Title:

Maternal height and adverse health and nutritional outcomes in Roma children in Türkiye

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Objectives

A large and growing number of studies show that health and nutrition in early life are effective predictors of mortality and morbidity during adolescence and adulthood. There are three different and somewhat separate strands of empirical research on the linkages between early childhood health and nutritional status, and adult health and mortality. The first of these (*theory of child growth)* extends and strengthens a much older research tradition that investigates the determinants of child physical growth and development, health, and mortality, with an empirical foundation mostly built on findings about relations from developing countries (Martorell and Habicht 1986, Martorell and Zongrone 2012, Mertens et al. 2023, Aizawa 2020). This group of research emphasizes the physiological damages that irreversibly affect health and development over the life-course. The second strand of research (*theory of nutrition-driven mortality decline*) is preoccupied with the roots of the post-1800 secular mortality decline in Western Europe and North America. The hallmark of this body of work is the assessment of the contribution of long-run improvements in nutritional status and increasing stature in populations implicated in the mortality decline (Fogel 1997, Fogel and Costa 1997, Fogel 2004). Finally, the third line of research (*theory of Barker frailty)* is associated with the explosive growth of studies in the area of Developmental Origins of Health and Disease (DOHaD), a field of research that is best, but only incompletely, associated with the work of Barker and his group (Barker et al. 1993, Barker 1998, Gluckman et al. 2005, Gluckman and Hanson 2006). The main conjectures put forward in this literature revolve around the idea that early child growth deficiencies manifested as short gestation, low birthweight, growth-faltering, underweight and stunting are imprints of early scarring that result in penalties in the form increased risks of adult chronic diseases.

A common thread that links these strands of empirical research is the significance attributed to the intergenerational effects on health and mortality. In particular, maternal traits encapsulated in 'maternal height' emerges as one of the pathways that transmit health and mortality risks to the offspring. There is robust evidence that short maternal stature reflects conditions whose effects are felt at various stages in the life-course of children, involving premature birth, low birth weight, the risk of stunting, wasting and underweight in young children, infant mortality, short stature in adolescence, and ultimately, elevated mortality and morbidity risks in adulthood (Hernandez-Diaz et al. 1999, Black et al. 2008, Victora et al. 2008, Lawn et al. 2009, Varela-Silva et al. 2009, Ozaltin et al. 2010, Ramakrishnan et al. 2012, Addo et al. 2013, Gausman et al. 2019, Aizawa 2020, Mertens et al. 2023). In this paper, we assess the strength of relations between maternal height, poor birth outcomes, infant mortality and child growth deficiencies in one of the most marginalized and socio-economically vulnerable minority groups in Türkiye's population, the Roma community. Against the backdrop of limited or lack of access to basic education and health services, inadequate housing and overcrowding, unsafe environments, and social discrimination and exclusion, the Roma community in Türkiye have been experiencing hunger, malnutrition, disease and general ill-health more frequently than the general population for multiple generations. We use a very unique and recent dataset that is nationally representative of the 1.2 - 2.3 million Roma population living in the country. By studying the associations between maternal anthropometry and health and nutritional deficits in infants and young children often born into disadvantaged families, we question the role of maternal height as a pathway in the intergenerational transfer of health and mortality risks across two generations.

Background

Even though height is one of the earliest human traits for which the concept heritability has been discussed and investigated, genetics is unlikely to be a major contributor to explaining mean differences in height across populations and changes in height over time (Fogel 1997, Fogel and Costa 1997, Fogel 2004, Perkins et al 2016). Adult height is achieved as the result of a combination of genetic and environmental factors during childhood and adolescence, and nutrition and diseases are universally the most important environmental factors affecting growth and body height during these stages of life. Furthermore, because low- and middle-income countries have a higher share of chronically malnourished populations and more frequent infections than high-income countries, height heritability estimates are expected to be lower because of the increased importance of nutrition, disease, and socioeconomic conditions during the critical periods of growth (Martorell and Habicht 1986, Martorell et al. 1994, Silventoinen 2003, Perkins et al. 2016).

Attained height by adulthood is an effective predictor of adult mortality and morbidity risks, and the relationship between adult height and chronic diseases such as cardiovascular disease, cancer, diabetes type 2, and congestive obstructive pulmonary diseases (COPD), as well as late life disabilities, are well-documented (Silventoinen et al. 1999, Smith et al. 2000, Crimmins 2015). By and large these relations are thought to be the result of a close association between in utero and early-life conditions, and adult diseases and disabilities (Scrimshaw 1997, Barker 1998, Gluckman et al. 2005). Relatedly, the findings of research from developing countries highlight early childhood height as an effective predictor of adult morbidity and mortality risks due to the high fidelity of height as an indicator of genetic traits, environmental factors, and their interactions acting over extended periods of time during the critical windows of development (Martorell 2017, Dewey and Begum 2011, Victora et al. 2008). There is also growing evidence of the connections between slow growth in height early in life and impaired health and educational and economic performance later in life, including cognitive development, school achievement, and economic productivity in adulthood (Martorell 2017, Dewey and Begum 2011, Victora et al. 2008, Adair et al. 2013, Victora et al. 2021).

During infancy and early childhood, height is highly sensitive to nutritional intake, energy demands associated with infectious and parasitic diseases, stresses originating in precarious household conditions, limited parental care and sibling competition, and to interactions between these and genotypic traits. Studies show that the degree of exposure to unfavorable environmental factors that stall growth is highly correlated with parental socio-economic status (SES), as measured by income, education, occupation and employment status (Wadsworth 1997, Webb et al. 2008, Tucker-Seeley and Subramanian 2011). This is because SES determines access to resources, exposure to risk factors, and the practice of correct health behaviors, which are all critically intertwined with nutrition and disease.

An important, albeit not well-established, fact is the role played by maternal height as a marker of mother-children influences via phenotypic and epigenetic changes. It is possible that there is an intergenerational linkage due to, among other things, in-utero and very early life deprivation (Victora et al. 2008, Dewey and

Begum 2011, Ramakrishnan et al. 2012, Martorell 2017, Victora et al. 2021, Mertens et al. 2023). While other intergenerational effects such as maternal nutritional and health status during pregnancy, delivery, and post-partum, and maternal child care including breastfeeding onset and duration, are significant factors of early health and largely determined by mother-child shared experiences such as poverty and generalized economic adversity, maternal height reflects the childhood nutrition and disease environment of the mother, yet affects the offspring. Findings of previous research show that maternal short stature leads to poor reproductive outcomes and exacerbates the risk of poor birth outcomes such as fetal loss, fetal growth restriction, preterm delivery and low birth weight (Victora et al. 2008, Lawn et al. 2009, Varela-Silva et al. 2009, Victora et al. 2021) . Intriguingly, the inverse relationship of maternal height and child stunting, morbidity and mortality levels persists even after adjusting for multiple indicators of mother-child shared conditions and child specific factors such as maternal age and parity (Hernandez-Diaz et al. 1999, Ozaltin et al 2010, Addo et al. 2013). For instance, an analysis using data from Demographic and Health Surveys (DHS) conducted between 1991 and 2008 in fifty-four countries showed that children under 5 years of age who were born to the shortest mothers had a 40% increased risk of mortality after controls (Ozaltin et al. 2010). These effects are so strong that they are virtually equivalent to effects of maternal education and poverty.

The implications of the relations described above are manifold. One of these is that if maternal height reflects conditions that are different from those shared by mother and child (social class, poverty, generalized adversity etc...) then there is a distinct possibility that the intergenerational transmission of health and mortality risks works through multiple pathways (Black et al 2008, Stein et al. 2010, Dewey and Begum 2011, Mertens et al. 2023). Another implication, the one that is at the core of our paper, is that, to the extent that it reflects the childhood environment of the mother yet affects offspring's health and mortality risks throughout life, maternal height might be acting as one of the pathways laying biological foundations for growth deficiencies and related health and mortality risks, across two generations.

Data, Models and Empirical Estimation

We used data collected by the Institute of Demographic Studies at Hacettepe University (Ankara, Türkiye) for the project "The Demographic Integration and Differentials of Roma Population and Policy Priorities in Türkiye" in 2023, funded by the Scientific and Technological Research Council (TUBITAK). The Roma Population Survey was based on interviews carried out with 1,265 women of reproductive ages (15-49) in 1,547 households. Nationally representative of the Roma population living in Türkiye, the dataset was rich with detailed pregnancy, birth and postnatal histories, and anthropometric data for mothers and children. A variety of individual- and household-level measures included the most important SES indicators such as parental education levels and household wealth index.

The initial findings of the project revealed that the Roma population is severely disadvantaged in terms of household composition, housing characteristics, household wealth, fertility level, infant mortality level, maternal and child health, employment, child labor, child marriages and child nutrition (Koç et al., 2024). 52% of Roma women either have no formal education or are drop-outs from primary school, and child marriages are common with 53% and 21% getting married before the age of 18 and 15, respectively. Roma women have Türkiye's fertility levels in the 1990s with a total fertility rate (TFR) of 2.8, and the mean age at first birth is only 19.4. 15% of babies born to Roma women have low birth weight, which increases to 20% for babies born to mothers with no formal education, and to 26% in low-income households. Over 30% of Roma babies are reported by mothers to have small size at birth. With regard to indicators of nutritional deprivation, the prevalence of stunting among Roma children is approximately 11%, which is noticeably higher than the prevalence observed for the total population (6%) in 2018. The prevalence of underweight among children (3.8%) is more than two times the prevalence for the total population (1.5% in 2018). Finally, infant mortality rate (IMR) is 19 per 1,000 births, more than double Türkiye's IMR (9 per 1,000 births) in 2022.

In order to assess the strength of associations of maternal height with birth outcomes, infant mortality and child growth deficiencies we estimate logistic models to explain the risk of preterm birth and low birth weight and size, the risk of stunting and underweight, and the risk of infant death. We specify maternal height as a continuous and categorical variable in separate models for each outcome. All models contain socio-demographic and socio-economic variables (mother's age at first marriage, mother's age at birth, mother's education, father's education, geographic region, household wealth, number of people living in the household), and controls for child age, sex and parity. Two models that predict the probability of child stunting and underweight additionally control for birth weight. We obtain predicted probabilities for each health outcome in the postestimation, corresponding to different levels of maternal height across different values of significantly associated SES predictors.

Results

The final analytical sample consisted of 594 Roma children aged 0-59 months, born to 459 Roma women in their reproductive ages. Table 1 provides descriptive statistics for the data, and Table 2 presents results from logistic regressions. Our results show that maternal height is significantly associated with the risk of stunting, underweight and small birth size among Roma children. One cm increase in maternal height decreases the odds of stunting and underweight by 13 percent and 11 percent, respectively. The effect of short maternal stature (height less than 150 cm) on child stunting is noticeably strong: The likelihood of stunting among children with mothers in this category is more than six times higher than the likelihood of stunting among children of mothers who are at least 160 cm tall. The likelihood of stunting among children with maternal height between 150-154.9 cm is more than double times higher than the likelihood among children of tallest mothers. The effects on birth size are more moderate: One cm increase in maternal height decreases the odds of small size at birth by 4 percent. The likelihood of small size at birth for babies of the shortest mothers is more than double of that for the babies of mothers who are at least 160 cm tall. In our findings we find no significant relations between maternal height and the risks of low birth weight, preterm birth, and infant mortality. Nevertheless, the significant and strong associations between maternal and child heights, maternal height and child weight, and maternal height and birth size, indicate that maternal stature is an important determinant of the growth impairment in the early-life of Roma children, even after adjusting for SES factors.

Table 1. Descriptive Statistics for Roma children

	%	n			%	n
Preterm birth	23.2	132		Father's education		
Total		569		No education	27.7	159
Low birth weight	16.4	92		Primary education	37.7	217
Total		561		Secondary or higher education	34.6	199
Small birth size	32.3	190		*Total*		575
Total		589		Geographical region		
Infant mortality	2.4	14		Mediterranean	18.4	109
Total		594		Central Anatolia	8.8	52
Child stunting	14.2	54		Eastern Anatolia	14.1	84
Total		381		Marmara	19.9	118
Child underweight	5.4	21		Aegean	18.4	109
Total		388		Black Sea	20.5	122
Mother's height in cm (continuous)	Mean	156.6		*Total*		471
	SD	5.6		Household Wealth		
Total		594		Low-wealth households	48.0	285
	%	n		Middle-wealth households	21.0	125
Mother's height in cm (categorical)				High-wealth households	31.0	184
≤ 149.9	12.0	71		*Total*		471
150-154.9	26.9	160		Number of people in the household	Mean	5.4
155-159.9	32.8	195			SD	1.8
≥ 160	28.3	168		*Total*		594
Total		594		Birth weight in kg	Mean	
Mother's age at first marriage	Mean	17.0			SD	
	SD	3.2		*Total*		
Total		594				
				Age in months	Mean	28.4
Mother's age at birth	Mean	24.3			SD	17.7
	SD	5.9		*Total*		594
Total		594			%	n
	%	n		Sex		
Mother's education				Male	51.4	305
No education	35.7	212		Female	48.7	289
Primary education	35.2	209		*Total*		594
Secondary or higher education	29.1	173		Parity		
Total		594		1st	28.8	171
Mother's marital status				2nd	29.3	174
Married	92.4	549		3rd	21.6	128
Widowed, divorced or separated	7.6	45		4th or higher	20.4	121
Total		594		*Total*		594

Table 2. Results of the Logistic Regressions Predicting the Risks of Poor Health and Growth Outcomes, Odd Ratios

	Preterm Birth						Low birth weight						Small size at birth					
Number of Observations	555			555			545			545			570			570		
LR	chi2(23)	=	36.5	chi2(21)	=	36.2	chi2(23)	=	35.15	chi2(21)	=	33.05	chi2(23)	=	35.24	chi2(21)	=	35.27
Prob > chi2	0.0367			0.0269			0.0502			0.0457			0.0492			0.0264		
Pseudo R2	0.06			0.06			0.07			0.07			0.05			0.05		
Log likelihood	-280.262			-280.916			-223.365			-224.42			-340.144			-340.133		
	OR		Std. Err.	OR		Std. Err.	OR		Std. Err.	OR		Std. Err.	OR		Std. Err.	OR		Std. Err.
Mother's height in cm (categorical)																		
≤ 149.9	0.89		0.35				1.93		0.79				2.30	★★	0.76			
150-154.9	1.03		0.29				1.00		0.35				1.35		0.36			
155-159.9	0.77		0.22				0.98		0.33				1.21		0.31			
≥ 160 *(Omitted)*	-		-				-		-				-		-			
Mother's height in cm (continuous)				1.00		0.02				0.97		0.02				0.96	★★	0.02
Mother's age at first marriage	0.91	★	0.04	0.91	★	0.04	0.93		0.05	0.94		0.05	1.00		0.04	1.01		0.04
Mother's age at birth	1.08	★★	0.03	1.08	★★	0.03	1.04		0.03	1.04		0.03	1.03		0.03	1.03		0.03
Mother's education																		
No education	1.53		0.42	1.55		0.42	0.87		0.28	0.92		0.29	0.70		0.17	0.72		0.18
Primary education *(Omitted)*	-		-	-		-	-			-		-	-		-	-		-
Secondary or higher education	0.84		0.23	0.87		0.24	0.67		0.23	0.70		0.23	0.63		0.16	0.65		0.16
Mother's marital status																		
Married *(Omitted)*	-		-	-		-	-		-	-		-	-			-		-
Widowed, divorced or separated	0.49		0.25	0.49		0.25	0.65		0.37	0.62		0.36	0.81		0.33	0.77		0.31
Father's education																		
No education	1.20		0.35	1.16		0.33	0.75		0.24	0.77		0.24	0.90		0.22	0.93		0.23
Primary education *(Omitted)*	-		-	-		-	-		-	-		-	-		-	-		-
Secondary or higher education	1.56		0.40	1.57		0.40	0.89		0.26	0.90		0.27	1.04		0.24	1.05		0.24
Geographical region																		
Mediterranean	1.14		0.40	1.17		0.41	1.26		0.51	1.30		0.52	1.02		0.33	1.04		0.33
Central Anatolia	2.18		0.87	2.09		0.83	1.06		0.51	1.02		0.49	1.11		0.43	1.06		0.41
Eastern Anatolia	1.19		0.44	1.22		0.45	0.73		0.32	0.76		0.33	0.84		0.28	0.82		0.28
Marmara *(Omitted)*	-		-	-		-	-		-	-		-	-		-	-		-
Aegean	0.62		0.23	0.64		0.23	0.76		0.32	0.76		0.32	1.08		0.34	1.07		0.34
Black Sea	0.69		0.24	0.70		0.24	0.94		0.36	0.93		0.36	1.25		0.37	1.23		0.36
Household Wealth																		
Low-wealth households	0.89		0.26	0.88		0.26	1.55		0.55	1.55		0.55	1.86	★	0.50	1.86	★	0.50
Middle-wealth households *(Omitted)*	-		-	-		-	-		-	-		-	-		-	-		-
High-wealth households	1.11		0.34	1.12		0.34	1.02		0.39	1.01		0.39	1.01		0.28	0.99		0.28
Number of people in the household	1.01		0.06	1.01		0.06	0.86		0.07	0.86		0.07	1.03		0.06	1.03		0.06
Age in months	0.99		0.01	0.99		0.01	1.00		0.01	1.00		0.01	1.00		0.01	1.00		0.01
Sex																		
Male *(Omitted)*	-		-	-		-	-		-	-		-	-		-	-		-
Female	1.45		0.31	1.43		0.31	1.66	★	0.42	1.60		0.40	1.55	★	0.30	1.52	★	0.29
Parity																		
1st	4.35	★★	2.12	4.32	★★	2.10	1.17		0.63	1.11		0.59	2.11		0.90	2.05		0.87
2nd	2.75	★	1.19	2.72	★	1.18	0.53		0.26	0.51		0.25	1.08		0.41	1.06		0.40
3rd	2.20	★	0.84	2.23	★	0.85	0.49		0.21	0.47		0.20	1.23		0.40	1.19		0.39
4th or higher *(Omitted)*	-		-	-		-	-		-	-		-	-		-	-		-

Note: *** = p < 0.001, ** = p < 0.01, * = p < 0.05

Table 2 (Continued). Results of the Logistic Regressions Predicting the Risks of Poor Health and Grwoth Outcomes, Odd Ratios

	Infant mortality						Child stunting						Child underweight					
Number of Observations	474			474			360			360			365			365		
LR	chi2(21)	=	63.58	chi2(19)	=	62.89	chi2(24)	=	55.43	chi2(22)	=	55.2	chi2(24)	=	35.13	chi2(22)	=	37.31
Prob > chi2	0.0000			0.0000			0.0003			0.0001			0.0665			0.0219		
Pseudo R2	0.53			0.53			0.19			0.19			0.24			0.26		
Log likelihood	-27.7831			-28.1274			-117.345			-117.46			-54.1547			-53.0669		
	OR		Std. Err.	OR		Std. Err.	OR		Std. Err.	OR		Std. Err.	OR		Std. Err.	OR		Std. Err.
Mother's height in cm (categorical)																		
≤ 149.9	7.79		12.36				7.01	★★	4.19				3.00		2.80			
150-154.9	2.05		2.79				3.73	★★	1.92				2.13		1.72			
155-159.9	3.31		4.46				1.34		0.76				0.94		0.75			
≥ 160 *(Omitted)*	-		-				-		-				-		-			
Mother's height in cm (continuous)				0.91		0.08				0.87	★★	0.03				0.89	★	0.05
Mother's age at first marriage	0.95		0.15	0.97		0.14	0.87		0.07	0.87		0.07	0.81		0.11	0.81		0.11
Mother's age at birth	1.07		0.12	1.03		0.11	0.94		0.04	0.94		0.04	0.90		0.06	0.89		0.06
Mother's education																		
No education	0.42		0.59	0.46		0.62	0.81		0.38	0.85		0.39	0.51		0.37	0.51		0.37
Primary education *(Omitted)*	-		-	-		-	-		-	-		-	-		-	-		-
Secondary or higher education	2.51		2.85	2.53		2.65	0.74		0.36	0.81		0.40	0.10	★	0.12	0.10	★	0.12
Mother's marital status																		
Married *(Omitted)*							-		-	-			-			-		-
Widowed, divorced or separated							1.19		0.79	1.07		0.71	1.23		1.47	1.11		1.36
Father's education																		
No education	0.83		0.80	0.90		0.85	0.75		0.34	0.71		0.32	1.44		1.00	1.46		1.01
Primary education *(Omitted)*	-		-	-		-	-		-	-		-	-		-	-		-
Secondary or higher education	0.23		0.23	0.25		0.25	0.54		0.24	0.57		0.25	0.67		0.52	0.72		0.56
Geographical region																		
Mediterranean							0.77		0.46	0.83		0.49	2.17		1.89	2.16		1.89
Central Anatolia	2.27		3.37	2.51		3.33	0.52		0.46	0.51		0.45	0.83		1.06	0.78		1.00
Eastern Anatolia	0.95		1.57	0.65		1.01	2.10		1.19	2.26		1.27	1.16		1.03	1.10		0.99
Marmara *(Omitted)*	-		-	-		-	-		-	-		-	-		-	-		-
Aegean	1.42		1.95	1.25		1.70	0.56		0.38	0.58		0.39	0.34		0.45	0.27		0.36
Black Sea	3.45		4.87	3.49		4.79	0.59		0.34	0.60		0.35	0.31		0.32	0.29		0.30
Household Wealth																		
Low-wealth households	1.66		2.27	1.63		2.16	1.88		1.01	1.88		1.01	1.54		1.37	1.41		1.27
Middle-wealth households *(Omitted)*	-		-	-		-	-		-	-		-	-		-	-		-
High-wealth households	0.93		1.19	0.86		1.05	1.42		0.86	1.51		0.90	0.73		0.80	0.78		0.86
Number of people in the household	0.56		0.18	0.55		0.17	0.94		0.10	0.94		0.10	0.87		0.17	0.88		0.18
Birth weight in kg							0.85		0.20	0.85		0.20	0.48	★	0.17	0.48	★	0.17
Age in months	0.68	★★	0.08	0.68	★★	0.08	0.99		0.01	0.99		0.01	1.01		0.02	1.01		0.02
Sex																		
Male *(Omitted)*	-		-	-		-	-		-	-		-	-		-	-		-
Female	0.42		0.40	0.44	0.39	0.31	0.61		0.22	0.61		0.22	0.69		0.38	0.68		0.38
Parity																		
1st	1.59		2.54	1.67	2.63	2.10	0.59		0.47	0.60		0.46	0.76		0.98	0.77		0.99
2nd	0.90		1.29	0.98	1.42	1.18	0.33		0.24	0.33		0.24	0.72		0.91	0.83		1.04
3rd	1.56		2.34	2.03	2.88	0.85	0.61		0.38	0.58		0.36	2.44		2.41	2.73		2.71
4th or higher *(Omitted)*	-		-	-		-	-		-	-		-	-		-	-		-

Note: *** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$

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