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, malnutrition and infant mortality in one of the most marginalized and socio-economically vulnerable minority groups in Türkiye's population, the Roma community. 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). This involves maternal nutritional and health status during pregnancy, delivery, and post-partum, and maternal child care including breastfeeding onset and duration. 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 (disease and nutritional) 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 to sustain the existing inequalities in health across generations.

Data, Models and Empirical Estimation

We use data collected by the Institute of Demographic Studies at Hacettepe University (Ankara, Türkiye) in 2023 for the TUBITAK project (122R016) "The Demographic Integration and Differentials of Roma Population and Policy Priorities in Türkiye" abbreviated as 2023 Türkiye Roma Population Survey (2023 TRPS). Interviews were 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 is rich with detailed pregnancy, birth and postnatal histories, and anthropometric data for mothers and children. A variety of socio-demographic measures are available at the individual- and household-levels, including the most important SES indicators.

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 adverse birth outcomes, malnutrition, and infant mortality, 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 variables (mother's age, mother's education, father's education, household wealth, geographic region, number of people living in the household), and controls for child age, sex and parity. 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.

Preliminary Findings

Our analysis include 608 Roma children aged 0-59 months, born to 471 Roma women in their reproductive ages. Table 1 provides descriptive statistics for the data, and Table 2 presents results from initial logistic regressions. Our preliminary results show that maternal height is significantly associated with the risk of stunting and small birth size among Roma children. One cm increase in maternal height decreases the odds of stunting by 8 percent. The effect of short maternal stature on child stunting is particularly strong: In comparison to children of mothers who are at least 160 cm tall, children of those mothers whose height is less than 150 cm are more than four times as likely to be stunted, and children of those mothers whose height is between 150-154.9 cm are almost three times as likely to be stunted. 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. In comparison to children of mothers who are at least 160 cm tall, children of those mothers whose height is less than 150 cm are more than two times as likely to be born with a small birth size. In our preliminary findings we find no significant relations between maternal height and the risks of low birth weight, preterm birth, underweight and infant mortality. Nevertheless, the significant and strong associations between maternal and child heights, 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 independent of SES factors.

Table 1. Descriptive Statistics

	%	n
Stunting	13.10	63
Total number of children		481
Underweight	5.10	25
Total number of children		490
Infant death	2.30	14
Total number of children		608
Small birth size	32.01	193
Total number of children		603
Low birth weight	16.17	93
Total number of children		482
Preterm birth	22.64	132
Total number of children		583
Mother's height in cm (continuous)	Mean	156.53
	SD	5.60
Total number of mothers		459
	%	n
Mother's height in cm (categorical)		
≥ 160	11.55	53
155-159.9	28.1	129
150-154.9	31.81	146
< 149.9	28.54	131
Total number of mothers		459
Mother's age	Mean	27.49
	SD	6.44
Total number of mothers		471
	%	n
Mother's education		
No education	36.94	174
Primary education	34.82	164
Secondary or higher education	28.24	133
Total number of mothers		471
Father's education		
No education	26.27	119
Primary education	37.97	172
Secondary or higher education	35.76	162
Total number of mothers		453
Household Wealth		
Low-wealth households	46.28	218
Middle-wealth households	20.38	96
High-wealth households	33.33	157
Total number of mothers		471
Geographical region		
Mediterranean	17.83	84
Central Anatolia	8.28	39
Eastern Anatolia	12.74	60
Marmara	20.17	95
Aegean	20.17	95
Black Sea	20.81	98
Total number of mothers		471
Number of people in the household	Mean	5.31
	SD	1.83
Total number of mothers		471
Child's age in months	Mean	28.49
	SD	17.65
Total number of children		608
	%	n
Child's sex		
Male	51.15	311
Female	48.85	297
Total number of children		608
Parity	Mean	2.49
	SD	1.45
Total number of children		608

Table 2. Results of the Logistic Regressions Predicting the Risks of Poor Health and Nutritional Outcomes in Infants and Children, Odd Ratios

	Stunting						Underweight						Infant mortality					
Number of Observations	469						476						474					
	OR		Std. Err.	OR		Std. Err.	OR		Std. Err.	OR		Std. Err.	OR		Std. Err.	OR		Std. Err.
Mother's height in cm (continuous)	0.92	★★	0.03				0.93		0.04				0.90		0.07			
Mother's height in cm (categorical)																		
≥ 160				*Omitted*						*Omitted*						*Omitted*		
155-159.9				1.46		0.69				2.03		1.34				4.89		6.46
150-154.9				2.97	★	1.33				1.83		1.34				2.09		2.80
< 149.9				4.56	★★	2.28				2.51		1.94				9.44		14.36
Mother's age	0.91	★	0.04	0.91	★	0.04	0.86	★	0.06	0.86	★	0.06	1.06		0.08	1.11		0.10
Mother's education																		
No education	1.04		0.40	0.99		0.39	0.59		0.32	0.63		0.36	0.41		0.53	0.39		0.52
Primary education	*Omitted*			*Omitted*			*Omitted*			*Omitted*			*Omitted*			*Omitted*		
Secondary or higher education	1.15		0.46	1.04		0.42	0.21	★	0.15	0.22	★	0.16	3.03		3.24	3.42		4.02
Father's education																		
No education	0.63		0.24	0.64		0.25	2.08		1.18	1.99		1.14	0.99		0.94	0.85		0.83
Primary education	*Omitted*			*Omitted*			*Omitted*			*Omitted*			*Omitted*			*Omitted*		
Secondary or higher education	0.72		0.26	0.70		0.25	1.16		0.70	1.24		0.76	0.28		0.27	0.22		0.23
Household Wealth																		
Low-wealth households	1.95		0.86	1.85		0.82	0.95		0.56	0.98		0.57	1.87		2.45	2.01		2.74
Middle-wealth households	*Omitted*			*Omitted*			*Omitted*			*Omitted*			*Omitted*			*Omitted*		
High-wealth households	1.13		0.58	1.08		0.56	0.40		0.36	0.41		0.36	0.72		0.84	0.73		0.91
Geographical region																		
Mediterranean	0.73		0.37	0.69		0.35	1.81		1.32	1.82		1.31	-		-	-		-
Central Anatolia	0.76		0.50	0.78		0.51	2.17		1.77	2.02		1.66	2.30		2.99	1.90		2.80
Eastern Anatolia	1.77		0.84	1.76		0.84	1.63		1.18	1.80		1.30	0.72		1.13	1.13		1.82
Marmara	*Omitted*			*Omitted*			*Omitted*			*Omitted*			*Omitted*			*Omitted*		
Aegean	0.52		0.30	0.50		0.29	0.36		0.43	0.37		0.44	1.20		1.66	1.36		1.88
Black Sea	0.69		0.35	0.67		0.35	0.40		0.36	0.38		0.35	3.49		4.83	3.42		4.88
Number of people in the household	0.92		0.09	0.92		0.09	0.82		0.13	0.80		0.13	0.59		0.18	0.61		0.20
Child's age in months	0.66		0.20	0.68		0.21	1.04		0.47	1.01		0.45	0.69	★★	0.07	0.68	★★	0.08
Child's sex																		
Male	*Omitted*			*Omitted*			*Omitted*			*Omitted*			*Omitted*			*Omitted*		
Female	1.01		0.01	1.01		0.01	1.02		0.01	1.02		0.01	0.44		0.39	0.39		0.36
Parity	1.46	★	0.23	1.47	★	0.23	1.36		0.33	1.36		0.33	0.86		0.35	0.88		0.37

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 Nutritional Outcomes in Infants and Children, Odd Ratios

	Small size at birth				Low birth weight				Preterm Birth			
Number of Observations	570				545				555			
	OR	Std. Err.	OR	Std. Err.	OR	Std. Err.	OR	Std. Err.	OR	Std. Err.	OR	Std. Err.
Mother's height in cm (continuous)	0.96 ★	0.02			0.97	0.02			1.00	0.02		
Mother's height in cm (categorical)												
≥ 160			*Omitted*				*Omitted*				*Omitted*	
155-159.9			1.20	0.30			1.03	0.34			0.77	0.22
150-154.9			1.34	0.35			1.09	0.37			1.01	0.28
< 149.9			2.32 ★	0.75			1.94	0.78			0.84	0.33
Mother's age	1.03	0.02	1.03	0.02	1.01	0.03	1.01	0.03	1.05	0.02	1.04	0.02
Mother's education												
No education	0.72	0.17	0.71	0.17	1.03	0.31	0.99	0.30	1.55	0.41	1.53	0.41
Primary education	*Omitted*		*Omitted*		*Omitted*		*Omitted*		*Omitted*		*Omitted*	
Secondary or higher education	0.66	0.16	0.64	0.16	0.72	0.23	0.69	0.23	0.79	0.21	0.77	0.21
Father's education												
No education	0.90	0.22	0.88	0.22	0.71	0.22	0.70	0.22	1.15	0.33	1.20	0.34
Primary education	*Omitted*		*Omitted*		*Omitted*		*Omitted*		*Omitted*		*Omitted*	
Secondary or higher education	1.06	0.24	1.05	0.23	0.85	0.25	0.84	0.24	1.52	0.38	1.51	0.38
Household Wealth												
Low-wealth households	1.86 ★	0.49	1.86 ★	0.49	1.70	0.59	1.68	0.59	0.95	0.27	0.96	0.28
Middle-wealth households	*Omitted*		*Omitted*		*Omitted*		*Omitted*		*Omitted*		*Omitted*	
High-wealth households	0.97	0.27	0.98	0.27	1.00	0.38	1.00	0.38	1.07	0.32	1.06	0.32
Geographical region												
Mediterranean	1.00	0.32	0.99	0.31	1.15	0.45	1.11	0.44	1.18	0.41	1.15	0.40
Central Anatolia	1.05	0.40	1.09	0.42	1.03	0.48	1.07	0.51	1.98	0.78	2.05	0.81
Eastern Anatolia	0.86	0.29	0.89	0.30	0.78	0.34	0.76	0.33	1.24	0.45	1.22	0.45
Marmara	*Omitted*		*Omitted*		*Omitted*		*Omitted*		*Omitted*		*Omitted*	
Aegean	0.98	0.31	1.00	0.31	0.69	0.28	0.69	0.28	0.66	0.24	0.65	0.23
Black Sea	1.17	0.34	1.20	0.35	0.92	0.35	0.94	0.35	0.72	0.25	0.72	0.24
Number of people in the household	1.05	0.06	1.05	0.06	0.89	0.07	0.89	0.07	1.03	0.06	1.03	0.06
Child's age in months	1.00	0.01	1.54	0.29	1.57	0.39	1.62	0.40	1.48 ★	0.31	1.50 ★	0.32
Child's sex												
Male	*Omitted*		*Omitted*		*Omitted*		*Omitted*		*Omitted*		*Omitted*	
Female	1.50 ★	0.28	1.00 ★	0.01	1.00	0.01	1.00	0.01	0.99	0.01	0.99	0.01
Parity	0.86	0.08	0.86	0.08	1.10	0.14	1.09	0.14	0.78 ★	0.09	0.79 ★	0.09

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

References

Adair L. S., Fall C.H., Osmond C., Stein A.D., Martorell R., Ramirez-Zea M., Sachdev H.S., Dahly D.L., Bas I., Norris S.A., Micklesfield L., Hallal P., Victora C.G. (2013) Associations of linear growth and relative weight gain during early life with adult health and human capital in countries of low and middle income: findings from five birth cohort studies. *The Lancet* 382:525–534.

Addo, O. Y., Stein, A. D., Fall, C. H., Gigante, D. P., Guntupalli, A. M., Horta, B. L., ... & Consortium on Health Orientated Research in Transitional Societies (COHORTS) Group. (2013). Maternal height and child growth patterns. *The Journal of pediatrics*, 163(2), 549-554.

Aizawa, T. (2020). Trajectory of inequality of opportunity in child height growth. *Demographic research*, 42, 165-202.

Barker, D. J., Godfrey, K. M., Gluckman, P. D., Harding, J. E., Owens, J. A., & Robinson, J. S. (1993). Fetal nutrition and cardiovascular disease in adult life. *The Lancet*, 341(8850), 938-941.

Barker, D. J. P. (1998) *Mothers, babies, and health in later life*. Edinburgh; New York: Churchill Livingstone, 2nd ed.

Black, R. E., Allen, L. H., Bhutta, Z. A., Caulfield, L. E., De Onis, M., Ezzati, M. & Rivera, J. (2008). Maternal and child undernutrition: global and regional exposures and health consequences. *The Lancet*, 371(9608), 243-260

Crimmins, E. M. (2015). Physiological Differences Across Populations Reflecting Early Life and Later Life Nutritional Status and Later Life Risk for Chronic Disease. *Journal of Population Ageing*, 1-19.

Dewey, K. G., & Begum, K. (2011). Long‐term consequences of stunting in early life. *Maternal & Child Nutrition*, 7(s3), 5-18.

Fogel, R. W., & Costa, D. L. (1997). A theory of technophysio evolution, with some implications for forecasting population, health care costs, and pension costs. *Demography*, 34(1), 49-66.

Fogel, R. W. (1997). New findings on secular trends in nutrition and mortality: some implications for population theory. *Handbook of population and family economics*, 1, 433-481.

Fogel, R. W. (2004). *The escape from hunger and premature death, 1700-2100: Europe, America, and the Third World* (Vol. 38). Cambridge University Press.

Gausman, J., Kim, R., & Subramanian, S. V. (2019). Stunting trajectories from post‐infancy to adolescence in Ethiopia, India, Peru, and Vietnam. *Maternal & Child Nutrition*, 15(4), e12835.

Gluckman, P. D., Hanson, M. A., & Pinal, C. (2005). The developmental origins of adult disease. *Maternal & child nutrition*, 1(3), 130-141.

Gluckman, P. D., & Hanson, M. A. (2006). *The developmental origins of health and disease*. Cambridge University Press

Hernandez-Diaz, S., Peterson, K. E., Dixit, S., Hernandez, B., Parra, S., Barquera, S., ... & Rivera, J. A. (1999). Association of maternal short stature with stunting in Mexican children: common genes vs common environment. European Journal of Clinical Nutrition, 53(12), 938-945.

Koç, İ., Saraç, M., Abbasoğlu Özgören, A., & Çağatay, P. (2024) “The Demographic Integration and Differentials of Roma Population and Policy Priorities in Türkiye” Project Final Report, TUBITAK 1001 Program, Project no: 122R016.

Lawn J.E., Lee A.C., Kinney M., Sibley L., Carlo W.A., Paul V.K. et al. (2009) Two million intrapartum-related stillbirths and neonatal deaths: where, why, and what can be done? *International Journal of Gynaecology and Obstetrics* 107 (Suppl. 1), S5–S18, S19.

Martorell, R., and J. P. Habicht. 1986. "Growth in Early Childhood in Developing Countries." In *Human Growth: A Comprehensive Treatise*, vol. 3 (2nd ed.), ed., F. Falkner and J. Tanner, 241-62. New York: Plenum Press.

Martorell, R., Khan, L. K., & Schroeder, D. G. (1994). Reversibility of stunting: epidemiological findings in children from developing countries. *European journal of clinical nutrition*, 48, S45-57.

Martorell, R., & Zongrone, A. (2012). Intergenerational influences on child growth and undernutrition. *Paediatric and perinatal epidemiology*, 26, 302-314.

Martorell, R. (2017). Improved nutrition in the first 1000 days and adult human capital and health. *American Journal of Human Biology*, 29(2), e22952.

Mertens, A., Benjamin-Chung, J., Colford Jr, J. M., Coyle, J., Van der Laan, M. J., Hubbard, A. E., ... & Arnold, B. F. (2023). Causes and consequences of child growth faltering in low-resource settings. *Nature*, 621(7979), 568-576.

Özaltin, E., Hill, K., & Subramanian, S. V. (2010). Association of maternal stature with offspring mortality, underweight, and stunting in low-to middle-income countries. *Jama*, 303(15), 1507-1516.

Perkins, J. M., Subramanian, S. V., Davey Smith, G. & Ozaltin, E. (2016) Adult height, nutrition, and population health. *Nutrition reviews* 74, 149–165.

Ramakrishnan, U., Grant, F., Goldenberg, T., Zongrone, A., & Martorell, R. (2012). Effect of women's nutrition before and during early pregnancy on maternal and infant outcomes: a systematic review. *Paediatric and perinatal epidemiology*, 26, 285-301.

Scrimshaw, N. S. (1997). The relation between fetal malnutrition and chronic disease in later life. *BMJ*, 315(7112), 825-826.

Silventoinen, K., Lahelma, E., & Rahkonen, O. (1999). Social background, adult body-height and health. *International Journal of Epidemiology*, 28(5), 911-918.

Silventoinen, K. (2003). Determinants of variation in adult body height. *Journal of biosocial science*, 35(2), 263-285.

Smith, G. D., Hart, C., Upton, M., Hole, D., Gillis, C., Watt, G., & Hawthorne, V. (2000). Height and risk of death among men and women: aetiological implications of associations with cardiorespiratory disease and cancer mortality. *Journal of epidemiology and community health*, 54(2), 97-103.

Tucker-Seeley, R. D., & Subramanian, S. V. (2011). Childhood circumstances and height among older adults in the United States. *Economics & Human Biology*, 9(2), 194-202.

Varela-Silva, M. I., Azcorra, H., Dickinson, F., Bogin, B., & Frisancho, A. R. (2009). Influence of maternal stature, pregnancy age, and infant birth weight on growth during childhood in Yucatan, Mexico: a test of the intergenerational effects hypothesis. *American Journal of Human Biology*: The Official Journal of the Human Biology Association, 21(5), 657-663.

Victora, C. G., Adair, L., Fall, C., Hallal, P. C., Martorell, R., Richter, L., & Sachdev, H. S. (2008). Maternal and child undernutrition: consequences for adult health and human capital. *The Lancet*, 371(9609), 340-357.

Victora, C. G., Christian, P., Vidaletti, L. P., Gatica-Domínguez, G., Menon, P., & Black, R. E. (2021). Revisiting maternal and child undernutrition in low-income and middle-income countries: variable progress towards an unfinished agenda. *The Lancet*, 397(10282), 1388-1399.

Wadsworth, M. E. J. (1997). Health inequalities in the life course perspective. *Social Science & Medicine*, 44(6), 859-869.

Webb, E., Kuh, D., Peasey, A., Pajak, A., Malyutina, S., Kubinova, R., ... & Bobak, M. (2008). Childhood socioeconomic circumstances and adult height and leg length in central and eastern Europe. *Journal of epidemiology and community health*, 62(4), 351-357.