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Stunting and Wasting in a Growing Economy: Biological Living Standards in Portugal during the Twentieth Century[1]

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Abstract

Portugal's real income per head grew by a factor of eight during the second half of the twentieth century, a period of fast convergence towards Western European living standards. We use a new sample of about 3,400 infants and children living in Lisbon to document trends in the prevalence of stunting and wasting between 1906 and 1994. We find that stunting and wasting fell quickly from around 1950, for both males and females. We additionally use a sample of more than 26,000 young adult males covering the entire country, which shows a consistent decrease in wasting and stunting with the expected time lag. We discuss these trends in relation to changes in income and public policy, which affected the ontogenetic environment of children. Sustained progress began well before the introduction of democracy.

JEL codes: I15, N34, O15

Keywords: anthropometrics, economic development, poverty, child health.

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1. Introduction

Portugal's real income per capita grew by a factor of eight during the second half of the twentieth century, a period characterized by fast growth and convergence towards Western European standards of living.[2] Portugal converged from around one-third of the GDP per capita of the core of Western Europe's high-income countries in 1940 to approximately 60% in 1974, and up to about 65% in 1994 (Lains 2003). In this paper, we collect heights and weights for a new sample of 3,360 infants and children from birth to 18 years of age. We use the prevalence of stunting and wasting to document trends in biological living standards among infants and children during the twentieth century, including a period of fast economic development from around 1950. We find a dramatic secular decrease in the prevalence of stunting and wasting of children, reflecting an improvement in living standards that occurred over the period. We also use a representative sample of more than 26,000 young adults and find similar trends. Overall, the evidence we find contradicts the dominant paradigm in Portugal's historiography, which considers that the undemocratic regime known as Estado Novo prevented the economic and social modernization of the country. For example, Cardoso (2008, p. 270-2) writes that Portugal "did not experience major social and economic changes after World War II like other European countries", that "the dictatorship represented a long period of economic stagnation", and that "changes were occurring at an unbearable slow rate".[3]

In this study, we focus on two measures of physical growth as indicators of societal changes in the standard of living: stunting and wasting. Stunting refers to impaired growth, resulting in reduced height-for-age (World Health Organization, 2006). A child is stunted if their height-for-age is below two standard deviations from a reference mean height. It represents a long-term and cumulative manifestation of chronic undernutrition, recurrent infections, lack of psychosocial stimulus or increased emotional stress in childhood. It can also occur before birth during fetal development brought about by malnourishment of the mother and other pregnancy factors. In turn, wasting concerns individuals who are underweight for their height and reflect short-

[2] Amaral (2002, 2019); Lopes (2004); Stolz et al. (2013); Costa et al. (2016); Palma and Reis (2021). Portugal has been Western Europe's poorest country since the mid nineteenth century (Palma and Reis 2019).

[3] See also Rosas (1996, p. 52). This paradigm is not only present in the academic literature but also in school curricula (Mendes et al 2001, p.52).

term changes in nutrition and disease or stress exposure (World Health Organization, 2006). We use the WHO Child Growth Standards (De Onis et al. 2006) to identify individuals in our sample as stunted or wasted.[4] We then calculate the prevalence of stunting and wasting by decade, sex and age group: infants (up to 24 months of age) and children (ages 2 to 5, and 5 to 18 years of age).[5]

We find that the prevalence of stunting and wasting decreased over time as income per capita grew and access to improved nutrition, sanitation and medical care. The prevalence of stunting and wasting in the city of Lisbon fell gradually from the 1950s. The largest declines occurred before the 1970s, prior to the social changes brought by the transition from a dictatorship to a democratic political regime, including the creation of a national health service. However, progress was not only due to better nutrition – undoubtedly an important factor, as we document – but also due to gradually increased access to health and public sanitation services (Deaton 2014; Pato 2011; Saraiva et al. 2011, 2014). The evolution was impressive; for example, for both sexes, the prevalence of wasting fell from 45% in infants during the 1950s to around 15% in 1985-1994. The prevalence of stunting also showed remarkable progress, with close to 50% of infants and children stunted in the postwar period to around 20% in 1985-1994. There were larger incidences in older children, reflecting a lag in the improvements relative to the younger generations. The observed progress must have led to large welfare gains, especially as we show that stunting had long-term negative health consequences for most individuals affected.

The observed drop in the prevalence of stunting and wasting occurs in tandem with the dramatic decrease in infant mortality from the early 1950s onwards (Baganha and Marques 2001, Instituto Nacional de Estatística 2001). We discuss these trends in the context of improvements in the health of children and young adults. We also compare

[4] Given that the World Health Organization Growth Standards describe the growth of healthy children under optimal conditions, we also take into account the growth reference from the Center for Disease Control and Prevention (CDC, Cole et al. 2000) as a robustness check. The CDC growth reference simply presents the growth patterns of children in a specific location and time, which may not align with optimal conditions as it is likely to some of the children in our sample. Therefore, using this reference provides an additional level of robustness to our analysis.

[5] In order to conform to the conventional categories established by the World Health Organization (WHO) in their Growth Standards (De Onis et al. 2006), we divided our age groups into 0-24 months, 2-5 years of age, 5-18 years of age (note that the last category of the WHO is up to 19 but there are no individuals beyond 18 in our sample). Although the WHO considers all individuals under 18 years of age as children, we adopted the distinction of classifying individuals younger than 24 months as infants and those older as children, which aligns with the guidelines of the Center for Disease Control and Prevention (CDC) (Cole et al. 2000).

the observed trends to the macroeconomic and infrastructure development of the time. We discuss developments in access to nutrition, health care, sanitation, and housing. The improvements that happened in Portugal during the second half of the twentieth century led to a fast convergence of health and welfare outcomes relative to the Western European standards, which did not improve as quickly then.[6] Finally, we consider potential sample selection issues in detail.

2. Data

We rely on three separate archive sources for our data collection. First, records from the *Hospital de São Roque*, which belonged to the House of Mercy (*Misericórdia*) of Lisbon, were created in 1943.[7] Second, records from *Casa Pia* a home for children who lost one or both of their parents, which opened in the 1780s but offers records from the early 1900s.[8] We cleaned the data and restricted the sample to the period 1905 to 1994.[9] Finally, since both prior sources cover infants and children only, we additionally study young adults through the *Livros de Recenseamento Militar*, a military source belonging to the army. Unfortunately, the latter source only allows the study of males.

Santa Casa da Misericórdia

The *Hospital de São Roque* is part of the *Santa Casa da Misericórdia de Lisboa*, founded in 1498, and historically the largest private (i.e. Catholic) charitable organization in

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[6] In contrast with Portugal, most Western European countries experienced the bulk of their increase in mean stature prior to the Second World War (Hatton and Bray 2010; see also Floud et al. 2011). In rural Spain, too, a difference in life expectancy of shorter conscripts tended to disappear for twentieth century birth cohorts (Marco-Gracia and Puche 2021); for the case of Spain see also Cámara et al. (2021).
[7] Arquivo Histórico da Santa Casa da Misericórdia de Lisboa, SCML, Assistência Médica, Hospital Infantil de São Roque, Processos Clínicos de Internamento.
[8] Arquivo Histórico da Casa Pia de Lisboa, IP, Mensurações Antropométricas (1906-1913); Arquivo Histórico da Casa Pia de Lisboa, IP, Processos individuais de alunas e alunos (1914-1970). The Casa Pia provided shelter, food, assistance and education to these children. There have been prior studies of some of its anthropometric data, most of which in the Portuguese language, but the associated datasets are different from ours and not publicly available.
[9] Our hand-collected dataset consists of 2,227 individuals who visited the *Hospital de São Roque* in Lisbon for medical appointments or hospital stays between 1945 and 2010, 1,566 children registered in the *Casa Pia* school/home for orphans, and more than 26,000 young adults in the military recruitment records. We restricted the sample to the period 1905 to 1994 because the number of observations for the later years was too small for prevalence measures to be meaningful. We also cleared our dataset of outliers as a result of typing errors, omissions and record-keeping issues. To make sure that our sample does not include unrealistic outliers, we used the WHO Multicenter Growth Reference Study Group (2006) criterion by which Z-scores lower than -6 and greater than 6 in terms of weight for age and weight for length were considered outliers and removed from the analysis. This resulted in a final dataset consists of 1,928 children for the *Misericórdia* dataset, 1,461 children for the *Casa Pia* dataset, and 26,412 for the military recruitment dataset.

Portugal. The hospital sample consists of 1,928 infants and children who attended the hospital between 1945 and 1994.[10] The individuals in the sample lived within the proximity of the hospital or were transferred there from hospitals and institutions located elsewhere. Until 1979, when the Portuguese public universal health care system was created, the country relied mainly on a private and charity-run network of hospitals and other similar facilities.[11]

Because of the charitable nature of this hospital, children from wealthy families were unlikely to attend as they sought better quality private institutions with high service fees. While a few children from well-off families are likely excluded, the sample can still be considered representative of the population.[12] We show in the Appendix that the children in our sample for Casa da Misericórdia are no different from children that visit the hospital for simple consultations. The representativeness of our Misericórdia sample is also confirmed with the comparison with the later 20-year old outcomes.[13]

Data were collected from the clinical file of each child initiated by the doctor or nurse when the child was first admitted. For each child, we collected the year of observation, age of the individual (in months), sex, weight in kilograms, and height in centimetres. We also collected handwritten notes from the attending physician or nurse, namely the clinical diagnoses. To follow the WHO Growth Standards and for simplicity, we divided our Misericórdia sample into three age groups: infants (0 to 24 months), children (2 to 5 years) and children (5 to 18 years). The number of observations in each group is listed in Table 1. Note that the Misericórdia sample only covers children up to 10 years old.

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[10] Our sample contains a comparable set of males and females. The number of surviving records with usable information decreases over time but the trend reverts during 1985-1994: as Figure A1 in the Appendix shows, most records of the children observed in the hospital pertain to the 1945-1965 and 1985-1994 periods.

[11] A few public hospitals also existed in the main cities, complemented by private clinics and co-operative health centers.

[12] The low-to-middle socioeconomic segment which were the bulk of Lisbon's population across the period considered is sure to be observed. Nonetheless, it is still possible that as incomes were growing and more hospitals were built, an emerging middle class looked for other options, selecting out over time. If so, our results can be seen as a lower bound for the progress that occurred, as negative selection happened over a period for which we still show considerable anthropometric progress.

[13] Additionally, a number of number of children were sent to the hospital from areas outside of Lisbon. After the mid- to late 1990s, this hospital's data can no longer be considered to represent a representative sample of the city of Lisbon. From 1994 onwards, not only is data more scarce but it is also the case that the clinical files progressively indicate that the children who attended the hospital were sent from shelter homes – a reflection of its increased focus on underprivileged infants and children, often those who had been subject to mistreatment by their families. Hence our dataset is truncated at 1994.

Table 1: Number of observations by sex (Misericórdia sample)

	INFANTS (0-24 MONTHS)	CHILDREN (2-5 YEARS)	CHILDREN (5-10 YEARS)	TOTAL
MALES	774	179	89	1,042
FEMALES	609	155	94	858
TOTAL	1,383	334	183	1,900

Notes: We split our sample into three different age groups for consistency with the WHO (2006) guidelines. An alternative split following the CDC reference group guidelines that we use for robustness can be found in the Appendix.

The z-score for height and weight is calculated for each child based on the WHO growth reference. The z-score is a relative measure of growth calculated in terms of standard deviations from the sex- and age-specific mean.[14] Finally, a dummy variable identifies those below the -2 z-score threshold (following De Onis et al. 2006) and classified as stunted and/or wasted. In the Appendix, we perform several tests to demonstrate that our results are not driven by sample selection effects.[15] Namely, we compare our quantitative information with an extra sample of 150 children from the same hospital where there was no biological information other than the diagnosis. We code the doctors' diagnoses into a binary growth-impairing disease variable and show that the probability of finding children with growth impairing diseases is the same in both samples.[16]

In addition, we study whether the children in the dataset are heterogenous by the nature of their interaction with the hospital during 1985-1994. This is the period for which we have records of patients that went for regular checkup appointments as well as lengthy hospital stays.[17] We check whether inpatients were more stunted or wasted than those who just went for a consultation with a doctor using a t-test of the means

[14] This facilitates analysis because individuals of different ages can be pooled together and thus overcome issues with sample size.

[15] We only collected height and weight from a subset of the records that have available data. If heights and weights were recorded more often in those children whose medical condition was more likely to affect growth, then our sample would represent a selection of the most growth-compromised children. However, our comparison shows that children who presented impaired growth or a condition likely to impair growth during the medical appointment, are not more likely to include height or weight measurements compared to the other children. Because of the lack of selection in the sample, variations in the prevalence of stunting and wasting can be taken to represent temporal changes in child well-being.

[16] See Tables A1, A2 and A3 of the Appendix.

[17] There are two types of data in the archive, one concerning inpatients and the other scheduled appointments. We divided children into these two groups based on this division.

of the dummies stunted and wasted. We also look for significant differences in their height and weight and their individual z-scores, which control for sex and age. We reject any differences in the inpatients from those that only attended a doctor's appointment (i.e. outpatients). The differences in means on the z-scores (which adjust for sex and age) for both height and weight are not statistically significant which suggests that our main results are not subject to sample selection on observables.[18]

Casa Pia

The *Casa Pia de Lisboa* is a school located in Lisbon. It is still in operation. During the period we cover in this paper, it received children from all parts of the country, including a few born in the colonies. We collected data from this source for all periods.[19] This school was dedicated to receiving children who had lost at least one of their parents.[20] In Table 2, we indicate the birthplace of the children received who appear in our sample, splitting it between the Lisbon district and other regions. In the case of children who appear more than once in the source, we only use their first appearance for these results.[21]

Table 2: Number of children and teenagers 7-18 years old by birth origin (Casa Pia sample)

	MALES	FEMALES	TOTAL
BORN IN LISBON	607	260	867
BORN IN OTHER REGIONS	431	162	593
TOTAL	1,038	422	1,460

Note: All individuals were observed in Lisbon. The table refers to their birthplace. We show the number of individuals with at least one record. Data for females is available only from 1943.

We collected the *Casa Pia* data from two documents: the *Livros de Mensurações* – actual books containing data from 1906 to 1913 – and the *Fichas de Admissão*, which are files of students that include data from 1914. From 1942-1943 the information became better organized, as it was systematically collected when students entered *Casa Pia* (i.e., the measurements were made just before the student entered *Casa Pia* or shortly after

[18] See Tables A4, A5, A6, A7, A8, A9 and A10 of the Appendix.
[19] Figure A2 of the Appendix shows the distribution of our *Casa Pia* sample over time.
[20] There was a separate school for children with cognitive limitations, which we do not consider here.
[21] Below, we consider repeated visits taking advantage of the longitudinal dimension for those who are observed more than once.

their entry).[22] As in the *Santa Casa da Misericórdia* sample, we calculate z-scores for height and weight for each child based on the WHO growth reference.

Children's full sample

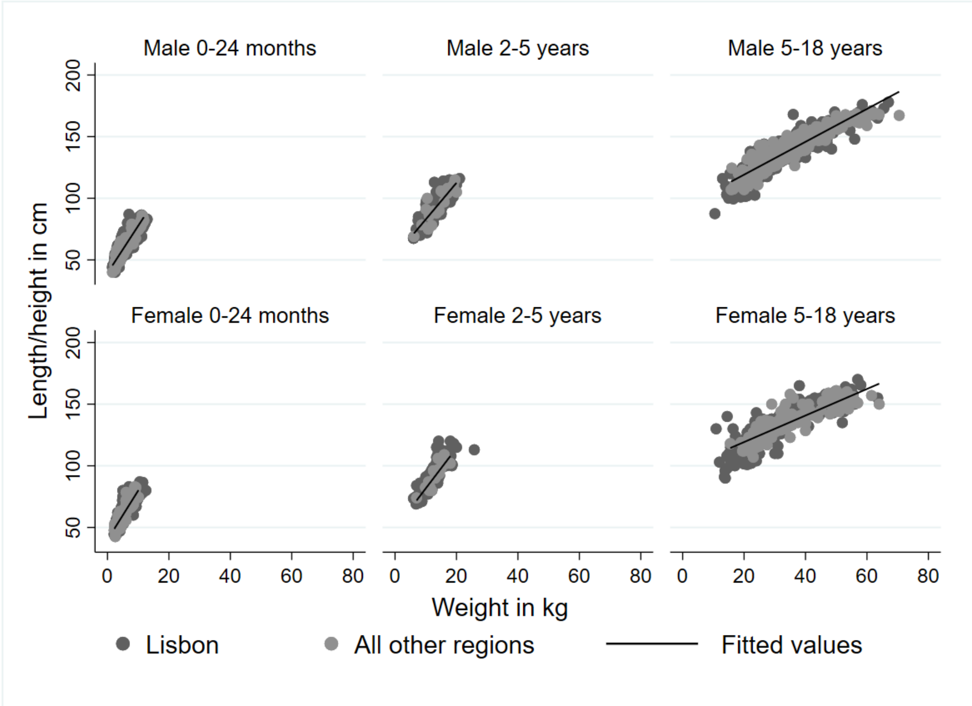
Our full sample for children (i.e., individuals below eighteen years old, including infants and teenagers) consists of the pooling together of the *Misericórdia* and *Casa Pia* samples.[23] Table 3 shows details about the contribution of each subsample to the totals.[24] Figure 1 shows correlations of height and weight, separated by sex and age by place of birth. As expected, we observe infants (0-24 months old) have a lower weight, height, and variability than children and teenagers (2-5 and 5-18 years old), for both sexes.[25]

Table 3: Total children in the sample by decade and institution

	TOTAL	MISERICÓRDIA		CASA PIA	
DECADE		Males	Females	Males	Females
1905-1914	171	0	0	171	0
1915-1925	168	0	0	168	0
1925-1934	93	0	0	93	0
1935-1944	59	0	0	59	0
1945-1954	1,043	328	304	247	164
1955-1964	933	309	210	217	197
1965-1974	164	9	11	83	61
1975-1984	95	50	45	0	0
1985-1994	634	346	288	0	0
TOTAL N	3,360	1,042	858	1,038	422
		1,900		1,460	

[22] Before 1942 the children were not measured when institutionalized, but they were always measured on their birthdays, meaning that they were measured within a year, at most. After 1942-3, they were measured when they were institutionalized, but this might not have been done immediately; there could have easily been a lag of a few weeks. Hence, the average lag was likely not too different across time.
[23] In the Appendix, we show that for the main periods when the two samples overlap (1945-64), the results for each subsample are not statistically different. See Table A11 and the surrounding discussion.
[24] We align with the recommendations of Jenkins and Quintana-Ascensio (2020) that sample sizes of 25 or higher provide reliable indicators for health statistics.
[25] We show further information about weights and heights in our sample in Tables A12 and A13 of the Appendix. Our descriptive statistics are in line with what previously existing studies reported about the heights and weights of Portuguese children or young adults for the years in which they overlap our sample (Rosa 1986, Padez 2002, 2007).

Figure 1: Height on weight for infants and children of both sexes



Note: the total sample size corresponds to 1,928 individuals from the Misericórdia hospital and 1,459 observations for Casa Pia.

Livros de Recenceamento Militar

From the archival sources of the military in Portugal (*Arquivo Geral do Exército, Livros de Recenseamento Militar*), we obtained 26,412 observations of young adults' heights from 1924 to 1968.[26] This data originates from military records concerned with mandatory inspection for potential recruiting of young males for the Portuguese armed forces. The procedure covered the whole country and was organized to ensure that all young men complied with the military and medical inspection.[27] We collected a random sample which includes observations for municipalities (*concelhos*) covering all major regions of continental Portugal (Table 4). This allows us to compare trends in stunting and wasting for young adults across space and time. The benefit of this source of height data is that the information was universally collected across adult 20-year-old males in Portugal, and it was drawn without sample selection (for survivors).[28] Hence, it is representative of the entire young adult male population in the country. The main disadvantage of this sample is that it is available for males only.

[26] This data is part of the collection entitled *Exército Portugês, Relatórios de Inspeção.*
[27] For details concerning the this source, see Palma and Reis (2021, p. 416).
[28] See Palma and Reis (2021) for more details about this source.

The heights were collected during the mandatory military medical inspection that all 20-year-old males undertook. We collected the height of these individuals for several annual benchmarks (1924, 1930, 1940, 1950, 1960 and 1968) covering the entire country.[29]

Table 4: Number of young adult males (20 years old) by location

	BIRTHPLACE	LIVING/WORKING PLACE
LISBON	5,438	8,479
OTHER REGIONS	20,974	17,933
TOTAL	26,412	

Note: The living/working division is based on the location of the military inspection.

3. Wasting and stunting among infants and children

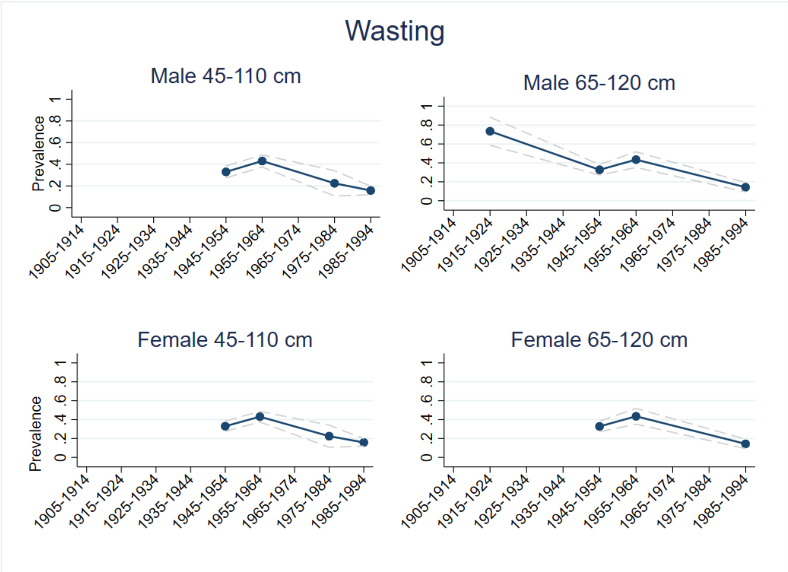
Wasting among infants

Wasting is a measure of acute malnutrition and identifies infants with at least one of the following conditions: weight-for-height z-score (WHO) below two standard deviations and/or mid-upper arm circumference <125 mm; the presence of bilateral pitting edema. We focus on the first criterion alone since it is the only one we can measure in our dataset. Wasting references are available at different ages and by sex from the growth references at WHO (De Onis et al. 2006), but only until 120 cm. The World Health Organization (WHO) has two different references for weight-for-height measurements and wasting: one for children who cannot stand in a recumbent position (length from 45 to 110cm) and another for children who are measured in a standing position (height from 65 to 120 cm).[30] The WHO Multicountry Reference Group (De Onis et al. 2006) measured children between 18 and 30 months old in both positions, resulting in two different standards. Therefore, we focus on wasting among these two specific groups (all our infants and children up to 120 cm). [31] Figure 2 shows that wasting among infants fell steadily from the mid-1950s, and in the case of males between

[29] The distribution of observations by municipality is listed in Table A14 of the Appendix. From 1969, the age of observation of recruits by the military changed from 20 to 18 years old, which means that further benchmarks would not be directly comparable.
[30] For the WHO standards, see: https://www.who.int/tools/child-growth-standards/standards.
[31] See Table A15 and Table A16 of the Appendix for the prevalence of wasting among infants over time.

65 and 120 cm, improvements come from even earlier (though the timing of the improvement remains uncertain).[32]

Figure 2. Wasting for infants (WHO Growth Standard)



Note: Wasting prevalences calculated by the authors based on WHO growth standards at recumbent length (45-110 cm) and standing height (65-120 cm). Periods without a dot are interpolated due to low sample size. Please, refer to appendix Table A15 and A16 for sample size information for each group.

Stunting among infants and children

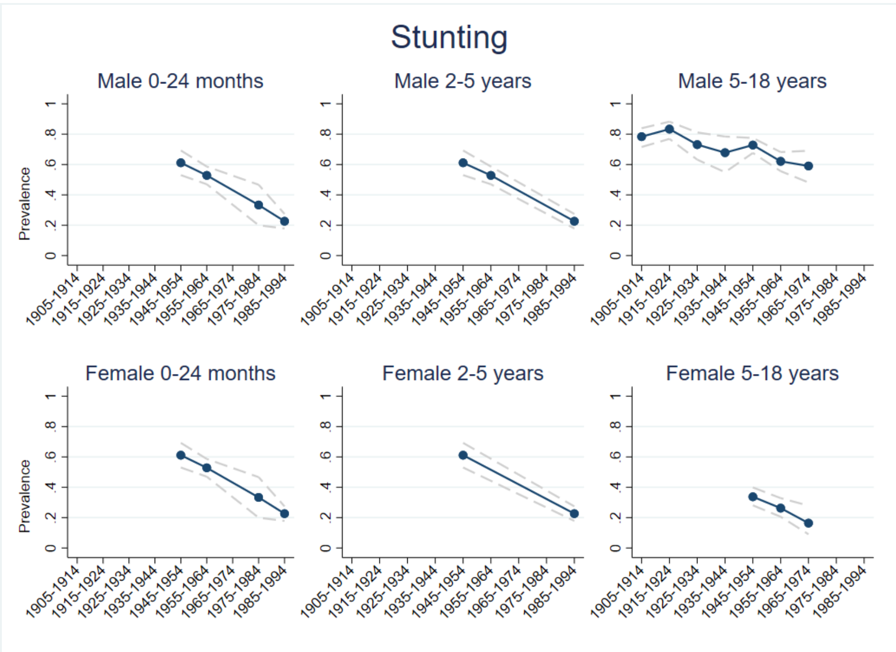
Child stunting is a reduction in growth and measures chronic malnutrition and recurrent infections (most notably leading to diarrhea). These can occur in early childhood or before birth due to inadequate fetal development by a malnourished mother. The World Health Organization (WHO) defines a stunted child as one whose height for age is less than two standard deviations from the mean of that age taken from the Growth Reference Standard. Severe stunting is defined as height-for-age below three standard deviations. There are three height-for-age reference values for children of different ages: one for 0-24 months of age, another for those 2-5 years old, and one for

[32] Wasting criteria can also be found at CDC and our robustness calculations are available in the Appendix (Figure A3). Our results are consistent looking at both references. Data available at different ages, and by sex, from the CDC (https://www.cdc.gov/growthcharts/clinical_charts.htm).

children between 5 to 19 years of age.[33] This paper considers children in these three categories consistently with WHO categories.

The stunting prevalence by decade and age category is shown in Figure 3.[34] Our calculations suggest that the prevalence of stunting was close to 60% for all age groups in 1945, for both males and females, and that it consistently decreased to 20% for younger children. The available evidence for the 5 to 18-year-old group is more limited but also shows improvement over time. We can observe previous decades for this group, which indicates that prevalences at the beginning of the century were even larger, at least for males, which suggests that the improvement started even before. Please notice that the slight increase in the prevalence of the 5 to 18 years of age in 1965 is accompanied by a reduction in sample size corresponding to larger confidence intervals.

Figure 3. Stunting by sex and age group (WHO growth standard)



Note: Stunting prevalences calculated by the authors are based on WHO growth standards. Periods without a dot are interpolated due to low sample size. Please refer to appendix Tables A17, A18 and A19 for sample size information for each group.

[33] Since the individuals in our infants and children sample are only 0 to 18 years of age, our calculation only refer to children up to 18 years of age when we refer to the main sample. We focus on the 19 year old references when we consider young adults.
[34] Note that the CDC equivalent table for the Casa Pia sample is the same as for the WHO criteria, hence we do not repeat it. Table A20 of the Appendix shows the number of observations by group according to CDC criteria for the Misericórdia sample. For specifics about sample sizes, see Table A21 and A22.

The prevalences shown in this graph are larger than the ones reported by the CDC standards. This is because the WHO and the CDC make different assumptions.[35] Given the different thresholds, the stunting prevalences vary for each reference although not substantially. The trends described, however, are remarkably similar. Hence we also report the CDC statistics in the Appendix, Figure A4, which show a consistent decreasing trend.

4. Stunting among young adult males

We now move to the discussion of young adults.[36] As explained in section 2, we can only observe males due to the military nature of the source. However, our sample is representative of those who survived to the age of 20 and lived in Portugal, since the military inspection was universal. We collected a random sample of 26,412 observations from all around the country, focusing on mainland Portugal only, i.e., we do not consider the islands or the former colonies.[37] This sample allows us to check that for each generation, the improvements seen in the children are seen in an different sample concerning 20-year olds observed later.[38] This is hence an independent check for the plausibility of our results. Given that the young adults sample covers the entire country, it also allows us to also track the trends of the spread of improvements to the rest of the country. A downside of this young adults sample is that given its military origin, women are not observed.

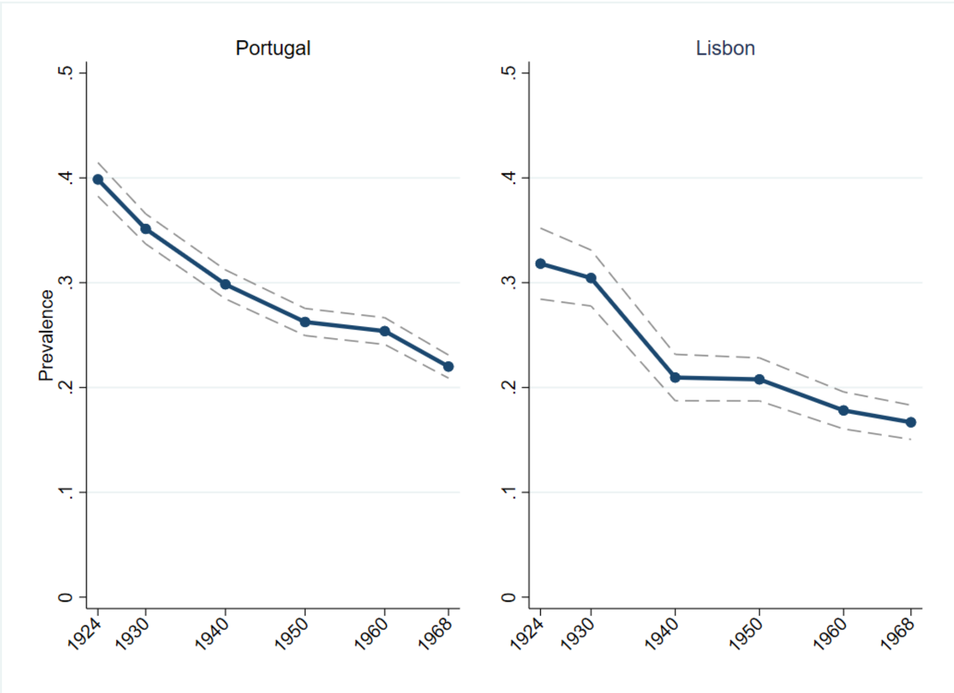
Figure 4 shows that the prevalence of stunting was consistently lower in Lisbon than in Portugal.[39] As with infants and children, there was a decreasing trend over time: for the country, stunting decreased from around 40% of individuals in 1924 to close

[35] The WHO mean stature at 19 for males is 176.54 cm, and the -2 S.D. equals 161.95 cm. Instead, for the CDC, the mean stature for males at 20: 176.86 cm, and the -2 S.D. height value is 162.48 cm.
[36] Figure A5 in the Appendix shows the number of observations over time for this database.
[37] We did not collect data beyond 1968 because from 1969 the military inspection began to happen at the age of 18 instead of 20.
[38] There is a literature on catch-up growth after the critical early years and prior to completed height. Some of it suggests that when circumstances change, a rapid catch-up breaking the link between growth in the early years and completed heights might be possible (Schneider and Ogasawara 2018, Depauw and Oxley 2019). The evidence suggests that this did not happen in our particular case.
[39] Our dataset includes information on the place of inspection, typically corresponding to where the individual was living and working or studying. We have alternatively used birthplace as the criteria; doing so the results are similar, and shown in the Appendix (Figure A6).

to 20% by 1968.[40] Progress happened earlier for those living in Lisbon: stunting decreased from more than 35% in 1924 to less than 20% by 1968. As with infants and children, health improvements began before a tax-financed national health service was created.

The age of measurement of these young adults is 20 years of age, but the WHO growth standards only reach until the age of 19; therefore, we took particular interest in the CDC version of this graph that is provided in the Appendix (Figure A7), as the CDC growth reference reaches the age of 20. Since the CDC growth reference does not assume optimal growth conditions, it suggests a shorter z-score at 20 than the WHO at 19; hence generally, stunting prevalences are larger using the CDC. However, we can confirm the decreasing trends.

Figure 4. Comparison of stunting in Portugal vs. Lisbon for 20 year-old males



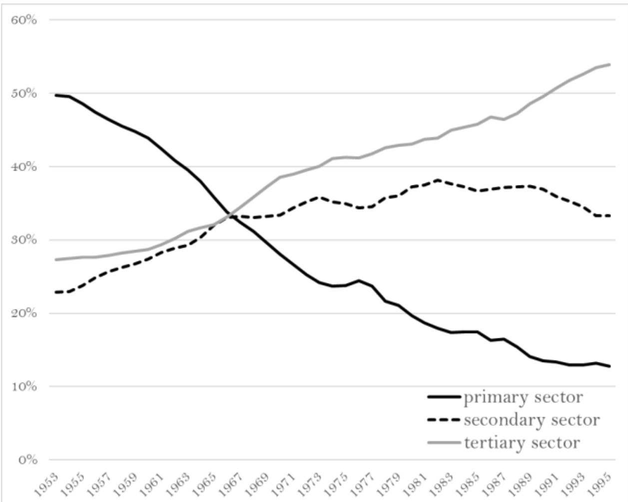
Note: Stunting prevalences calculated by the authors are based on WHO growth standards at 19 years of age (the latest possible). For details, please see the Appendix, Figure A6. *Source: Arquivo Geral do Exército, Livros de Recenseamento Militar (1924-1968).*

[40] The lower stunting incidence for young adult males compared with male infants for corresponding periods is likely due to survivorship bias. This levels effect is not in contradiction with the decrease in trends concerning the average effects on adults lagging those of children.

5. Interpretation

Portugal's income and health improvements over the second half of the twentieth century led to the decreased incidence of both stunting and wasting that we have demonstrated. In this section, we provide additional context and interpretation. The proximate causes were improved nutrition and sanitation and increased availability of medical care, which have been documented to have had an impact elsewhere (Fogel 2004; Deaton 2013).[41] Infant mortality due to digestive diseases up to 3 years of age fell, and literacy levels among children rose steadily from the late 1920s onward (Palma and Reis 2021). From around 1950, infrastructure improved considerably regarding water access, sewage, and the quality of dwellings (Pato 2011; Saraiva et al. 20111, 2014).[42] This decreased the incidence of diarrhea and digestive diseases that commonly affect children.[43] The infrastructure improvements happened earlier in urban areas, particularly in Lisbon, than elsewhere in the country (Pato 2011, pp. 97-98). The country began to industrialize systematically and experienced high economic growth and convergence rates to the European core from the early 1950s, hence a decade before entering the European Free Trade Association (EFTA): see Figure 5 and Lains (2003).

Figure 5. The sectorial distribution of employment in Portugal's economy, 1953-1995.



Source: our calculations based on the data by Pinheiro (1997).

[41] We do not find surprising that outcomes for females improved as much as those for males did, given that historical evidence suggests that Portuguese traditional social norms did not discriminate against women more systematically than was the case in other Western European regions (Palma et al. 2023).
[42] For other regions of the world, research has shown that access to water and sanitation infrastructure has a stronger negative relationship with stunting than other public services (Bridgman and von Fintel 2022).
[43] This had great implications for health outcomes. The proportion of deaths due to digestive diseases reduced from more than 14 percent in 1940 to less than 3 percent in 1990. Improvements began in the 1940s, in line with what we find for stunting improvements. For details, see Table A23 in the Appendix, based on Morais (2019), and the accompanying discussion we provide there.

Nutrition in Portugal improved considerably over the twentieth century. At least from the 1950s, and for the country overall, per capita protein consumption from foodstuffs, including meat, eggs, and milk, increased significantly (Table 5).[44] Progress was only interrupted by a temporary breakdown related to the adverse effects of the agrarian reform and economic crisis during the initial post-revolution years (Barreto 2017), but resumed in the late 1970s.

Table 5. Average per capita annual food consumption for selected staples, in kg or litres.

	1948/9	**1963**	**1970**	**1974**	**1977**	**1980**	**1990**
WHEAT	55.0	67.9	75.2	75.2	72.0	75.0	76.7
RICE	8.6	14.5	14.8	17.8	16.1	13.9	17.4
POTATO	80.6	102.3	121.7	110.9	91.9	130.1	128.3
SUGAR	12.0	19.1	25.6	30.0	27.9	31.3	29.3
PORK	3.8	6.0	7.5	9.4	9.4	9.5	15.6
POULTRY	1.3	1.4	7.1	11.9	15.0	11.6	13.0
BEEF	3.8	6.8	11.2	14.3	13.4	10.3	13.0
COD	6.1	6.8	10.1	6.8	5.2	3.0	5.0
EGGS	1.6	3.7	4.4	4.5	4.4	5.1	6.6
MILK	11.9	30.8	51.8	57.3	59.6	60.6	83.5
OLIVE OIL	7.5	6.7	6.9	5.3	4.2	4.2	3.3
WINE	90.6	91.3	79.4	131.0	85.9	95.0	63.3
BEER	2.0	4.4	14.8	32.6	29.5	40.1	67.8

Note: the figures refer to continental Portugal until 1980 and the entire country henceforth. The range of figures for 1980 corresponds to the information in both sources. The unit for beverages corresponds to litres, all else in kg. We focus on the edible part of foodstuffs, e.g. rice without chaff. In the case of 1977, the source is not clear whether quantities correspond to totals or edible parts.
Source: For 1948/9, Instituto Nacional de Estatística (1951). For 1963 to 1974, we rely on Campos (1980); see also Barreto et al. (1996, p. 84). For 1977, we rely on Instituto Nacional de Estatística (1984). For 1980 and 1990, we rely on Instituto Nacional de Estatística (1994, pp. 24-25, 44-45) and Instituto Nacional de Estatística (1999).

In addition to improved nutrition, stunting also reflects non-nutritional factors such as the health environment during childhood. The initial increase in the heights of the Portuguese was essentially the result of a reduction in child stunting. While the most

[44] Cardoso (2008, p. 272) presents an alternative but less detailed breakdown of per capita food consumption starting in 1948/9. This also shows that much progress in per capita food consumption had taken place in the 1950s, even though the author ignores this fact in the written text. In particular, consumption of all animal productions except fats increased considerably, and milk consumption quadrupled. Animal protein in meat and milk provide micronutrients which matters greatly for human health and growth (Baten and Blum 2014, p. 145).

significant decrease in stunting occurred before the 1960s, most mean height increases occurred afterwards (Cardoso 2008). Portuguese eighteen-year-old males were considerably taller after 1970 due to the greatest increase in mean stature of individuals born in the 1960s and later (Padez 2007). Mean height continued to increase into the early 2000s (Cardoso 2008). These changes reflect ongoing progress in socioeconomic circumstances and material living conditions concerning higher incomes and more access to public goods.

We lack most Portuguese health-related data series for the period under study. The exceptions are perinatal, neonatal, and infant mortality. Analysis indicates a steep decrease between 1940 and 1950, which continued to decrease and then became steep again around 1970 (Veiga et al. 2004). From the 1930s, there was a decline in the mortality rate and a decrease in the infant mortality rate (Schmidt et al. 2011). Deaths caused by infectious and parasitic diseases, usually related to poor social environment and hygiene, in turn, started to decline in the 1950s due to improvements in living conditions, better literacy, and progress in medical care (Palma and Reis 2019; Schmidt et al. 2011; Leão and Rodrigues 2016).

In line with the remainder of our evidence, child mortality showed great improvements in the period we cover in this paper (Table 6). As the table shows, infant mortality declined sharply after an initial temporary rise during the 1910s.[45] Relatedly, Portugal began a fertility transition in the second half of the 1920s, with the birth rate – measured as the number of surviving births per 1,000 people in the population – falling persistently and at times quickly in the following decades, despite a temporary pause during 1940-1960 (Instituto Nacional de Estatística 2013, p. 38). Data for the fertility rate – average number of children per woman – is unavailable in detail before 1960, but by then, it was down to three.[46] This indicates that a demographic transition was already occurring. The fertility rate fell further to 2.7 by 1974, 1.7 in 1985, and only 1.4 by 1994 (Instituto Nacional de Estatística 2013, p. 41). High income growth and low fertility levels from the 1950s meant that feeding better each surviving child became possible.

[45] For comparative evidence showing that Portugal's child mortality was considerably higher than in other Western European countries in the early twentieth century but converged during the period we cover in this paper, see Global Burden of Disease Collaborative Network (2018).
[46] Historically in Portugal, women had 4 or more children, with about a third dying before the age of 7 (Palma et al. 2020).

Table 6: Perinatal, neonatal, and infant mortality (per 1000)

YEAR	**PERINATAL**	**NEONATAL**	**INFANT**
1910	-	-	133.9
1920	-	-	164.1
1930	-	-	143.6
1940	-	-	126.1
1950	-	-	94.1
1960	42.2	28.0	77.5
1970	38.9	25.4	55.5
1980	23.8	15.4	24.3
1990	12.4	6.9	10.9
2000	6.2	3.4	5.5

Notes: infant mortality corresponds to children less than one year of age. It was 38.9 in 1975. Source: Perinatal and neonatal data from Instituto Nacional de Estatística (2001). Infant mortality from Rodrigues (2008, p. 426). As alternative infant mortality figures, Baganha and Marques (2001, pp. 38-42) alternatively give 131 for 1950 and 94 for 1960, while Instituto Nacional de Estatística (2001) alternatively gives 58 for 1970 and 34.4 for 1980.

The supply of tax-financed health services increased substantially in quantity and quality during the period under study. These public policies had an impact on health and well-being as happened elsewhere in Western Europe over the twentieth century (Jong 2015). A reform to the Social Security system in 1945 led to greater state involvement in providing health services. As a result, more people were covered by public health insurance (*caixas de providência*) until 1971 (Campos and Simões 2012). During this period, much progress was made towards constructing a system of hospitals financed by the state, such as *Hospital de Santa Maria* in Lisbon and *Hospital de São João* in Porto. Further reforms in 1971 laid the foundation of a National Health Service, which gradually became a universal health system provided by the state, but which would only become accessible to all from 1979, following the implementation of democracy and its associated constitutional mandate (Campos and Simões 2012, p. 120). There was also a public national vaccination plan from 1965, which reduced child mortality due to communicable diseases for children 1-4 years old to less than half within a decade (Campos 2000, p. 406). There was hence a gradually increased access to health services. The percentage of the population with access to public healthcare increased from less than 10% in 1954 to 16% by 1960, 30% in 1965, 60% in 1970, and finally, 78% in 1975

(Carreira 1999, p. 412).[47] In addition, from 1963, a healthcare system known as ADSE (*Assistência na Doença aos Servidores Civis do Estado*) was available to public servants. It covered as much as 8% of the population in 1975 (Carreira 1999, p. 412). The military and their families had a specific health system as well.

Individual persistence

Our prior results point to a long-run improvement in the prevalence of stunting and wasting, backed by an improvement in the provision of nutrition and health. However, we have not discussed the effect of attending a given institution on individual well-being over time. In the Casa Pia database, extant records indicate that some individuals attended several medical inspections over time during their stay, generally on their birthdays. In this section, we take advantage of the possibility of considering the persistence of stunting over time (scarring effects). For individuals appearing in our sample more than once, we consider the probability of stunting in each subsequent health inspection conditional on the outcome of the previous one. This simple test aims to assess the probability of individuals being able to improve their health indicators in the medium run (over their childhood), once being institutionalized.

Table 7 describes our observations of individuals with multiple records and the stunting prevalence per number of inspection. Firstly, we observe a high level of attrition in the sample (there are fewer observations with a higher number of inspections). Secondly, the stunting prevalence for individuals considered in different inspection numbers increases over time. Note, however, that this table does not track the time of the inspection, so this increase in prevalence does not correspond to an increase of stunting over time: visits took place within a maximum difference of a year (entry day and/or birthdays), so we consider individuals who stayed a maximum of six years in the Casa Pia.[48]

[47] Public healthcare was often run by private providers but was nevertheless tax-financed and marginally free from the perspective of the user.
[48] Hence, it is unlikely that any of these individuals belong to the stunting statistics of the next decade.

Table 7: Observations of children in Casa Pia sample, number of health inspections

INSPECTION NUMBER	OBSERVATIONS	STUNTED AND PREVALENCE
FIRST	1,460	503 (0.35)
SECOND	615	237 (0.39)
THIRD	122	54 (0.44)
FOURTH	90	44 (0.48)
FIFTH	59	24 (0.40)

Note: This table shows the number of individuals who had 1 to 5 health inspections in our records and their stunting prevalence.

Given the constraints of our dataset, we cannot look at other factors affecting the probability of stunting other than the fact that these individuals appear in a previous inspection.[49] We estimate the following model by OLS, resulting in a Linear Probability Model:

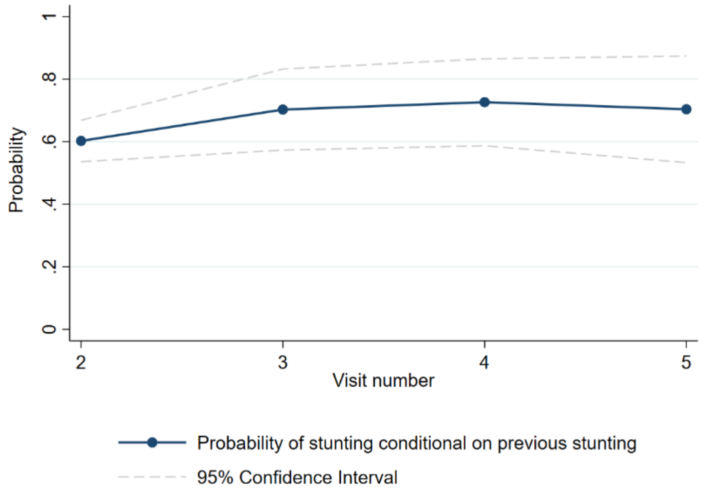
$$Stunted_{t,i} = a_0 + b_1 stunted_{t-1,i} + b_2 controls_i + \varepsilon_i$$

The controls of our regression include the age and sex of the individual as well the corresponding cohort. This way, we control for different probabilities of stunting for earlier periods and for younger individuals.[50] The results (Figure 6) show that the probability that individuals' weight was 2 S.D. below the average for their reference group was heavily dependent on the person's prior status during the previous measurement. Individuals stunted in their first inspection likely remained stunted in subsequent visits. This shows that initial deprivation had long-term – likely permanent – adverse health effects for most individuals. Our results also suggest there was no catch-up growth. Hence, the institutional conditions of Casa Pia were at least not so much better than outside that they would have generated it, alleviating concerns about the effect of the time of measurement at Casa Pia.

[49] We consider individuals inspected and measured up to 5 times. Most individuals were measured upon entry on the institution and again, systematically, on their birthday. The cohorts they belong to go from 1895-1904 to1965-1974.

[50] See Table A24 in Appendix for details.

Figure 6. Probability of stunting by inspection number conditional on stunting in previous visit



Note: This graph shows the probability of appearing as stunting conditional on stunting in the previous inspection, as described in equation (1), using robust standard errors. The regression includes controls on age at measurement, sex and cohort. Data from Casa Pia, described in the text. Refer to Table A24 in the Appendix to check for the regression coefficient results.

6. Conclusion

Portugal witnessed its fastest economic development during the second half of the twentieth century. In this paper, we have documented a remarkably decreasing incidence of undernourished and stunted infants and children over that time. The progress in health outcomes affected individuals of both sexes and covered the entire country. The most noticeable changes happened during the Estado Novo regime, before democracy and the creation of a modern tax-financed national health service. Using an additional source of military origin, we find that a similar pattern of improvement in stunting occurred for young adult males during the same period, with the expected time lag.

Our results show that the good macroeconomic performance of the Portuguese economy during the second half of the twentieth century translated into considerably better living standards for infants, children and adults. The decreases in stunting and wasting were related to increases in income, sanitation and medical improvements that gradually spread through the country despite a limited (but expanding) healthcare system. The progress in health and physiological capital that took place under the Estado Novo regime from around the mid-century is plausibly connected to these public policies, in interaction with the economic growth of the period. Healthcare improvements mattered, but so did better nutrition, with much-increased consumption of high-protein foodstuffs such as poultry, beef, and milk.

Previous work has documented the reformist and developmental nature of the Estado Novo regime (1926/33-1974), along dimensions such as education (Palma and Reis 2021), banking (Amaral 2013, 2015), and law (Álvares and Garoupa 2020). In fact, during the postwar European golden age, despite being a dictatorship, this regime invested in public policies and generated material gains from which most of the population benefited, as was similarly the case in Spain (Prados de la Escosura et al. 2012). Political institutions in any given context are a bundle, and while the Estado Novo was a dictatorship, it provided certain investments and reforms which led to economic development, convergence to European living standards, and, in time, cultural change as well (Acemoglu and Robinson 2022).

The macroeconomic progress that occurred was associated with considerable improvements in ordinary citizens' living standards, including infants and children, as we show here. That progress then continued further under democracy. As a result of this joint progress, Portugal was transformed during the 1945-1994 half-century from a country with dismal development outcomes into a modern developed country as far as health outcomes are concerned.

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Appendix (for online publication only)

Figure A1: Percentage observations in the Misericórdia dataset by sex and year

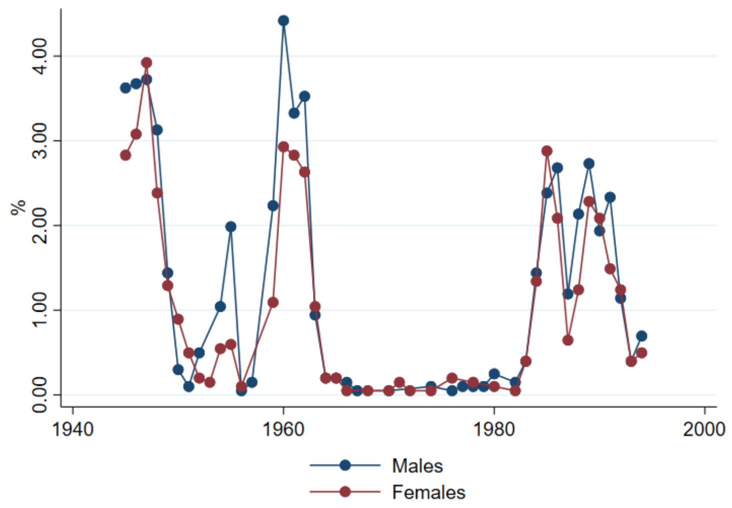


Figure A2: Percentage observations in the Casa Pia dataset by sex and year

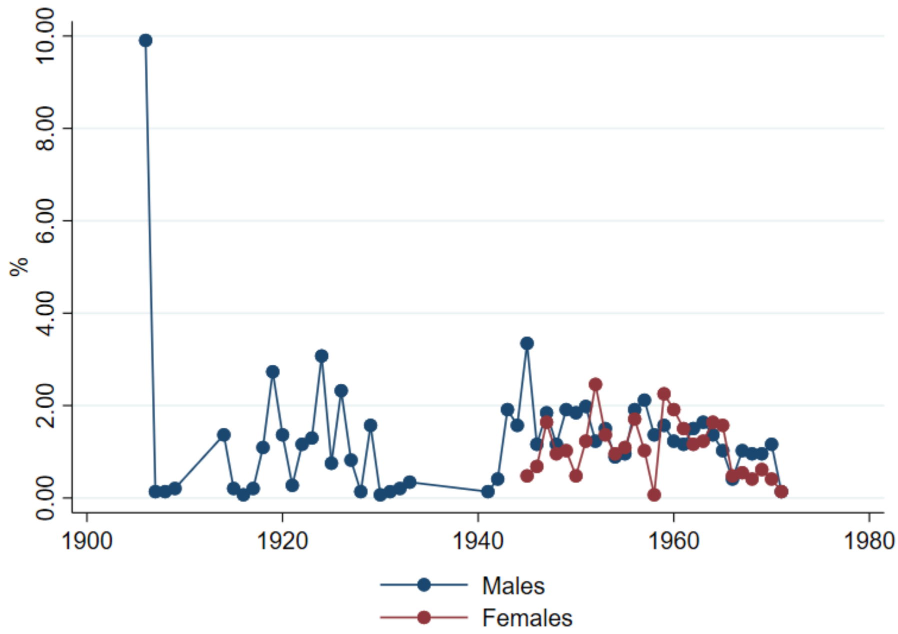
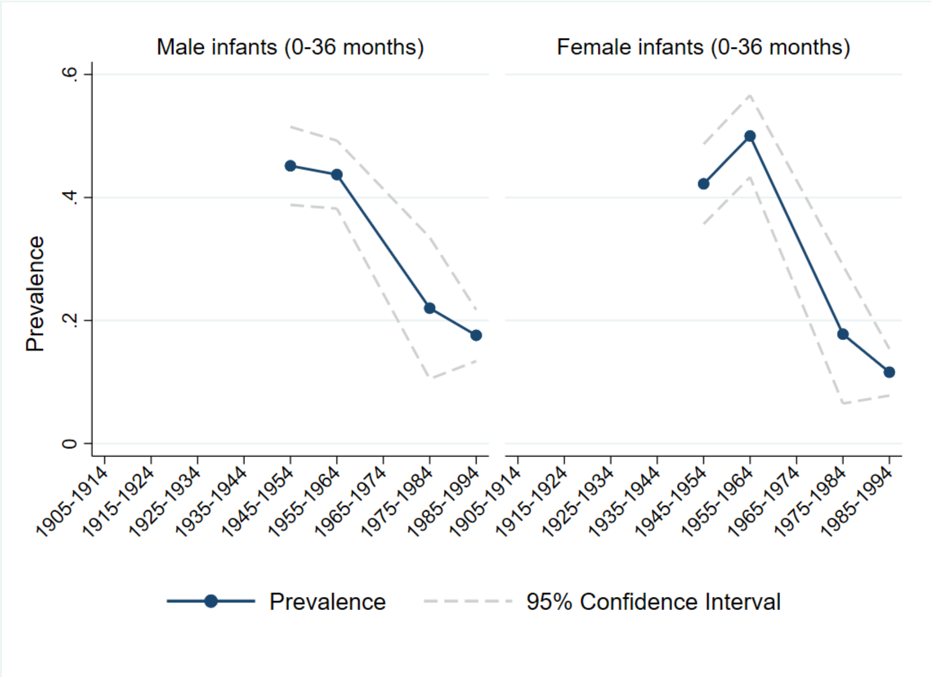
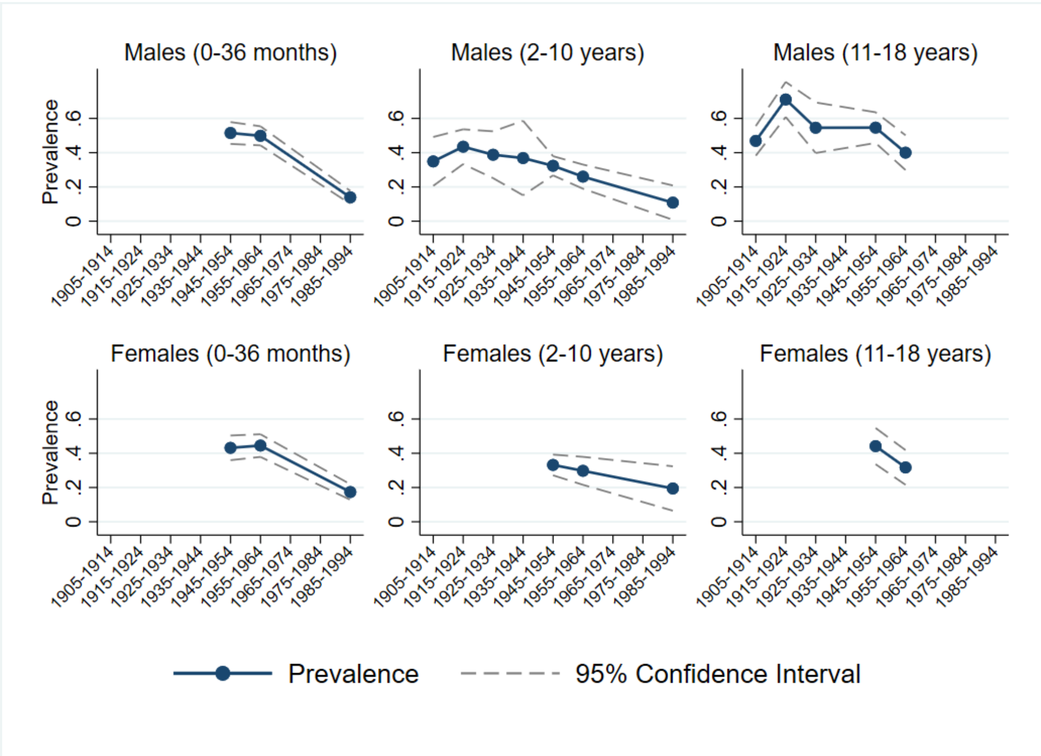


Figure A3. Wasting for infants (CDC growth reference)



Note: Wasting prevalences calculated by the authors for children below 103 cm and up to 36 months of age as defined by CDC growth reference. Periods without a dot are interpolated due to low sample size; note that different groupings make sample sizes differ with respect to WHO.

Figure A4. Stunting by age group (CDC growth reference)



Note: Stunting prevalences calculated by the authors for infants and children as defined by CDC growth reference. Periods without a dot are interpolated due to low sample size; note that different groupings make sample sizes differ with respect to WHO.

Figure A5: Total number of observations in the young adult military database

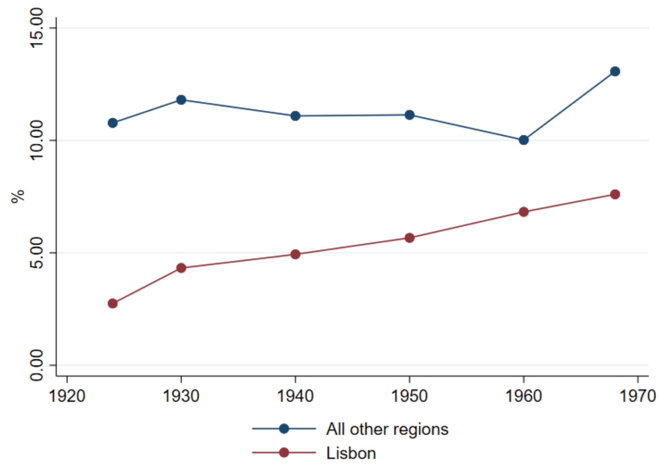
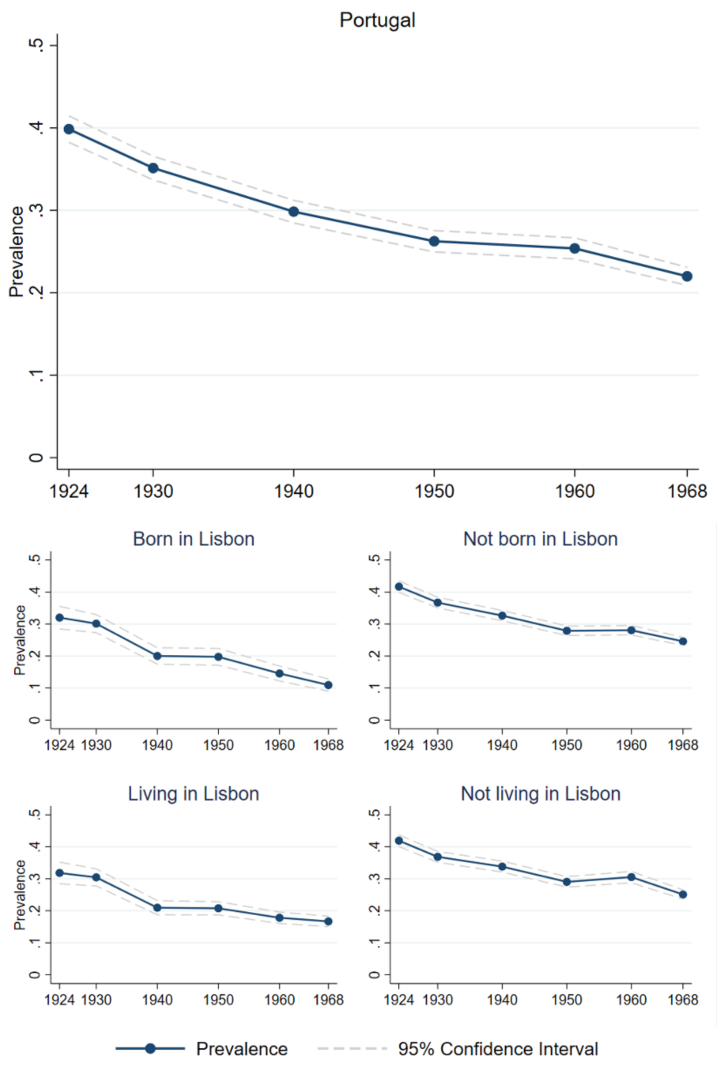
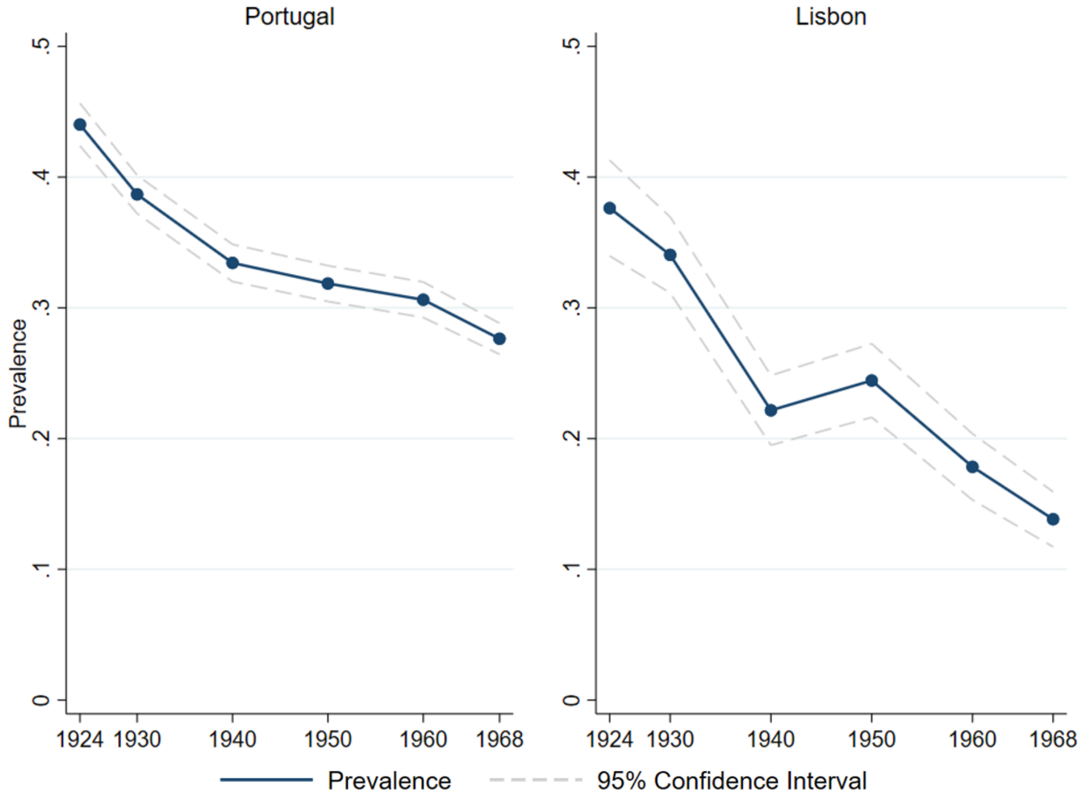


Figure A6. Stunting among young adult males (WHO growth reference)



Note: Stunting prevalences calculated by the authors are based on WHO growth standards at 19 years of age (the latest possible). Please refer to appendix Table A14. Source: Arquivo Geral do Exército, Livros de Recenseamento Militar (1924-1968).

Figure A7. Comparison of stunting in Portugal vs. Lisbon for 20 year-old males with CDC growth reference



Source: Arquivo Geral do Exército, Livros de Recenseamento Militar (1924-1968).

Discussion of sample representativeness

In this section, we present evidence that our results are not driven by the selection of observables. For example, weight length/height information might have been observed conditional on diseases (for example, if a doctor or nurse could have noted this quantitative information with a higher probability in situations of malnourishment). To test for this, we collected 150 additional observations for the Misericórdia sample, without no information recorded on the height or weight of the individual, but for whom we know the medical diagnosis. We then compare this qualitative information with our original dataset. We do not find evidence in favor of sample selection. Therefore, we argue that even though less than half the records in the archive include data on the heights and weights of children, they are representative.

The test is performed based on our extraordinary information on the doctor's diagnosis of the patients. We can use the clinical information reported by the doctors in the records to detect whether patients with diseases that can affect their weight/stature are statistically different. In practice, the classification of diseases is complicated, and disentangling causality is challenging. To simplify matters, we coded the doctors' diagnosis in a binary variable that equals 1 when the diagnosis reports at least one disease that can potentially affect long-term height/growth – such as congenital malformations or a precise diagnosis of growth delay/impairment – and 0 when there is no certainty of a growth-impairing disease.

We show that data on heights and weights are missing at random, which, as argued, increases the credibility of our main results not being driven by sample selection. Table A1 shows the reported incidence of growth diseases coded in a "Growth Disease" dummy in the primary dataset and the 150 qualitative sample (random observations across decades, 25 males and 25 females for each period). The rationale behind this test is to check that the reason for recording height/weight in the hospital is not dependent on the existence of a clinical issue directly or indirectly related to a growth deficit, hence making our results endogenous, but simply a random outcome related to the current policies of the hospital or the diligence of the nurse which happened to record the patients' information.[51]

Table A1: Growth-impairing diseases in the total sample by decade (Misericórdia sample)

DECADE	**MAIN SAMPLE**	**GROWTH DISEASE**		**QUALITATIVE SAMPLE**	**GROWTH DISEASE**	
		=1	**=0**		**=1**	**=0**
1945-1954	632	248	384	50	17	33
1955-1964	519	183	336	50	23	27
1965-1974	20	10	10	0	0	0
1974-1985	95	25	70	0	0	0
1985-1994	634	171	463	50	7	43
TOTAL N	1,900	637	1,263	150	47	103

We split the analysis into age groups like 0-24 months infants and 2-10 years old children because there is not enough data to carry out a separate study between 5-10 year-olds. These tests study whether the information on diagnosis behaves the same way for the main and the additional qualitative samples. Tables A2 and A3 show that infants

[51] The criteria that we adopted for the presence of a growth disease is given in detail below.

and children diagnosed with a growth-impairing condition are found in the same proportion in the qualitative and main samples.

Table A2: T-test results of the binary coding of growth impairing conditions from the diagnosis of 0-24 months old infants (Misericórdia sample)

GROUP	N	GROWTH IMPAIRING DISEASE DUMMY (MEAN)
Qualitative sample	107	0.383
		(0.047)
Main sample	1,369	0.330
		(0. 013)
Diff = Mean (Qualitative) – Mean (Main)		0.053
		(0.047)
T-Statistic		1.119
P-Value (Pr(|T| > |t|))		0.263

Note: this table reports the t-test statistics for the means of the dummy variables coding the growth-impairing conditions from the doctor's diagnosis of children between 0-24 months old across decades for the main sample and the extra quantitative observations. The null hypothesis is that the sample means are equal, and we have 1,474 degrees of freedom. Standard errors are reported in brackets under the means.

Table A3: T-test results of the binary coding of growth impairing conditions from the diagnosis of 2 to 10-year-old children (Misericórdia sample)

GROUP	N	GROWTH IMPAIRING DISEASE DUMMY (MEAN)
Qualitative sample	84	0.286
		(0.050)
Main sample	513	0.363
		(0. 02)
Diff = Mean(Qualitative) - Mean(Main)		-0.077
		(0.056)
T-Statistic		-1.367
p-value (Pr(|T| > |t|))		0.172

Note: This table reports the t-test statistics for the means of the dummy variables coding the growth-impairing conditions from the doctor's diagnosis of children between 2 and 10 years old across decades for the main sample and the additional quantitative observations. The H_0 is that the sample means are equal, and we have 595 degrees of freedom. Standard errors are reported in brackets under the means.

These tables show that infants aged 0-24 months old for whom data on height and weight has been reported are less affected by growth-impairing diseases (around 5%). The trend is the opposite for older children, who show a higher prevalence of growth-impairing diseases when their weight and height were recorded. However, we cannot reject the null that the difference of means equals zero for both age groups at conventional statistical confidence levels (p-values: 0.263 and 0.172>0.05). There is enough evidence to demonstrate that our data do not suffer from self-selection issues.

We classify the doctors' diagnoses into two groups, one for conditions more likely to affect growth and another for less growth-impairing conditions. This classification was made using a single diagnosis without knowing whether these were chronic or acute afflictions, medical history, or comorbidities. As such, it is an imperfect classification that, for the most part, identified the following conditions as impacting growth potentially more than others: 1) congenital malformations; 2) heart conditions; 3) rheumatic conditions; 4) cancer; 5) chronic infections; 6) autoimmune diseases and 7) explicit diagnoses of growth delay/impairment.

In addition, we performed another test for sample selection bias: whether the infant patient went for a regular doctor's checkup appointment (outpatient) or was interned in the hospital for days (inpatients). We coded the sample based on whether the children stayed in the hospital or just got inspected by the doctor. Table A4 shows that a change in this distribution cannot drive the observed changes between 1945-1954 and 1955-64.

Table A4: Children distribution by kind of stay in the hospital by decade (Misericórdia sample)

DECADE	INPATIENTS	OUTPATIENTS	TOTAL
1945-1954	632	0	632
1955-1964	519	0	519
1965-1974	20	0	20
1975-1984	95	0	95
1985-1994	285	349	634
TOTAL	1,551	349	1,900

Based on the classification of these criteria, we can test whether the children in the dataset are different by kind of interaction with the hospital for the sample 1985-1994, the period for which we have both kinds of patients.[52] We check whether the interned in the hospital are more stunted/wasted than those who go for a consultation with a doctor using a t-test of the means of the dummies stunted and wasted. For infants aged 0-24 months, we carried out the two-sample t-test with equal variances in Table A5.[53] We reject any differences between the interned children and those who had routine medical appointments.

Table A5: T-test results on wasting and stunting prevalence differences by kind of stay in the hospital for infants between 0-24 months old (Misericórdia sample)

GROUP	N	STUNTED	WASTED
Inpatients	299	0.134	0.211
		(0.020)	(0.024)
Outpatients	263	0.125	0.221
		(0.020)	(0.026)
Diff = Mean(Inpatients) - Mean(Outpatients)		0.008	-0.010
		(0.029)	(0.035)
T-Statistic		0.292	-0.282
P-Value (Pr(|T| > |t|))		0.771	0.777

Note: This table reports the t-test statistics for the means of the dummy variables stunted and wasted for the sample of children between 0 and 24 months old in 1985-1994. The H_0 is that the sample means are equal, and we have 560 degrees of freedom. Standard errors are reported in brackets under the means.

The two-tailed p-value computed using the t distribution (Pr(|T| > |t|)) is the probability of observing a greater absolute value of t under the null hypothesis. The p-values for the sample of 0-24 months old children between 1985-1994 are larger than 0.05; therefore we cannot conclude that the difference in means is statistically significantly different from 0. We do not have enough evidence that stunting or wasting prevalences for infants between 0 and 24 months of age behave differently for inpatient and outpatient observations in the Misericórdia sample.

[52] There are two sources of data in the archive, one which concerns interns and the other for appointments. We divided children into these two groups based on this archival division.
[53] T-test with unequal variances leads to the same conclusions.

Alternatively, we can test whether there are any significant differences between children visiting the hospital under the null hypothesis that they were shorter, lighter and further from their reference group, suggesting that stunting or wasting affects inpatients more than outpatients. We test that hypothesis by looking at each group's average weight and height and their z-scores based on the WHO growth standards by age and sex (i.e., each individual's z-score is adjusted for their age and sex). As before, we find no significant differences (Tables A6 and A7).

Table A6: T-test results on weight and sex-adjusted z-scores for weight by age by kind of stay in the hospital for infants between 0-24 months old (Misericórdia sample)

GROUP	**N**	**WEIGHT IN KG**	**INDIVIDUAL Z-SCORE**
Inpatients	299	6.799	-0.360
		(0.137)	(0.080)
Outpatients	263	6.944	-0.470
		(0.157)	(0.080)
Diff = Mean(Inpatients) - Mean(Outpatients)		-0.136	0.110
		(0.208)	(0.113)
T-Statistic		-0.652	0.972
P-Value (Pr(|T| > |t|))		0.514	0.331

Note: This table reports the t-test statistics for the means of the weight and z-scores for the sample of children between 0 to 24 months old in the period 1985-1994. The H_0 is that the sample means are equal, and we have 560 degrees of freedom. Standard errors are reported in brackets under the means.

Table A7: T-test results on height and sex-adjusted z-scores for height by age by kind of stay in the hospital for infants between 0-24 months old (Misericórdia sample)

GROUP	**N**	**HEIGHT IN CM**	**INDIVIDUAL Z-SCORE**
Inpatients	299	64.852	-0.604
		(0.574)	(0.095)
Outpatients	263	65.747	-0.814
		(0.634)	(0.097)
Diff = Mean (Inpatients) – Mean (Outpatients)		-0.896	0.009
		(0.853)	(0.136)
T-Statistic		-1.053	0.069
P-Value (Pr(|T| > |t|))		0.293	0.945

Note: This table reports the t-test statistics for the means of the height and z-score value for the sample of children between 0 and 24 months old in the period 1985-1994. The H_0 is that the sample means are equal, and we have 560 degrees of freedom. Standard errors are reported in brackets under the means.

These tests show that, on average, 0-24 months-old inpatients are shorter and lighter than outpatients, and that their z-score is around 1% further from the mean. However, p-values are too large to reject the null that the difference of means equals zero (0.293>0.05; 0,945>0.05). Hence, there is no evidence suggesting that inpatient infants were different from outpatients, which supports the universal use of this sample. We perform the same analysis for children 2 to 10 years of age. With a low number of observations for the older cohort, we need to group our children into an overall group of 2-10 instead of 2-5 and 5-10 years of age, as done in the rest of the paper following the WHO growth reference age groups. The results for individuals between 2 and 10 years old are shown in Tables A8, A9 and A10.

Table A8: T-test results on stunting prevalence differences by kind of stay in the hospital for children between 2 and 10 years old (Misericórdia sample)

GROUP	N	STUNTED	WASTED
Inpatients	73	0.260	0.219
		(0. 052)	(0. 048)
Outpatients	40	0.275	0.125
		(0.071)	(0.053)
Diff = Mean(Inpatients) - Mean(Outpatients)		-0.015	0.094
		(0.088)	(0.077)
T-Statistic		-0.168	1.223
P-Value (Pr(|T| > |t|))		0.867	0.222

Note: This table reports the t-test statistics for the means of the dummy variables stunted and wasted for the sample of children between 2 and 10 years of age in the period 1985-1994. The H_0 is that the sample means are equal, and we have 111 degrees of freedom. Standard errors are reported in brackets under the means.

Consistently with the test for infants, we find that the p-values are too large to reject the null that the difference of means equals zero (0.222 >0.05; 0.867>0.05): we do not have enough evidence to state that the sample of inpatient children is different from the sample of outpatients. We cannot reject the null for any age for the period we can test.

Table A9: T-test results on height and sex-adjusted z-scores for weight by age by kind of stay in the hospital for children between 2 and 10 years old (Misericórdia sample)

GROUP	N	WEIGHT IN KG	INDIVIDUAL Z-SCORE
Inpatients	73	15.333	-0.205
		(0.749)	(0.162)
Outpatients	40	13.065	-0.240
		(0.702)	(0.173)
Diff = Mean(Inpatients) - Mean(Outpatients)		2.268	0.036
		(1.138)	(0.243)
T-Statistic		1.992	0.147
P-Value (Pr(|T| > |t|))		0.049	0.884

Note: This table reports the t-test statistics for the means of the weight and z-scores for the sample of children between 2 and 10 years old in the period 1985-1994. The H_0 is that the sample means are equal, and we have 111 degrees of freedom. Standard errors are reported in brackets under the means.

Table A10: T-test results on height and sex-adjusted z-scores for height by age by kind of stay in the hospital for children between 2 and 10 years old (Misericórdia sample)

GROUP	N	HEIGHT IN CM	INDIVIDUAL Z-SCORE
Inpatients	73	98.466	-0.768
		(2.256)	(0.206)
Outpatients	40	91.788	-1.295
		(2.224)	(0.282)
Diff = Mean(Inpatients) - Mean(Outpatients)		6.678	0.527
		(3.466)	(0.348)
T-Statistic		1.926	1.514
P-Value (Pr(|T| > |t|))		0.057	0.133

Note: This table reports the t-test statistics for the means of the heights and z-score values of the sample of children between 2 and 10 years old in the period 1985-1994. The H_0 is that the sample means are equal, and we have 111 degrees of freedom. Standard errors are reported in brackets under the means.

Tables A8, A9 and A10 show that inpatients between 2-10 year-olds were 7 cm taller than outpatients. The same is true for weight, which shows a difference of around 2.3

kg. However, when we account for their z-scores which account for sex and age differences in the distributions (how far they are from the WHO growth reference mean), we can see that the deviation from the mean for inpatients is smaller than for outpatients. This indicates a larger share of males or older patients in this sample and a notably smaller sample than in the infant sample considered above, potentially leading to weaker results. The differences in z-score means are not statistically significant (p-values are too large to reject the null that the difference of means equals zero, 0.884>0.05; 0.133>0.05), which is no different for the one-tail test. This confirms that our main results are not subject to sample selection on observables.

Poolability tests

We have done several tests to ensure that the Misericórdia and the Casa Pia sample observations for the period 1945-1964, when both archives have observations available, are drawn from the same underlying population and hence can be pooled together. Table A11 below shows the mean differences in stunting by sex and decade for both institutions. We test the null hypothesis that the differences in the z-score differences are equal to zero, i.e. H_0: Mean (z-score Misericordia) – Mean (z-score Casa Pia) = 0. We do not find significant differences overall.

Table A11. Poolability test

	DECADE	
Ho: z-score stunting (Misericórdia - Casa Pia) = 0	1945-1954	1955-1964
MALES 2-10	0.269	-0.593
	(0.827)	(0.360)
FEMALES 2-10	0.499	-0.567
	(0.337)	(0.901)
OVERALL	0.288	0.086
	(0.211)	(0.643)

*Notes: The group is composed by 408 individuals in Misericórdia and 85 in Casa Pia. The table shows the difference in prevalence by group and the p-value in parenthesis. *, **, and *** denote significance at 10, 5 and 1%.*

Table A12: *Sample mean weight by age and cohort (children's full sample)*

	Females				Males		
Age (years)	1945-1954	1955-1964	1985-1994		1945-1954	1955-1964	1985-1994
0	3.75	3.93	4.96		4.26	4.36	5.55
0.5	5.64	5.46	7.47		6.64	5.76	7.90
1	7.39	7.16	9.01		7.74	7.76	9.66
2	9.65	9.38	10.45		10.21	10.60	11.47
3	11.87	9.68	13.2		12.07	12.5	13.35
4	13.88	17	16.2		14.76	15.3	15.6
5	15.4	15.2	19.675		15.63	16.1	16.13
6	17	-	18.8		18.05	17.35	18.63
7	20.65	23.67	-		20.73	23.09	19.5
8	22.83	25.83	23.03		23.51	24.60	25.25
9	25.49	26.64	-		25.77	26.07	22.37
10	26.25	30.79	-		26.77	28.39	31.1
11	30.55	35.29	-		29.41	31.49	-
12	38.06	40.24	-		30.88	30.56	-
13	40.11	43.22	-		33.77	39.21	-
14	41.81	46.4	-		36.08	38.25	-
15	45.25	48.21	-		46.4	39.33	-
16	45.58	49.71	-		48.83	-	-
17	48.5	55.5	-		56.8	47	-
18	52.25	-	-		57	-	-
Average	18.89	17.89	8.04		18.90	14.87	8.02
Observations	483	428	296		599	556	355

Table A13: Sample mean height by age and cohort (children's full sample)

	Females				**Males**		
Age (years)	1945-1954	1955-1964	1985-1994		1945-1954	1955-1964	1985-1994
0	53.86	55.05	56.96		55.08	56.13	59.36
0.5	63.5	62.76	67.89		63.52	63.80	69.41
1	71.78	69.59	75.89		72.11	70.18	77.16
2	81.28	74.5	91		81.75	83	85.19
3	90.41	82	85.86		89.82	89	92.25
4	96.64	102	100.71		96.68	97.9	101
5	104.16	102.5	106.13		104.28	99	-
6	109.20	-	109		109.34	106	109.33
7	115.66	118.9	-		115.75	117.75	116
8	118.91	121.42	122		120.18	122.18	132.25
9	127.25	123.31	-		125.70	125.89	125.33
10	127.54	132.80	-		129.20	131.45	129
11	132.21	138.17	-		132.96	136.19	-
12	142.82	141.08	-		134.60	134.40	-
13	146.25	146.88	-		142.33	143.92	-
14	147.73	149.6	-		143.42	148	-
15	147.42	153.86	-		151.8	147	-
16	145.83	150.86	-		155.33	-	-
17	144	153	-		165.2	157	-
18	161	-	-		162	-	-
Average	102.93	93.22	69.86		103.61	89.02	69.71
Observations	483	428	296		599	556	355

Table A14: Distribution of observations by municipality, based on place of military inspection, young adult males database (Military Archives – Livros de Recenseamento Militar dataset).

COUNTY	FREQ.	PERCENT	CUM.
ALCOUTIM	383	1.45	1.45
AMARANTE	826	3.13	4.58
AMARES	357	1.35	5.93
ARGANIL	440	1.67	7.60
ARMAMAR	288	1.09	8.69
ARRAIOLOS	197	0.75	9.43
AVEIRO	647	2.45	11.88
BAIÃO	655	2.48	14.36
BARREIRO	436	1.65	16.01
CADAVAL	293	1.11	17.12
CANTANHEDE	646	2.45	19.57
CARRAZEDA DE ANSIÃES	350	1.33	20.89
CHAVES	931	3.52	24.42
FAFE	627	2.37	26.79
GÓIS	164	0.62	27.41
LAMEGO	885	3.35	30.76
LISBOA	8,479	32.10	62.87
LOURES	625	2.37	65.23
LOURINHÃ	374	1.42	66.65
MAFRA	759	2.87	69.52
MANGUALDE	549	2.08	71.60
MATOSINHOS	984	3.73	75.33
MAÇÃO	374	1.42	76.74
MESÃO FRIO	400	1.51	78.26
MORTÁGUA	232	0.88	79.13
MURÇA	380	1.44	80.57
NELAS	282	1.07	81.64
RIBEIRA DE PENA	474	1.79	83.44
SILVES	728	2.76	86.19
SINTRA	645	2.44	88.63
SÁTÃO	352	1.33	89.97
TAVIRA	163	0.62	90.58
VALE DE CAMBRA	353	1.34	91.92
VIDIGUEIRA	207	0.78	92.70
VILA FRANCA DE XIRA	589	2.23	94.93
VILA REAL	847	3.21	98.14
ÍLHAVO	491	1.86	100.00
TOTAL	26,412	100.00	

Table A15: Sample size, wasting and prevalence by sex and decade for infants (0-24 months) 45 to 110 cm (recumbent length).

	Individuals			**Wasting**		
Decade	Total	Males	Females	Total	Males	Females
1915-1924	3	3	-	2 (0.66)	2 (0.66)	-
1925-1934	-	-	-	-	-	-
1935-1944	-	-	-	-	-	-
1945-1954	521	279	306	231 (0.44)	92 (0.33)	139 (0.45)
1955-1964	513	302	252	276 (0.53)	130 (0.43)	146 (0.58)
1965-1974	19	8	20	17	2	15
1975-1984	93	49	44	18 (0.19)	11 (0.23)	7 (0.16)
1985-1994	603	329	281	76 (0.13)	52 (0.16)	24 (0.09)
Total	1,873	970	903	620	289	331

Note: The table shows the total and wasted individuals according to the WHO standards defined by the general weight-for-length distribution from 45 to 120 cm of length. Prevalence in parenthesis under wasting count for each group. We report no prevalences for N lower than 25.

Table A16: Sample size, wasting and prevalence by sex and decade for infants (0-24 months) 65 to 120 cm (standing height).

	Individuals			Wasting		
Decade	Total	Males	Females	Total	Males	Females
1905-1914	6	6	-	2	2	-
1915-1924	34	34	-	25 (0.74)	25 (0.74)	-
1925-1934	5	5	-	5	5	-
1935-1944	9	9	-	4	4	-
1945-1954	518	272	246	160 (0.31)	89 (0.33)	71 (0.29)
1955-1964	228	138	90	97 (0.43)	60 (0.44)	37 (0.41)
1965-1974	15	2	13	9	1	8
1975-1984	37	21	16	11 (0.29)	8	3
1985-1994	345	189	156	37 (0.11)	27 (0.14)	10 (0.06)
Total	1,197	676	521	350	221	129

Note: The table shows the total and wasted individuals according to the WHO standards defined by the general weight-for-length distribution from 45 to 120 cm of length. Prevalence in parenthesis under wasting count for each group. We report no prevalences for N lower than 25.

Table A17: Sample size, stunting prevalence by sex and decade for infants (0-24 months old).

	Individuals			Stunting		
Decade	Total	Males	Females	Total	Males	Females
1945-1954	258	139	119	151 (0.58)	85 (0.61)	66 (0.56)
1955-1964	485	282	203	243 (0.50)	149 (0.53)	94 (0.46)
1965-1974	19	9	10	14	6	8
1975-1984	91	48	43	30 (0.32)	16 (0.33)	14 (0.33)
1985-1994	530	296	234	115 (0.21)	67 (0.23)	48 (0.21)
Total	1,383	774	609	553	323	230

Note: The table shows total and stunted individuals according to the WHO growth standards defined by the general length-for-age distribution. Prevalence in parenthesis under the stunting count for each group. We report no prevalences for N lower than 25.

Table A18: Sample size, stunting and prevalence by sex and decade for children.

(2 – 5 years old).

	Individuals			**Stunting**		
Decade	Total	Males	Females	Total	Males	Females
1945-1954	226	123	103	89 (0.39)	52 (0.43)	37 (0.36)
1955-1964	23	17	6	9	6	3
1965-1974	1	-	1	0	-	0
1975-1984	3	1	2	2	1	1
1985-1994	81	38	43	14 (0.17)	6 (0.16)	8 (0.19)
Total	334	179	155	114	65	49

Note: The table shows total and stunted individuals according to the WHO growth standards defined by the general weight-for-age distribution from 2 to 10 years old. Prevalence in parenthesis under the stunting count for each group. We report no prevalences for N lower than 25.

Table A19: Sample size, stunting and prevalence by sex and decade for children (5-18 years old).

	Individuals			**Stunting**		
Decade	Total	Males	Females	Total	Males	Females
1905-1914	171	171	-	134 (0.80)	134 (0.80)	-
1915-1924	168	168	-	140 (0.93)	140 (0.93)	-
1925-1934	93	93	-	68 (0.73)	68 (0.73)	-
1935-1944	59	59	-	40 (0.67)	40 (0.67)	-
1945-1954	559	313	246	311 (0.56)	228 (0.73)	83 (0.34)
1955-1964	425	227	198	193 (0.45)	141 (0.63)	52 (0.26)
1965-1974	144	83	61	59 (0.40)	49 (0.59)	10 (0.16)
1975-1984	1	1	-	-	0	-
1985-1994	23	12	11	10	7	3
Total	1,643	1,127	516	955	807	148

Note: The table shows total and stunted individuals according to the WHO growth standards defined by the general weight-for-age distribution from 5 to 18 years old. Prevalence in parenthesis under the stunting count for each group. We report no prevalences for N lower than 25.

Table A20: Number of observations by sex (Misericórdia sample) CDC criteria

	INFANTS (0-24 MONTHS)	CHILDREN (3-10 YEARS)	OVERLAP (24 – 36 MONTHS)	TOTAL
MALES	796	157	135	1,088
FEMALES	610	161	111	882
TOTAL	1,406	318	246	1,970

Note: for simplicity, we split the children by age following the headings of the table. Note, however that the group of children aged between 24 to 36 months (OVERLAP) is counted in both INFANTS and CHILDREN samples for calculations, following the CDC guidelines of measurement (Cole et al. 2000).

Table A21: Number of observations for wasting statistics by decade and sex.

	NUMBER OF OBSERVATIONS	
	Male	Female
	45-110 cm	
1915-1924	3	-
1945-1954	279	306
1955-1964	302	252
1965-1974	8	20
1975-1984	49	44
1985-1994	329	281
TOTAL	970	903
	65-120 cm	
1905-1914	6	-
1915-1924	34	-
1925-1934	5	-
1935-1944	9	-
1945-1954	272	246
1955-1964	138	90
1965-1974	2	13
1975-1984	21	16
1985-1994	189	156
TOTAL	676	521

Table A22: Number of observations for stunting statistics by decade and sex

	NUMBER OF OBSERVATIONS	
	Male	Female
	0-24 months old	
1945-1954	139	119
1955-1964	282	203
1965-1974	9	10
1975-1984	48	43
1985-1994	296	234
TOTAL	774	609
	2-5 years old	
1945-1954	123	103
1955-1964	17	6
1965-1974	-	1
1975-1984	1	2
1985-1994	38	43
TOTAL	179	155
	5-18 years old	
1905-1914	171	-
1915-1924	168	-
1925-1934	93	-
1935-1944	59	-
1945-1954	313	246
1955-1964	227	198
1965-1974	83	61
1975-1984	1	-
1985-1994	12	11
TOTAL	1,127	516

Table A23: Proportion of deaths according cause of death

Cause of death	1920	1930	1940	1950	1960	1970	1980	1990
Breathing disease	**10.16**	**9.36**	**17.53**	**15.93**	**13.91**	**10.64**	**5.44**	**3.05**
Tuberculosis	*5.48*	*9.36*	*8.16*	*9.55*	*3.65*	-	-	-
Pneumonia	*2.73*	-	*7.49*	*6.38*	*7.82*	*8.01*	*2.85*	*3.05*
Bronquitis	*1.95*	-	*1.88*		*2.44*	*2.63*	*2.59*	-
Digestive disease	***11.1***	**14.2**	**14.25**	**9.21**	**7.64**	**5.81**	**3.22**	**2.87**
Diarrhea and enteritis (< 2 years)	*7.69*	10.99	11.23	7.2	-	-	-	-
Diarrhea and enteritis (> 2 years)	*3.41*	3.21	3.02	-	-	-	-	-
Cirrosis	-	-	-	-	-	2.91	3.22	2.87
Circulatory disease	***5.16***	**8.52**	**9.9**	**12.42**	**12.41**	**12.36**	**43.2**	***39.27***
Tumors	**-**	**2.67**	**2.9**	**4.89**	**9.14**	**11.72**	**15.06**	**5.87**
Accidents, violence	**-**	**2.44**	**2.51**	**2.74**	**4.61**	**4.7**	**6.15**	**11.4**
Unknown cause at the time	***49.61***	**20.87**	**17.23**	**17.71**	**14.95**	**19.78**	**12.83**	**13.32**
Senility	**4.69**	**6.7**	**9.64**	**11.02**	**-**	**-**	**-**	**-**

Source: this table shows the main causes of death constistent to the 2nd, 4th, 6th and 9th revisions of the International Classidication of Disease. The statistics we show come from Morais (2019) and are based on primary source data from the Instituto Nacional de Estatística.

Some discussion concerning this table and underlying data is warranted. The National Statistical Insitute of Portugal (Instituto Nacional de Estatística, also known as INE) provides decennial reports that track the physiological movements of the population and describe the causes of death consistent with the knowledge and classification accepted at the time. We rely on Morais's work on these primary sources (2019) which shows that from 1920 to 1930, diarrhea and enteritis were described as the leading cause of death, representing around 8% of the deaths for the youngest section of the infant population and around 11% for all deaths in 1920, rising to 14% in 1930. During these decades, tuberculosis and other respiratory diseases were the second cause of death, and in 1940 respiratory infections took the largest share of lives in Portugal, closely followed by a stable rate of 14% affected by diarrhea and enteritis. By 1950, diarrhea was mentioned as the fifth cause of death; however, those affected by respiratory diseases were still around 16%. By 1990, digestive disease is no longer a leading cause of death (not even for infants) in Portugal. Instead, circulatory and brain diseases take the largest share of lives.

The statistics are affected by two factors. Firstly, in 1960, diarrhea ceased to be considered a disease and instead became a symptom. However, according to Morais, the percentage of deaths attributed to digestive illnesses decreased to less than 3%, and it appears to be predominantly associated with cirrhosis, primarily impacting adults. Secondly, for previous periods, approximately 50% of deaths cannot be linked to a particular disease due to reasons such as doctors not being required to report the cause of death, resulting in a lack of records, as well as cases where the disease was misidentified or unknown. Notably, the International Classification of Diseases of the World Health Organization identified around 40 diseases in 1920, and almost 150 by 1990, which could lead to overestimating some causes of death until 1940.[54] A systematic cod-ing of illnesses accompanied by the increase of medical knowledge largely improved over the century. Although this admittedly lowers the credibility of some of the early primary sources, we can still conclude that digestive conditions were the largest reported caused of death at the beginning of the century, and ceased to be so after the mid-twentietn century.

Table A24: Regression coefficients for subsequent measurements of stunting

	Stunting in subsequent inspections			
	Second	Third	Fourth	Fifth
Stunted in the previous inspection	0.577***	0.792***	0.766***	0.791***
	(0.034)	(0.055)	(0.068)	(0.075)
Controls				
Age at measurement	-0.008***	-0.003***	0.002***	0.001***
	(0.000)	(0.001)	(0.002)	(0.000)
Sex	-0.206	-2.766		
	(0.057)	(1.453)		
Cohort	0.002	0.055		
	(0.001)	(0.032)		
Observations	602	123	91	59
R-squared	0.351	0.623	0.575	0.620

*Note: regression coefficients show the probability of subsequent measurements of height (dependent variable) provided that the current measurement reports stunting, controlling for the individual's ages, sex and cohort. Note that for fourth and fifth visit all our individuals are male and come from the same cohort. Robust standard errors in parentheses, statistical significance denoted by *** p<0.01, ** p<0.05, * p<0.1*

[54] See the *International Classification of Diseases*, Eleventh Revision (ICD-11), of the World Health Organization here: https://icd.who.int/en (last consulted June 7, 2023).