Evidence of Stalinist Terror in Modern Adult Height Data

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Honors Thesis submitted in partial fulfillment of the requirements for Graduation with Distinction in Economics in Trinity College of Duke University.

Duke University
Durham, North Carolina
2019

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Abstract:

Adult height is often used to evaluate standards of living experienced in childhood, as it is highly dependent on early-life nutrition (Komlos and Baten, 1998). I employ adult height data collected by the Russian Longitudinal Monitoring Survey (RLMS) to measure well-being among the population of the USSR during two periods of Stalinist repression: The Great Terror from 1937-1938, and *dekulakization*, which led directly to the Great Famine of 1932-1933. Heights are normalized by gender and birth year using data from the Survey of Health, Ageing, and Retirement in Europe. I find that both the Great Terror and Great Famine had significant negative impacts on health. In particular, I find the impact of famine on adult height was greatest for those of low socioeconomic status and those born in rural areas. The Great Terror, however, primarily impacted the health of those of high socioeconomic status, those born in urban areas, and those born in areas that were heavily targeted by repression campaigns.

Keywords: Soviet Union, Economic History, Epidemiology, Population Health

Acknowledgments:

This paper would not have been possible without the endless energy, enthusiasm, and kindness of my advisor Charlie Becker. I am also grateful to Michelle Connolly and Duncan Thomas at Duke as well as Riccardo Welters at James Cook University. All three bring excitement, rigor, and humor to the classroom each time they teach. I owe a debt of gratitude to Mitchell Ochse and Khuong Do for their patience with my questions, and their encouragement to pursue this project. Both have bright futures ahead of them in the field of economics. The following 40 pages would be much more painful to read if Claire Payton and Jonathan Katz had not generously ceded dozens of hours of their time to carefully edit my writing throughout my sophomore year.

Most importantly, I want to thank my parents and the whole Henderson family (including its newest member, Emma Volk) for encouraging me to devote my time and energy to whatever I am most interested in, even when that entails spending a year analyzing the heights of 10,000 Russians.

Introduction:

Even before Josef Stalin emerged as Lenin's clear successor, repression had become a critical component of Stalinist leadership. But repression was not limited to Stalin's early years solidifying his power—during the course of Stalin's rule as many as seven million political enemies would be sentenced to forced labor in the gulag (Gregory et al., 2006). While exile to the gulag and execution by firing squad were common sentences for all those deemed "enemies of the people" throughout Stalin's rule, the period from 1937 to 1938—the Great Terror—was still unique in its intensity.

Research on how Stalinist repression tactics affected the well-being of those not purged is scant. While a slight slowdown in industrial output during the period of the Great Terror has been documented, the prior economic literature has not determined conclusively whether this slowdown was due to harsh Stalinist policy, or some other contributing factor (Katz, 1975). Most likely, this is due to the dearth of sound financial and manufacturing data collected in the USSR during Stalin's early years in power.

Anthropometric data can be used to address this gap. Adult height is often used to evaluate conditions of living at birth, given it is highly tied to infant and child nutrition. I employ adult height data collected by the Russian Longitudinal Monitoring Survey to measure well-being among the population of the USSR during the Great Terror. I use this adult height data to compare the Great Terror's impacts on well-being to the impacts of the wave of repression that preceded it: *dekulakization,* which led directly to the Great Famine of 1932-1933. In my analysis I test the hypothesis that the Great Terror was especially impactful on the citizens of areas targeted by Stalin's twin campaigns of repression, Mass and National Operations, while the Great Famine primarily impacted Ukraine, Kazakhstan, and rural areas of the Russian Soviet

Federative Socialist Republic (RSFSR). I also test the hypothesis that the Great Terror primarily impacted wealthier, more urban populations, while *dekulakization* was a phenomenon that impacted those living in poor, rural areas. But first, I briefly review the existing English language economic scholarship on the Great Terror, summarizing the majority view of the Terror's economic impact.

Literature Review:

Historical background: Great Terror

Given this paper will focus specifically on the Great Terror, it is important to separate the Great Terror from Stalin's overall penchant for repression. Pinpointing the symbolic beginning of the Great Terror is a matter of choosing between a number of major executions, arrests, and leadership changes. The Moscow Show Trials commenced in 1936, and continued in waves until the fall of 1938. The show trials were highly public affairs and are often taken as shorthand for the Great Terror. The show trials were also critical—Stalin was able to solidify his power by forcing public confessions to anti-Soviet conspiracy from many of his most powerful political enemies (Hodo 1987).

While many consider the first of the show trials in August 1936 to be the start of the Great Terror, the Terror was not set in motion until after the official who oversaw the trial, Genrikh Yagoda—at the time head of the NKVD—was arrested and charged with Trotskyism and espionage in late September 1936 (Gregory et al. 2006). Yagoda's arrest is not only symbolic of the massive disorganization and managerial turnover that followed the terror, but it also enabled Stalin to install a successor who was perfectly amenable to his wishes for mass violence and organizational chaos. In a paper that provides the background for much of the analysis conducted here, Paul Gregory, Philipp Schroder, and Konstantin Sonin (2006) attribute as much of the Great Terror's intensity to Yagoda's successor, Nikolai Yezhov, as Stalin himself.

On July 30, 1937 Yezhov's issued Order 00447 to party officials in Moscow. Yezhov ordered the officials to "beat, and threaten without sorting out" (Gregory et al., 2006). Yezhov also set forth a series of arrest and execution quotas. Roughly 75,000 "enemies of the people" were to be executed, and 193,000 sentenced to gulag labor over a four-month period. However, these limits were routinely raised, and what was supposed to be a four-month campaign beginning in July 1937 ended up carrying on until November 1938, at which point Yezhov himself was arrested. Gregory, Schroder, and Sonin deem this period the Mass Operations wave of Stalinist repression.

As primarily a campaign to eliminate political enemies, which was built around a series of massive show trials held in Moscow, Mass Operations had a more urban and centralized focus than preceding and subsequent waves of repression. The official NKVD figures show 1.4 million convictions under Mass Operations from August 1937 to November 1938, with 687,000 of those convicted executed, and the rest sentenced to gulag labor. However, it is possible these figures are inaccurate, or underreported (Garf, 1953; Gregory, 2006).

While Mass Operations is remembered by Stalin ruling Moscow with an iron fist, the repression campaign known as National Operations took on a more diffuse nature. Enforcement was spread amongst managers throughout the RSFSR and USSR constituent republics. Mandates were vague, but all political enemies were to be rooted out. In the case of National Operations, one's status as an enemy of the people was mostly determined by nationality. Poles, Germans, Kazakhs, Ukrainians, Latvians, and Koreans were all targeted (Gregory, 2006; Conquest, 2008). Given that these groups were dispersed throughout the USSR, National Operations affected a great deal of the Soviet Union. National Operations varied in intensity by region, and carried on until the late 1940's, long after the end of the Great Terror. Like the Great Terror, however, National Operations began in 1937. Because National Operations began at the same time as Mass Operations, the effects of the two are difficult to separate. Indeed, while most typically mean to refer to Mass Operations when discussing the Great Terror, National Operations were in full swing at the same time.

Historical background: Great Famine

Another massive wave of repression came just a few years before Mass and National Operations. The Great Famine began with Stalin's campaign of *dekulakization*, which may have been his most brutal campaign of repression during his tenure as leader of the USSR. Under *dekulakization*, Stalin declared all landowning farmers enemies of the state, and forced collectivization of all private farms. Those who resisted, were purged. Stalin eventually got his way. About 64% of Soviet farm land was collectivized (Gardner, 1984). But Stalin's victory came at great cost to efficiency. Collectivization was unsuccessful in increasing output. Many experienced farmers were purged, and many others destroyed their land in protest.

In the immediate aftermath, mass crop failures caused untold devastation in Kazakhstan, the Ukraine, and rural parts of the RSFSR. Even as grain yields were down significantly, Stalin's government actively seized as much grain as it could to feed urban Soviets, essentially condemning rural peasants to death (Lovell, 2009). Stalin-caused starvation was widespread in the Ukraine and Kazakhstan, and throughout the North Caucasus region of the RSFSR.

Estimates of the death toll due to the Great Famine vary wildly, but according to the UN, at least 3.5-7 million Ukrainians died as a result of the famine, in addition to about 1.3 million ethnic Kazakhs (UN, 2003; Pianciola, 2001). The worst of the Great Famine cannot be captured in modern adult height data: there is a huge selection bias, as those most affected by the nutritional impacts wrought by the famine have long since died. However, it is straightforward to conclude that any children born in heavily famine-afflicted areas would likely have been severely malnourished during that time, resulting in lower adult heights for those born in famine-touched areas from 1932 to 1933. Comparing this effect on adult height with any observed effects of being born during the Great Terror in a heavily Terror-affected area will provide context for interpreting the overall effect of Terror on Soviets' well-being.

Expected economic impacts of Stalinist terror

While the removal of large portions of the urban industrial workforce would likely impose negative impacts on the Soviet economy, it is worth analyzing this assumption more closely. Though indirect, there could certainly could have been positive effects of terror. Stalin did choose to enact terror policies. He may have had rational motives for doing so.

Marcus Miller and Jennifer Smith propose that the presence of terror could have increased productivity among workers who were not purged (Miller and Smith, 2015). They use the efficiency wage model developed by Shapiro and Stiglitz to make this argument, and suggest that the threat of being purged for shirking work responsibilities could have raised individual workers' productivity during the Terror. But, enforcement of workplace rules was not uniform. In fact, Stalin urged workers to turn in their peers for any potential infractions, arguing it would be better to falsely sentence 95 innocents to prison labor or execution than to let 5 bad workers roam free (Gregory and Harrison, 2005). Miller and Smith conclude that the threshold for an infraction to be considered purge-worthy was so low (in the 1930's arriving late for work made one an "enemy of the people") and enforcement was seemingly so random, that little or no productivity gains were likely realized by scaring workers into working hard.

A slowdown in urban industrial output certainly did occur during the Great Terror--but the Great Terror is not typically considered the cause of this slowdown. Instead, the common explanation is that Soviet manufacturers became so focused on preparing for conflict with Hitler's Germany that production suffered. The economist Barbara Katz investigates the Great Terror and war preparations as possible explanations for the 1937-1940 drop in output growth.

Katz finds that in all four years, terror intensity (as measured by drops in Communist Party membership due to purging) is a negative, statistically significant predictor of output. She also finds that terror intensity is highest in 1937 and 1938 (Katz, 1975). Katz's methods and data are rather outdated, given her study was conducted a full two decades before the opening of the Soviet archives. But, Katz's paper remains the only English language study of the Great Terror's economic impacts.

Under Stalin, prison labor played an important role in the USSR's economy. During the Great Terror, the workforce in Soviet gulags skyrocketed, rising by 21% in 1937, then increasing by a further 32% in 1998 (Miller and Smith 2015). One might suspect that the negative impacts of the Great Terror on the civilian sector could have been counteracted by this swelling of the Soviet Union's prison labor system. However, David Nordlander's history of the Dalstroi network of prison camps in the northern RSFSR makes clear that camps likely did not benefit significantly from the flood of additional workers. Instead, marginal returns dropped precipitously. In the gold mining Dalstroi for example, the average prisoner excavated about half a kilogram of gold annually in the run up to the purge. But in 1938, each new inmate accounted for only an additional 1/17th of a kilogram of gold (Nordlander, 2003). Nordlander's account fails to take even simple economic concepts (for example diminishing marginal productivity, and the decreasing stock of gold) into consideration, but it is true that by the 1940's, a number of gulag managers and penal colony administrators actively advocated paying workers in order to increase productivity. Gregory and Harrison (2005) conclude that Soviet administrators' reckoning with the inefficiency of forced labor in the years following the Great Terror was responsible for the closing of the gulags, rather than concerns about human rights. It seems unlikely that significant gains in gulag productivity occurred during the Great Terror.

Problems with Soviet economic data

While it would seem intuitive to seek industrial output or financial data to measure the economic impact of the Great Terror, in the case of the Soviet Union, relying on traditional economic indicators may not be the best approach. Data quality problems plague research on the economic development of the USSR, particularly studies focusing on the Stalin era. The economist William Easterly has deemed data quality “the fundamental problem” for researchers attempting to understand the economic course of the Soviet Union (Brainerd, 2010; Easterly, 1994). The available data are problematic for a number of reasons, though data quality has improved in recent decades.

Initially, the data available to researchers outside of the Soviet Union was mostly gathered from official publications: newspapers, reports, and propaganda materials released by the USSR to the general public (Ofer, 1987). The misreporting in these materials would have been significant: the USSR’s leaders had a strong incentive to overstate their economic successes and minimize their economic struggles. Doing so encouraged workers to remain loyal to the bright Soviet future Lenin (and Stalin after him) promised repeatedly. USSR officials also had an incentive to project an image of economic strength and power to the outside world, especially as the prospect of conflict with Germany began to loom large in the late 1930's.

The opening of the Soviet archives in 1991 released vast stores of data to outside researchers, and did improve the data quality situation, as internal government figures became widely available (Gregory and Harrison, 2005). However, problems with these figures remain. The performance of managers and manufacturing plants was largely judged by whether or not output targets were met. Therefore, Soviet industrialists had a strong incentive to misreport their true output to government officials (Brainerd, 2010). It seems likely that over-reporting of output would have been especially common during the Great Terror, when managers who missed targets were likely to face harsh prison labor sentences or execution.

Use of anthropometric data in the economic literature

We can avoid the inherent pitfalls of using Soviet economic data to make assertions about the Terror's impact on quality of life by using a different kind of data: anthropometric data, in particular, data on adult height. Anthropometric data are often used by economic historians to supplement traditional measures like GDP, especially in cases where the recording of traditional economic indicators is lacking. Additionally, anthropometric data sources can provide a more direct measure of living standards, as they are directly tied to the health and nutrition status of the population under study (Brainerd, 2010).

On an individual level, height is primarily a function of childhood nutrition and genetics––but when aggregated to a wider population, the influence of genetics is greatly diminished. The average height of adults has increased in high income countries over the past two hundred years, and the pace of this change greatly exceeds the pace of change that could be explained by evolution (Perkins et al., 2016). Indeed, rapid growth in average adult height can be seen today in rapidly developing LMICs—in many cases it can even be observed year by year. These changes should be viewed as entirely divorced from genetics. The gene pool could not possibly change so rapidly (Perkins et al., 2016).

Therefore, average height is often used as a measure of socioeconomic well-being in an international development context, as it is a function of sanitation, proximity to disease, and net nutrition, the last of which plays by far the greatest role in determining adult height (Perkins et al. 2016; Silventoinen 2003). Economic historians have typically used adult height data to compare the long term growth paths of nations. However, adult height data can be used to analyze more acute events as well. Researchers have used modern adult height data to better understand the health impacts of multiyear famines in China (1959-1961) and the Netherlands (1944-1945) for example (Huang et al., 2010; Portrait et al., 2017).

Not only does using anthropometric data solve problems with the reliability of economic data, one could argue height is actually a tighter proxy for a population's well-being than monetary figures, given its direct relation to nutrition, health, and expected longevity.

Prenatal nutrition plays an important role in determining height, but early childhood, post-birth nutrition is most important. While some researchers pin the most important period to the time between conception to about 4 years of age, for this paper we will use the more precise estimate provided by another modern pediatrics study (Perkins, 2016; Silventoinen, 2003; Bogin, 1999). In a systematic review of data from 54 developing countries published by the American Academy of Pediatrics, height was determined to be most associated with nutrition during the prenatal period and up to 24 months after birth (Victorial et al., 2010). We will use this span in our analysis.

Use of anthropometric data in Soviet economic history

No anthropometric studies that focus on the Great Terror could be located. However, a number of economic historians have utilized anthropometric data to glean new insights about Russia's distant past. Boris Mironov's study of adult heights in the late Tsarist era provides compelling evidence that increased taxation and feudal dues in the late 18th century led to worse health for peasants (Mironov, 2008). Another of Mironov's studies uses growing discrepancies in height between social classes to bolster the commonly-held belief that the anti-tsarist revolution in 1917 was the result of persistent, growing inequality (Mironov, 1999).

Anthropometric data have also been used to study Russia's more recent history. The economist Elizabeth Brainerd uses infant mortality, adult mortality, child height, and adult height data to investigate the beginning of the economic collapse of the Soviet Union. Brainerd focuses on child and adult height because they "directly measure the well-being of a population in terms of health status, nutrition, and longevity" and are less affected by the undercounting that plagues mortality data (Brainerd, 2010). No studies could be found that employ anthropometric data to analyze quality of life in the USSR in the 1930's, the period analyzed in this paper.

Potential influence of terror on childhood health and adult height

If the Great Terror did have a negative economic impact, this impact would reduce families' ability to provide their children with adequate nutrition. This would be reflected in the average heights of adults born during the Great Terror, with adults born during the Great Terror having lower average heights than those born immediately before or after.

Given the nature of Stalinist terror policies, this outcome is entirely plausible. For those purged, their family and acquaintances were under serious threat. According to NKVD order 001233, when one member of a family was arrested (typically the patriarch) the rest of the family was then to be deported to "distant regions". In the case of military desertion or a civilian's attempted escape abroad during the Terror, the deserter's entire family could be arrested, whether or not they knew of their family member's plans. Generally, any person suspected of knowing of an alleged offense before it occurred could be purged or executed. Only children under 12 years old were eligible to be spared from purging due to association with an "enemy of the state" (Conquest, 2008).

These policies forced many families into exile in rural regions, which would have had significant impacts on the health of young children. Meanwhile, it seems highly likely that many children would have been orphaned during the Terror, with both of their parents, and even any siblings over 12 years old, liable to be purged because of one family member's offence.

In cases of orphaning due to the purge of parents, there would likely have been little in the way of a social safety net. In the years following the Great Famine, for example, the number of homeless orphans is rumored to have been reduced by government-mandated shooting (Conquest, 2008; Orlov, 1953). While there is no evidence for the execution of purge orphans, there is little reason to expect the Soviet government would have gone to the trouble to vastly increase its capacity for orphan care in the time between the famine and the Great Terror. Additionally, given that being associated with someone who had been purged was officially a criminal offence, relatives, neighbors, and friends of those purged were likely hesitant to care for their remaining children. Many children born during the Terror presumably struggled to survive in families that had been exiled, lost a breadwinner, or had both parents purged.

Model:

This paper seeks to analyze whether Stalinist repression significantly affected the health and well-being of those living in the areas most-affected through use of linear regression, with an adult height for birth year z-score as the dependent variable. This regression is run five times, for five separately defined geographical zones.

Equation 1: Regression model used. Dependent variable: height for birth year z-score.

$$\boldsymbol{Z_{it} = \beta_0 + \beta_{1,g} BornDuringTerror + \beta_{2,g} BornDuringFamine + \beta_{3,g} Education + \beta_{4,g} Gender + \beta_{5,g} BirthplaceType + \beta_{6,g} BirthRegion + \beta_{7,g} Rainfall + \mu_i}$$

i = individual t = year of birth g = geographic zone under study

Our outcome variable is modelled after the height for age z-score, a common metric used to measure childhood stunting in international development. The height for age z-score compares the height of children in a sample to the average height of children their age among a reference population (typically the global average). The deviation between a child's height and the average height for a child their age is then divided by the standard deviation of heights among children in the reference population (WHO, 2018). For our analysis, heights of Soviet adults are compared to the average heights of Eastern European adults of the same gender and birth year.

Equation 2: Z-Score creation.

$$\boldsymbol{Z_{it} = \frac{Height - Avg\ Height\ for\ Gender\ and\ Birth\ Year\ Among\ Eastern\ European\ Cohort}{St.Deviation\ of\ Heights\ for\ Gender\ and\ Birth\ Year\ Among\ Eastern\ European\ Cohort}}$$

Hence, our outcome variable measures the deviation in Soviet heights from average heights for gender and birth year in Eastern Europe. The six Eastern European countries used to create these averages (Austria, Czech Republic, Estonia, Poland, Slovenia, and Sweden) were selected for their proximity and similarity to the USSR. Therefore, changes in our outcome variable can be attributed to events and policies affecting the USSR but not the rest of Eastern Europe. This eliminates the possibility of confounding due to regional or global growth trends in adult height.

Additionally, there is a steady, if inconsistent growth trend in adult height in the RLMS data. The z-score effectively controls for the continuous rise in heights that occurred in the Soviet Union throughout the Stalin era. Without normalization based on an outside reference point, the regression analysis would potentially be biased by the fact that those born in earlier years were shorter than those born later in the Stalin era.

For our analysis, we use an indicator variable for whether or not one was born during the Great Terror. We run three separate regressions to gauge the impacts of terror on adult height. Regression 1 is used to analyze whether being born during the Great Terror had an impact on those born within the areas most affected by Terror (the "terror zone"); Regression 2 analyzes whether being born during the Great Terror had an impact on adult height for those born outside of the terror zone; and Regression 3 analyzes whether being born during the Great Terror had a negative impact on adult height for those born in the USSR as a whole.

Segmenting by whether or not one was born within the terror zone allows for a better understanding of whether any observed negative shocks to height during the terror period are truly a result of the presence of terror: negative terror-related impacts should only be present (or at least be most significant) for those born within the terror zone. For the purposes of this analysis, both Mass and National Operations are considered to be a part of the Great Terror. Therefore, all areas targeted by these repression campaigns are considered part of the terror zone.

A number of controls are included to ensure that any measured impacts on adult height are in fact the result of Stalinist policies. Climactic factors are accounted for through use of regional annual rainfall data, taken from sites throughout the RSFSR and neighboring countries. Additionally, birthplace type (urban or rural) and region are controlled for, in addition to socioeconomic factors (years of education) and gender. A model that interacts the presence of terror with whether or not one was born in the terror zone could be used, but it is expected that the effect of each of the control variables may vary by the zone under study. For example, the effect of years of education and rainfall on adult height may vary significantly for those inside and outside of the terror zone, especially given that the terror zone contains the two largest urban areas in the USSR, while the non-terror zone is predominantly rural.

An identical set of regressions measuring the impact of being born during the Great Famine are also included. Regression 4 analyzes the impact of being born during the Great Famine on those born in the famine zone, and Regression 5 analyzes the impact of being born during the terror or famine on those outside of the famine zone.

We also wish to test the hypothesis that the Great Terror was a predominantly urban phenomenon, while the Great Famine primarily impacted rural areas. Therefore, we also run the regression model for only those members of the study sample born in urban areas (Regression 6) and for only those members of the study sample who were born in rural areas (Regression 7). It is also expected that the Great Terror impacted the health of upper class soviets more than lower class soviets, while the opposite was true of the Great Famine. Therefore, the model is also run for solely upper class (Regression 8) and solely lower class members of the study sample

(Regression 9).

The regression model was also run with a dummy variable for being born during WWII, because the war likely had differential impacts on health in the Soviet Union compared to other Eastern European nations. We would therefore want to control for this period of deviation when analyzing the famine and terror as periods of potential deviation. However, the born during WWII dummy variable was not statistically significant in any regression, likely due to the small number of RLMS respondents born during the WWII period (See Table 3 in appendix). For simplicity, the WWII coefficient is not included in the final model.

Data:

Adult height data for this analysis comes from the Russian Longitudinal Monitoring Survey (RLMS), a joint project by Moscow’s Higher School of Economics and the University of North Carolina’s Carolina Population Center. The study is ongoing, but so far has followed a cohort over the course of 15 years. Only adults born under Stalin (from when he solidified his position as sole ruler in 1928 until his death in 1953) are factored into our analysis. The inclusion of years with average heights vastly different from the treatment years under study (say, in the 2000's after decades of post-Stalin economic and adult height growth) could easily lead to erroneous conclusions. Though the RLMS began in 1994, it does include 10,486 individuals born during the Stalin era.

The data used to construct the Eastern European benchmarks for computing adult height for birth year z-scores come from the Survey of Health, Ageing, and Retirement in Europe (SHARE), a project of the Max Planck Institute for Social Law and Policy (CenterData, 2019).

More than 120,000 adults age 50+ from 27 European nations were surveyed, though only the 6 Eastern European nations (Sweden, Slovenia, Czech Republic, Poland, Estonia, and Austria) closest to Russia are used to calculate average heights in Eastern Europe for each gender and birth year.

The RLMS data include 1,436 individuals born during the Great Terror and 531 individuals born during the Famine. These sample sizes are substantial. However, this analysis is primarily focused on pinning down the regional effects of terror and famine. Given that the RLMS breaks respondents into 38 different sampling regions, and effect sizes on our outcome variable are likely to be small, power begins to disappear quickly. This is a problem that will make obtaining conclusive results for our analyses challenging. However, the regional sample sizes are not so small that they make this analysis unproductive, or coming away with meaningful insights impossible. Nearly every region sampled contains at least 200 individuals born during Stalin's rule.

Defining the famine and terror zones

Figure 1: Map of Terror Zone. Darker shading denotes targeted area.

All areas targeted by Stalin under Mass or National Operations are considered to be part of the terror zone. Mass Operations were centered upon Moscow; all those born in Moscow are considered to have been born in the terror zone. National Operations were more diffuse. As under Mass Operations, purged individuals were either sentenced to gulag labor or executed. Targeted nationalities included Germans, Koreans, Poles, and Ukrainians (Gregory 2005). Targeted nationalities were purged from their home regions, either in the provinces or in soviet republics. Therefore, all those born in the Volga region (repression of Germans), Belarus (repression of Poles), Ukraine (repression of Poles, Ukrainians), the far east (repression of Koreans), and Saratov Oblast (repression of Poles, Germans) were coded as being born in the terror zone (Sommer 2010; Armstrong 1990; Gelb 1995). In total, our sample contains 1,344 individuals born in the terror zone. Two hundred and thirty-four members of this sample were born during the Great Terror period.

Figure 2: Map of Famine Zone. Darker shading denotes heavily-impacted area.

The Ukraine, Kazakhstan, and several rural regions of the RSFSR were hit hardest by the Great Famine. Those born in Ukraine, Kazakhstan, the Southern Caucasus, the Northern

Caucasus, West Siberia, the Southern Urals, and the Volga region were coded as being born within the famine zone (Werth, 2008). In total, 1,689 of the adults under study were born in the famine zone, with only 59 of these born during the Great Famine. This small sample size will hinder our analysis.

Controls

The critical variables from the RLMS under study are adult height (in centimeters), population sampling unit, republic of birth, gender, and education. The adults sampled vary in age at time of measurement by about thirty years. Therefore, adult heights are corrected for shrinking through use of a formula developed by JD Sorkin and used in a study of Eastern European height trends published in *Economics and Human Biology* (Sorkin et al. 1999; Webb et al. 2008). Through use of birth years and response recording dates from SHARE and the RLMS, each person's height is normalized from their measured height to their theoretical height at 45 years of age, the age at which shrinking generally begins (Niewenweg et al. 2009).

Unfortunately, though the RLMS does contain detailed data on family socioeconomic status, those born during Stalin's rule are asked about their occupational history and the well-being of their children—rather than about their own parents and childhood. Therefore, these questions do not provide sound measures of early life social status. Our best estimator for early life social class is therefore years of education. Children's educational levels have repeatedly been shown to be highly tied to their parents' income and socioeconomic status across a variety of contexts (IMF 2012; De Witt 2013). Education level is used as a control for socioeconomic status in every regression. For our analysis of the impact of famine and terror on those of higher and lower social status, members of the sample population are considered to be of lower social status if they did not graduate high school, and of higher social status if they did graduate high school.

While our analyses do not explicitly control for typical levels of nutrition in each area, including dummy variables for birthplace type and region of birth should control for differential levels of health in urban vs. rural environments, and in different regions. The birthplace type variable from the RLMS is used to code individuals as having been born into a rural or urban environment. We also code those who were born in semi-urban areas as having been born in an urban environment. The divide in health between urban and rural areas is expected to be stark given Stalin's harsh grain requisition policies, which forced rural farmers to give most of their crop to Soviet authorities for distribution in urban centers.

For our analysis, we rely on breaking respondents up by the sub-region of Russia they were born in, using the RLMS' population sampling region variable. The RLMS does not contain information on what population sampling region respondents were born in, but the survey does ask participants if they have ever moved. Therefore, when categorizing by population sampling region, movement can be accounted for, though at the expense of statistical power. For example, in our first regression, those sampled in the regions of the RSFSR that are considered part of the terror zone are coded as having been born in the terror zone only if they have never moved. The RLMS does contain information on what republic respondents were born in, which is useful given the Ukraine and Kazakhstan are considered part of the famine zone.

Because adult height is most affected by childhood nutrition, non-policy related climactic factors that could affect crop growth should be accounted for in our analysis, though this data is not provided in the RLMS. Rainfall trends, in particular, should be controlled for. Historic annual rainfall data are pulled from the World Bank's Climate Change Knowledge Portal for the relevant years (1927-1953) in the non-Russia nations under study (Ukraine, Kazakhstan, and Belarus). While aggregate annual rainfall data for Russia is provided by the World Bank, our analysis focuses on several sub-regions of the RSFSR, meaning a more specific data source is needed to account for differences among these sub-regions.

Fortunately, the US Department of Energy's Carbon Dioxide Information Analysis Center (CDIAC) contains daily rainfall data from 223 sampling sites in the USSR, over the years spanning 1881 to 2010, though not all stations began operations at the same time (CDIAC 2018). From these daily tallies, annual totals are calculated. Each of the 38 sampling regions within the RSFSR used in this analysis is matched with its nearest rainfall sampling site, using geographic coordinates provided by the CDIAC.

Through use of the World Bank and CDIAC data, annual rainfall totals for each sampling region and nation are calculated, as is the annual average rainfall total for the period under study (1927 to 1953). For each RLMS respondent, the deviation between the annual rainfall total in their year of birth and the average annual rainfall total in their region of birth is calculated, as is the deviation in the year following birth. These two deviations are then averaged to calculate the "rainfall deviation" in the respondents' region of birth during the two critical growth years. In this way, variation in regional rainfall trends is controlled for. The same process is used for those born outside of the RSFSR, using the annual World Bank data.

Determining the "born during the Great Terror" window

We use birth year data from the RLMS to create a dummy variable for whether or not an individual was born during the period of the Great Terror's greatest impact. Officially, the Great

Terror lasted until the last day of November 1938. Yet, the cumulative effect of the removal of members of the population, and the difficulty adjusting to missing family members, managers, and workers would have lasted for at least several months post-Terror, if not through all of 1939.

Adult heights are most affected by prenatal nutrition and childhood nutrition between months 0-24 (Victoria et al. 2010). The effects of the Terror were greatest in 1937, 1938, and 1939. Therefore, we will consider the period of the terror's greatest effects as running from January 1, 1937 to December 31, 1939. The only children who would have experienced the greatest effects of terror during both critical growth years (from 0-1 and 0-2) would have been those born during 1937 and 1938.

However, most children born during 1939 would have experienced at least nine months of terror's greatest impact during the critical growth period, with those born earlier in 1939 experiencing more. For example, a child born on January 1, 1939 would have experienced 1 year of critical postnatal growth and 9 months of critical in utero growth during the Great Terror, while a child born on December 31, 1939 would still have experienced 9 months of critical growth during the terror period. Therefore, all children born from 1937 to 1939 are considered to be born during the Great Terror. The Great Famine was at its peak for two years as well, from 1932 to 1933. Therefore, by the same logic, all children born from 1932 to 1934 are considered to have been born during the Great Famine.

Results:

Terror zone results

Table 1a: Abbreviated regression results for inside and outside of the terror zone. Dependent variable: deviation in adult height for birth year z-scores.

VARIABLES	(1) In Terror Zone	(2) Outside of Terror Zone	(3) Entire USSR
Terror Period	-0.183**	-0.0686**	-0.0870***
	(0.0790)	(0.0332)	(0.0305)
Famine Period	-0.252	-0.107*	-0.124**
	(0.164)	(0.0632)	(0.0590)
Graduated Primary	0.457***	0.201***	0.221***
	(0.155)	(0.0451)	(0.0431)
Graduated Secondary	0.455***	0.320***	0.326***
	(0.147)	(0.0417)	(0.0400)
Graduated Tertiary	0.715***	0.498***	0.516***
	(0.153)	(0.0470)	(0.0445)
Unknown Education Level	0.745	0.512***	0.524***
	(0.522)	(0.138)	(0.133)
Rural Birthplace	0.0550	-0.105***	-0.0938***
	(0.102)	(0.0289)	(0.0277)
Unknown Birthplace Type	0.324	-0.247**	-0.233**
	(0.710)	(0.104)	(0.102)
Rainfall	0.000167	-0.000158	-8.31e-05
	(0.000307)	(0.000148)	(0.000134)
Constant	-1.332*	-0.950***	-0.965***
	(0.725)	(0.0454)	(0.0437)
Observations	1,190	8,188	9,378
R-squared	0.041	0.037	0.038
Region Control	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Stalinist repression may have had a negative impact on quality of life for those born during the terror years. This finding is not only supported by the coefficient on being in the terror zone in Regression 1, but by the coefficients on being born during the terror years in all three regressions.

The effect of being born during the Great Terror was greatest for those born within the Terror Zone. Those born in the Terror Zone during the Great Terror had adult height for birth year z-scores -0.183 lower than those born in the Terror Zone during other periods ($p<.05$). Crucially, the impact on height for birth year z-score of being born during the Great Terror was greater for those within the Terror Zone ($\beta_{1,1}$= -0.183, $p<.01$) than for those born outside of the Terror Zone ($\beta_{1,2}$=-.0686, $p<.01$) and for all those born in the USSR as a whole ($\beta_{1,3}$=-0.0870, $p<.05$). Both of these differences are statistically significant at the $p < 0.1$ level.

Additionally, multiple controls proved significant. Increasing education levels resulted in statistically significant rises in adult height, with higher education levels consistently resulting in greater adult height relative to those born during the same year in Eastern Europe. In Regression 3 (for the entire USSR), those born in urban and suburban regions had greater adult heights than those born in rural areas. In Regression 3, only 9 of 54 birth regions were statistically significant predictors of z-scores. Rainfall deviation was also an insignificant predictor of height for birth year z-score across all regressions.

Famine zone results

Table 1b: Abbreviated regression results for inside and outside of the famine zone. Dependent variable: deviation in adult height for birth year z-scores.

VARIABLES	(3) Entire USSR	(4) In Famine Zone	(5) Outside of Famine Zone
Famine Period	-0.124**	-0.218	-0.109*
	(0.0590)	(0.146)	(0.0646)
Terror Period	-0.0870***	-0.116	-0.0796**
	(0.0305)	(0.0733)	(0.0341)
Graduated Primary	0.221***	0.134	0.237***
	(0.0431)	(0.101)	(0.0477)
Graduated Secondary	0.326***	0.212**	0.347***
	(0.0400)	(0.0964)	(0.0440)
Graduated Tertiary	0.516***	0.417***	0.534***
	(0.0445)	(0.109)	(0.0488)
Unknown Education Level	0.524***	0.973*	0.517***
	(0.133)	(0.588)	(0.138)
Rural Birthplace	-0.0938***	-0.165	-0.0873***
	(0.0277)	(0.103)	(0.0289)
Unknown Birthplace Type	-0.233**	-0.259	-0.225**
	(0.102)	(1.007)	(0.104)
Rainfall	-8.31e-05	-9.80e-05	-5.86e-06
	(0.000134)	(0.000170)	(0.000216)
Constant	-0.965***	-0.589	-0.988***
	(0.0437)	(1.015)	(0.0474)
Observations	9,378	1,586	7,792
R-squared	0.038	0.052	0.035
Region Control	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results from the famine-centric regressions are slightly less clear, though they do imply that Soviets born during the famine years are generally shorter in relation to their contemporaries in Eastern Europe than those born during other periods of Stalinist rule ($\beta_{2,3}$ = -

.124, p < .05). This coefficient suggests that health impacts due to famine were larger than health impacts due to terror when analyzing the USSR as a whole.

Likely due to a small sample size, the effect on height for birth year z-score of being born during the famine years was not statistically significant for those within the famine zone (Regression 4). Meanwhile there was a statistically significant, negative effect of being born during the famine for those outside of the famine zone (Regression 5).

This result should not be considered evidence that those born outside of the famine zone during the Great Famine were actually healthier than those born within the famine zone. Only 59 RLMS participants were born within the famine zone during the Great Famine, while 305 respondents were born outside of the famine zone during the Great Famine. This, coupled with the fact that the famine zone was the only region for which a statistically significant drop in z-scores was not recorded during the Great Terror, suggests that a small sample size could be driving the lack of statistical significance for those born within the famine zone.

Differential effects in urban and rural areas

Table 1c: Abbreviated regression results, with the model run separately for RLMS respondents born in urban and rural areas. Dependent variable: deviation in adult height for birth year z-scores.

VARIABLES	(6) Urban Areas	(7) Rural Areas
Terror Period	-0.103*	-0.0544
	(0.0569)	(0.0502)
Famine Period	0.0569	-0.152*
	(0.125)	(0.0916)
Graduated Primary	0.214*	0.200***
	(0.123)	(0.0586)
Graduated Secondary	0.292**	0.347***
	(0.115)	(0.0542)
Graduated Tertiary	0.513***	0.476***
	(0.117)	(0.0674)
Unknown Education Level	0.260	0.670***
	(0.280)	(0.210)
Rainfall	-9.69e-05	-0.000667
	(0.000685)	(0.000757)
Constant	-0.945***	-1.063***
	(0.112)	(0.0485)
Observations	2,525	3,792
R-squared	0.025	0.026
Region Control	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The Great Famine was a primarily rural phenomenon, but the Great Terror was centered upon intense repression of Stalin's enemies in Moscow and Leningrad, the USSR's two largest cities. This difference between the two events is reflected in the results of our regressions. For those born in urban areas, only being born during the Great Terror had a statistically significant, negative impact on adult height ($\beta_{1,6}$= -0.103, p<.1). For those born in rural areas, only being born during the Great Famine had a statistically significant, negative impact on adult height ($\beta_{2,7}$= -0.152, p<.1).

Differential effects among social classes

Table 1d: Abbreviated regression results, with the model run separately for RLMS respondents of low and high social class. Dependent variable: deviation in adult height for birth year z-scores.

VARIABLES	(8) High Social Class	(9) Low Social Class
Terror Period	-0.101***	-0.0483
	(0.0366)	(0.0571)
Famine Period	-0.0522	-0.248***
	(0.0823)	(0.0902)
Rural	-0.115***	-0.177***
	(0.0303)	(0.0638)
Unknown Birthplace Type	-0.0258	-0.673***
	(0.121)	(0.236)
Rainfall	1.17e-05	-0.000178
	(0.000162)	(0.000251)
Constant	-0.568***	-0.756***
	(0.0235)	(0.0589)
Observations	6,551	2,759
R-squared	0.018	0.041
Region Control	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

While our proxy for early life socioeconomic status (years of education) is not perfect, it does allow us to explore whether the Terror and Famine had differential impacts on certain social classes. The famine was mostly man-made—a result of Stalin forcing poor, rural farmers to give up what grain they had in order to feed residents of the USSR's major cities. Therefore, we would expect the famine to affect the poor much more than those of higher social classes. Meanwhile, during the Great Terror Stalin primarily targeted political enemies. It seems likely that those who qualified as potential enemies of the state would have been more powerful members of Soviet society, and thus those of higher social class would have have been more heavily impacted by the Great Terror.

Our results suggest both of these assumptions may be correct. For those of high social class (as measured by level of education), only being born during the Great Terror was predictive of statistically significant drops in z-score ($\beta_{1,8} = -0.101$, $p<0.01$). Meanwhile, for those of low social class, only being born during the Great Famine was predictive of statistically significant drops in z-score ($\beta_{2,9} = -0.248$, $p<0.01$).

Discussion:

The problem of survivorship bias

Survivorship bias could be playing a significant role in determining the results of these regressions, and even be playing a role in determining the sample sizes used to derive these results. Obviously, the sample size within the famine zone is low, given that the famine zone represents a relatively small (and relatively rural) portion of the USSR. In addition, RLMS respondents would have needed to live until at least their mid 60's (if they were born during the Great Famine) to be recorded in the early rounds of the RLMS. Given that life expectancy in the 1930's in the USSR was roughly 40 (due in large part to high infant and child mortality), only the healthiest among those born during the Great Famine would have lived to have their heights recorded.

This could hinder our ability to detect drops in standard of living due to famine. There could be upward bias in our results: the children most affected by famine died as infants, while many other heavily affected children likely did not live to be surveyed in their sixties. If only the healthiest survive, survivors would presumably be amongst the tallest members of the population born during a particular period, making comparisons between effects on adult height for those inside and outside of the famine zone difficult to interpret.

The data do suggest that survivorship bias is a significant problem. It is reasonable to assume that a relatively small fraction of RLMS participants would have been born in the early 1930's, given these respondents would need to be in their mid 60's to participate in the survey, while those born in the final year of Stalin's rule would only need to be 41.

Table 2: Birth years of sample respondents. Full table in appendix.

Birth Year	Frequency	Percentage
1928	274	2.76
1929	279	2.81
1930	312	3.14
1931	290	2.92
1932	289	2.91
1933	75	0.76
1934	260	2.62
1935	339	3.42
1936	363	3.66
1937	499	5.03
1938	483	4.87
1939	478	4.82
1940	436	4.39

Indeed, there is generally a steady upward trend in respondents by birth year, rising from 274 respondents born in 1930, to 592 born in 1953 (See Table 3 in appendix for full data). Yet, there is strong evidence that those born in the famine years are uniquely underrepresented in the RLMS. Among all RLMS respondents born during the Stalin era, 3.7% were born during the Great Famine in 1932 and 1933, while 6.1% were born in the two years preceding the famine (1930 and 1931). Further, 5.6% were born in the two-year period between 1928 and 1929.

Much of this drop-off can be attributed to the fact that only 0.76% of sample respondents were born during 1933, when the Great Famine was at its peak. This result suggests that premature mortality due to the famine was significant—and could result in significant upward bias in our results, as well as diminished sample sizes with which to work. Both decrease the likelihood of finding a statistically significant, negative deviation in height for birth year z-scores during the Great Famine.

This problem does not appear to be as big of a factor in our terror results. A greater percentage of respondents were born during the three-year terror period (15%) than in the three-year period preceding it (10%). Still, with measurement taking place decades after the events under study, survivorship bias is likely influencing our results. The fact that statistically significant drops in z-score are still detected by our model suggests our approach is fairly robust to survivorship bias—and the impact of the Great Terror and Great Famine must have been felt even by those who survived into old age.

Comparing famine and terror

Despite potential confounding due to survivorship bias, the impact of being born during the Great Famine on height for birth year z-scores ($\beta_{2,3}$ = -.125) in the USSR taken as a whole was greater than the impact of being born during the Great Terror ($\beta_{1,3}$ = -.083). This is to be expected, given that the famine resulted in more direct deaths than the Great Terror, and directly impacted food output and child nutrition.

The fact that being born during the Great Terror period had a negative impact on adult height for the former Soviets under study relative to adult height for those born in neighboring Eastern European nations (and controlling for climactic, regional, and socioeconomic factors) suggests that there was a systematic difference between these Eastern European nations and the USSR during this timespan, which was impacting child health and nutrition. Obviously, these Eastern European nations would not have experienced the impacts of Stalinist terror, making the Great Terror a potential culprit for the drop in z-scores observed for those born in the USSR during this period.

The fact that the drop in z-scores during this period was greatest for those born within the terror zone compared to all other geographically defined zones under study provides further evidence that Stalinist terror may have been driving drops in standard of living that systematically diminished levels of child health during the Great Terror period.

For those from the terror zone, being born during the Great Terror is associated with a -.183 drop in height for age z-score. According to our data, men born during the Great Terror are therefore 0.98 cm shorter relative to their Eastern European contemporaries than men born within the terror zone at other times. For women, the difference is .84 cm (due to slightly lower standard deviation among women's heights).

These differences are not trivial. Economic historians Jörg Baten and John Komlos have concluded that for every centimeter a population increases its average height, life expectancy tends to increase by about 1.2 years (Komlos and Baten, 1998). While those who were purged certainly faced the gravest consequences of Terror, the toll on their families, children, and the rest of the USSR has mostly gone unrecorded. The results of this study indicate the impacts on the health of children who survived the Great Terror were likely significant.

The results of the regressions segmented by rurality and social class also confirm the historical narratives that surround the Great Famine and the Great Terror. The Terror was primarily an urban affair, and only those born in urban, rather than rural, areas showed decreased height due to being born during the Great Terror. The fact that only those of higher social class showed decreased heights due to being born during the Terror period suggests that Stalin systematically targeted potential enemies of higher social classes—perhaps those he considered most threatening.

Meanwhile, the Great Famine occurred in large part due to Stalin's harsh policies of grain requisition. It is because Stalin forced poor, rural farmers to surrender their grain for shipment to wealthier residents in the USSR's major cities that millions starved to death. It is no surprise, then, that being born during the Great Famine was predictive of drops in adult height for those of low social class and those born in rural areas, who had their grain seized, but not for those of high social class, or those born in urban areas, who received it. In our sample, being born during the famine period had almost twice as great of an impact on the sample of low social class respondents as the sample of rural respondents. While survivorship bias could be playing a role, our results suggest that social class was at least as important as geography in determining who suffered as a result of the Great Famine.

Taken together, the results of this analysis suggest that both the Great Terror and the Great Famine had long-term impacts on the health of the USSR's population. Perhaps more importantly, this study suggests that the use use of height data from modern longitudinal studies can provide new insights for economists and historians seeking to better understand the health impacts of events that occurred in the distant past, particularly in contexts where accurate collection of economic data did not occur. The usefulness of this approach is not limited to the Soviet context, though adult height data offers significant opportunities to measure quality of life under highly secretive, repressive regimes, like that of Josef Stalin. While the negative impacts of Stalinist repression may not have been recorded in Soviet output figures, there does appear to be a crude record visible in the heights of modern Russians.

Data Appendix:

Figure 1: Map of Terror Zone. Darker shading denotes targeted area.

Figure 2: Map of Famine Zone. Darker shading denotes heavily-affected area.

Figure 3: Average age-adjusted height of men by birth year.

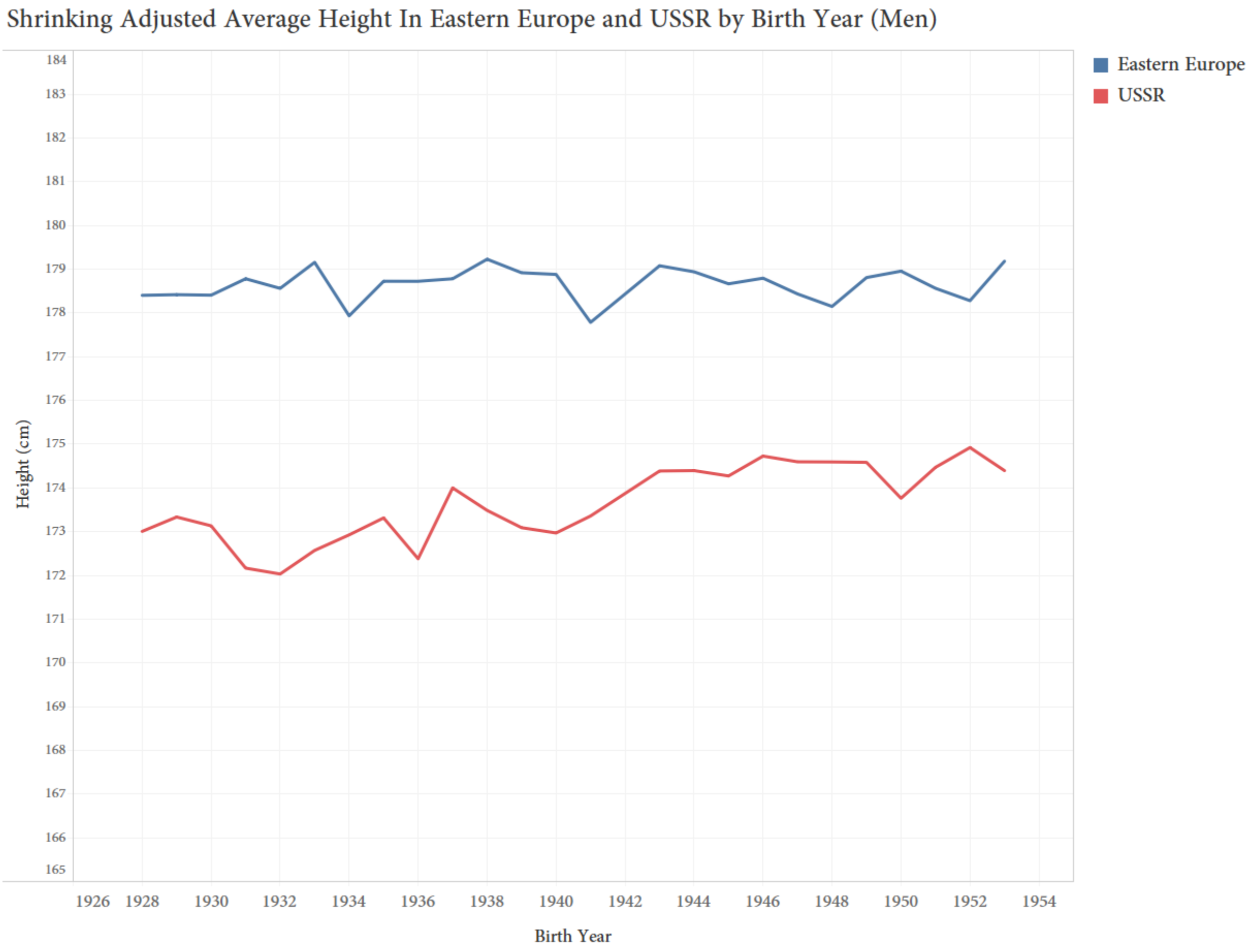


Figure 4: Average age-adjusted height of women by birth year.

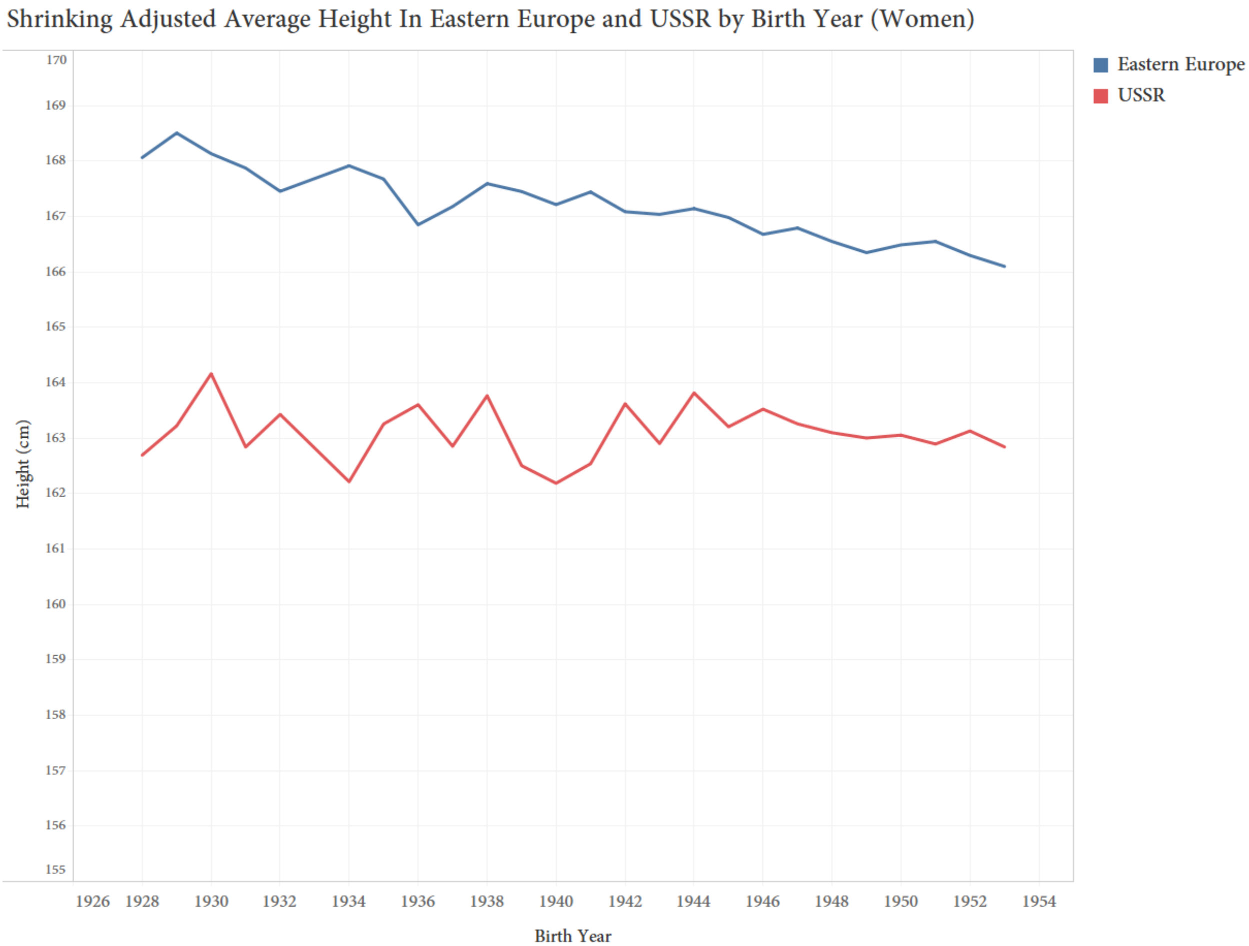
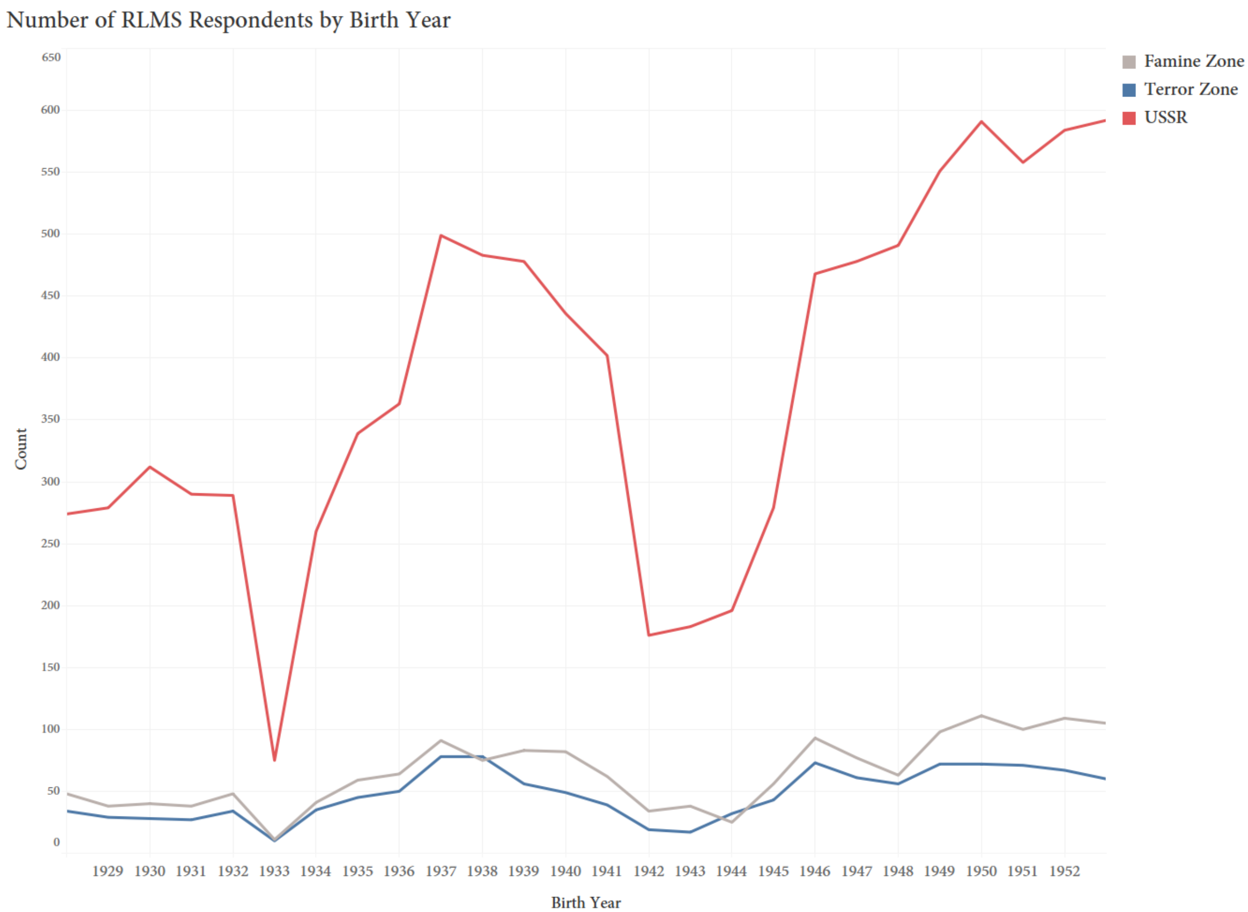


Figure 5: Number of RLMS respondents by birth year.



Equation 1: Regression model used. Dependent variable: height for birth year z-score. Model is run for 8 different cohorts.

$$\boldsymbol{Z_{it} = \beta_0 + \beta_{1,g}BornDuringTerror + \beta_{2,g}BornDuringFamine + \beta_{3,g}Education + \beta_{4,g}Gender + \beta_{5,g}BirthplaceType + \beta_{6,g}BirthRegion + \beta_{7,g}Rainfall + \mu_i}$$

i = individual t = year of birth g = geographic zone under study

Equation 2: Z-Score creation

$$\boldsymbol{Z_{it} = \frac{Height - Avg\ Height\ in\ Eastern\ Europe\ for\ Gender\ and\ Birth\ Year}{St.Deviation\ of\ Eastern\ European\ Heights\ for\ Gender\ and\ Birth\ Year}}$$

Equation 3: Test of statistical significance of difference between coefficients from separate regressions. Adapted from Clogg et al. (1995).

$$\boldsymbol{Z = \frac{\beta_2 - \beta_1}{\sqrt{(SD_{\beta_2})^2 + (SD_{\beta_1})^2}}}$$

Equation 4: Shrinking adjustment. Adapted from Webb et al. (2008).

$$Adjusted\ height = measured\ height + cumulative\ height\ change$$

For Men:

$$Cumulative\ height\ change = -0.0021age^2 + 0.1258age - 1.8829$$

For Women:

$$Cumulative\ height\ change = -0.0027age^2 + 0.1727age - 2.7616$$

Table 1: Abbreviated regression results for different birth zones. Dependent variable: deviation in height for birth year z-scores.

VARIABLES	(1) In Terror Zone	(2) Outside of Terror Zone	(3) Entire USSR	(4) In Famine Zone	(5) Outside of Famine Zone
Terror Year	-0.183**	-0.0686**	-0.0870***	-0.116	-0.0796**
	(0.0790)	(0.0332)	(0.0305)	(0.0733)	(0.0341)
Famine Year	-0.252	-0.107*	-0.124**	-0.218	-0.109*
	(0.164)	(0.0632)	(0.0590)	(0.146)	(0.0646)
Graduated Primary	0.457***	0.201***	0.221***	0.134	0.237***
	(0.155)	(0.0451)	(0.0431)	(0.101)	(0.0477)
Graduated Secondary	0.455***	0.320***	0.326***	0.212**	0.347***
	(0.147)	(0.0417)	(0.0400)	(0.0964)	(0.0440)
Graduated Tertiary	0.715***	0.498***	0.516***	0.417***	0.534***
	(0.153)	(0.0470)	(0.0445)	(0.109)	(0.0488)
Education Status Missing	0.745	0.512***	0.524***	0.973*	0.517***
	(0.522)	(0.138)	(0.133)	(0.588)	(0.138)
Rural Birthplace	0.0550	-0.105***	-0.0938***	-0.165	-0.0873***
	(0.102)	(0.0289)	(0.0277)	(0.103)	(0.0289)
Unknown Birthplace Type	0.324	-0.247**	-0.233**	-0.259	-0.225**
	(0.710)	(0.104)	(0.102)	(1.007)	(0.104)
Rainfall	0.000167	-0.000158	-8.31e-05	-9.80e-05	-5.86e-06
	(0.000307)	(0.000148)	(0.000134)	(0.000170)	(0.000216)
Constant	-1.332*	-0.950***	-0.965***	-0.589	-0.988***
	(0.725)	(0.0454)	(0.0437)	(1.015)	(0.0474)
Observations	1,190	8,188	9,378	1,586	7,792
R-squared	0.041	0.037	0.038	0.052	0.035
Region Control	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2: Abbreviated regression results for cohorts separated by urban/rural birthplace and early-life socioeconomic status. Dependent variable: deviation in height for birth year z-scores.

VARIABLES	(6) Urban Areas	(7) Rural Areas	(8) High Social Class	(9) Low Social Class
Terror Period	-0.103*	-0.0544	-0.101***	-0.0483
	(0.0569)	(0.0502)	(0.0366)	(0.0571)
Famine Period	0.0569	-0.152*	-0.0522	-0.248***
	(0.125)	(0.0916)	(0.0823)	(0.0902)
Graduated Primary	0.214*	0.200***		
	(0.123)	(0.0586)		
Graduated Secondary	0.292**	0.347***		
	(0.115)	(0.0542)		
Graduated Tertiary	0.513***	0.476***		
	(0.117)	(0.0674)		
Unknown Education Level	0.260	0.670***		
	(0.280)	(0.210)		
Rural			-0.115***	-0.177***
			(0.0303)	(0.0638)
Unknown Birthplace Type			-0.0258	-0.673***
			(0.121)	(0.236)
Rainfall	-9.69e-05	-0.000667	1.17e-05	-0.000178
	(0.000685)	(0.000757)	(0.000162)	(0.000251)
Constant	-0.945***	-1.063***	-0.568***	-0.756***
	(0.112)	(0.0485)	(0.0235)	(0.0589)
Observations	2,525	3,792	6,551	2,759
R-squared	0.025	0.026	0.018	0.041
Region Control	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Birth year frequency table for RLMS respondents.

Birth Year	Frequency	Percent of Sample
1928	274	2.76
1929	279	2.81
1930	312	3.14
1931	290	2.92
1932	289	2.91
1933	75	0.76
1934	260	2.62
1935	339	3.42
1936	363	3.66
1937	499	5.03
1938	483	4.87
1939	478	4.82
1940	436	4.39
1941	402	4.05
1942	176	1.77
1943	183	1.84
1944	196	1.97
1945	279	2.81
1946	468	4.71
1947	478	4.82
1948	491	4.95
1949	551	5.55
1950	591	5.95
1951	558	5.62
1952	584	5.88
1953	592	5.96

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Russian Longitudinal Monitoring Survey (RLMS) acknowledgement:

This paper was made possible by the data collection efforts of the researchers behind the RLMS. The "Russia Longitudinal Monitoring survey, RLMS-HSE", is conducted by Higher School of Economics and ZAO "Demoscope" together with Carolina Population Center, University of North Carolina at Chapel Hill and the Institute of Sociology RAS. (RLMS-HSE sites: http://www.cpc.unc.edu/projects/rlms-hse, http://www.hse.ru/org/hse/rlms)

Survey of Health, Ageing, and Retirement in Europe (SHARE) acknowledgement:

This paper uses data from SHARE Waves 1, 2, 3, 4, 5, 6 and 7 (DOIs: 10.6103/SHARE.w1.700, 10.6103/SHARE.w2.700, 10.6103/SHARE.w3.700, 10.6103/SHARE.w4.700, 10.6103/SHARE.w5.700, 10.6103/SHARE.w6.700, 10.6103/SHARE.w7.700), see Börsch-Supan et al. (2013) for methodological details.(1)

The SHARE data collection has been primarily funded by the European Commission through FP5 (QLK6-CT-2001-00360), FP6 (SHARE-I3: RII-CT-2006-062193, COMPARE: CIT5-CT-2005-028857, SHARELIFE: CIT4-CT-2006-028812) and FP7 (SHARE-PREP: N°211909, SHARE-LEAP: N°227822, SHARE M4: N°261982). Additional funding from the German Ministry of Education and Research, the Max Planck Society for the Advancement of Science, the U.S. National Institute on Aging (U01_AG09740-13S2, P01_AG005842, P01_AG08291, P30_AG12815, R21_AG025169, Y1-AG-4553-01, IAG_BSR06-11, OGHA_04-064, HHSN271201300071C) and from various national funding sources is gratefully acknowledged (see www.share-project.org).

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