and a measure of out-of-pocket spending on prescription drugs, from an administrative data set that covers 2003–11 based on a 50 per cent random sample of the 2003 population of individuals aged 5–74. We use health spending measures for 2011, and restrict the sample to individuals aged 25 or older. For more details on the availability of healthcare spending information linked to administrative data, see Bíró and Prinz (2020).

To describe access to care, we use the HCSO's T-STAR municipal statistical system. For each settlement, we know if there was a pharmacy and an outpatient specialist care unit in 2014. Based on this information, and using the road distance measures included in the 'GEO' database of the Centre for Economic and Regional Studies, for each settlement we calculate the distance (in kilometres) to the nearest pharmacy and nearest outpatient specialist care unit. We set the distance to zero for settlements with a facility.

We measure ambulance response time in minutes, for all settlements in 2009, using the road distance measure from Kemkers et al. (2010).

The share of households using solid fuel for heating comes from the 2011 Census of Hungary. The census dwelling questionnaire asks respondents about the energy used for heating. In this analysis, solid fuel heating is defined as heating with wood or coal.

To understand health-related behaviours, we use measures of the average daily amount of time spent watching TV and participating in sports from the 2009–10 Hungarian Time Use Survey (HTUS) administered by the HCSO. The HTUS covers a one-year period and follows an open diary design. The sampling units are households, but only one person per household completes a diary for the previous day (starting at 4 a.m. and covering 24 hours) in the course of a face-to-face interview, providing detailed information on their time allocation. For these measures, we use data from individuals aged 25 or older.

We also obtain a rich set of health-related indicators from the Hungarian edition of the European Health Interview Survey (EHIS) for 2014. We use binary indicators of preventive care use during the previous year: specifically, indicators for whether an individual had a cholesterol test, a glucose test, and/or a mammography. We also use binary indicators of unmet need for drugs and medical care due to: (1) financial difficulties; (2) having to wait too long for treatment; and (3) distance to a treatment unit. Finally, we also use the following indicators of consumption of healthy and unhealthy goods: daily or almost daily consumption of fruit, vegetables, sugary drinks, pre-packed sweets, salty snacks, and wholemeal food at least weekly consumption of fish; daily smoking; and alcohol consumption categorized as high or medium risk. For these indicators, the sample is restricted to individuals aged 25 or older.

Table A1 in the supplementary material provides an overview of all variables used and their source; Table B2 provides descriptive statistics. Tables of all variables by settlement-level income groups are available at the authors' website (Bíró et al. 2020).

Analytic approach

For each time period (1991–96, 2001–06, and 2011–16), we group Hungarian settlements based on their per capita taxable income, dividing the income distribution of settlements into ventiles (20 equally sized bins). Each group represents approximately 5 per cent of the Hungarian population, that is, around 500 thousand individuals out of the total population of around 10 million. As the largest towns and the districts in the capital city each contain about 100–250 thousand inhabitants, using ventiles implies that a group is about two or three times the size of the population of a large town. We analyse six-year periods to reduce the noise in the data. The first period thus starts right after the end of communism in Hungary; the last period ends at the end of our observation period (2016 is the latest year for which income and mortality data were available).

Figure B1 in the supplementary material shows that although the top income ventiles are concentrated mainly in Budapest (the capital city) and north-west Hungary, there is spatial variation in settlement-level income in all regions of the country.

We calculate life expectancy at age 45. We choose age 45 because our focus is on the life expectancy of adults. Life expectancy at age 45 is also used as a key health indicator by the World Health Organization (2018). For each time period (1991–96, 2001–06, and 2011–16) and income group, we construct sex-age–specific mortality rates. Specifically, mortality rates are calculated as the number of deaths in a period-sex-age-income cell divided by the population count in that period-sex-age-income cell. For each period, we use the average yearly number of deaths and population size. We then follow a standard procedure to calculate sex-specific life expectancy for each income group (for more details, see Appendix A1).

To examine the role of avoidable deaths in life expectancy differences across income groups, we calculate an adjusted version of life expectancy. In this exercise, we assume that the avoidable mortality rate of each income ventile is equal to the avoidable mortality rate observed in the richest income ventile, whereas the non-avoidable mortality rate is unchanged (for more details, see Appendix A2). We also calculate life expectancy adjusted for preventable mortality and for amenable mortality in a similar way. As the definitions of avoidable, preventable, and amenable deaths change over time, adjusted life expectancy is only calculated for the period 2011–16. Our definitions of avoidable, preventable, and amenable mortality are based on the definition used by the Office for National Statistics (2011).

We group the health-related indicators listed earlier into three categories: health behaviours, access to care, and healthcare use. For each indicator within a category, we calculate the mean value for each income ventile. In the main text, we report a normalized measure for each indicator (the mean-standardized difference): the difference between the mean of the richest (top) and poorest (bottom) settlement ventiles, divided by the overall mean of the indicator. In addition, we calculate the correlation coefficient between income ventile and the ventile-specific mean of each health-related indicator. Thus, we obtain comparable inequality indicators for the 27 indicators we use in our analysis.

Results

Relationship between income and life expectancy

We start by focusing on our results for the overall relationship between income and life expectancy in the period 2011–16. Figure 1 suggests that there are large inequalities in life expectancy at age 45 across settlement-level income ventiles (i.e. approximately 5 per cent bins of the Hungarian population ordered by settlement-level income). These inequalities are larger among males than among females. Among females, the difference in life expectancy at age 45 between the top and bottom ventiles is 4.6 years (37.4 years vs 32.8 years). In relative terms,

Figure 1 Life expectancy at age 45 in Hungary by settlement income ventile for (a) females and (b) males, 1991–96, 2001–06, and 2011–16

Notes: For more details on how settlement income ventiles are defined and life expectancies are calculated, see the 'Analytic approach' subsection and the Appendix.

Source: Authors' calculations based on data from the Hungarian Central Statistical Office.

this is a 14 per cent difference. Among males, this difference is even larger, both in absolute terms (6.9 years; 32.7 years vs 25.8 years) and relative terms (27 per cent). Interestingly, whereas there are large differences between the top three ventiles and the bottom three ventiles, life expectancy averages do not differ too much in the middle part of the income distribution. For example, the difference between the 5th and 15th ventiles is only 0.8 years (2 per cent) among females and 1.8 years (7 per cent) among males.

Evolution of inequality over time

Figure 1 also presents life expectancy at age 45 for the periods 1991–96 and 2001–06. While average life expectancy at age 45 increased by around 3–4.5 years between 1991–96 and 2011–16, life expectancy also increased in all settlement-level income ventiles. Among females, the difference in life expectancy at age 45 between the top and bottom ventiles increased substantially: it was 2.4 years (8 per cent) in 1991–96 and 4.6 years (14 per cent) in 2011–16, an approximate doubling in both absolute and relative terms. Among males, the difference was 5.8 years (26 per cent) in 1991–96 and 6.9 (27 per cent) in 2011–16. Importantly, among both females and males, the life expectancy of the bottom ventile in 2011–16 was lower than the life expectancy of the top ventile 20 years earlier. Figure 1 also shows that both the level of life expectancy and the magnitude of income inequalities in life expectancy in 2001–06 were between the levels and inequalities seen in 1991–96 and 2011–16. Thus, the increase in inequalities happened gradually over the observed 25 years.

Role of avoidable vs unavoidable deaths

What fraction of the observed inequality in mortality is due to avoidable causes of death? Figure 2 shows estimates of adjusted life expectancies at age 45, which are calculated based on the assumption that mortality due to avoidable causes of death (and, separately, preventable or amenable causes of death) is the same in each settlement-level income ventile as in the richest ventile. Thus, the remaining inequalities will show mortality inequalities due to unavoidable causes of death.

Among females, the baseline (unadjusted) difference in life expectancy between the top and bottom ventiles in 2011–16 is 4.6 years (14 per cent). This difference reduces to 2.4 years (7 per cent) if income inequalities in avoidable causes of death are eliminated. The roles of preventable and amenable causes of death in mortality inequalities are similar to each other.

Among males, avoidable causes of death contribute even more to the income inequalities in mortality. The baseline (unadjusted) difference in life

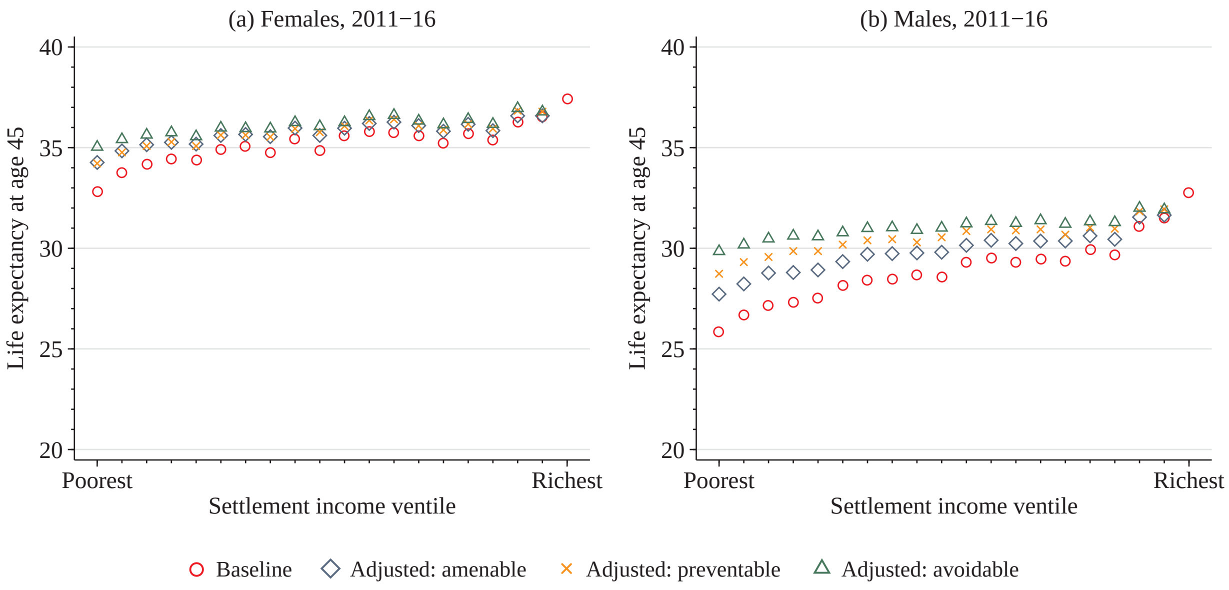

Figure 2 Adjusted life expectancy at age 45 in Hungary by settlement income ventile for (a) females and (b) males, 2011–16

Notes: Figures show life expectancy at age 45 based on overall mortality (shown by circles; same as in Figure 1) and counterfactual (adjusted) life expectancy estimates if preventable, amenable, or avoidable mortality were eliminated. In each panel, diamonds show counterfactual life expectancy at age 45 if income inequality in amenable mortality were eliminated, squares show counterfactual life expectancy at age 45 if income inequality in preventable mortality were eliminated, and triangles show counterfactual life expectancy at age 45 if income inequality in avoidable mortality were eliminated. For more details on how settlement income ventiles are defined and life expectancies are calculated and adjusted by type of mortality, see the 'Analytic approach' subsection and the Appendix.

Source: As for Figure 1.

expectancy between the top and bottom ventiles is 6.9 years (27 per cent). This reduces to 2.9 years (10 per cent) if income inequalities in avoidable causes of death are eliminated. Thus, among males, more than half of the income inequality in mortality can be attributed to avoidable causes of death. As Figure 2 shows, the role of preventable causes of death is somewhat larger among males than the role of amenable causes. This may be due mainly to deaths related to excess consumption of alcohol and to smoking, but note that accidents and suicide are also considered to be preventable rather than amenable causes of death.

Health-related indicators

To analyse which factors might contribute to income inequalities in life expectancy, we look at income inequalities in health-related indicators. We select indicators of health behaviours, access to care, and healthcare use known to be linked to life expectancy. For example, Prentice and Pizer (2007) have shown the impact of timely access to healthcare on mortality, and Aakvik and Holmås (2006) investigated the link between primary care access and mortality. There is also evidence on the impact of preventative healthcare use on mortality (see e.g. Moss et al. (2006) for the effect of mammography), and some evidence for the causal effects of health behaviours on mortality (see e.g. Cesur et al. (2017) for the effect of air pollution due to heating and Stallings-Smith et al. (2013) for the effect of smoking).

The following analysis uncovers associations rather than causal relationships. Our aim is not to establish a causal relationship between a selected health-related indicator and life expectancy, but to show in a unified framework how much wide-ranging health-related indicators can vary with income. As Figure B2 in the supplementary material illustrates, many of the health-related indicators we analyse are strongly correlated, making it difficult to separate the causal impact of each indicator on life expectancy.

Our results provide evidence suggesting that certain economic, social, and health policies may reduce inequalities in life expectancy by decreasing inequalities in the health-related indicators that are strongly associated with life expectancy.

These health-related indicators act as mediating variables in the linkage between income and life expectancy.

Health behaviours. Figure 3 shows, for various indicators of health behaviours, the difference between the top and bottom income ventiles, standardized by the overall mean, in addition to their correlation coefficient with income ventile. (Figure B3 in the supplementary material shows the distribution of each of the indicators across all income ventiles.) The two health behaviours showing the most difference between the top and bottom ventiles are heating with solid fuel only (where the difference between the top and bottom ventiles is 2.5 times the overall mean) and time spent participating in sport (where the difference between the top and bottom ventiles is 1.8 times the overall mean). All other health behaviours show the expected signs: health behaviours that are known to be harmful for health are more prevalent among people living in poorer settlements. Specifically, the mean-standardized difference between the poorest and richest settlements in the consumption of sweets and sugary drinks, salty snacks, and daily smoking is around 0.5–1.5. We see moderate income differences in time spent watching TV and the consumption of alcohol, vegetables, and fruit, partly due to the high overall means (for consumption of vegetables, fruit, and time spent watching TV), and partly due to a weaker relationship with income (for consumption of alcohol). Indeed, the consumption of vegetables and fruit both show strong positive correlations with income ventile (correlation coefficients of +0.67 and +0.73), whereas the correlation between the alcohol consumption indicator and income ventile is a moderate −0.27. The mean-standardized differences in the consumption of food generally considered healthy (wholemeal food and fish) and time spent participating in sports activities are between 0.5 and 1.8, with higher prevalence in the richer settlements.

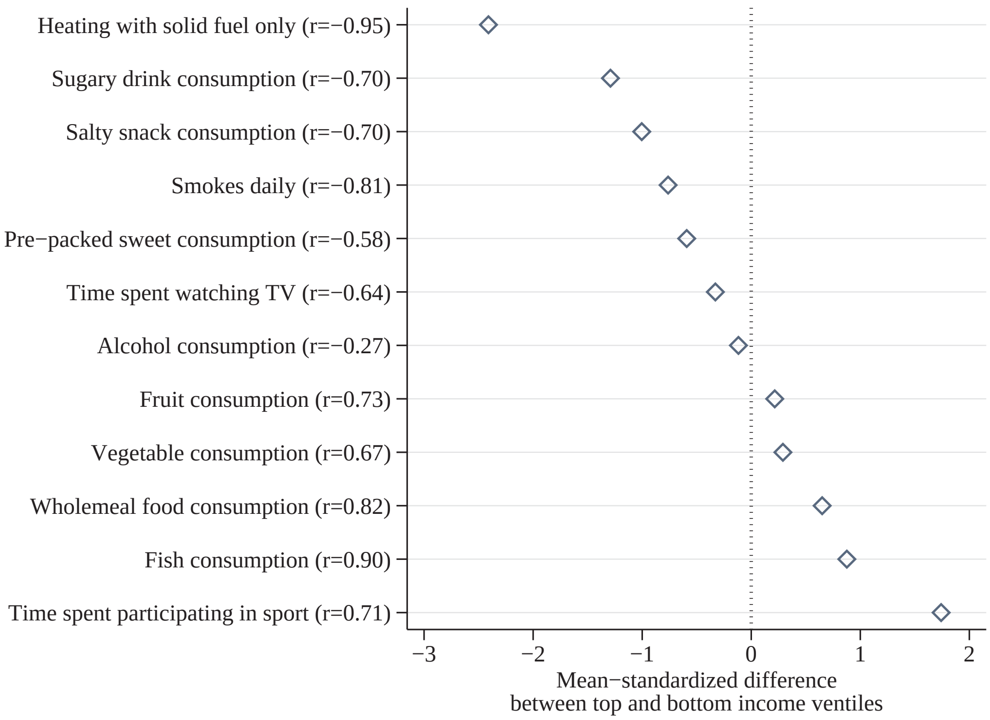

Figure 3 Income inequalities in health behaviours in Hungary
Notes: Standardized measures of income inequality for measures of health behaviour are calculated by taking the difference between the top and bottom income ventiles and dividing by the mean. The correlation coefficient between income ventile and the ventile-specific mean of each indicator is shown in parentheses. For the full distribution of each of the indicators, see Figure B2 in the supplementary material. For more details on how these standardized measures are defined, see the 'Analytic approach' subsection.
Source: Hungarian Time Use Survey 2009; European Health Interview Survey 2014; Census of Hungary 2011. For more details on the definition and sources of the indicators, see the 'Health-related indicators' subsection and Table A1 in the supplementary material.

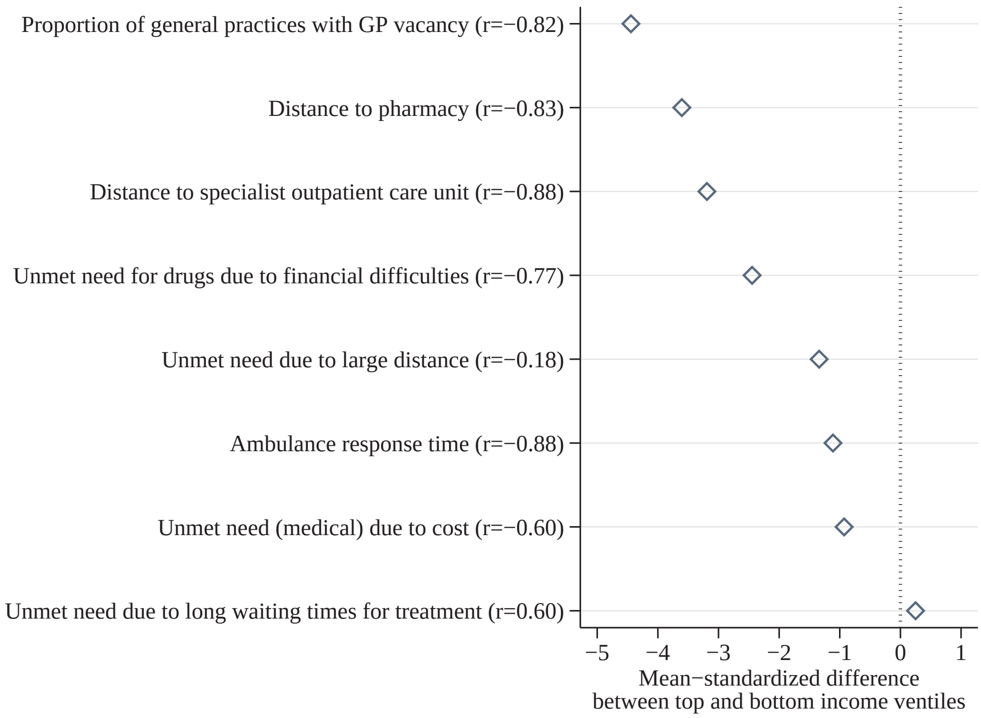

Figure 4 Income inequalities in access to care in Hungary
Notes: Standardized measures of income inequality for measures of access to care are calculated by taking the difference between the top and bottom income ventiles and dividing by the mean. The correlation coefficient between income ventile and the ventile-specific mean of each indicator is shown in parentheses. For the full distribution of each of the indicators, see Figure B3 in the supplementary material. For more details on how these standardized measures are defined, see the 'Analytic approach' subsection.
Source: National Health Insurance Fund Administration of Hungary 2016; Kemkers et al. (2010); Hungarian Central Statistical Office T-STAR Municipal Statistical System 2014, European Health Interview Survey 2014. For more details on the definition and sources of the indicators, see the 'Health-related indicators' subsection and Table A1 in the supplementary material.

Access to care. Figure 4 shows, for various indicators of healthcare access, the mean-standardized difference between the top and bottom income ventiles, and their correlation coefficient with income ventile. (Figure B4 in the supplementary material shows the distribution of each of the indicators across all income ventiles.) There are large inequalities in access to care across income groups. In poorer settlements, general practices with vacant GP posts are more widespread (mean-standardized difference −4.4), distances to pharmacies and specialist outpatient care units are larger (mean-standardized differences −3.6 and −3.2), and waiting times for ambulances are longer (mean-standardized difference −1.1). Among the four indicators of unmet need, the income gradient is the strongest for unmet need for drugs due to financial difficulties: the mean-standardized difference in the prevalence of unmet need between the poorest and richest settlements is around 2.5. Unmet need due to distance to treatment facilities and unmet need due to cost of medical care are also more widespread in poorer areas, although the correlation coefficient of −0.18 indicates a weak relationship between income ventile and unmet need due to distance. We do not see clear evidence of an income gradient in unmet need due to long waiting times for treatment—while the correlation coefficient with income ventile is 0.60, the mean-standardized difference between the poorest and richest settlements is close to zero. Overall, these results reveal that in remote settlements, limited access to medical care (such as greater distance to a pharmacy and to specialist outpatient care) is coupled with low average incomes.

Healthcare use. Figure 5 shows the same two measures for various indicators of healthcare use. (Figure B5 in the supplementary material shows the distribution of each of the indicators across all income ventiles.) The use of preventive care is

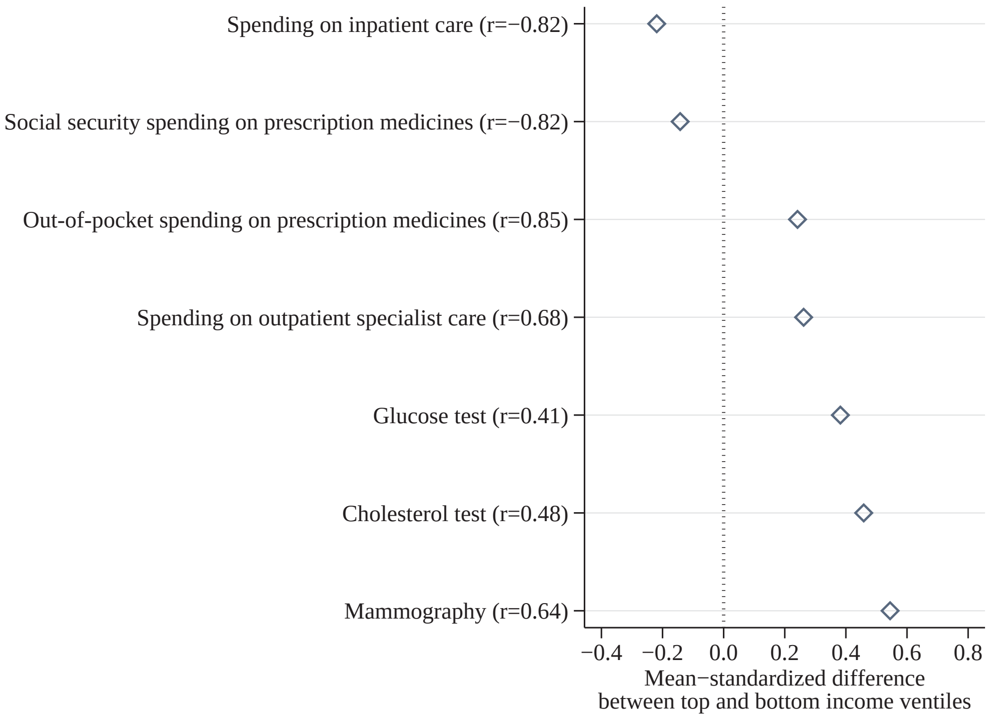

Figure 5 Income inequalities in healthcare use in Hungary
Notes: Standardized measures of income inequality for measures of healthcare use are calculated by taking the difference between the top and bottom income ventiles and dividing by the mean. The correlation coefficient between income ventile and the ventile-specific mean of each indicator is shown in parentheses. For the full distribution of each of the indicators, see Figure B4 in the supplementary material. For more details on how these standardized measures are defined, see the 'Analytic approach' subsection.
Source: Centre for Economic and Regional Studies administrative data set 2011; European Health Interview Survey 2014. For more details on the definition and sources of the indicators, see the 'Health-related indicators' subsection and Table A1 in the supplementary material.

more widespread in richer settlements: the mean-standardized difference between the top and bottom income ventile is around 0.4–0.6 for the three indicators of screening. We also see that out-of-pocket spending on prescription medicines and on outpatient specialist care is higher in the richer settlements, probably due to income effects and better access to care. However, social security spending on prescription medicines and on inpatient care is slightly higher in the poorest settlements than in the richest, seen in their strong negative correlation coefficients with income ventile. This is likely to be because inpatient care use and social security spending on drugs reflect the worse health status of individuals living in poorer areas.

Conclusion

We have presented evidence on life expectancy inequality in Hungary. To our knowledge, this is the first paper documenting life expectancy inequalities by income and type of death over a long time period in Hungary. We also contribute to an established international literature by examining the experience of a country that has gone through tectonic shifts in its economy and society. During the 25-year period between 1991 and 2016 that we examined, Hungary made the transition from planned socialist economy to market economy. The country experienced a 19 per cent increase in its Human Development Index, including a seven-year increase in life expectancy at birth, a four-year increase in expected years of schooling, and a $9,000 (55 per cent) increase in its per capita Gross National Income (United Nations Development Programme 2019). It is striking that despite this significant progress, inequality in life expectancy also increased. Our result that life expectancy inequalities increased more among females than males is in line with other findings in the literature (Fodor and Horn 2015; Scheiring, Stefler et al. 2018).

Despite methodological differences, we can compare our results on life expectancy inequality with related results from other countries. We estimated that the gap in life expectancy at age 45 between the top and bottom settlement-level income ventiles was 4.6 years for females and 6.9 years for males (in 2011–16). Using household-level income data from the US, Chetty et al. (2016) estimated that the gap in life expectancy at age 40 between the richest 1 per cent and poorest 1 per cent of individuals was 10.1 years for females and 14.6 years for males. According to estimates by Kinge et al. (2019), inequalities in life expectancy in Norway are very similar to those in the US. Since our results are based on settlement-level income and we used ventiles instead of percentiles, our estimated gaps being about half the size of the estimates from the US and Norway suggests that individual-level inequalities are likely to be of similar magnitudes.

Our paper is subject to some limitations. We studied inequalities in life expectancy by income at the settlement level and not at the individual (or household) level. Thus, our estimated inequalities underestimate individual-level (or household-level) inequalities. Second, when looking at the health-related indicators, we documented associations with income and thus with life expectancy, not causal effects. Finally, while Hungary's economy and its healthcare system are similar to those of other countries in the region, we could not compare our findings with those from other Central and Eastern European countries due to the lack of comparable data.

The most important result of this paper is the major role of avoidable causes of death (both preventable and amenable) in overall inequality in life expectancy. Life expectancy inequality between the top and bottom income groups could be cut in half by reducing avoidable mortality to the level seen in the richest settlements. The evidence on the role of avoidable deaths and the association of mortality inequality with health behaviours, access to care, and healthcare use suggests that there remains substantial scope for policymakers to increase the life expectancy of individuals in poorer areas and to decrease existing inequalities. Specifically, incentivizing dietary improvements and cuts in smoking; reducing solid fuel heating to improve air quality; ensuring better access to healthcare; and helping poorer individuals attend standard healthcare screening could all result in reduced life expectancy inequalities.

Notes and acknowledgements

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Appendix: Life expectancy calculation

A1 Baseline

The calculation of baseline life expectancy is based on Arias et al. (2019).

(1) Mortality rate (m):

$$m_{sia} = \frac{D_{sia}}{P_{sia}} \quad (1)$$

where s denotes sex, a denotes age (45,46 … 90), i denotes the income ventiles, D is the number of deaths, and P is the population. We note that deaths and population at ages over 90 are included in the age 90 category.

(2) Age-specific probability of death (q):

$$q_{sia} = \begin{cases} \dfrac{m_{sia}}{1 + 0.5\, m_{sia}} & \text{if } a = 45, 46 \ldots 89 \\ 1 & \text{if } a = 90 \end{cases} \quad (2)$$

(3) The (hypothetical) number of people alive at start of interval (l):

$$l_{sia} = \begin{cases} 1,000 & \text{if } a = 45 \\ l_{si(a-1)} \times (1 - q_{si(a-1)}) & \text{if } a = 46, 47 \ldots 90 \end{cases} \quad (3)$$

(4) The number of deaths (d) occurring between ages a and $a + 1$:

$$d_{sia} = l_{sia} \times q_{sia} \quad (4)$$

(5) Person-years lived between ages a and $a + 1$ (L):

$$L_{sia} = \begin{cases} l_{sia} - 0.5 d_{sia} & \text{if } a = 45, 46 \ldots 89 \\ \dfrac{l_{sia}}{m_{sia}} & \text{if } a = 90 \end{cases} \quad (5)$$

(6) Person-years lived beyond age a (T):

$$T_{sia} = \sum_{a}^{90} L_{sia} \quad (6)$$

(7) Life expectancy (e):

$$e_{sia} = \frac{T_{sia}}{l_{sia}} \quad (7)$$

A2 Adjusted

In calculating adjusted life expectancy, we assume that the avoidable mortality rate in each income ventile is equal to the avoidable mortality rate observed in the richest income ventile. At the same time, all non-avoidable mortality rates remain unchanged.

The overall mortality rate can be defined as the sum of the number of avoidable and non-avoidable deaths divided by the total population:

$$m_{sia} = \frac{D_{sia}}{P_{sia}} = \frac{D^{A}_{sia} + D^{N}_{sia}}{P_{sia}} = m^{A}_{sia} + m^{N}_{sia} \quad (8)$$

where s denotes sex, a denotes age, i denotes the income ventiles, D is the number of deaths, P is the population, and m is the mortality rate. A and N, respectively, denote avoidable and non-avoidable deaths and mortality rates.

The adjusted mortality rate (m*) is calculated as follows:

$$m^{*}_{sia} = m^{A}_{s(i=20)a} + m^{N}_{sia} \quad (9)$$

that is, the avoidable mortality rate of all income groups set to be equal to the avoidable mortality rate of the richest group ($i = 20$). We note that due to this definition, the adjusted and non-adjusted mortality rates of the richest group are identical.

Next, the calculation of adjusted life expectancy follows steps 2 to 7 of the baseline procedure (section A1) using m* instead of m.

Adjusted life expectancy is also calculated for preventable and amenable mortality in a similar way by applying the adjustment for differences in preventable and amenable mortality rates.