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EDUCATION AND INCOME GRADIENTS IN LONGEVITY: THE ROLE OF POLICY

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ABSTRACT

Education and income are strong predictors of health and longevity. In the last 20 years many efforts have been made to understand if these relationships are causal and what the possible role of policy should be as a result. The evidence from various studies is ambiguous: the effects of education and income policies on health are heterogeneous and vary over time, and across places and populations. I discuss explanations for these disparate results and suggest directions for future research.

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I - introduction

Health is a major component of well-being. This has been demonstrated empirically. Estimates show that society is extremely willing to pay to extend life, as recently demonstrated by the large expenditures the US and other countries made in order to fight the COVID pandemic. Estimates also show that changes in life expectancy account for a substantial fraction of the improvements in welfare observed over the last century, comparable to the increases in welfare from GDP (Becker, Philipson, and Soares 2005; Jones and Klenow 2016).

Education and income are some of the best predictors of life expectancy today. Moreover, differences in life expectancy by education and income are large—in the US, they are larger than differences by race and gender. To many observers this suggests that government policies should be implemented with the explicit aim of decreasing these gaps by attempting to either increase education or income.

In this paper I review what we know about the effects of education and income-transfer policies on longevity (and on health). Surprisingly the evidence does not consistently show that these (education or income) policies are uniformly successful at improving health. I discuss possible reasons for the discrepancies in findings across studies and suggest directions for future research.

II-Education policy and health

In the US, there are large and growing differences in life expectancy by education level. Meara et al. (2008) show that in the 1980s individuals with at least some college lived about 2.8 years longer than individuals with a high school degree or less. By the year 2000 the gap between the two groups had grown to almost 7 years. By 2008, Olshansky et al. (2012) estimated the gap in life expectancy between high school dropouts and those with at least a college degree to be 14.2 years for males and 10 years for females. A ten-year gap is equivalent to a third of a century of progress

in life expectancy (or more). [1] These gaps continued to increase in the 2010s.[2] Today these gaps are larger than gaps by race or gender.

There are many possible direct and indirect ways in which education can improve health and ultimately increase longevity, which I briefly summarize here.[3] Education changes information, beliefs, and attitudes towards science, and in general, affects cognition. Thus, educated individuals are not only better informed about how to improve their health, they also have better general decision making abilities (Cutler and Lleras-Muney 2010). Attending school can also affect individuals' personalities or traits, such as risk aversion, conscientiousness and patience, that have been shown to be health improving (Hill et al. 2011, Savelyev 2020). Most importantly attending school likely affects social skills and social networks: a large literature finds for example that college-educated individuals are more likely to marry other college graduates (Eika et al. 2019), and marriage in turn has been shown to be protective of health, at least for men (Hu and Goldman 1990). Social connectedness more generally predicts longevity (Holt-Lunstad et al. 2010, Xue et al. 2020). Education also changes outcomes in the labor market and therefore levels of income, health insurance and the type of occupation individuals have. Income and health insurance increase access to food, shelter and health care. Different occupations expose individuals to different health risks – many occupations are well known to be hazardous to health, and in general blue-collar occupations (which require lower levels of schooling) are associated with worse health (Case and Deaton 2007, Fletcher et al. 2011, Kelly et al. 2014). Finally, education changes the individual's environment: more educated individuals live and work in different locations. Therefore, they are also potentially exposed to different levels of pollution and to different levels of crime or segregation-related stress.

A different possibility is that what matters for health is relative rank. Link and Phelan (1995) hypothesized that higher ranked individuals will always take advantage of whatever they can to

[1] Life expectancy in the US grew from 45 to 75 years in the 20th century. It grew much less in the previous centuries.
[2] Case and Deaton (2021) document that these education gaps have further increased since 2010. Case and Deaton use different education groupings than earlier authors. They estimate that the gap in life expectancy at age 25 between those with college and those with less than college rose from 2.6 years in 1992 to 6.3 years in 2018.
[3] For a more detailed discussion of potential mechanisms see Cutler and Lleras-Muney (2006 and 2010).

improve their health. Evidence from animal studies further shows that social rank is itself a predictor of health, because it affects stress levels, which in turn affect health (Sapolsky 2005).[4]

These observations suggests that there are many possible mechanisms by which education might improve health. Of course, it is possible that education does not improve health but that the cross-sectional associations are driven by third factors. Family background is likely important: well-off families likely invest in their children's education and in their health. Similarly individual traits like patience or intelligence are likely to predict both educational attainment and lifetime health. Lastly it is also possible that individuals who have poor health in childhood obtain less education and turn into unhealthy adults. For this reason, many studies in the last 20 years in economics have focused on estimating causal impacts of education.

The relevant question however is not whether education increases health, but whether policy-induced changes in education can increase health and longevity in a population. We now have evidence from a significant number of studies that have looked directly at various education policies, and their effects on health and longevity. Here I concentrate on early education programs and compulsory schooling and review what we have learned.

a. Early education programs.

Evidence on the effects of early education on health comes from two influential randomized control trials (RCTs): the Abecederian Program and the Perry School program. These programs provided intensive intervention to disadvantaged children in the early 60s and 70s. Studies show that in addition to changing educational outcomes and labor market outcomes, these programs improved health behaviors and health measures in adulthood among the male recipients (Heckman et al. 2013, Campbell et al. 2014.). It is not clear why women's health did not improve.[5]

[4] Note that if rank is the main mechanism at play then education policies may just redistribute health, by changing who attends school, or not affect health at all, if they do not affect rank, whereas many of the mechanisms above would imply increases in population health associated with increases in education. I return to this issue below.

[5] While promising, this evidence it has some limitations: the trials only had about 100 participants, participants were very disadvantaged (they were chosen to be quite poor, and to have very low IQ at baseline) and were limited to black children.

Evidence is also available on the effects of Headstart, a large federal public preschool program created in the 1960s as part of the War on Poverty, which serves children aged 3-5 from poor families. Reduced-form evaluations of Head Start show long-term improvements in several measures of health (including mental health) and rates of smoking and obesity. (For a detailed review see Cascio 2021.) Although these early childhood programs are not pure education programs (participants in Head Start and Abecederian also receive food and other health-improving inputs), studies suggest that very early interventions with children improve health in adulthood.[6]

b. Compulsory education studies

By far the most studied education policy is compulsory schooling legislation. This is an interesting policy to study because almost every country in the world has compulsory schooling laws (CSL) on the books, and has changed them over time. These laws apply to the entire population of a country and are thus highly relevant. Because they vary over time, we can learn about their effects using reduced-form approaches. Moreover these laws remain popular and politically feasible: for example recently the Obama administration considered whether to make college compulsory, so it's still a relevant policy instrument that could be leveraged today. However, the evidence on what these laws do is ambiguous. Many studies have investigated the effects of these policies on educational attainment, labor market outcomes and health. Some studies find large effects and others find precisely estimated zeroes.

I illustrate this variation first by comparing effects CSL-driven education on mortality. Lleras-Muney (2005) was the first study to look at the effects of compulsory schooling in the US. Focusing on cohorts born between 1900 and 1925, the study found that cohorts that were forced to go to school longer had lower mortality rates in adulthood. A more recent study by Davis et al. (2018) shows that compulsory schooling reforms in the UK in 1972 also had positive effects on health and longevity. However, there are other studies that find precisely estimated zero effects. Clark and Royer (2013) looked at UK reforms in 1947 and 1972, and found no effects of either reform on mortality. Meghir et al. (2018) look at reforms in Sweden and also find no effects on

[6] It is too early to know about longevity because the programs are too recent and participants are still young.

mortality. There are many other studies that find effects of compulsory education on mortality of varying sizes. Investigations of the effect of causal education on other outcomes (such as smoking obesity or mental health) also vary substantially in their conclusions.[7]

Galama et al. (2018) review these findings and come to some general conclusions. In general, the estimates are either zero or show declines in mortality, but some estimates show that education induced by compulsory schooling actually *increased* mortality. Typically studies find larger effects for men than for women or find no effects (or "wrong signed" effects) for women. Larger effects are more likely to be observed for older cohorts, and for poorer countries, but not necessarily in places with lower schooling.

Other reviews (Baker et al. 2011, Byhoff et al. 2017, Hamad et al. 2018, Xue et al. 2021) similarly conclude that there is a lot of unexplained heterogeneity. Using a meta-analysis that collects estimates from many studies, Xue et al (2021) conclude that methodological differences account for all the variation across studies and that education does not have a causal effect on mortality. But other studies (Gathmann, Jürges, and Reinhold 2015, Kamhofer et al. 2019, Barcellos et al. forthcoming, Lleras-Muney et al. 2020) that estimate the causal effects of education, explicitly allowing for heterogeneity within the same study, find evidence that returns are indeed heterogeneous.

Assuming that the differences across studies are not all methodological, why would the results differ across settings? Why would education, or compulsory-schooling-driven education have different effects in different contexts? In what follows I ignore methodological differences across studies and I consider possible ways to reconcile the results by exploring how the health returns to school depend on various factors such as the quality of school, the outside options, the nature of labor market opportunities related to education, etc.

c. Understanding heterogeneity

[7] For example, a few recent studies investigate the causal effects of schooling on mental health. (Wang, 2021) and (Crespo et al 2014) conclude education improves mental health, but Kamhöfer et al. (2019), Avendano et al. (2020) find no mental health benefits of education. Mazzonna (2014) finds beneficial effects for men but not women. Galama et al. (2018) review various studies investigating causal effects of schooling on smoking and obesity and document similar variation.

Different counterfactuals. Klein and Walters (2016) demonstrate that the benefits of Headstart to children depends only on the alternative source of care. In the absence of Headstart some children might be neglected, in which case Head Start might be very beneficial. But if mom and grandma were taking care of the child and the child is sent to a low-quality Headstart program instead, the benefits might be small or even negative. The same logic applies to CSL. Being in a room with other kids is probably better for health than working in a mine. Perhaps the reason why some of the effects of compulsory schooling are larger for earlier cohorts is that CSL were keeping children out of the workforce at a time when child labor was far more dangerous than it is today.[8]

Direct effects of schools. There could be some direct benefits of going to school on health: they often require vaccinations, provide food and a safe environment, all of which improve health directly. It's also possible that there are some direct physiological benefits of learning. fMRI scans show that when people learn different activities, their brain structure changes, with possible effects on physical health. Evidence from Alzheimer's patients for example suggests that people "either use it or lose it": those who use their brain a lot are less likely to get diseases like Alzheimer's, and get them later.[9]

Conversely, it's also possible that some schools are bad for health. In the past, when physical punishment and sexual abuse were common in some settings, forcing children to attend school would likely be bad for children's education and health. A recent gruesome example was the forcing of children of native tribes in Canada to attend boarding schools, where many of them died as a result of deprivation or abuse.[10] Feir (2016) finds that forcing Indian children to attend boarding schools in Canada had heterogeneous effects: on average children benefitted, but in abusive schools, children were worse off as a result of their participation.

[8] In the early 20th century, children were working mostly in agriculture and in manufacturing. Today children start working 14 and 15 years old and do so mostly in the service sectors which are less dangerous.
[9] This was suggested by the studies of Alzheimer's with nuns (Snowdon 2002). Also see Wilson et al. (2002) and Livingston et al. (2017).
[10] See https://www.nytimes.com/2021/06/24/world/canada/indigenous-children-graves-saskatchewan-canada.html for Canada. Similar events occurred in the US and in Australia. Also recent scandals suggest hundreds of thousands of children were abused by priests often in Sunday schools or other types of catholic schools around the world.

Aside from these direct "incarceration" effects or physiological effects, it's much more likely that the effect of schooling on education is really driven by the effect of education on what I would call intermediate health inputs. That is, education changes access to other factors that in turn affect health.

Effects on intermediate inputs. As noted earlier, education likely affects many aspects of a person's life and is associated with increased earnings, different political views and personality traits, different information sets and cognitive processes, and finally with distinct social networks. The total effect of education on health then is the sum of the interplay of all of these "indirect" effects. To illustrate, suppose that there are two inputs into health (*H*): income (*Y*) and health knowledge (*k*), and that education affects each. How will a change in education (e) affect health though each mechanism? This is given by the total differential equation:

$$\frac{dH}{de} = \frac{dH}{dY} * \frac{dY}{de} + \frac{dH}{dk} * \frac{dk}{de} \qquad \text{eq. (1)}$$

Then the total effect of education on health is going to depend on 1-how much education changes an individual's knowledge ($\frac{dk}{de}$), 2-how much their knowledge affects health ($\frac{dH}{dk}$), 3-how much their education affects income ($\frac{dY}{de}$) and 4-how much their income affects health($\frac{dH}{dY}$).

There is no reason to believe that these indirect effects would be the same over time and space. For example, health knowledge has changed dramatically over the century. Smoking was not known to be deleterious to health before the 1950s, and prior to that, more educated individuals smoked more. But this pattern reversed after evidence emerged that smoking causes cancer and cardiovascular disease (Cutler and Lleras-Muney, 2014). Indeed some studies find that compulsory schooling lowered smoking rates, while others do not—it may be these differences are related to the knowledge individuals in different time and places were exposed to.[11] So the extent to which education changes knowledge in a way that improves health is not constant.

[11] See Galama et al. for a discussion of these studies.

Similarly, if we look at the returns to education on income ($\frac{dY}{de}$), we see that over the century they have varied considerably as Goldin and Katz (2010) document: the returns to schooling were very high in 1915, they were low during 1950-1970, and then at some point, particularly after 1980, they started rising. If the effect of education operates only through its effect on income, then the returns to education would also be large today and in 1915 but not during 1950-1970. These income returns also likely differ across places. In the US in the 1920s one more year of school raised earnings by approximately 8%. In the UK, right after the war, that number is estimated to be more like 3 or 4% (Deveraux and Heart 2010), and in Sweden it was about 2% (Meghir and Palme 2005, Fischer, Karlsson, & Nilsson, 2013). This might explain the lack of effects on health found in those studies. But regardless of the effect of education on income, having larger incomes may not be as helpful in countries with generous health care systems ($\frac{dH}{dY} = 0$). So perhaps some of the differences across studies have to do with the fact that the return to education, in terms of other health inputs, has varied over time.

What constitutes a health input may also itself vary over time and space. For example, the relationship between education and BMI changes substantially with the level of development. Cutler and Lleras-Muney (2014) document that in poor countries education is positively associated with BMI, but negatively associated in rich countries. In poor countries where individuals still die mostly of infectious diseases, being hefty is protective against mortality, whereas in rich countries where chronic diseases are the main reasons people die, being overweight or obese is a health risk. So what an educated/informed individual may want to do varies across contexts.[12]

Another possibility is that some of these intermediate inputs may harm health, instead of improving health, but they might have other benefits. For instance, more educated individuals tend to be more likely to migrate, but migration is not always health-improving. For example, Aaronson et al. (2021) show that Blacks who received more and better education in the South were more likely to migrate North, where they tended to find higher wages; but they still tended to die younger as a result of their migration. (Also see Black et al. 2015.)

[12]Similarly, Smith, Anderson, Salinas, Horvatek, and Baker (2015) document that the association between education and chronic disease depends on stage of epidemiological transition.

Finally, education might affect some intermediate inputs in unsuspected ways. Today more educated individuals are more likely to have sedentary jobs and sit for long periods of time, which worsens cardiovascular function. The work by Barcellos et al. (2018) indeed finds that compulsory schooling reforms in the UK led to higher blood pressure and worse inflammatory markers, which is what you would expect to see if occupations of the more educated are indeed more stressful or sedentary.[13] But until recently this was not known. Similarly, more educated women change their marriage and fertility behaviors: they are more likely to use more contraceptives, they have fewer kids, and have those kids at older ages. As a result, they are exposed to considerably higher levels of hormones throughout their lives, increasing the likelihood of developing cancers of the reproductive system. (See e.g. Heck et al. 1997, Strand et al. 2007, though also see Albano et al. 2007.) But of course these effects are likely stronger in places/times where contraceptives and contraceptive pills are available.

In sum, there are in fact a host of ways by which education might ultimately impact health. The returns to schooling vary across contexts because education leads to different intermediate inputs in different contexts, and because the effects of these inputs on health are going to vary over the lifetime of individuals, in a way that's not fully predictable, at least not when they go to school. This is a broader point that was made by Rosenzweig and Udry (2020), who show that returns to education in the labor market vary with aggregate stochastic shocks. Therefore, we will estimate different returns depending on when and where we measure these returns.

Complementary inputs. We typically measure the effect of education by investigating the returns to attending school for a certain number of years. However, the returns likely depend on many other factors. There are in fact many complementary inputs in the production of education that are likely to ultimately determine its health and income returns.[14] Forcing children to go to school for one more year may not have the same impact in different places depending on what happens to these other complementary inputs.

[13] Courtin et al. (2019) also show that the 1959 French education reform led to worse blood pressure and inflammatory markers.

[14] In terms of equation (1), this argument is equivalent to stating that for example $\frac{dk}{de}$ is a function of other factors Z.

The first important input is the quality of school. Individuals who attend school for the same amount of time might get very different levels of education as a result of school quality differences. Research by Chetty et al. (2014) for example demonstrated that having better teachers results in greater long-term earnings. CSL reforms may have different effects based on the quality of the school system. In the US in the early 20th century CSL increases were in fact associated with increased expenditures in schools. But many CSL reforms, particularly in low-income countries, are associated with a decrease in the quality of school: they increase the number of children in school and the length of attendance without increasing the resources that the schooling system has, resulting in overcrowded classrooms and lower per capita resources. If more time in school doesn't translate into better skills because of low resources, then it probably won't translate into better health either. Indeed, research by Pischke and von Wachter (2008) show that in Germany compulsory schooling reforms forced children to stay in school longer but didn't increase their cognitive skills. Frisvold and Golderstein (2011) and Lleras-Muney et al. (2021) document that in the US the health returns to education for men are larger in states with greater schooling quality.

Peers are another crucial input. A large literature shows that many health behaviors, and particularly risky behaviors, are strongly influenced by peers: individuals do the same things that the people around them do.[15] This suggest that how individuals are sorted into schools and, within schools, into classes, could significantly affect the costs and benefits of attending school and its returns. Many schooling reforms implement tracking and other sorting mechanisms in addition to increasing length of attendance requirements. Galama et al. (2018) note that reforms that included tracking appear to have larger effects on health, consistent with the importance of peers.

A final and crucial complementary input is the child's attention, which brings us to the role of compulsion. When compulsory schooling laws are binding for many individuals (such as in the UK) a lot of children and parents think that going to school is bad idea. If individuals are

[15] Jensen and Lleras-Muney (2012) examine a randomized control trial implemented in Dominican Republic that gave information to kids at age 14 about the returns to attending high school. This intervention resulted in lower smoking and lower drinking among those who stayed in school. They reported having fewer friends that smoked, which is not surprising because smoking among the working population are much higher than among the school population. For more evidence on peer effects on risky behaviors see Eisenberg et al. (2014) and the literature reviewed therein.

perfectly informed, they estimate that the costs of attendance exceed the returns. If we forced them to attend, in the absence of market failures, the returns to compulsory schooling could be negative. This is particularly true because of how children and parents respond when they are forced to do an activity they perceive as worthless. In many settings treatment effects are "endogenous": what individuals do as a response to a given treatment determines the benefit of the treatment itself (Chassang et al. 2012). If schooling is not seen as good, then chances are children won't pay attention in school (and parents won't buy them books or make sure they attend regularly or study, etc.). They are therefore much less likely to learn and benefit from attending. Ultimately this raises the question of what is it that we can learn about the effect of voluntarily attending school, from observing the effect of forcing individuals to attend school, which is what the compulsory schooling experiments estimate.

This again provides a possible reason for heterogeneous treatment effects. Across these different countries and time periods that have been studied in the literature, who was forced, and why did they have to be forced? What was the market failure? And what was it that the law was aiming to resolve? Some of this is known but differences across contexts are poorly documented.[16] But it is likely that in contexts where a lot of people were forced, returns were perceived by many as low. If these perceptions are correct, then these are precisely the settings where the returns will indeed be low. This discussion suggests that studies that look at interventions that lower the cost of attending school are likely to find different and likely more positive effects from those that investigate the impacts of compulsory schooling. Indeed, consistent with this intuition, two recent papers (Fletcher and Noghanibehambari 2021, Connolly 2021) investigate the effects of college openings on mortality and find increases in longevity as a result.

Complementary policies. Another important factor that likely determines the returns to attending school is the broader context in which the reforms are occurring and, more specifically, the other legislative efforts that are ongoing. In the literature these are treated as "identification threats":

[16] In the United States, the compulsory schooling laws 1900-1940 were part of an Americanization movement targeting mostly immigrants (Lleras-Muney and Shertzer 2015). Its intention was to integrate immigrants by forcing them to learn English and American values. I am not aware of why reforms were passed for example in the UK or in other European countries and why compulsion was seen as necessary.

perhaps CSL are really capturing the effects of other policies (such as health policies) and researchers must test for and rule out this possibility. However, these policies likely *interacted* with CSL and moderated their effects. For example, in the US, CSL changed substantially during 1900-1940, a progressive period during which many other programs that targeted infant, maternal and public health were implemented, likely improving the health of children, in turn making them more likely to be school-ready. More generally speaking it is notable that the interventions that have the largest returns, such as the Perry School and the Abecederian programs, tend to be comprehensive and help families address many issues they face (Aizer et al. 2021), suggesting that there are indeed important complementary inputs/policies.

Aggregate effects. Some CSL affected a lot of children, and some did not. This may also result in different effects of CSL due to different aggregate impacts. If education matters only because it determines social rank, then when everyone increases their education by one year, everyone's rank remains unchanged. But when only a few people are affected, their relative position might improve. If on the other hand the effect of education on health is mediated mostly through knowledge, we would see an improvement in population health when everyone goes to school for one more year, because everybody can learn how to better take care of themselves and/or navigate the healthcare system. However, this may depend on how access to health care is rationed. If what saves your life is accessing beds in a hospital, and those are limited, then the health benefit of more education will be limited. These aggregate effects will therefore vary across contexts depending on whether many are affected and on the specific mechanism by which education affects health in that context.

Dynamic lifecycle effects. Health is a stock that cumulates slowly (Grossman 1972). In general, it takes many years for the effect of any behavior or environmental insult to show its full impacts on health and particularly on mortality. The importance of these cumulative effects has been emphasized recently in the influential work of Case and Deaton (2015, 2017, 2020) who study the evolution of mortality among prime age adults by education in the US. While they do not claim that education has causal effects, they document that individuals without a college degree have lifetime experiences that differ very substantially in a number of dimensions from those who have one. They argue that the long-term deterioration of economic opportunities and social connections

for individuals with low education levels cumulatively lead to higher mortality in middle age, with increases in pain and deterioration in mental health being important mechanisms.

Consistent with the idea of long delays, research outside of economics (and some recent research in economics, e.g. Kaestner et al. 2020, Lleras-Muney and Moreau 2021) has documented that the effects of education on health and mortality vary substantially over the life cycle. Percentage gaps in mortality (or in health) between the more and the less education are barely visible among healthy prime-age populations and then rise and fall in old age. Different studies measure outcomes at different points in the life cycle—studies investigating health and mortality effects among young adults are less likely to find effects. And different studies also focus on populations with different individuals' baseline health. Individuals aged 40 today are in much better health than were individuals aged 40 in 1900—their mortality rates reflect this. It is therefore not surprising that we see smaller or no effects of CSL when we look at 40-year-olds today, but we might have seen benefits 100 years ago.

Does education matter? Many studies investigating the causal effects of education find zero effects. An unknown and unaddressed question is why education appears to matter so much in an observational sense. Most data show strong associations between education and health. Yet some/most natural experiments fail to find a causal effect. If education is not what matters and sending people to school is not what's going to make them healthier, than what was education standing in for? This is important for policy. For example, if it was the income of the parents that was the source of the better education and health outcomes, perhaps we should give the parents money. But if the omitted variable is a personality trait, then the policy implications would be different. (Perhaps we can teach patience, e.g.) There are no studies that I am aware of that identify the source of the omitted variable bias. I have argued here that the discrepancy between quasi experimental studies and observational ones might be due to the fact that most experimental variation in education comes from forcing individuals to attend school, which may have smaller or negative effects on health, whereas in the population most variation in education is of a voluntary nature. But there might be other explanations.

In sum there are a large number of reasons why the returns to education policy on health will vary over time and space. I now turn to a discussion on what we know about the effects of income policies.

III-Income Redistribution and Health

Income is also a very strong predictor of longevity. For example, Chetty et al. (2016) use IRS records matched to mortality records in the US to show that the gap in life expectancy between the richest 1% and the poorest 1% of individuals is 14 years among men, and 10 years about among women. These are very large differences, and they appear to be growing.[17] These differences are observed even in countries with equitable access to health care, education and other social services, such as Norway, Sweden, Denmark and Finland (Mortensen et al. 2016). In Canada for example this gradient is somewhat smaller than in the US (about 75% of the US gradient) but still very large: at age 50 men in the top 5 percent of earnings can expect to live 8 years longer than those in the bottom 5% (Milligan and Schirle 2021). But differences in Norway are in fact similar to those observed in the US and also appear to be growing (Kinge 2018).

Of course, there are many other reasons why income and health are correlated. First, because unhealthy individuals will be less likely to work and will make less money when/if they do. This is nicely illustrated by a recent paper by Dobkin et al. (2018), which shows that among adults, hospitalizations result in subsequent declines in earnings. This fact, that poor health lowers earnings, is the basis for the disability insurance system. It is also partly the reason why social security systems exist in most countries—the capacity to work among the elderly is low because their health is on average poor. Second, many factors could result in both good health and high incomes. For example, well-off parents and societies likely invest in their children's health and also in securing their economic success.

But of course, there are also many reasons why income can improve health. Income improves access to basic necessities like health care, food, and shelter. Individuals with higher incomes can

[17] At the state level the correlation between income and mortality has risen substantially since 1992 (Couillard et al. 2021).

afford to look for more satisfying and better jobs, and they can also afford to work less and to spend more time exercising, socializing and helping others. They can also afford to live in better places. Richer individuals marry different individuals and have very different social networks. And, like education, income is a marker for higher social rank, which may also affect health.[18]

The policy question however is whether income transfers improve the health and longevity of the population, and in particular, whether income transfers would improve the health and longevity of the poor. Several papers investigate this question and, just as in the case of education, the evidence for the effects of income is mixed, despite the fact that the associations between income and health are very strong and observed almost everywhere. Next I review some key studies attempting to estimate causal effects and hypothesize about why findings differ across studies, abstracting again from methodological differences.

a. Experimental evidence.

The ideal experiment would randomize income across individuals and compare the health of those receiving transfers with the health of those who don't. While there are no RCTs investigating this question exactly, a recent paper by Price and Song (2018) comes close. They study the long-term effects of the Seattle-Denver Income Maintenance Experiment, matching the original randomized program data with social security records. They find no effects on the longevity of either the adult recipients or their children. It is not clear whether this experiment can be interpreted as a cash transfer. The program, which lasted five years, made cash transfers to poor recipients to guarantee a minimum income, but it taxed earned income at high rates. As a result, the differences in total income between treated and non-treated families were small. The authors report an increase of $640 per year in family income as a result of the program participation, which they then adjust to $2000 due to under-reporting. Depending on which number one uses, this corresponds to an increase of 3 to 9% of the mean. So perhaps no effects on longevity were observed because the

[18] As this paragraph highlights, access to health care is not the only or most important way in which richer individuals can improve their health. It is well known that access to health care alone cannot explain income differences in health and mortality, as the evidence in the introduction to this section highlighted. For example, Dunlop et al. (2000) show that in Canada the introduction of national health insurance systems has not diminished income gradients in health -- despite equal access poorer individuals visit specialist at lower rates. Moreover, poorer individuals will tend to be in poorer health even before they access the health care system.

income increases were modest. Importantly the program also disincentivized work through its transfer scheme, so the intervention is not equivalent to a pure cash transfer. The question of whether income changes are tied to work or not is an important one for determining its health effects, an issue that I return to at multiple points.

There are no other randomized experiments that address the question of whether policies that transfer income improve health. Most papers addressing this question try to establish causal effects using natural experiments instead. I review them now.

b. Aggregate evidence and aggregate effects.

One strand of the literature uses aggregate fluctuations in economic conditions and investigates whether health and longevity fall during recessions. A set of now very famous studies started by Ruhm in 2000 document that, at least in rich countries today, recessions *decrease* mortality rates, or conversely, more people die in good economic times.[19] This held true even for the Great Depression in the 1930s, when, despite the deep economic depression, life expectancy actually rose (Granados and Roux 2005). These papers assume that recessions are caused by economic forces (like productivity shocks) that do not directly impact health, except that they cause unanticipated decreases in employment and earnings, which are expected to lower health and longevity. However, we observe the opposite.

These results are puzzling. The data show that the health of unemployed individuals suffers during recessions and after (Tapia Granados et al. 2014). And yet the average population health appears to improve. Why? The literature has made some progress on this question, showing that decreased economic activity does in fact have some, perhaps unanticipated, benefits: less economic activity results in lower transmission of infectious diseases (Adda 2016), fewer car accidents and lower pollution emissions (Cutler et al. 2016). It also turns out that when people have more free time (because they are working less), they spend more time exercising, using preventive care for themselves (Ruhm 2005, 2004, Xu 2013) or caring for their children (Dehejia and Lleras-Muney, 2004, Aguiar et al. 2013). When times are good the quality-of-care elderly individuals receive worsens (Stevens et al. 2015). Note then that this "experiment" is not ideal, because the main effect

[19] See Ruhm (2000), Ruhm (2003) and Ruhm (2005). Ruhm (2016) reviews of the evidence by many scholars.

of recessions on incomes operates through employment, and because in the aggregate these additional effects have important consequences on the health of the population, even among those whose jobs and earnings are unaffected by the economic recession.

This evidence also highlights that, as in the case of education, broad income changes likely have important aggregate and general equilibrium effects that would not be captured in experiments where only a few individuals obtain more income. This is relevant for policy, particularly for policies such as Universal Basic Income proposals, which would likely raise the mean income of entire communities substantially. These policies would likely have other aggregate impacts, beyond those discussed above, as documented in Egger et al. (2019)'s experimental study of the effects of the giving poor people money across different villages in Kenya. The transfers add up to about 15% of per capita GDP for villages receiving them—a very substantial increase. Crucially, the total amounts of the transfers in the experiment vary not only across households within villages but also across villages. Two years later the investigators found that the transfers had very small effects on labor supply and resulted in large increases in consumption. They also observe very small price inflation (which one might be concerned about), important changes in the distribution of economic activity and very large positive spillovers for non-recipient households: individuals who didn't get the money also appear to benefit economically. If income improves health then villages with greater transfers might see their population's health improve in the coming years—but note that a comparison between those households that received the transfers and those that didn't would likely lead to incorrect inferences about the effects of the money. The study did not track health outcomes (and it is not reasonable to expect effects in the very short term), and took place in a poor agriculture-based economy. Thus the results may not be applicable to modern rich countries like the US. But they illustrate that aggregate effects can be non-trivial and likely to lead to complex effects on health that might not be predicted by simple models of the effects of income on health.

c. Individual level studies.

It turns out that even if we look at the individual level, the research is ambiguous: more income is not always good for individuals' health and longevity. While there is no evidence from randomized

experiments on this question (aside from the RCT mentioned earlier on the NIT, which is not exactly ideal), some natural experiments come close.

An excellent recent study by Cesarini et al. (2016) investigates the effects of winning a large lottery in contemporary Sweden, using very large administrative data on the entire population. The lottery prizes range from one to 40 median annual incomes. They demonstrate that conditional on playing the game and being in a certain place, the amount won in the lottery is as good as random.[20] They find no effects of winning a large lottery on mortality or healthcare utilization among adults, though they do see some modest improvements in their mental health. They also find no effects on most children's health outcomes, though the children are too young to study longevity impacts.[21]

This study contrasts with a similar earlier study by Lindahl (2005), who also looked at lottery winners in Sweden, using a smaller sample of lottery winners, and found substantial decreases in mortality. He concluded that almost all of the observed OLS relationship between income and mortality was causal. By comparison, Cesarini et al. (2016) conclude that almost all the differences in mortality by income in Sweden (which is significant, though smaller than the differences in the US) are due to third factors—their large dataset allows them to rule out large effects of the lottery money. It is not clear why the studies' results differ. Cesarini et al. hint that maybe the Lindahl study benefitted from "small sample luck". But perhaps there are other explanations including heterogeneity in the income-health relationship in their samples. I start by discussing the role of age.

d. Understanding heterogeneity

Lifecycle effects. Consider the studies by Aizer et al. (2016 and 2020). They study the effects of cash transfers to poor families in the early 20th century, the Mother's Pension program, the first welfare program in the United States upon which the current welfare program was based. To identify the effects of the program the authors compare the longevity of individuals in families

[20] Note that this design does not compare lottery winners to individuals who have never played the lottery, and therefore avoids the *lottery-tickets (LT) bias* described in Kim and Oswald (2021).
[21] The authors also show that the population of lottery winners is not particularly different from that of nonplayers assuaging concerns of external validity.

who applied for and received money to those who were initially deemed eligible but were ultimately rejected. The transfers were roughly equivalent to about 30% of income and lasted for a median of three years. They find that the adult women who got the transfers did *not* live longer as a result. However, they find that the sons of these women did live about 1.5 years longer.

It is not clear why there are discrepancies between the mothers and their sons. It's possible that children benefit more than adults, because their bodies are still being formed and they exhibit more "plasticity"— more income might translate into better food, shelter and access to care, which have large effects on heights and ultimately longevity for children, but matter a lot less for adults. It might also be that there are more mechanisms through which income improves the health of children: more income might result in more education for children, for example, whereas the same is not true for adults. Indeed Aizer et al. (2016) find that sons of recipients also obtained more education and had greater incomes, whereas Aizer et al. (2020) find that in the long run the economic circumstances of their mothers were unchanged.

This discussion highlights the importance of lifecycle effects: *when* individuals receive money matters for its effects. A broader look at the literature suggests this is an important pattern: positive effects tend to be more commonly found among children and the elderly. The influential paper by Case et al. (2002) showed that there are strong associations between measures of households' permanent income and the health of children, which grow with age. A number of recent papers find that policies that transfer income also have beneficial effects on children. The Earned Income Tax Credit (EITC) decreases the incidence of low birth weight among infants (e.g. Strully et al. 2010, Hoynes, Miller and Simon 2015). Food stamps also improve health and longevity in the long run (Hoynes, Schanzenbach and Almond 2016, Bailey et al. 2019). This evidence is consistent with the idea that early interventions (during childhood, before roughly age 20) have larger impacts than interventions later in life, as documented by Hendren and Sprung-Keiser (2020).

Several papers also find positive effects among the elderly in the US. For example, Schwandt (2018) documents that wealth increases due to stock market fluctuations improve the physical and mental health of retirees, as well as their survival rates. Two other very recent papers using credible policy variation also find similar results. Gelber, Moore and Strand (2018) show that increased

SSDI payments lower mortality, and Berman (2020) finds that greater SS pensions amounts (induced by arbitrary changes in the pension formula) lower mortality rates among elderly individuals in Medicare.[22]

Why would the effects of income be positive among the elderly but not among prime age adults? One possibility is that the consequences of bad health shocks are not visible among prime age adults because their stock of health is large, and the effects of any shocks on health and mortality only materialize over time.[23] They become significant (and thus more easily detectable in finite samples) when their health starts to decline and their mortality starts to rise, i.e. in old age. So perhaps if we could follow adults over longer time periods, we would find that significant changes in lifetime incomes do affect their health. But it is not possible to observe that in the short term.

Alternatively, the effects of income on the health of the elderly might be simpler to predict because many of the mechanisms by which income translates into health are shut down. There are many health inputs that are potentially impacted by changes in income, but perhaps many of these channels are not relevant for the elderly. The elderly are mostly retired, they have already married and had their children, and they're less likely to move or change their social networks. They are also unlikely to significantly change many of their behaviors, like exercise and diet. So for the elderly for whom health is deteriorating rapidly, the first order effect of greater income might be to increase access to better health care. In contrast, among prime age adults, large changes in income are likely to induce a host of lifestyle changes that may have unexpected effects as discussed further below.

Even within a given age group there is still some important heterogeneity across high-quality studies. For example, this is the case among studies looking at children. Page (2021), who conducts an extensive review of the impacts of money on children's short- and long-term outcomes, including health, concludes the effects of income on children's health across studies is mixed. A few notable studies do not find effects on income transfers on children's health, in contrast to the

[22]In contrast to these studies, Snyder and Evans (2006) find that increases in pensions actually increased mortality.
[23] For a model describing how the effects of health shocks affect health and mortality over the life course see Lleras-Muney and Moreau (2021).

Mother's Pension, EICT and Food Stamp research mentioned earlier. For example, Price and Song's study discussed earlier, based on a long term follow up of an RCT, finds that the intervention had no effects on children's longevity. Akee et al. (2013) show that unanticipated and large casino-related earning downfalls among the Cherokee increased child obesity. Two studies find no effects of housing vouchers on child health (Jacob, Kapustin and Ludwig 2015; Daysal, Lovenheim and Siersbaek 2021). Interestingly many of these populations are also quite poor so it is particularly surprising that income does not improve their outcomes.[24]

Among prime age adults, studies also differ in their findings. There are a number of studies finding no causal effects of income, consistent with Cesarini et al.'s findings: inheritances (Meer, Miller, and Rosen 2003) or due to changes in estate taxes (Erixson 2017) seem to have no or modest impact on health in the short run (within a few years). There are also some studies that find *increases* in mortality in the very short-term after receiving anticipated increases in government transfers (Dobkin and Puller, 2007, Evans and Moore 2011, 2012). The work by Evans and Moore shows, for instance, that the day individuals receive their tax rebates, they are more likely to die. And of course there are some studies finding the converse: that mortality increases when income falls. For example, individuals who lose their jobs due to plant closures see substantial declines in their lifetime incomes and exhibit greater mortality for at least twenty years (Sullivan and von Wachter 2009). Similarly, individuals who graduated during the 1982 recession suffered not only large employment and income losses but also had elevated mortality for many years thereafter (Schwandt and von Wachter 2020).

There are several important differences across these papers worth highlighting because they illuminate why the effects might differ. First, there is a stark contrast between the short- and long-term effects on income receipt. This is particularly well illustrated by Schwandt and von Wachter (2020): immediately after the 1982 recession mortality for the unlucky graduating cohort actually falls despite the declines in employment and income (consistent with the earlier work by Ruhm). This is entirely accounted for by external causes of death (e.g. accidents) in this young sample.

[24] Many hypothesize the effects of income on health are significant mostly for the poor, see Marmot (2015) for example.

However, in the long run mortality from biological causes rises.[25] This highlights the fact that the timing of when effects are measured matters. Second, there are important differences in the types of shocks that are being studied. Inheritances are more properly described as one-time changes in wealth, whereas job losses (or the impact of a recession) are better characterized as changes in lifetime (permanent earned) incomes. Some research suggests that individuals treat these types of income increases differently. Unearned income such as lottery income or inheritances is often treated differently from earned income (Thaler 1999).[26] Third, just as it was the case in the aggregate study of recessions, many of these papers consider shocks that affect employment and labor supply, not only incomes. It would appear that employment and labor supply responses to shocks are crucial in understanding the effects of income and why it differs across settings.

These results raise several questions again. If income doesn't not improve health and longevity, why do we observe richer people living longer? In these studies, it's not clear why observationally richer people do better but in the (natural) experiments people who receive money do not. The results also raise the question of why the money was not beneficial in some settings, or even detrimental. At a basic level it seems to be almost trivially true that the income would help individuals, particularly poor ones. And yet we don't see that. Why?

Multiple inputs into health. Similar to education, obtaining more income leads to a host of changes in peoples' lives and behaviors, and some of these changes may not actually benefit health. The fact that there are many intermediary inputs can possibly help explain why the effects are 0 and why they might differ across settings or populations.

First, rich individuals do spend more money, not surprisingly, but some of the things that they buy are not good for health. For example alcohol and cigarettes are all normal goods. The estimated elasticity of smoking with respect to income is 0.4, and the elasticity of alcohol with respect to income is 0.9 (Cawley and Ruhm 2011).[27] Both are positive: richer people buy more. Unhealthy

[25] Cutler et al. (2016) also document similar difference between the short and the long-term impact of income shocks using cohort data from the early 1800s onwards.
[26] Indeed Khun et al. (2011) find that individuals that win a car spend more on food, house renovations and cars, consistent with either the presence of credit constraints before the win or with mental accounting.
[27] Since it is difficult to find good instruments for income (or good natural experiments) these elasticities might be biased, but nevertheless they provide a possible explanation for the puzzling findings. Studies show that lottery

food is also a normal good: Jensen and Miller (2008) show that in India, when people get richer, they tend to buy things that are less nutritious and not as good for them—in fact this provides an explanation for the fact that as countries get rich, they also get fat (and is consistent with the Cherokee study findings by Akee et al.).

It is also the case that richer individuals engage in some behaviors that may not be known to be bad. For instance, richer, more educated people have more sex (sex is a normal good). In contexts where the incidence of sexually transmitted disease is high, this behavior can be deadly, as evidenced by the HIV crises in Africa. Initially, when the HIV crisis first came out, people did not know that HIV AIDS was sexually transmitted. And so rich and educated individuals were actually the first to become sick. In the US individuals with HIV were also on average richer than those without it. Eventually, this gradient reversed once people understood the transmission mechanism and how to protect against it, consistent with our general expectation that wealthy, educated people make better use of health information. Nevertheless, this example illustrates that its possible for income to have deleterious consequences on health in some contexts.

A crucial consequence of increasing incomes is that individuals may stop working. The Seattle experiment reviewed above, and similar experiments with Negative Income Tax programs, find negative (though modest) effects on labor supply (Robins 1985). Lotteries studies have also found this to be true, though the effects are more modest than one might expect.[28] It may be that as individuals become rich they work less, and this may not be beneficial for health. In modern contexts where individuals work mostly in service occupations that are not hazardous to health, work may provide a source of self-esteem and a social network. A study by Fitzpatrick and Moore (2018) among the elderly, for example, shows that individuals who are allowed to retire early actually die younger than their counterparts. People may derive a significant benefit from working when they work in good conditions. Interestingly, as noted above, many lottery winners do not quit their job. Of course, work can be very unhealthy for people working in bad conditions (Case

winners increase their consumption of alcohol and cigarettes (Apouey and Clark 2015) consistent with these being normal goods.

[28] This literature estimating the effects of lotteries on labor supply is reviewed by Golosov et al. (2021) who find substantially larger responses than all previous papers. Not all studies find labor supply effects of income. For example, Akee et al. (2010) find no effects of casino dividends on labor supply, Jones and Marinescu (2018) report no effects of the Alaska cash dividend on labor supply.

and Deaton 2007, Fletcher et al. 2011, Kelly et al. 2014). The bottom line is that some individuals whose income increases substantially work less. In some contexts, this might be beneficial, and in others, not, depending on the nature of work.

There are other important responses to income increases that might ultimately affect health.

Individuals tend to change their marriage and fertility behaviors as a result of getting more money. Golosov et al. (2021) find that lottery winners who are single are more likely to marry, and marriage is associated with longer lives. But in the case of a welfare mothers, Aizer et al. (2020) find that women who received transfers delayed getting remarried, as expected since women would lose the transfer upon remarriage. This suggests that *how the money is obtained matters*: when money is earned, when it is unexpectedly won or when it is given conditional on certain behaviors or conditions, it has different effects on the recipients.

Lastly individuals move when they have the money to do so. Place of residence is a strong predictor of mortality (Finkelstein et al. 2019; Deryugina and Molitor 2020). But policies that give people money might in fact reduce mobility ex-post. In the case of the Mother's Pension program in the US, Aizer et al. (2020) document a significant *decline* in mobility as a result of receiving transfers. This is not surprising: eligibility rules required that women remain in their county of residence in order to continuing getting transfers, so they moved less. Perhaps that was bad, because they already lived in places that were disadvantaged. In other settings when people e.g. win the lottery, the money that might allow them to move more, possibly to better locations. Golosov et al. (2021) document that in the US, lottery winners, particularly poorer households, do use their new incomes to move locations. But interestingly they do not necessarily move to neighborhoods with higher observed quality. This result is again consistent with the previous observations that money is often not well spent, at least from the point of view of health.

In sum when individuals obtain more money some health behaviors might deteriorate (drinking and smoking), some outcomes might improve (mental health) and others outcomes might shift in ways that may affect health unbeknownst to individuals. The net effect of all these changes can be ambiguous and may vary depending on the intensity of each of these responses.

Complementary inputs. Money alone might not be enough. Money is only useful if you know where to locate and how to get into a particular school, how to purchase a home, and what constitutes a good diet. For instance, you can give individuals generous housing vouchers. But they will not be sufficient if households face discrimination in the housing market, or they have other barriers: their networks might prevent them from being able to use that voucher, or their imperfect information might prevent them from identifying the best locations for their families. Recent work indeed documents important non-financial barriers to improving one's residential location (Bergman, et al. 2020). Thus, individuals' ability to make good use of the money depends on other individual or environmental characteristics. Thus, a final reason why the effects of income might vary across populations is that they differ in the level of other resources that are needed to translate income into better health.

Effects of income vs. income transfer policies. The discussion so far suggests that lottery studies (or perhaps inheritance ones) provide the best and cleanest evidence on the effects of income: they do not directly affect employment and they study meaningfully large income changes. However, it is not clear these results would generalize to other types of income increases. Accounts of lottery winners suggest that their lives are disrupted as a result, often in many negative ways. Family members and extended families often made requests and demanded transfers. This effect has been documented in developing countries: when people get a visible income windfall, their extended family immediately taxes this income (Jakiela and Ozier 2016). In addition to affecting marriage and divorce, individuals might marry different people once they are rich, but these new matches might be inferior if they are motivated by one's party's interest in obtaining income. Finally, there might be a "Gatsby effect" for individuals who become rich: although they move and access different locations and social networks, they may tend to remain outsiders, which might be detrimental to health. Of course, some of these effects might also be present for those who, for example, become rich through entrepreneurship.

Another important caveat of these studies and one that is crucially important to policy is that they do not capture some important effects that are likely to be present in government programs that transfer cash. These programs typically have various eligibility requirements, and these

requirements might offset or amplify the effects of the money itself. For example, as noted above, the geographic mobility of MP recipients declined as a result of the transfer—because women would lose the transfer if they moved counties. But the same is not true to lottery recipients, they get a one-time infusion of money that places no restrictions on its use. Similarly, the EITC rules encourage labor supply (at least among some households) because the transfers increase with earned income for some range of income, and discourage it among others because of the design of the program. The same is not true of lotteries. Welfare monies can come with substantial stigma (Moffit 1983), whereas earned income does not. And lastly large government programs likely have important general equilibrium effects that may increase (or decrease) their desirability and their impact. Thus, it's not clear that natural experiments that are not policy-based can be used to project the effects of policy-based transfers because these will depend on the exact way in which the cash transfer program is designed.

Why does income appear to matter? At both aggregate and individual levels income is a strong predictor of mortality. Yet many of the studies cited here suggest that exogenous changes in income do not result in improved health. This raises a question of why the observational data shows such strong correlations. Some progress on this question has been made recently by authors investigating the importance of place in the determination of mortality, which we have already noted is a strong predictor of mortality. Couillard et al. (2021) document that today there are large correlations between state mortality and state level income, and these correlations are larger than 40 years ago. They argue these increases in the associations are due to the fact that rich states invested more in health infrastructure, which over time has benefitted its population, particularly its poor and uneducated. Recent work on the long-term effects of Medicaid (see Goodman-Bacon, 2021; Miller and Wherry 2019) or environmental policy (Isen et al. 2017), which were more likely to be implemented by rich states, supports this hypothesis. However, a full accounting has not yet been possible due to the difficulty of accounting for the long lags between policy implementation and its effects, highlighting again the need to improve our models of health accumulation and of long-term exposures. But these findings underscore the fact that there is no constant or necessarily structural relationship between income and health—mortality has fallen in states with high incomes only because in recent time these states have chosen to implement policies that improve the health of its most vulnerable populations. And these effects have only become visible over a

fairly long period of time. There may be other explanations for the discrepancies between observational and quasi-experimental studies. A fuller accounting of the difference is warranted.

IV- Concluding thoughts.

The causal effects of education and income policies appear to vary over time, space and context. This article has explored reasons for this heterogeneity and proposed several explanations. However, a more systematic empirical evaluation of these explanations is warranted to understand what works, when it works, why it works and for whom it works.

A final observation pertains to the poorly understood roles of gender and race. Causal estimates of the effects of education and income on health often differ by gender and race. Studies that investigate the effects of education policy on health tend to find smaller benefits of education for females than males (Galama et al. 2018). Socio-economic differences in health are smaller for Blacks that for whites (e.g see Bell et al. 2018). Why would money and education policies be less beneficial for women or Blacks' health? Although this article has suggested some possibilities, future work should seek to more systematically understand these.

I end by suggesting that the study of mental health should be a greater priority. The literature in economics has more frequently focused on mortality and other objective measures of health. Mental health is itself an important predictor of longevity (Walker et al. 2015).[29] Regardless of its effects on physical health, mental health is a crucial component of welfare and thus of interest in its own right. Sadly, it appears that mental health is deteriorating in the US. For example, suicide rates increased by 33% from 1999 to 2019.[30] Thus questions on whether education or income *policies* can improve mental health are increasingly important.

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