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HUNGRY CHILDREN AGE FASTER

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Hungry Children Age Faster

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Abstract. We analyze how childhood hunger affects human aging for a panel of European individuals. For this purpose, we use six waves of the Survey of Health, Aging, and Retirement in Europe (SHARE) dataset and construct a health deficit index. Results from log-linear regressions suggest that, on average, elderly European men and women developed about 20 percent more health deficits when they experienced a hunger episode in their childhood. The effect becomes larger when the hunger episode is experienced earlier in childhood. In non-linear regressions (akin to the Gompertz-Makeham law), we obtain greater effects suggesting that health deficits in old age are up to 40 percent higher for children suffering from hunger. The wedge of health deficits between hungry and and non-hungry individuals increases absolutely and relatively with age. This implies that individuals who suffered from hunger as children age faster.

Keywords: health; aging; health deficit index; hunger episodes; childhood health.
JEL: I10, I19, J13.

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1. Introduction

Health shocks early in life influence late-life health outcomes. While most of the earlier studies establishing this link focused on child development in utero (Barker, 1992; Almond and Currie, 2011), more recent studies document a similar pathway for early life conditions to health in old age. The original "fetal origins" literature matured into a more general "developmental origins" literature (Gluckman et al. 2005; Almond and Currie, 2017). In particular, undernutrition in early life has been found to be detrimental to late-life health. Through the direct biological pathways of epigenetic changes and 're-programming' of bodily functions, undernutrition early in life causes metabolic dysfunction across all ages, resulting in a higher risk of diseases, such as diabetes, hypertension, and cardiovascular diseases later in life (McMillan and Robinson, 2005). Indirect effects are mediated through health behavior, cognitive and non-cognitive development, education, and socio-economic status in adulthood (Case et al., 2005; Kesternich et al., 2016; Havari and Peracchi, 2017).

In this paper, we extend the literature, which so far focused on the link between early-life circumstances and the *state* of adult health, by establishing a link between early life circumstances and the *change* of adult health as people get older. Specifically, we show that the experience of a hunger episode in childhood affects biological aging, measured by the accumulation of age-related health deficits with age. Across 14 European countries, elderly women who experienced a hunger episode between age 0 and 4, have developed 30 percent more health deficits by age 50 and 50 percent more health deficits by age 75, compared to women of the same age who did not suffer from hunger in childhood. Effects are somewhat smaller for men and when hunger was experienced from age 4 to 8. The qualitative conclusion, however, remains robust. Early-life nutritional shocks lead to faster biological aging later in life.[1]

The result that undernutrition in childhood affects aging is immediately plausible by noting that the diseases that have been associated with early-life nutritional shocks, like cardiovascular disease, diabetes, and hypertension, are chronic, age-related diseases. They can be considered as specific expressions of the general phenomenon of aging, understood as intrinsic, cumulative,

[1]Related studies on the impact of childhood hunger on the state of health later in life are Kesternich et al. (2016), van den Berg (2016), and Havari and Peracchi (2017). At a more general level, the influence of childhood exposure to World War II on adult health has been investigated by Kesternich et al. (2014), Halmdienst and Winter-Ebmer (2014), and Akbulut-Yuksel (2017). A large literature documents the impact of nutrition and disease exposure in childhood on adult height as a health indicator, see e.g. Fogel and Costa (1997); Case and Paxson (2008); and Bozzoli et al. (2009). An economic theory establishing the link between childhood nutrition and adult body size is provided by Dalgaard and Strulik (2015, 2016).

progressive, and deleterious loss of bodily function (Arking, 2006). A micro-foundation of the impact of childhood conditions on adult health is provided by the reliability theory of aging. Reliability theory explains why humans and other living organisms age although they are constructed of non-aging elements. A particular challenge is to explain aging such that mortality (the failure rate of the system) follows the Gompertz-Makeham law (Gavrilov and Gavrilova, 1991). To do so, it has been suggested that one can conceptualize human bodies as systems that achieve reliability not by the initial quality of their elements but through their large redundancy. Indeed, the functional capacity of organs in young adults is estimated to be tenfold higher than needed for mere survival (Fries, 1980). The fact that many elements are initially defective motivates aging according to the Gompertz-Makeham law. The "self-assembly" process of construction of living systems explains why many elements are already defective early in life. The number of initially functioning elements determines the speed of aging and the age at death. The final step is to note that nutritional deprivation reduces redundancies (of cells, organ tissue, etc) and increases initial damage (Gavrilov and Gavrilova, 2004).

In this paper, we follow Mitnitski et al. (2002) and measure health and aging by a health deficit index (a frailty index). This index measures the number of health deficits that a person has at a given age relative to the number of potential health deficits. Health deficits include mild nuisances as well as serious disabilities. The exact choice of deficits is not crucial provided that sufficiently many indicators are present in the index (see Rockwood and Mitnitski, 2006, 2007 for methodological background). The seminal paper by Mitnitski et al. (2002) has catalyzed a very large research program with hundreds of studies applying the methodology.[2]

Economically speaking, the health deficit index is a stock variable that accumulates as individuals age. We exploit this feature to measure the speed of aging by the increase of health deficits from one birthday to the next. We use six waves of the Survey of Health, Aging and Retirement in Europe (SHARE data set) and construct a health deficit index consisting of 38 symptoms, signs, and disease classifications for individuals of age 50 and above. We use information on hunger episodes in childhood from retrospective life data (wave 3 of SHARE)[3]. We

[2] Originally, the methodology was established by Mitnitski, Rockwood, and coauthors as the frailty index. Newer studies also use the term health deficit index (e.g. Mitnitski and Rockwood, 2016), which seems to be a more appropriate term when the investigated population consists, to a significant degree, of non-frail persons. A handful of studies have investigated the health deficit index (frailty index) using the SHARE data (Romero-Ortuno and Kenny, 2012; Harttgen et al., 2013, Theou et al., 2013; Romero-Ortuno, 2014; Abeliansky and Strulik, 2017).

[3] Only five waves of the SHARE have information on health related variables (1-2 and 4-6) but we use six waves in total since we use the information on the hunger episodes from wave 3.

then regress the health deficits of individuals at a given age on age and the hunger indicator. Employing a log-linear regression analysis, we find that childhood exposure to hunger leads to about 20 percent more health deficits at any given age in old age. Since health deficits increase exponentially with age, this means that the wedge of health deficits between exposed and non-exposed individuals gets larger as individuals get older. In non-linear regressions, akin to the Gompertz-Makeham law, we find even larger effects of hunger on aging and that the late-life health wedge between exposed and non-exposed individuals increases also in relative terms, i.e. that the factor by which the health deficit index of formerly hungry individuals exceeds the the health deficit index of non-hungry individuals increases with age. This means that individuals exposed to hunger do not only age faster but that the speed of aging accelerates faster than for non-exposed individuals.

One reason for the success of the health deficit index is that it is easily understood and implemented. The convenience of the health deficit index becomes particularly salient when we compare it with health capital, i.e. the latent variable in the focus of many studies in health economics (following Grossman, 1972). More importantly, the notion of health capital is not conducive to the understanding of early-life origins of late-life health. The reason is that according to health capital theory, healthy people (i.e. those with a large health capital stock), by assumption, lose more health capital through depreciation (see Almond and Currie, 2011). This creates an equilibrating force such that initial health differences (e.g. from exposure to nutritional shocks) are depreciated away as individuals age such that they play asymptotically no role in old age. The health deficit model (Dalgaard and Strulik, 2014), in contrast, predicts just the opposite. Small initial health differences are amplified with age such that the health wedge between initially well nourished and malnourished individuals becomes larger over time (Dalgaard et al., 2017). Subsequently, the consequences of initial health differences become salient and noticed for the first time when individuals reach old age. In the context of our study this means that evidence for a widening health wedge between individuals exposed to hunger and well-nourished children refutes the health capital model and supports the health deficit approach.

The paper is organized as follows. In Section 2 we describe the data. In Section 3 we estimate the relationship between the health deficit index, age, and hunger in childhood using log-linear panel regressions. In Section 4 we continue with non-linear (Gompertz-Makeham style) regressions and in Section 5 we estimate the impact of the length of the hunger episode on health and aging. Section 6 concludes.

2. Hunger and the Health Deficit Index

2.1. **Data Description.** We use the Survey of Health, Aging and Retirement in Europe (SHARE dataset release 6.0.0) for the empirical analysis.[4] We consider five waves (1, 2, 4, 5 and 6) that provide health-related information; for methodological details, see Börsch-Supan et al. (2013) and Gruber et al. (2014). Wave 1 took place in the year 2004, wave 2 in 2006/7, wave 4 in 2011 (in 2012 for Germany), wave 3 in 2008/2009 (except Ireland 2009-2011), wave 5 in 2013, and wave 6 in 2015. Wave 3 does not report health-related variables, since it is a retrospective wave from where we retrieve information on the hunger episodes (whether the person has had one, and if so, when). We considered individuals aged 50 and up to 85 of the 14 countries that participated in wave 3 and other waves: Austria, Belgium, Czech Republic, Denmark, France, Germany, Greece, Ireland, Italy, Netherlands, Poland, Spain, Sweden, and Switzerland.[5] We only kept individuals up to age 85 since a significant share of older people show "super healthy" characteristics, presumably because of selection effects.

For each individual, we constructed a health deficit measure following Mitnitski et al. (2002), which is described in greater detail in our earlier paper (Abeliansky and Strulik, 2017). Since we understand aging as the accumulation of health deficits, based on the available data, we considered 38 symptoms, signs and disease classifications, as summarized in Table A.1 in the Appendix. We followed Mitnitski et al. (2002) and coded multilevel deficits using a mapping to the Likert scale in the interval 0-1. Details on how each variable was constructed can be found in Table A.2 in the Appendix. We then computed the health deficit index as the proportion of deficits that an individual suffers from. When there were missing data for an individual, we computed the deficit index based on the available information about potential deficits (i.e. if for a given individual information was not available for x potential health deficits, the observed health deficits were divided by $38 - x$). From the surveyed individuals we kept only those with information on at least 30 health deficits. Due to missing values in the construction of the

[4]DOIs: 10.6103/SHARE.w1.600, 10.6103/SHARE.w2.600, 10.6103/SHARE.w3.600, 10.6103/SHARE.w5.600, 10.6103/SHARE.w5.600

[5]Although the main target is to survey adults aged 50 or above (aiming at the creation of a dataset that is representative of the non-institutionalized population of age 50+), younger people can also be found in the data since partners are also interviewed. These were removed since they do not belong to the representative sample. People are followed across time when possible but there are also sample refreshments in the different waves.

health deficit index or because of the lack of sufficient deficits to reach the 30-item minimum we lost 0.1% of the potential data set. After further cleaning of the data because of the age we considered and the fact that the log operator needs positive values, we kept 78% of the potential dataset for the panel analysis and 88% for the pooled regressions.

2.2. **Summary Statistics: Hunger Episodes.** Hunger episodes affected countries with different levels of severity. In Table 1 and 2 we report the summary statistics for wave 3 where individuals answered the question "Looking back at your life, was there a distinct period during which you suffered from hunger?". Less than 0.5% of the surveyed individuals did not respond to the question. If they replie "yes", they were asked "When did this period of hunger start?" and subsequently, "When did this period stop?". From these questions, we constructed the age at which individuals experienced a hunger episode and the length of the hunger period. We focus on hunger episodes suffered in childhood, subdivided in two periods: "early childhood" from age 0 to age 4 and "middle childhood" from age 4 to 8. The fourth birthday is included in the second period and excluded from the first period. The eighth birthday is excluded from the second period. In principle, individuals could have suffered another hunger episode, but they are likely to report the most severe period. We acknowledge that this fact is a limitation of our analysis.

Table 1. Hunger Episodes from Age 0 to 4 by Country and Gender

Country	Female				Male			
	Binary		Length		Binary		Length	
	Mean	Std. Dev.	Mean(>0)	Freq.	Mean	Std. Dev.	Mean(>0)	Freq.
Austria	0.018	0.134	7.333	494	0.036	0.187	7.615	360
Germany	0.033	0.178	5.500	916	0.020	0.141	8.353	844
Sweden	0.001	0.033	16.000	918	0.008	0.088	10.167	775
Netherlands	0.016	0.124	4.471	1,096	0.015	0.120	5.000	958
Spain	0.044	0.206	12.756	1,015	0.046	0.210	12.171	884
Italy	0.026	0.158	10.806	1,207	0.027	0.163	8.034	1,069
France	0.008	0.088	10.667	1,162	0.018	0.133	8.176	950
Denmark	0.001	0.032	4.000	969	0.001	0.034	5.000	866
Greece	0.020	0.139	17.630	1,369	0.025	0.157	15.000	1,225
Switzerland	0.010	0.098	8.833	618	0.006	0.076	19.000	519
Belgium	0.011	0.103	8.000	1,304	0.009	0.093	8.600	1,154
Czech Rep	0.004	0.065	10.250	944	0.005	0.074	9.250	732
Poland	0.015	0.123	9.467	971	0.017	0.130	15.643	812
Ireland	0.005	0.070	6.500	406	0.003	0.056	18.000	315
Total	0.016	0.125	10.300	13,389	0.018	0.131	10.597	11,463

Binary shows the summary statistics on the variable that reports whether people have suffered hunger or not. *Length* reports the average years that people have suffered the hunger episode, conditional on having had hunger (i.e. only people who have suffered hunger).

As shown in Figure A in the Appendix, most hunger episodes were experienced during or shortly after World War II. During this time, childhood hunger was a fairly common phenomenon and it was experienced independently from parental socio-economic status (Kesternich et al.,

Table 2. Hunger Episodes from Age 4 to 8 by Country and Gender

Country	Female				Male			
	Binary		Length		Binary		Length	
	Mean	Std. Dev.	Mean(>0)	Freq.	Mean	Std. Dev.	Mean(>0)	Freq.
Austria	0.047	0.211	5.609	494	0.058	0.235	6.857	360
Germany	0.073	0.261	4.925	916	0.078	0.269	5.076	844
Sweden	0.014	0.118	4.692	918	0.013	0.113	8.900	775
Netherlands	0.027	0.163	5.467	1,096	0.025	0.156	4.833	958
Spain	0.072	0.258	12.110	1,015	0.095	0.293	9.940	884
Italy	0.056	0.229	7.896	1,207	0.065	0.247	6.214	1,069
France	0.027	0.161	7.194	1,162	0.042	0.201	6.250	950
Denmark	0.003	0.056	3.000	969	0.003	0.059	3.333	866
Greece	0.037	0.189	16.725	1,369	0.045	0.207	11.500	1,225
Switzerland	0.019	0.138	6.917	618	0.012	0.107	11.500	519
Belgium	0.020	0.140	6.577	1,304	0.018	0.134	6.524	1,154
Czech Rep	0.010	0.097	8.111	944	0.007	0.082	9.200	732
Poland	0.035	0.184	8.059	971	0.048	0.214	8.923	812
Ireland	0.010	0.099	7.750	406	0.006	0.080	14.000	315
Total	0.033	0.179	8.610	13,389	0.039	0.193	7.787	11,463

Binary shows the summary statistics on the variable that reports whether people have suffered hunger or not. *Length* reports the average years that people have suffered the hunger episode, conditional on having had hunger (i.e. only people who have suffered hunger).

2016). Suffering from hunger is such a drastic childhood experience that even very young children have little problem recalling such a unique event. This is confirmed by a series of consistency checks provided in related studies. Kesternich et al. (2016) show that in Germany, where regional data on food rationing is available, the fraction of self-reported hunger varies closely over time with the amount of daily calories available per person. Van den Berg et al. (2016) show that the reported hunger episodes were very similar to those self-reported in a different survey for Germany (the German Socio Economic Panel). Havari and Mazzonna (2015) use external historical data and demonstrate that respondents of the SHARE-life survey seem to remember fairly well their health status and their living conditions between age 0 to 15. Nevertheless, we acknowledge that our analysis might suffer from recall bias. A further concern is that selective mortality removed the individuals from the sample who were most severely affected by hunger in childhood. Altogether this means that our estimates of the effect of childhood hunger on aging in old age should be considered as lower bounds of the actual effect.

In Table 1 we observe that Spain, Germany and Italy are among the countries with the highest percentage of female individuals having suffered from hunger between birth and age 4. In relative and absolute terms, the fewest hunger episodes were experienced in Sweden, Denmark and the Czech Republic. The numbers for males are fairly close to the ones of females (i.e. Spain having had the highest share of individuals with hunger between this age interval), except for Austria who holds the second position in the ranking with the highest share of males having reported a hunger episode. Table 2 shows the same statistics for the hunger spell in middle childhood. Again, Germany, Italy and Spain (with a minor change in ranking across genders) are among the countries whose population has suffered the most hunger spells (in relative terms). The mean length of the hunger episode refers to individuals who have actually had a hunger spell. The mean length of a hunger episode in early childhood is between 10 and 11 years, irrespective of gender. In middle childhood, the mean length of a hunger episode is almost 9 years for females and 8 years for males, with some variation across countries. This means that many individuals who experienced hunger in early childhood continued to experience it in middle childhood and that individuals who experienced hunger for the first time in middle childhood experienced it beyond age 8.

3. Panel Estimates

In this section we estimate a log-linear relationship between age, hunger episodes, and health deficits with the following equation:

$$\ln D_{igw} = r_g + \alpha_g \cdot age_{igw} + \gamma_g hunger_{ig} + \epsilon_{igw} \tag{1}$$

where the index i represents the individual, $g \in \{m, f\}$ the gender, and w the wave; age represents the age at the interview, hunger whether the person has suffered a hunger episode; and ϵ is the error term. We also include further covariates composed of wave dummies and country dummies. Equation (1) implies that health deficits grow exponentially with age akin to the Gompertz law of mortality:

$$D_{igw} = R_g \exp(\alpha_g \cdot age_{igw}) \exp(\gamma_g \cdot hunger_{ig}) \tag{2}$$

with $R_g = \exp(r_g)$. Exponential growth of health deficits can be motivated with a micro-foundation of aging from reliability theory (Gavrilov and Gavrilova, 1991; Dalgaard et al., 2017).

In the main text we consider all countries in the sample. In the Appendix we show results for the same regressions considering only war countries (all countries except Denmark, Ireland, Spain, Sweden, and Switzerland). By considering only war countries, we try to check whether hunger episodes affect health differently during times of war. Since our main variable of interest, hunger episodes, does not vary with age, we cannot use fixed effects to control for individual-level heterogeneity. Aside from OLS, we thus use a random effects estimator. Moreover, we use the correlated random effects estimator of Mundlak (1978). The Mundlak (1978) approach uses the means of the time changing variables in a random effects framework as an alternative method to fixed effects. In a balanced panel setting, the estimate of the coefficient of the time changing variables should be equivalent to the one of the within estimator.

Table 3. OLS and Random Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
constant	-4.188***	-4.248***	-4.180***	-4.241***	-4.167***	-4.247***	-4.151***	-4.235***
	(0.052)	(0.051)	(0.052)	(0.051)	(0.064)	(0.062)	(0.064)	(0.062)
age	0.034***	0.035***	0.033***	0.035***	0.028***	0.029***	0.028***	0.029***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
hunger 0-4	0.277***	0.274***			0.246***	0.232***		
	(0.042)	(0.042)			(0.049)	(0.049)		
hunger 4-8			0.183***	0.180***			0.185***	0.172***
			(0.029)	(0.036)			(0.034)	(0.034)
Method	OLS	RE	OLS	RE	OLS	RE	OLS	RE
Gender	Female	Female	Female	Female	Male	Male	Male	Male
Observations	43,791	43,791	43,791	43,791	36,129	36,129	36,129	36,129
Individuals	13,211	13,211	13,211	13,211	11,234	11,234	11,234	11,234

In columns (1) to (6) the log of the health deficit index is the dependent variable. Robust standard errors in parenthesis are clustered at the individual level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. Country and wave dummies are included.

Table 3 presents the results of the OLS and random effects regressions for females and males. All specifications include wave dummies and country dummies. In all regressions, childhood experiences of hunger increases health deficits in old age. The effect is larger when hunger is experienced early in life. Childhood hunger at age 0-4 increases health deficits by about a factor of $\exp(0.275) = 1.32$ for females and by about a factor of $\exp(0.234) = 1.26$ for males, i.e. the impact on males is slightly smaller. Hunger at age 4-8 increases health deficits by about a factor of $\exp(0.18) = 1.2$ for both genders. In Appendix Table A.3 we report results for the same regressions for the countries that have suffered from World War II, i.e. the countries included in the analysis of Kesternich et al. (2014). The estimated coefficients deviate insignificantly from the benchmark results.[6]

[6] We have also tried the IV strategy suggested by van den Berg et al. (2016) who use the famine experienced by Germany, the Netherlands, and Greece as an instrument for hunger (they only focus on wave 2 of the SHARE dataset). We have tried the instrument in the panel setting as well as with different cross-sections (also with different specifications including different controls and different methodologies) and we have found the instrument to be weak in most specifications such that no conclusive evidence can be drawn from this strategy for our analysis.

The force of aging is estimated as 0.035 for females and 0.028 for males, suggesting that women age faster than men. As shown in Abeliansky and Strulik (2017), attrition by death does not alter the estimated age coefficients. The outcome of faster aging of women conflicts with findings from previous studies (Mitnitski et al., 2002; Abeliansky and Strulik, 2017). This inconsistency is potentially explained by some unobserved heterogeneity that is biasing the estimates, as we show in the next regressions.

Table 4 presents the results of the Mundlak regressions by gender. The Mundlak estimator models the correlation of the unobserved heterogeneity assuming that the mean at the individual level of the explanatory variables is correlated with the factors that are unobserved (Wooldrige, 2010, Ch. 14.6.3). All specifications include country dummies. We have refrained from using wave dummies in this setting since they become collinear with age.

Table 4. Mundlak

	(1)	(2)	(3)	(4)
Constant	-4.318***	-4.308***	-4.200***	-4.186***
	(0.055)	(0.055)	(0.065)	(0.066)
age	0.022***	0.022***	0.028***	0.028***
	(0.001)	(0.001)	(0.001)	(0.001)
hunger 0-4	0.275***		0.234***	
	(0.042)		(0.049)	
hunger 4-8		0.180***		0.174***
		(0.029)		(0.034)
Gender	Female	Female	Male	Male
Observations	43,791	43,792	36,129	36,130
Individuals	13,211	13,212	11,234	11,235

The log of the health deficit index is the dependent variable. Robust standard errors in parenthesis are clustered at the individual level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. Country dummies are included. The mean age of each person is included as a control but not reported.

The Mundlak estimates confirm that the hunger episode between age 0-4 has the highest impact on the (log) level of health deficits, especially for women. The Mundlak results for females suggest that there is presence of individual-level heterogeneity that affects our variables of interest since the mean of age is statistically significant. For the force of aging, we now obtain a lower estimate for females (0.022) while the estimate for males does not change compared to the previous regressions (0.028). As a consequence, men are now observed to age faster than women, in line with the results from earlier studies. The estimated coefficients for the hunger episodes deviate insignificantly from the OLS and RE results. Table A.4 in the Appendix also shows that the Mundlak results change only insignificantly when we reduce the sample to war countries.

To finally corroborate the robustness of the results, we have added dummy variables for each year of birth in the sample to see whether the hunger episode is instead picking-up some heterogeneity that stems from the year of birth. As shown in Tables A.5 and A.6 in the Appendix, results remain unchanged. Overall, the impact of childhood hunger on old age health deficits is estimated to be insignificantly larger by the Mundlak estimates, compared to the OLS and RE regressions.

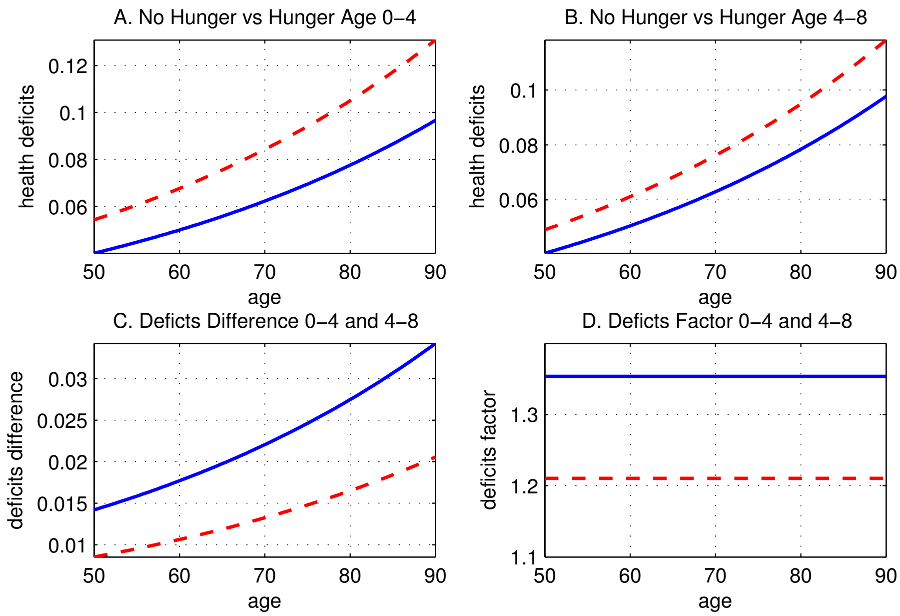
The quantitative effect of hunger is difficult to infer from the log-linear estimates. For an appropriate interpretation, we show in Figure 1 the age trajectories implied by the estimated coefficients for women. Solid (blue) lines show the trajectories for individuals not exposed to hunger and dashed (red) lines show trajectories for individuals exposed to hunger at age 0-4 (panel A) and age 4-8 (panel B). The health deficit index grows from about 4 percent at age 50 to about 10 percent at age 90 for non-exposed individuals. Individual who suffered from childhood hunger display about 20 to 30 percent more health deficits at any age.

The regression design implies that the relative wedge in terms of health deficits between hungry and non-hungry individuals stays constant: $D(hungry)/D(non-hungry) = e^{\gamma_g}$. As shown in panel D, this factor is about 1.2 for women who experienced hunger at age 4-8 and about 1.35 for women who experienced hunger at age 0-4. The wedge in absolute terms, however, computed as $D(hungry) - D(non-hungry) = R_g \mathrm{e}^{\alpha \cdot age_g}(e^{\gamma_g} - 1)$, is increasing with age. Individuals with a hunger episode at age 0-4 have accumulated 1.5% more health deficits at age 50 and 3.5% more health deficits at age 90 (solid lines in panel C). For hunger at age 4-8, the difference in health deficits runs from about 1% at age 50 to 2% at age 90. Effects are similar, yet mildly smaller for men, as shown in Figure 2. In short, this means that hungry children age faster in old age.

4. Non-linear Regressions

We now abandon the log-linear specification and estimate a quasi-exponential relationship of age and health deficits, akin to the Gompertz-Makeham law of mortality. This approach is inspired by Mitnitski et al. (2002) who argued in favor of such a specification based on the conceptual similarity of aging understood as health deficit accumulation and aging understood as

Figure 1: Hunger and Aging – Females



Panel A: health deficits by age; solid (blue) line: no hunger, dashed (red) line: hunger at age 0-4. Panel B: health deficits by age; solid (blue) line: no hunger, dashed (red) line: hunger at age 4-8. Panel C: health deficit difference $D(\gamma > 0) - D(\gamma = 0)$; solid (blue) line: hunger at age 0-4, dashed (red) line: hunger age at 4-8. Panel D: Health deficit factor $D(\gamma > 0)/D(\gamma = 0)$; solid (blue) line: hunger at age 0-4, dashed (red) line: hunger at age 4-8. Regression results from Mundlak estimates.

increasing mortality. If health deficits are accumulated in the Gompertz-Makeham fashion, then ignoring the Makeham-term would indeed bias the results, as shown by Gavrilov and Gavrilova (1991). In our previous study, we found evidence for such a quasi-exponential structure of aging in Europe (Abeliansky and Strulik, 2017). We thus proceed by estimating the following equation:

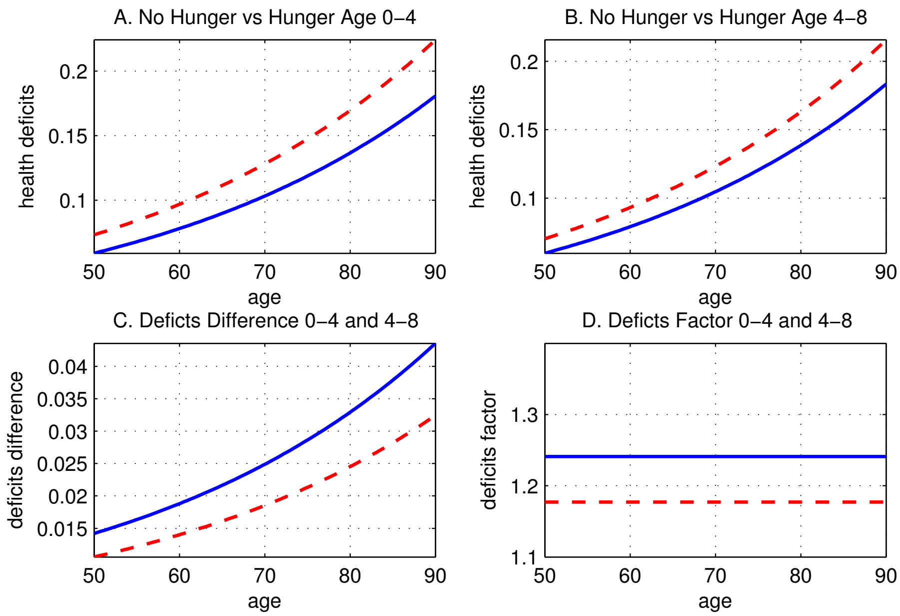
$$D_{ig} = A_g + R_g \cdot \exp\left(\alpha_g \cdot age_{iw}\right) \cdot \exp\left(\gamma_g \cdot hunger_i\right) + \epsilon_{igw} \tag{3}$$

where i is an index for age group and g is gender as before; ϵ is the error term.

As explained in detail in Abeliansky and Strulik (2017), including the Makeham-constant A_g means that the incidence rate $\Delta D/D$ is mildly declining with age such that health deficit trajectories intersect at a specific age. In our context, it is important to note that the quasi-exponential specification implies that the relative wedge of health deficits between individual exposed to hunger and individuals not exposed to hunger, given by

$$\frac{D(hungry)}{D(non-hungry)} = e^{\gamma_g}\left(1 - \frac{A_g}{A_g + R_g \mathrm{e}^{\alpha age_g}}\right),$$

Figure 2: Hunger and Aging – Males



Panel A: health deficits by age; solid (blue) line: no hunger, dashed (red) line: hunger at age 0-4. Panel B: health deficits by age; solid (blue) line: no hunger, dashed (red) line: hunger at age 4-8. Panel C: health deficit difference $D(\gamma > 0) - D(\gamma = 0)$; solid (blue) line: hunger at age 0-4, dashed (red) line: hunger age at 4-8. Panel D: Health deficit factor $D(\gamma > 0)/D(\gamma = 0)$; solid (blue) line: hunger at age 0-4, dashed (red) line: hunger at age 4-8. Regression results from Mundlak estimates.

increases as individuals get older. The wedge in absolute terms remains as computed for the log-linear model.

Regression results are shown in Table 5. The Makeham term (A) is indeed significantly positive and at about 8% of the size as in our earlier study (Abeliansky and Strulik, 2017). Men start out healthier than women (lower R_m than R_f) but age subsequently faster (higher α_m than α_f). The force of aging (α) increases in magnitude compared to the log-linear specification and is estimated as 0.06 for women and 0.08 for men. Thus, men are found to age (substantially) faster than women. For women, the hunger coefficient (γ) is significantly larger when the episode happened in early childhood. For men, the point estimate is (not statistically significantly) larger. Here we show results for a parsimonious model. Appendix Table A.7 shows results which include country and year of birth dummies. The estimates of the age and hunger coefficient differ insignificantly (in most cases) from those reported in the main text. However, the estimate of the Makeham-constant is not precise due to the incidental parameter problem caused by the inclusion of too many variables.[7] Table A.8 in the Appendix shows the same specifications, but for the war sub-sample. Although there is some variability in the estimated coefficients, there is not a clear pattern that hunger in the war countries has had a differential effect on health deficit accumulation.

Table 5. Non-linear Least Squares

	Female		Male	
	Estimated Coefficient	Standard Errors	Estimated Coefficient	Standard Errors
		Hunger between 0 - 4		
A	0.0888***	(0.0046)	0.0781***	(0.0029)
R	0.0015***	(0.0004)	0.0002**	(0.0001)
α	0.0608***	(0.0031)	0.0805***	(0.0050)
γ	0.5547***	(0.0402)	0.5139***	(0.0624)
Obs.	44,104		36,663	
R-squared	0.1364		0.0887	
		Hunger between 4 - 8		
A	0.0887***	(0.0046)	0.0791***	(0.0027)
R	0.0015***	(0.0004)	0.0002**	(0.0001)
α	0.0604***	(0.0031)	0.0818***	(0.0049)
γ	0.3634***	(0.0292)	0.4518***	(0.0447)
Obs.	44,104		36,663	
R-squared	0.1354		0.0903	

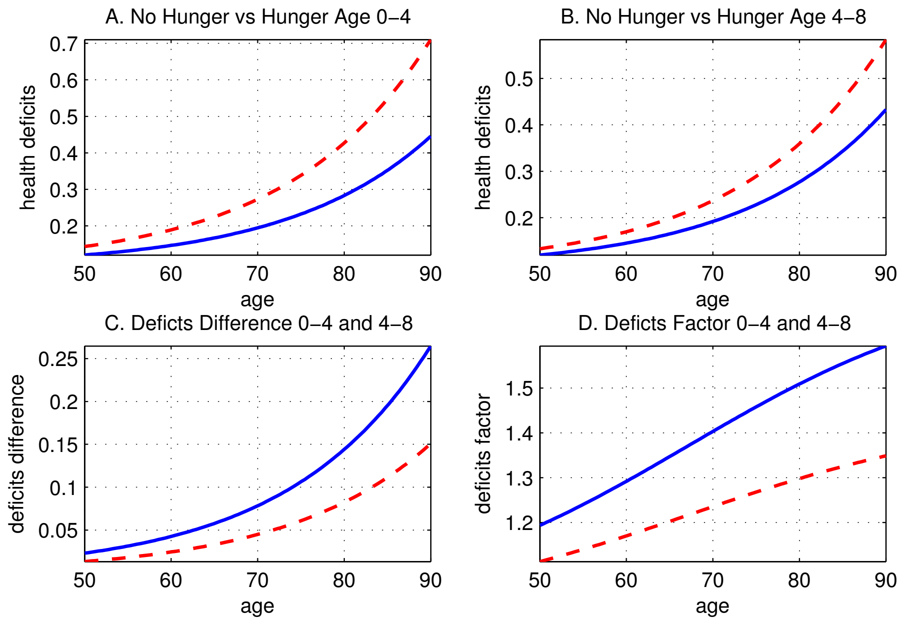
Robust standard errors in parenthesis. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level.

In order to assess the quantitative meaning of the results, we take another look at the health deficit trajectories implied by the estimated coefficients. As shown in Figure 3 and 4, the quasi-exponential estimates indicate a steeper increase of health deficits with age, implying that health deficits for individuals age 80 or older are higher than what was inferred from log-linear regression. The increase of health deficits in old age is even more pronounced when individuals had suffered from childhood hunger, as indicated by dashed lines in panel A and B.

The estimated difference in health deficits for hungry vs. non-hungry individuals is also more steeply increasing with age (panel C). Originating from about the same level at age 50 as for the log-linear case, the difference increases to almost 20 percent for women aged 85 when hunger was experienced at age 0-4 (10 percent for hunger at age 4-8). For men the difference is smaller and about the same for both periods (panel C in Figure 4). In panel D in Figure 3 and 4, we report the relative wedge in health deficits. For females, it increases from factor 1.2 at age 50 to factor 1.5 at age 80 when hunger was experienced in early childhood. For hunger in middle

[7] In further specifications, we also included year of birth dummies together with wave dummies and/or country dummies. The estimated speed of aging and the hunger coefficient did not differ significantly (in most cases) from the baseline estimate but the Makeham parameter became even more unstable.

Figure 3: Hunger and Aging – Females: Non-linear



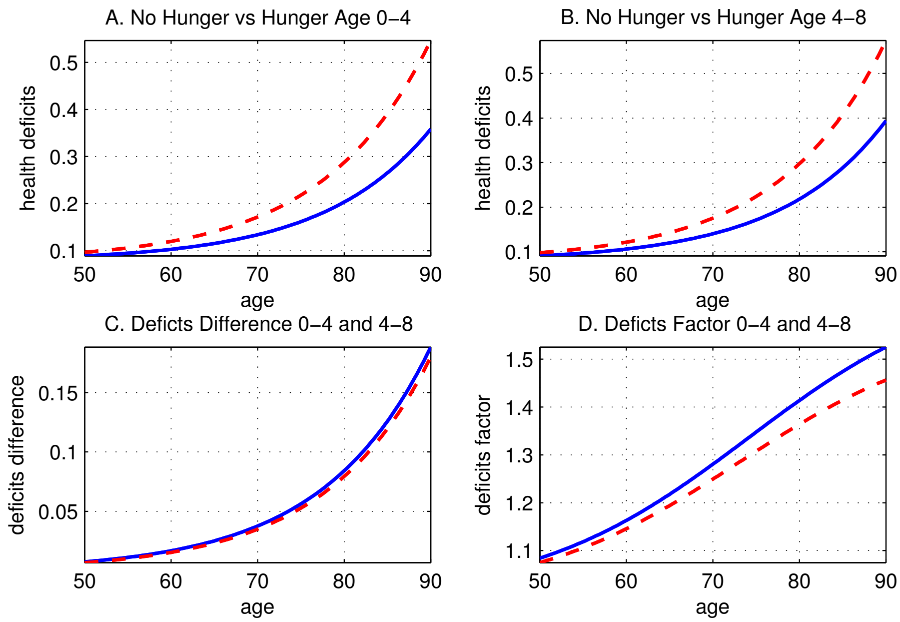
Panel A: health deficits by age; solid (blue) line: no hunger, dashed (red) line: hunger at age 0-4. Panel B: health deficits by age; solid (blue) line: no hunger, dashed (red) line: hunger at age 4-8. Panel C: health deficit difference $D(\gamma > 0) - D(\gamma = 0)$; solid (blue) line: hunger at age 0-4, dashed (red) line: hunger at age 4-8. Panel D: health deficit factor $D(\gamma > 0)/D(\gamma = 0)$; solid (blue) line: hunger at age 0-4, dashed (red) line: hunger at age 4-8. Regression results from nonlinear estimates.

childhood the increase is smaller and starts at a lower level. For men, the increase of the relative wedge is about the same for both hunger periods, starting at a factor of 1.1 and reaching about a factor of 1.4 at age 80. In short, this means that childhood hunger is not only associated with faster aging but also with an accelerating speed of aging.

5. Length of Hunger Episodes

In this section we investigate the health impact of the length of the hunger episode. We consider early-childhood and middle-childhood ages and compute the length of the hunger period during these age intervals. A first look at the summary statistics from Tables 1 and 2 suggest that most of the individuals who reported hunger have suffered an extended hunger episode, on average of about 8-10 years. Table 1 shows that Greek females have experienced the most severe hunger episodes in early childhood. Swedish females come second, although few of them have reported hunger in this period. In terms of men, Swiss and Irish men have experienced longer hunger spells. Danish men and women have experienced the shortest hunger spells. Table 2

Figure 3: Hunger and Aging – Males: Non-linear



Panel A: health deficits by age; solid (blue) line: no hunger, dashed (red) line: hunger at age 0-4. Panel B: health deficits by age; solid (blue) line: no hunger, dashed (red) line: hunger at age 4-8. Panel C: health deficit difference $D(\gamma > 0) - D(\gamma = 0)$; solid (blue) line: hunger at age 0-4, dashed (red) line: hunger at age 4-8. Panel D: health deficit factor $D(\gamma > 0)/D(\gamma = 0)$; solid (blue) line: hunger at age 0-4, dashed (red) line: hunger at age 4-8. Regression results from nonlinear estimates.

shows the equivalent statistics but for the hunger episodes in middle childhood. The rankings remain the same as in Table 1.

In order to assess the severity of the hunger episodes, the hunger variable is now defined as the number of years a person has suffered from hunger whereby the hunger episode begins either in early or middle childhood. The log-linear estimates (reported in Table A.9 in the Appendix) again show the problematic result that women accumulate health deficits faster than men, indicating bias from unobserved heterogeneity. We thus directly proceed with results estimated with the Mundlak approach. Results are shown in Table 6. We see that the estimates of the coefficient for the length of hunger are very close in value for both childhood periods and for both genders. Every extra year of a hunger episode in childhood (with a starting point in childhood) provides a percentage change of about 0.015 in the health deficit index. This means that, for example, taking the German average data for women, an upward change of the frailty index by $0.015 \cdot 5.5 = 0.0825$ percent.

We have performed the same robustness checks as we did for the binary hunger indicator. We used year of birth dummies as extra controls (Tables A.10 and A.11 in the Appendix) and

Table 6. Length of Hunger Episode (Mundlak)

	(1)	(2)	(3)	(4)
constant	-4.300***	-4.296***	-4.173***	-4.162***
	(0.055)	(0.055)	(0.066)	(0.066)
age	0.022***	0.022***	0.028***	0.028***
	(0.001)	(0.001)	(0.001)	(0.001)
hunger 0-4	0.015***		0.014***	
	(0.005)		(0.004)	
hunger 4-8		0.012***		0.016***
		(0.004)		(0.003)
Gender	Female	Female	Male	Male
Observations	43,791	43,791	36,129	36,129
Individuals	13,211	13,211	11,234	11,234

In columns (1) to (6) the log of the health deficit index is the dependent variable. Robust standard errors in parenthesis are clustered at the individual level. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level. Country dummies are included.

we have restricted the sample of countries to the war countries (Tables A.12 and A.13 in the Appendix). We found that results differ insignificantly from those of the baseline specification.

Finally, as with the binary version of the variable of interest, we estimate the non-linear specification, i.e. Equation (3) with the hunger measured in intensive form. Table 7 reports the results. It shows that men age faster than women, as in Mitnitski et al. (2002) and Abeliansky and Strulik (2017). The estimates for the impact of hunger lie between 0.014 and 0.021 and do not differ significantly from each other in most of the cases. The estimated Makeham and Gompertz parameters are also similar in value to the previous estimate using the binary hunger indicator (Table 5). Overall, we can claim that regardless of how we construct the hunger variable, we find a robust relationship between having experienced a hunger episode and a faster aging process.

We have performed the same robustness analysis as we did for the previous non-linear estimates. We have reduced the sample of countries to the war countries and have used year of birth dummies as extra controls. Table A.14 shows that there is a bit more variation when year of birth dummies are included, which is probably caused by having too many parameters included in the estimation. As shown in Table A.15, results for the war countries are essentially the same as the ones in the baseline specification.

Table 7. Non-linear Least Squares - Length

	Female		Male	
	Estimated Coefficient	Standard Errors	Estimated Coefficient	Standard Errors
	Hunger between 0 - 4			
A	0.0837***	(0.0053)	0.0786***	(0.0029)
R	0.0019***	(0.0005)	0.0002**	(0.0001)
α	0.0579***	(0.0032)	0.0816***	(0.0050)
γ	0.0213***	(0.0033)	0.0175***	(0.0035)
Obs.	44,104		36,663	
R-squared	0.1339		0.0872	
	Hunger between 4 - 8			
A	0.0817***	(0.0055)	0.0779***	(0.0029)
R	0.0021***	(0.0006)	0.0002**	(0.0001)
α	0.0566***	(0.0032)	0.0804***	(0.0050)
γ	0.0140***	(0.0017)	0.0204***	(0.0035)
Obs.	44,104		36,663	
R-squared	0.1335		0.0883	

Robust standard errors in parenthesis. One asterisk indicates significance at the 10-percent level, two asterisks indicate significance at the 5-percent level, and three asterisks indicate significance at the 1-percent level.

6. Conclusions

We used information about the experience of hunger in childhood and six waves of the Survey of Health, Aging and Retirement in Europe (SHARE) dataset and found that individuals from 14 European countries who experienced hunger in childhood aged faster in old age. To measure aging we constructed a health deficit index from the SHARE dataset. Log-linear regressions suggest that elderly individuals display about 20 percent more health deficits when they experienced hunger in childhood whereby the effect is stronger when the hunger episode started in early childhood. Non-linear (quasi-exponential) regressions provide even greater effects. Health deficits of formerly hungry men and women exceed those of non-hungry individuals by up to 40 percent.

The wedge of health deficits between hungry and non-hungry individuals increases absolutely and relatively with age. This implies that people who experienced childhood hunger age faster in old age. Childhood hunger is also found to be important at the intensive margin. Every year of hunger is estimated to increase health deficits in old age by 1.5 percent. We thus provide further evidence that early-life health shocks have detrimental effects on late-life health. In contrast to available studies, which considered the impact of childhood hunger on indicators of the state of health, we considered aging, i.e. the accumulation of health deficits, and found that it is amplified by the experience of childhood hunger. We thus found supportive evidence for the theory of health deficit accumulation, which predicts that early-life health shocks are amplified during the life course and lead to faster aging.

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Appendix A

Table A.1. Items of the Health Deficit Index

Arthritis	Difficulties concentrating
Stroke	Difficulties shopping
Parkinson	Difficulties lifting 5kg
Diabetes	Difficulties pulling/pushing object
Cholesterol	Less enjoyment
Asthma	Difficulties managing money
Depressed	Difficulties joining activities
High blood pressure	Difficulties bathing
Cataracts	Difficulties dressing
Pain	Difficulties doing housework
Difficulties seeing arm length	Difficulties walking across house
Difficulties seeing across street	Difficulties eating
Difficulties sitting long	Difficulties getting out of bed
Difficulties walking 100mt	Difficulties using the toilet
Difficulties getting out chair	Difficulties using map
Difficulties climbing stairs	Walking speed (only in wave 1 and 2)
Difficulties kneeing	BMI
Difficulties picking an object	Grip strength
Difficulties extending arms	Mobility

Table A.2. Variables from the SHARE data.

Dimension	Variable	Coding in SHARE dataset
Arthritis	ph006d8	yes=1, no=0
Stroke	ph006d4	yes=1, no=0
Parkinson	ph006d12	yes=1, no=0
Diabetes	ph006d5	yes=1, no=0
Cholesterol	ph006d3	yes=1, no=0
Asthma	ph006d7	yes=1, no=0
Depressed	mh002_	yes=1, no=1
High blood pressure	ph006d2	yes=1, no=0
Cataracts	ph006d13	yes=1, no=0
Pain	ph010d1	yes=1, no=0
Difficulties seeing arm length	ph044_	none=0, mild=0.25, moderate=0.5, bad=0.75, very bad=1
Difficulties seeing across street	ph043_	none=0, mild=0.25, moderate=0.5, bad=0.75, very bad=1
Difficulties sitting long	ph048d2	yes=1, no=0
Difficulties walking 100mt	ph048d1	yes=1, no=0
Difficulties getting out chair	ph048d3	yes=1, no=0
Difficulties climbing stairs	ph048d5	yes=1, no=0
Difficulties kneeing	ph048d6	yes=1, no=0
Difficulties picking an object	ph048d10	yes=1, no=0
Difficulties extending arms	ph048d7	yes=1, no=0
Difficulties concentrating	mh014_	yes=1, no=0
Difficulties shopping	ph049d9	yes=1, no=0
Difficulties lifting 5kg	ph048d9	yes=1, no=0
Difficulties pulling/pushing object	ph048d8	yes=1, no=0
Less enjoyment	mh016_	yes=1, no=0
Difficulties managing money	ph049d13	yes=1, no=0
Difficulties joining activities (because of health)	ph005_	not limited=0, limited, not severely=0.5, severely limited=1
Difficulties bathing	ph049d3	yes=1, no=0
Difficulties dressing	ph049d1	yes=1, no=0
Difficulties doing housework	ph049d12	yes=1, no=0
Difficulties walking across the house	ph049d2	yes=1, no=0
Difficulties eating	ph049d4	yes=1, no=0
Difficulties getting out of bed	ph049d5	yes=1, no=0
Difficulties using the toilet	ph049d6	yes=1, no=0
Difficulties using map	ph049d7	yes=1, no=0
Walking Speed (only available wave 1 and wave 2)	wspeed and wspeed2	no problem if: aged<75 (by construction);(wspeed>=0.4 or wspeed2==0); problem if: wspeed<=0.4 or wspeed2==1
BMI	bmi	(bmi<=18 or bmi>=30) =1; (bmi>=25 and bmi<30)=0.5; bmi>18.5 and bmi<25)=0
Grip strength	maxgrip and bmi	it is recorded as frail for women if (maxgrip<=29 & bmi<=24); (maxgrip<=30 & (bmi>=24.1 & bmi<=28)); (maxgrip<=32 & bmi>28); for men if : (maxgrip<=29 & bmi<=24); (maxgrip<=30 & (bmi>=24.1 & bmi<=28)); (maxgrip<=32 & bmi>28)
Mobility	mobility	(mobility>=3)=1; (1>=mobility<3)=0.5 and mobility=0

FIGURE A.1. Percentage of Hunger Episodes by Year of Birth and Country

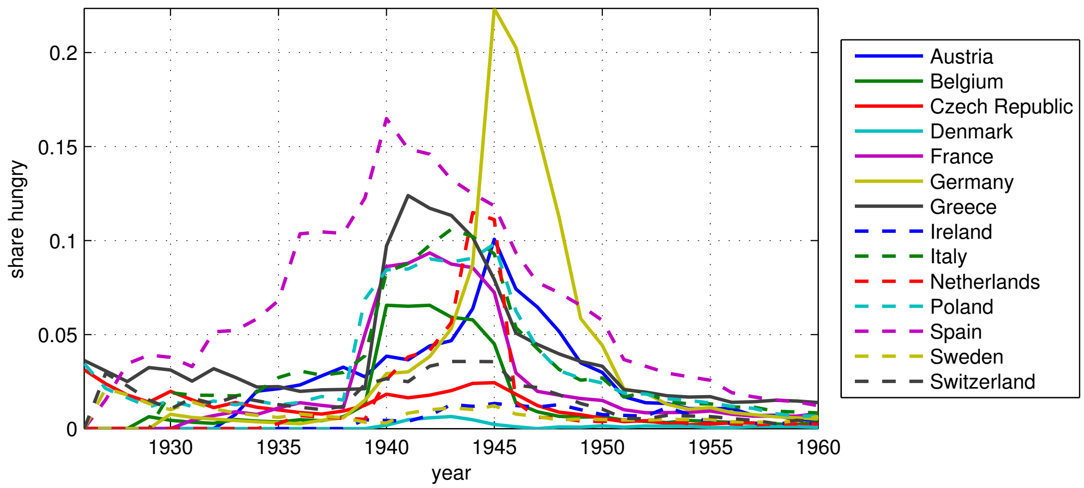

TABLE A.3. OLS and Random Effects – Female – War

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(7)
Constant	-4.237***	-4.291***	-4.228***	-4.282***	-4.167***	-4.253***	-4.152***	-4.239***
	(0.059)	(0.057)	(0.059)	(0.057)	(0.071)	(0.069)	(0.072)	(0.070)
age	0.034***	0.035***	0.034***	0.035***	0.028***	0.029***	0.028***	0.029***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
hunger 0-4	0.238***	0.252***			0.241***	0.224***		
	(0.050)	(0.050)			(0.061)	(0.061)		
hunger 4-8			0.151***	0.157***			0.170***	0.161***
			(0.033)	(0.033)			(0.042)	(0.041)
Method	OLS	RE	OLS	RE	OLS	RE	OLS	RE
Sample	War	War	War	War	War	War	War	War
Observations	30,411	30,411	30,411	30,411	25,029	25,029	25,029	25,029
Individuals	9,360	9,360	9,360	9,360	7,955	7,955	7,955	7,955

Notes: Robust standard errors in parenthesis clustered at the individual level. One asterisk indicates significance at the 10 percent level, two asterisks indicate significance at the 5 percent level, and three asterisks indicate significance at the 1 percent level. In columns (1) to (6) the log of the health deficit index is the dependent variable. Individuals with a health deficit index of 0 were dropped out of the sample. Country and wave dummies are included. Wave 1 and Austria are the base categories. This subsample does not include Ireland, Denmark, Sweden, Switzerland and Spain.

Table A.4. Mundlak - War

	(1)	(2)	(3)	(4)
Constant	-4.354***	-4.343***	-4.192***	-4.177***
	(0.062)	(0.062)	(0.074)	(0.074)
age	0.024***	0.024***	0.031***	0.031***
	(0.001)	(0.001)	(0.001)	(0.001)
hunger 0-4	0.252***		0.225***	
	(0.050)		(0.061)	
hunger 4-8		0.155***		0.164***
		(0.033)		(0.041)
Gender	Female	Female	Male	Male
Sample	War	War	War	War
Observations	30,411	30,411	25,029	25,029
Number of id	9,360	9,360	7,955	7,955

The log of the health deficit index is the dependent variable. Robust standard errors in parenthesis are clustered at the individual level. One asterisk indicates significance at the 10 percent level, two asterisks indicate significance at the 5 percent level, and three asterisks indicate significance at the 1 percent level. The mean age of each person is included as a control but not reported. Country dummies are included. This subsample does not include Ireland, Denmark, Sweden, Switzerland and Spain.

Table A.5. OLS and Random Effects – Year of Birth Dummies

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	-2.949***	-3.094***	-2.949***	-3.096***	-3.493***	-3.772***	-3.489***	-3.769***
	(0.141)	(0.129)	(0.141)	(0.129)	(0.167)	(0.168)	(0.166)	(0.168)
age	0.020***	0.022***	0.020***	0.022***	0.024***	0.027***	0.024***	0.027***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
hunger 0-4	0.284***	0.282***			0.259***	0.244***		
	(0.042)	(0.042)			(0.049)	(0.049)		
hunger 4-8			0.189***	0.185***			0.205***	0.194***
			(0.029)	(0.029)			(0.034)	(0.034)
Method	OLS	RE	OLS	RE	OLS	RE	OLS	RE
Gender	Female	Female	Female	Female	Male	Male	Male	Male
Observations	43,791	43,791	43,791	43,791	36,129	36,129	36,129	36,129
Individuals	13,211	13,211	13,211	13,211	11,234	11,234	11,234	11,234

In columns (1) to (6) the log of the health deficit index is the dependent variable. Robust standard errors in parenthesis clustered at the individual level. One asterisk indicates significance at the 10 percent level, two asterisks indicate significance at the 5 percent level, and three asterisks indicate significance at the 1 percent level. Country and wave dummies are included.

Table A.6. Mundlak – Year of Birth Dummies

	(1)	(2)	(3)	(4)
Constant	-1.682***	-1.657***	-0.663	-0.657
	(0.415)	(0.415)	(0.479)	(0.478)
age	0.022***	0.022***	0.028***	0.028***
	(0.001)	(0.001)	(0.001)	(0.001)
hunger 0-4	0.279***		0.241***	
	(0.042)		(0.049)	
hunger 4-8		0.184***		0.192***
		(0.029)		(0.034)
Gender	Female	Female	Male	Male
Observations	43,791	43,792	36,129	36,130
Number of id	13,211	13,212	11,234	11,235

In columns (1) to (6) the log of the health deficit index is the dependent variable. Robust standard errors in parenthesis clustered at the individual level. One asterisk indicates significance at the 10 percent level, two asterisks indicate significance at the 5 percent level, and three asterisks indicate significance at the 1 percent level. Country and year of birth dummies are included.

Table A.7. Non-linear Least Squares - Country and Year of Birth Dummies

	Female		Male	
	Estimated Coefficient	Standard Errors	Estimated Coefficient	Standard Errors
		Hunger between 0 - 4		
A	2.7437***	(0.0114)	68.4591***	(0.0058)
R	0.0003**	(0.0001)	0.0001*	(0.0001)
α	0.0762***	(0.0058)	0.0843***	(0.0069)
γ	0.6995***	(0.0644)	0.4546***	(0.0728)
Obs.	44,104		36,663	
R-squared	0.1945		0.1293	
		Hunger between 4 - 8		
A	7.7919***	(0.0114)	-3.2756***	(0.0150)
R	0.0003**	(0.0002)	0.0001*	(0.0001)
α	0.0750***	(0.0059)	0.0844***	(0.0068)
γ	0.4315***	(0.0486)	0.3893***	(0.0529)
Obs.	44,104		36,663	
R-squared	0.1934		0.1302	

Notes: Standard errors in parenthesis. One asterisk indicates significance at the 10 percent level, two asterisks indicate significance at the 5 percent level, and three asterisks indicate significance at the 1 percent level. Country and year of birth dummies are included.

Table A.8. Non-linear Least Squares – War

	Female		Male	
	Estimated Coefficient	Standard Errors	Estimated Coefficient	Standard Errors
		Hunger between 0 - 4		
A	0.0843***	(0.0066)	0.0797***	(0.0037)
R	0.0023***	(0.0007)	0.0003*	(0.0001)
α	0.0561***	(0.0036)	0.0766***	(0.0056)
γ	0.3862***	(0.0483)	0.4816***	(0.0726)
Obs.	30,554		25,292	
R-squared	0.1414		0.0916	
		Hunger between 4 - 8		
A	0.0846***	(0.0065)	0.0808***	(0.0036)
R	0.0023***	(0.0007)	0.0002**	(0.0001)
α	0.0560***	(0.0036)	0.0780***	(0.0056)
γ	0.2372***	(0.0326)	0.3702***	(0.0530)
Obs.	30,554		25,292	
R-squared	0.1409		0.0923	

Notes: Standard errors in parenthesis. One asterisk indicates significance at the 10 percent level, two asterisks indicate significance at the 5 percent level, and three asterisks indicate significance at the 1 percent level. Country and year of birth dummies are included. This subsample does not include Ireland, Denmark, Sweden, Switzerland and Spain.

Table A.9. OLS and Random Effects (Length)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	-4.190***	-4.249***	-4.185***	-4.246***	-4.166***	-4.246***	-4.155***	-4.237***
	(0.052)	(0.051)	(0.052)	(0.051)	(0.064)	(0.062)	(0.064)	(0.062)
age	0.034***	0.035***	0.034***	0.035***	0.028***	0.029***	0.028***	0.029***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
hunger 0-4	0.018***	0.015***			0.015***	0.014***		
	(0.004)	(0.005)			(0.004)	(0.004)		
hunger 4-8			0.013***	0.011***			0.017***	0.016***
			(0.003)	(0.004)			(0.003)	(0.003)
Method	OLS	RE	OLS	RE	OLS	RE	OLS	RE
Sample	All	All	All	All	All	All	All	All
Gender	Female	Female	Female	Female	Male	Male	Male	Male
Observations	43,791	43,791	43,791	43,791	36,129	36,129	36,129	36,129
Individuals	13,211	13,211	13,211	13,211	11,234	11,234	11,234	11,234

In columns (1) to (6) the log of the health deficit index is the dependent variable. Robust standard errors in parenthesis clustered at the individual level. One asterisk indicates significance at the 10 percent level, two asterisks indicate significance at the 5 percent level, and three asterisks indicate significance at the 1 percent level. Country and wave dummies are included.

Table A.10. OLS and Random Effects – Length – Year of Birth Dummies

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	-2.946***	-3.093***	-2.945***	-3.093***	-3.497***	-3.774***	-3.501***	-3.778***
	(0.142)	(0.129)	(0.141)	(0.129)	(0.167)	(0.168)	(0.167)	(0.168)
age	0.020***	0.022***	0.020***	0.022***	0.024***	0.027***	0.024***	0.027***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
hunger 0-4	0.018***	0.015***			0.015***	0.014***		
	(0.004)	(0.005)			(0.004)	(0.004)		
hunger 4-8			0.013***	0.011***			0.018***	0.017***
			(0.003)	(0.004)			(0.003)	(0.003)
Method	OLS	RE	OLS	RE	OLS	RE	OLS	RE
Gender	Female	Female	Female	Female	Male	Male	Male	Male
Observations	43,791	43,791	43,791	43,791	36,129	36,129	36,129	36,129
Individuals	13,211	13,211	13,211	13,211	11,234	11,234	11,234	11,234

Notes: Robust standard errors in parenthesis clustered at the individual level. One asterisk indicates significance at the 10 percent level, two asterisks indicate significance at the 5 percent level, and three asterisks indicate significance at the 1 percent level. In columns (1) to (6) the log of the health deficit index is the dependent variable. Country and wave dummies are included. Individuals with a health deficit index of 0 were dropped out of the sample. Wave 1 and Austria are the base categories.

Table A.11. Mundlak – Length - Year of Birth Dummies

	(1)	(2)	(3)	(4)
Constant	-2.189***	-2.179***	-1.811***	-1.817***
	(0.302)	(0.302)	(0.347)	(0.347)
age	0.022***	0.022***	0.028***	0.028***
	(0.001)	(0.001)	(0.001)	(0.001)
hunger 0-4	0.015***		0.014***	
	(0.005)		(0.004)	
hunger 4-8		0.011***		0.017***
		(0.004)		(0.003)
Gender	Female	Female	Male	Male
Observations	43,791	43,791	36,129	36,129
Number of id	13,211	13,211	11,234	11,234

The log of the health deficit index is the dependent variable. Robust standard errors in parenthesis are clustered at the individual level. One asterisk indicates significance at the 10 percent level, two asterisks indicate significance at the 5 percent level, and three asterisks indicate significance at the 1 percent level. The mean age of each person is included as a control but not reported.

Table A.12. OLS and Random Effects – Length – War

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	-4.239***	-4.293***	-4.234***	-4.289***	-4.166***	-4.251***	-4.158***	-4.243***
	(0.059)	(0.057)	(0.059)	(0.057)	(0.072)	(0.069)	(0.072)	(0.069)
age	0.034***	0.035***	0.034***	0.035***	0.028***	0.029***	0.028***	0.029***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
hunger 0-4	0.015***	0.012**			0.015***	0.013***		
	(0.005)	(0.006)			(0.004)	(0.004)		
hunger 4-8			0.012***	0.009**			0.017***	0.015***
			(0.004)	(0.005)			(0.004)	(0.004)
Method	OLS	RE	OLS	RE	OLS	RE	OLS	RE
Gender	Female	Female	Female	Female	Male	Male	Male	Male
Observations	30,411	30,411	30,411	30,411	25,029	25,029	25,029	25,029
Individuals	9,360	9,360	9,360	9,360	7,955	7,955	7,955	7,955

In columns (1) to (6) the log of the health deficit index is the dependent variable. Robust standard errors in parenthesis clustered at the individual level. One asterisk indicates significance at the 10 percent level, two asterisks indicate significance at the 5 percent level, and three asterisks indicate significance at the 1 percent level. Country and wave dummies are included.This subsample does not include Ireland, Denmark, Sweden, Switzerland and Spain.

Table A.13. Mundlak – Length – War

	(1)	(2)	(3)	(4)
Constant	-4.342***	-4.338***	-4.166***	-4.157***
	(0.062)	(0.062)	(0.074)	(0.074)
age	0.024***	0.024***	0.031***	0.031***
	(0.001)	(0.001)	(0.001)	(0.001)
hunger 0-4	0.013**		0.014***	
	(0.006)		(0.004)	
hunger 4-8		0.009**		0.016***
		(0.005)		(0.004)
Gender	Female	Female	Male	Male
Sample	War	War	War	War
Observations	30,411	30,411	25,029	25,029
Number of id	9,360	9,360	7,955	7,955

The log of the health deficit index is the dependent variable. Robust standard errors in parenthesis are clustered at the individual level. One asterisk indicates significance at the 10 percent level, two asterisks indicate significance at the 5 percent level, and three asterisks indicate significance at the 1 percent level. Country and year of birth dummies are included. The mean age of each person is included as a control but not reported. This subsample does not include Ireland, Denmark, Sweden, Switzerland and Spain.

Table A.14. Non-linear Least Squares – Length – Country and Year of Birth Dummies

	Female		Male	
	Estimated Coefficient	Standard Errors	Estimated Coefficient	Standard Errors
		Hunger between 0 - 4		
A	64.8059	(1064.0711)	49.9633***	(0.0143)
R	0.0003**	(0.0002)	0.0001*	(0.0001)
α	0.0743***	(0.0053)	0.0872***	(0.0070)
γ	0.0246***	(0.0022)	0.0156***	(0.0043)
Obs.	44,104		36,663	
R-squared	0.1927		0.1284	
		Hunger between 4 - 8		
A	-0.9208***	(0.0486)	-2.3842	(83.3348)
R	0.0003**	(0.0002)	0.0001*	(0.0001)
α	0.0736***	(0.0059)	0.0850***	(0.0069)
γ	0.0155***	(0.0021)	0.0184***	(0.0040)
Obs.	44,104		36,663	
R-squared	0.1924		0.1291	

Notes: Robust standard errors in parenthesis. One asterisk indicates significance at the 10 percent level, two asterisks indicate significance at the 5 percent level, and three asterisks indicate significance at the 1 percent level. Country and year of birth dummies are included.

Table A.15. Non-linear Least Squares – Length – War

	Female		Male	
	Estimated Coefficient	Standard Errors	Estimated Coefficient	Standard Errors
		Hunger between 0 - 3		
A	0.0803***	(0.0071)	0.0796***	(0.0038)
R	0.0028***	(0.0009)	0.0003**	(0.0001)
alpha	0.0542***	(0.0036)	0.0765***	(0.0057)
gamma	0.0168***	(0.0036)	0.0154***	(0.0035)
Obs.	30,554		25,292	
R-squared	0.1405		0.0904	
		Hunger between 4 - 7		
A	0.0782***	(0.0074)	0.0791***	(0.0038)
R	0.0030***	(0.0010)	0.0003**	(0.0001)
alpha	0.0531***	(0.0037)	0.0758***	(0.0057)
gamma	0.0106***	(0.0029)	0.0169***	(0.0034)
Obs.	30,554		25,292	
R-squared	0.1399		0.0909	

Notes: Standard errors in parenthesis. One asterisk indicates significance at the 10 percent level, two asterisks indicate significance at the 5 percent level, and three asterisks indicate significance at the 1 percent level. Country and year of birth dummies are included. This subsample does not include Ireland, Denmark, Sweden, Switzerland and Spain.