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RESEARCH ARTICLE

Stature and education among Roma women: taller stature is associated with better educational and economic outcomes

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Abstract

The association between body height and educational outcome, as measured by years of completed schooling, was investigated among Roma women in Serbia in 2014–2018. Height, demographic data, level of schooling and reproductive histories were collected from 691 Roma women aged between 16 and 80 years living in rural settlements in central and western Serbia. Multinomial logistic regression analysis showed that short stature was associated with an increased risk of low education, possibly as a result of poor growth and developmental disadvantage in early life. Roma cultural practices were also shown to influence the school achievement of these Roma girls: in addition to height, education was positively associated with a higher bride price and better socioeconomic status, as acquired through marriage. For Roma women, height might influence not only their level of education but also their lifetime prospects.

Keywords: Stature; Education; Roma women

Introduction

Educational achievement is often considered to be only influenced by environmental factors, but it has been shown to have a genetic foundation (Deary & Johnson, 2010; Calvin *et al*., 2012; Rietveld *et al*., 2013). For instance, height is highly heritable and a positive relationship between height and educational attainment has been found in large-sample studies and in smaller within-sibling comparisons (Silventoinen *et al*., 2000; Magnusson *et al*. 2006; Deaton & Arora, 2009). Height serves as an indicator of growth, nutrition and social environment in earlier life (Silventoinen, 2003; Case & Paxson, 2010), and is strongly associated with cognitive ability in childhood, as physical growth and cognitive development share childhood inputs (Case & Paxson, 2008; Murasko, 2013; Vogl, 2014). Studies have typically shown a correlation between height and IQ of around 0.25, while general cognitive ability has long been recognized as the single most important predictor of academic achievement (Deary *et al*., 2009; Deary & Johnson, 2010).

The Roma comprise one of the largest ethnic groups in Europe, with an estimated 6 million Roma people living in central and eastern European countries, characterized by poverty, unemployment and low levels of education. A large proportion of European Roma can neither read nor write: the share of Roma between the ages of 16 and 24 who say that they cannot read or write is 35% (FRA, 2014). Even when provided with schooling in their own language, Romani, many Roma fail to complete even a basic education (Ringold, 2000; Mag, 2012). To combat this, with the launch of the Decade of Roma Inclusion 2005–2015 in central and south-eastern Europe, governments have introduced strategies aimed at improving the Roma's situation in several areas, including education, but the lives of many Roma remain unaltered, with entire segments

remaining poor, uneducated and unemployed, especially females (Sardelić, 2017). This is usually explained not only by their limited access to education, but also by the impact of cultural practices, such as the early ages of marriage and childbearing of Roma females and the low value placed on education and professional success (Brüggemann, 2012).

At present, the Serbian Roma population is estimated to range from 100,000 to 500,000. This large range is due to many Roma declaring themselves to be members of the majority population at censuses and denying their ethnic identity. Reliable data on Roma students in Serbian education do not exist as there are no precise data about their total number. According to the latest census in 2011, 15% of Roma older than 10 years are illiterate; 21.2% of female Roma are illiterate, with only 33.3% having finished elementary school (Radovanović & Knežević, 2014). These figures may be an overestimation since the data were self-reported. For those who claimed to have finished elementary school, 17% of Roma females and 24% of Roma males could not read a simple statement/sentence. In addition, Roma demographic characteristics greatly differ from those of the Serbian population as a whole: a young population with higher fertility, earlier onset of reproduction, longer reproductive period and high infant and child mortality (Čvorović, 2014). Concerning marriage, a lot of Roma live in informal unions arranged by parents and kin groups and practise bride price – usually a significant sum of money and/or gifts, given by the groom's parents to the bride's household.

Serbia has a well-developed school network, inherited from the Federal Republic of Yugoslavia. Free, universal public primary education was established in 1958 (Pešikan & Ivić, 2016). A range of measures were purposefully initiated to support the enrolment of students belonging to minority groups, and in the early 2000s numerous affirmative measures were introduced to help the Roma, particularly in education. These included facilitation of entry into the education system by allowing children from vulnerable groups to enrol in school without proof of residency or a health certificate. Despite these equity measures, in Serbia (and the former Yugoslavia) Roma school absenteeism and high drop-out rates have persisted (Biro *et al*., 2009). Additionally, Roma assistants were employed to help with school drop-outs and the process of learning but, surprisingly, the data show that the number of drop-outs increased among Roma students who worked with a Roma assistant (Čekić Marković, 2016).

Despite widespread interest in Roma education (Reimer, 2016; Kyuchukov & New, 2016; Hinton-Smith *et al*., 2018), no studies have investigated Roma females' educational outcomes and their association with height as a proxy for growth and cognitive development. The present study aimed to assess this association among Roma women in Serbia.

Methods

Study population

Data were collected between 2014 and 2018 in several rural settlements in central and western Serbia as part of a larger anthropological study on the culture and health of Roma women (Čvorović & Coe, 2019). A description of the Roma communities and the methods used has been provided previously (Čvorović, 2018). The settlements were mostly poor with undeveloped infrastructure, but there were variations at the local level and also within settlements. Over 700 Roma women participated in the study, recruited through personal contacts and Roma organizations; ten women who never attended school were excluded from the analyses while all other women had been enrolled in elementary school for at least one year/grade. The final sample included 691 Roma women who ranged in age from 16 to 80 years. All the women were fluent in Serbian, while some also spoke Romani, which is half-Serbian, half-Romani. Only a few women reported that they occasionally worked, most often in open markets or as cleaners, while most derived their income from social welfare support and the grey economy.

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Measurements and variables

The study's outcome variable was 'level of schooling', measured as 'years of completed schooling'. A total of 132 women reported being enrolled in the 1st grade of elementary school but dropping out before finishing the school year. Thus, the women were divided into three groups, based on years of attending school: those who were enrolled in school for 0–4 years, 5–8 years and 9–12 years. These roughly correspond to Serbian elementary lower (1–4) and upper grades (5–8) and high/vocational school (9–12).

'Short stature' was adopted as an indicator of poor growth and developmental disadvantage (Spears, 2012). Stature was measured using a standard procedure (Lohman *et al*., 1988). The sample women were classified into stature quartiles: short (1st quartile: height $\leq$157 cm), medium height (2nd quartile: $>$157 cm and $\leq$160 cm; and 3rd quartile: $\geq$160 cm and $\leq$164 cm) and tall (4th quartile: $>$164 cm) (Čvorović, 2018).

In addition, a number of variables that might have influenced Roma women's schooling were collected through a questionnaire that focused on demographic characteristics (age, educational level, religion and socioeconomic status) and marital and reproductive histories (age at first marriage, bride price, age at first reproduction (AFR) and number of surviving children). Moreover, Roma women were asked to rate their parental/family support towards formal schooling with a question designed with a Likert-type rating scale: 'To what extent did your parents/family encourage formal (Serbian) education?' (1 = not at all; 2 = a little; 3 = somewhat; 4 = quite a bit; and 5 = a lot). Covariates were self-reported and selected based on previous stuidies (Hotchkiss *et al*., 2016; Čvorović, 2018; Čvorović, 2019).

As for the Roma's socioeconomic status (SES), frequently used measures that may contribute to educational attainment, such as parental education and income (Diemer *et al*., 2013), have little or no meaning in the Roma community as the majority of Roma in Serbia survive by combining social benefits with informal work, called 'private' business by many Roma. In addition, many Roma use a self-made hierarchy between subgroups and families, where long-term sedentary Roma families rank at the top. Thus, SES was measured by Roma women's internal perceptions of (their husband's) family's social standing relative to others in their communities: poor SES, average SES and above average SES.

Early child marriage is common among Roma, prompting concerns about the harmful consequences for young females marrying too early, which can include health risks (but see Čvorović, 2019), interrupted schooling and being prevented from taking advantage of economic opportunities (Mehra *et al*., 2018). Regarding Serbian Roma, a recent nationally representative household survey found Roma girls in Serbia to be at very high risk of being married as children in contrast to the general population; however, the study failed to find a significant association between early marriage and school enrolment among the Roma (Hotchkiss *et al*., 2016). As Roma women often enter motherhood as teenagers, age at first reproduction (AFR) was used instead.

Higher female education at marriage may be associated with a higher bride price (Ashraf *et al*., 2016). The custom of bride price is usually interpreted as 'payment about [for] the honor of the bride' (Pamporov, 2007, p. 472), but it can also serve as an additional 'screening' of the financial resources of future in laws (Apostolou, 2008) as well as the abilities of brides (Čvorović & Coe, 2019). 'Market value' can be a number of different combinations of attributes, but generally characteristics that serve as proximate cues to reproductive and parental investment (Trivers, 1972) are more favoured: for instance, intelligence, physical attractiveness, height and health would be more highly correlated with investment capability (Buss & Barnes, 1986; Ponzo & Scoppa, 2015). If the bride is known to have a chronic illness, disability or any condition that may affect fertility, the amount of money paid can be lower (Taghizadeh *et al*., 2016). Because the amount of payment varies among Roma groups and families, being dependent on fluctuating economic circumstances in time, Roma women's own perceptions of the amount of bride price paid relative to others in their communities were used in this study. Thus, bride price had four modalities: married without

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bride price, or married with a small, average or high bride price. High bride price was adopted as an indicator of greater investment capability.

Statistical analyses

To detect differences in background factors that might have influenced level of schooling, descriptive statistics, ANOVA, Tukey's post-hoc HSD, the Kruskal–Wallis test and the chi-squared test were performed for Roma women in different educational groups. The significance threshold was set at $p<0.05$. A multinomial logistic regression analysis was performed to model the relationship between the predictors and dependent (outcome) variable 'level of schooling', classified into three categories: 0–4, 5–8 and 9–12 grades/years. The reference group was those Roma women who attended school for 9–12 years; each of the other two categories was compared with this reference group. The predictor variables were age (in *z*-scores/standardized scores), age at first reproduction (AFR, continuous), number of surviving children (continuous), height (in three categories: 1st quartile ≤157 cm, i.e. short women; 2nd and 3rd quartiles, >157 cm and ≤164 cm i.e. medium height women; and 4th quartile >164 cm, i.e. tall women), religion (dichotomous variable: Christianity or Islam), family support towards schooling (continuous, collapsed into 3–5 to avoid low frequencies), socioeconomic standing (SES) of woman's family (woman's husband's family, in three categories: poor SES, average SES and high SES) and bride price (no bride price, small bride price, average bride price and high bride price paid for a woman at the time of her marriage).

Results

The socio-demographic characteristics and statures of the study participants are summarized in Table 1. The average age of the sample women was 41 years (range 16–80 years), and the majority were of average SES and had little schooling (mean (M) = 5.12 years, SD = 3.39, range 0–12); almost one-fifth (19.1%) dropped out before finishing even the first grade of elementary school. The majority (63.4%) were Christian Orthodox, while slightly over a third were Muslim (36%) (results not shown). The majority (79.7%) entered marriage as teenagers ($M = 16$ years, SD = 1.58), first reproduction was at an average of 18 years and the average number of surviving children per woman was 3.2. The majority of marriages were arranged by the woman's family and a bride price was paid at the time of marriage for 82% of marriages. The majority of women reported some sort of parental/family support towards formal schooling.

When the women were divided into three groups by level of schooling (0–4 years of schooling, $M = 1.93$ years, SD = 1.83; 5–8 years of schooling, $M = 6.79$ years, SD = 1.19; 9–12 years of schooling, $M = 10.97$ years, SD = 0.93), significant differences were found between all variables except religious affiliation ($\chi^2(2, n = 691) = 0.15$, $p = 0.93$, $C = 0.02$; results not shown). Thus, women who spent the least amount of time in school were the oldest ($M = 48.69$ years, SD = 13.85), while those with the most schooling were the youngest ($M = 34.02$ years, SD = 9.88) ($F(2, 688) = 97.19$, $p<0.001$, $\eta^2 = 0.22$). Furthermore, women with the least schooling were the shortest ($M = 159.77$ cm, SD = 5.16), while those with 9–12 years of schooling were the tallest ($M = 161.69$ cm, SD = 5.03; $F(2, 688) = 4.79$, $p = 0.01$, $\eta^2 = 0.01$). Women with 0–4 years of schooling had the lowest AFR ($M = 16.80$ years, SD = 1.81), while those with 9–12 years of schooling had the highest AFR ($M = 19.64$ years, SD = 3.11; $F(2, 688) = 59.26$, $p<0.001$, $\eta^2 = 0.15$). Also, women with 0–4 years of schooling had the most surviving children ($M = 4.10$, SD = 1.98), while those with 9–12 years of schooling had the least ($M = 1.94$, SD = 0.81; $F(2, 687) = 88.05$, $p<0.001$, $\eta^2 = 0.20$). However, they also had the most deceased children ($M = 0.23$, SD = 0.58), while women with 9–12 years of schooling had the least ($M = 0.04$, SD = 0.26; $F(2,688) = 6.87$, $p<0.001$).

Further differences between women by educational group were found by (husband's family's) SES, with those with 9–12 years of schooling reporting higher SES ($\chi^2(4, n = 689) = 62.27$,

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Table 1. Socio-demographic characteristics and statures of Roma women by years of schooling

Variable	0–4 years ($N = 300$)	5–8 years $N = 318$	9–12 years $N = 73$	p-value	Total sample ($N = 691$)
Age, mean (SD)	48.69 (13.85)	35.77 (11.46)	34.02 (9.88)	<0.05[b]	41.19 (14.04)
Height, mean (SD)	159.767(5.16)	160.65 (5.36)	161.69 (5.03)	<0.05[b]	160.38 (5.27)
AFR, mean (SD)	16.80(1.81)	18.08 (2.24)	19.64 (3.11)	<0.05[b]	17.69 (2.36)
No. surviving children, mean (SD)	4.10 (1.98)	2.64 (1.32)	1.94 (0.81)	<0.05[b]	3.20 (1.80)
No. deceased children, mean (SD)	0.23 (0.58)	0.12 (0.39)	0.04 (0.26)	<0.05[b]	0.16 (0.48)
SES, *n* (%)				<0.05[a]	
Poor	132 (44.1)	103 (32.5)	13 (17.8)		248 (36.0)
Average	160 (53.5)	196 (61.8)	42 (57.5)		398 (57.8)
Above average	7 (2.3)	18 (5.7)	18 (24.7)		43 (6.2)
Bride price, *n* (%)				<0.05[a]	
No bride price	93 (31)	32 (10.1)	3 (4.1)		128 (18.5)
Small	62 (20.7)	50 (15.7)	4 (5.5)		116 (16.8)
Average	125 (41.7)	81 (25.5)	7 (9.6)		213 (30.8)
High	20 (6.7)	155 (48.7)	59 (80.8)		234 (33.9)
Parental support, *n* (%)					
1	10 (3.3)	2 (0.6)	3 (4.1)		15 (2.2)
2	11 (3.7)	3 (0.9)	2 (2.7)	<0.05[c]	16 (2.3)
3	69 (23)	57 (17.9)	7 (9.6)		133 (19.2)
4	80 (26.7)	107 (33.6)	16 (21.9)		203 (29.4)
5	130 (43.3)	149 (46.9)	45 (61.6)		324 (46.9)

[a]Chi-squared test; [b]ANOVA; and [c]Kruskal–Wallis tests performed.

$p<0.001$, $C = 0.21$), but also a higher bride price (χ^2 (6, $n = 691$) = 213.08, $p<0.001$, $C = 0.39$) and more parental support towards formal education (χ^2 (2) = 10.12, $p = 0.01$), than women of average or short height.

When the women were divided into height quartiles significant differences in mean level of schooling were found ($F(2, 688) = 6.69$; $p<0.001$), with short women in the 1st quintile having on average 1.29 years less schooling than tall women ($p<0.001$), and women in the 2nd and 3rd quartiles having on average 0.90 years less schooling than tall women ($p = 0.02$). Schooling level and height were found to be positively correlated ($r = 0.141$, $p<0.001$).

A multinomial logistic regression was used to analyse the predictors of women's level of schooling (school attendance of 0–4 years, 5–8 and 9–12 years). The reference category was 9–12 years of schooling and each of the other two categories was compared with this reference group. The model was statistically significant, i.e. the predictors explained the dependent variable 'level of schooling' for the women ($\chi^2(20) = 484.14$; $p<0.001$; Pearson's $\chi^2(1316) = 1168.82$; $p = 0.99$; deviance χ^2 (1338) = 801.19; $p = 1.00$). The predictor variables explained between 50.9% (Cox–Snell R^2) and 59.8% (Nagelkerke's R^2) of the variance of the dependent variable. As shown in Table 2, significant unique contributions were made by age, AFR, number of surviving children,

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Table 2. Multinomial logistic regression showing the unique contributions of predictors to women's years of schooling

Predictor	χ^2	df	*p*-value[a]
Age	80.591	2	<0.001
AFR	28.279	2	<0.001
No. surviving children	35.947	2	<0.001
Parental support	0.661	2	0.718
Height (quartile)	13.107	4	0.012
SES	28.230	4	<0.001
Religion	0.384	2	0.825
Bride price	124.971	6	<0.001

[a]Significance taken at $p<0.05$.

Table 3. Results of multinomial logistic regression showing predictors of Roma women's level of schooling

	0–4 years		5–8 years	
Variable	OR (95% CI)	SE	OR (95% CI)	SE
Age	3.08 (1.96/4.84)*	2.01	1.10 (0.74/1.64)	0.20
AFR	0.62 (0.51/0.75)*	0.09	0.80 (0.69/0.93)*	0.75
No. surviving children	2.44 (1.67/3.57)*	0.19	1.75 (1.22/2.50)*	0.18
Height				
1st quartile	0.12 (0.34/0.45)*	0.65	0.31 (0.10/0.96)*	0.57
2nd/3rd quartile	0.58 (0.24/1.41)	0.45	0.73 (0.36/1.47)	0.36
SES				
Poor	46.35 (9.11/225.82)*	0.83	10.77(3.36/34.56)*	0.60
Average	19.03 (4.61/78.41)*	0.72	6.30 (2.67/14.86)*	0.43
Bride price				
None	70.18 (17.09/288.17)*	0.72	3.13 (0.83/11.25)	0.72
Small	55.13 (13.43/226.33)*	0.72	5.92 (1.66/21.12)*	0.64
Average	53.13(17.30/163.11)*	0.57	4.84 (1.84/12.72)*	0.49

Reference group: 9–12 years of schooling.
OR = Odds Ratio; SE = Standard Error; 95% CI = Confidence Interval.
*$p<0.05$.

height (quartile), SES and bride price, while level of family support towards formal schooling and religion were not significant ($p>0.05$) and were thus excluded from further analysis.

The first column in Table 3 shows the 0–4 years of schooling outcome compared with the 9–12 years of schooling outcome (reference category) by socio-demographic variables. The results suggest that age, AFR, number of surviving children, being in the 1st height quartile, SES and bride price had a significant overall effect on the level of schooling outcome for the sample women. That is, the risk of the outcome being the comparison group (0–4 years of schooling) relative to the reference group (9–12 years of schooling) increased as age (OR = 3.08, CI = 1.96–4.84, $p<0.001$) and number of surviving children (OR = 2.44, CI = 1.67–3.57, $p<0.001$) increased;

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furthermore, the risk of the outcome being the comparison group relative to the reference group was higher for women of poor or average SES versus those of high SES (OR = 46.35 CI = 9.11–225.82, $p<0.001$; and OR = 19.03, CI = 4.61–78.41, $p<0.001$, respectively). The risk of the outcome being the comparison group, with less education, was higher for women who were married and without a bride price (OR = 70.18, CI = 17.09–288.17, $p<0.001$) or only a small (OR = 55.13, CI = 13.43–226.33, $p<0.001$) or average bride price (OR = 53.13, CI = 17.30–163.11, $p<0.001$), compared with women married with a high bride price. In other words, for older Roma women, with more children, of poor or average SES, and without or with only a small or average bride price paid, the comparison outcome – less schooling – was more likely. In contrast, the risk of the outcome being the comparison group (0–4 years of schooling) relative to the reference group (9-12 years of schooling) decreased as AFR (OR = 0.62, CI = 0.51–0.75, $p<0.001$) and height for short women increased (OR = 0.12, CI = 0.34–0.45, $p<0.001$). That is, for Roma women with a later AFR, the outcome was more likely to be in the reference group; if height were to increase for short women, they would fall in the more educated group as well. Being of average height had no significant effect on Roma women's schooling level.

The second column in Table 3 shows the outcome of 5–8 years of schooling compared with 9–12 years of schooling (reference category). The statistical analysis shows that AFR, number of surviving children, being in the 1st height quartile, SES and bride price amounts had a significant overall effect on the level of schooling outcome. That is, the risk of the outcome being the comparison group (5–8 years of schooling) relative to the reference group (9–12 years of schooling) increased as the number of surviving children increased (OR = 1.75, CI = 1.22–2.50, $p<0.001$); women of poor or average SES had a higher risk of the outcome being the comparison group (5–8 years of schooling) versus women of higher SES (OR = 10.77, CI = 3.36–34.56, $p<0.001$; and OR = 6.30, CI = 2.67–14.86, $p<0.001$, respectively). Women married with a small or medium bride price had a higher risk of the outcome being the comparison group (5–8 years of schooling) versus women married with a high bride price (OR = 5.92, CI = 1.66–21,12, $p = 0,01$; and OR = 4.84, CI = 1.84–12.72, $p<0.001$, respectively). In other words, for Roma women with more children, of poor or average SES, and married with a small or average bride price, the comparison outcome – less schooling – was more likely. In contrast, the risk of the outcome being the comparison group (5–8 years of schooling) relative to the reference group (9–12 years of schooling) decreased as AFR (OR = 0.80, CI = 0.69–0.93, $p<0.001$) and height for short women increased (OR = 0.31, CI = 0.10–0.96, $p<0.001$). That is, for Roma women with a later AFR the outcome was more likely to be in the higher education group; similarly, if height were to increase for short Roma women, higher education was a more likely outcome. The rest of the variables – age, married without a bride price and being of average height – had no significant effect on Roma women's schooling levels.

Discussion

Among Serbian Roma women, short stature – indicating poor growth and developmental disadvantages in childhood – was found to be associated with an increased risk of low education. Many previous studies have reported an association between body height and educational attainment (Hensley, 1993; Cinnirella *et al.*, 2011; Huang *et al.*, 2015; Murasko, 2018; but see Tao, 2014) but to the best of the author's knowledge, this is the first study to apply categorical height cut-offs to show the association between height and educational outcomes among Roma women. The main finding of this study was that short Roma women (in the 1st height quartile) had less schooling than those who were tall or of average stature.

In addition to being highly heritable, height may impact behaviours and how individuals are treated in society (Rott, 2013; Stulp & Barrett, 2016). For instance, in addition to poorer education, short stature is a well-established risk factor for adverse health and social outcomes, even after

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adjusting for occupation and income (Guven & Lee, 2015; Perkins *et al*., 2016; Arendt *et al*., 2018). In general, taller people are more likely than shorter people to reach their full cognitive potential, as height is the outcome of childhood circumstances in terms of growth and nutrition, and greater growth correlates with greater cognitive ability and physical health (Case & Paxson, 2008). The positive correlation between height and intelligence is probably due to the quality of nutrition obtained by the fetus and by children, which affects the development of both height and the brain, linking the two into a positive correlation (Batterjee *et al*., 2013). Malnourished children, or those suffering from diseases that slow their growth during childhood, may not reach their full potential height or develop their full physical and cognitive potential, which in turn may lead to worse health and educational attainment in adulthood (Spears, 2012).

Underlying the need for education is the recognition that the cost of illiteracy and low education can be high (Haun *et al*., 2015; Agarwal *et al*., 2015). For females, other costs include those related to health and infant and child mortality: even a small increase in mother's education corresponds with a substantial decline in child mortality (Cleland & Van Ginneken, 1988; Bicego & Boerma, 1993). And while in this study the main exposure of interest was height, consistent with this finding, it was also found that Roma women with low education experienced more child mortality when compared with more-educated women. In addition, low levels of education among Roma women were found to be associated with having had an earlier AFR, greater number of children, older age, poor and average Roma SES and being married with or without a small or average bride price and the least family support towards formal schooling. Negative relationships between educational attainment and fertility have been reported worldwide (Meisenberg, 2008; Skirbekk, 2008) and for Serbian Roma (Čvorović & Lynn, 2014). A shift towards later childbearing, and at the same time educational participation, has been a characteristic of developed countries for many decades, but the patterns of marriage and childbearing are slow to change among the Roma. Whether childbearing impedes education more than education impedes childbearing is still unclear, while rising age at first birth is often described as fertility postponement (Cohen *et al*., 2011; Testa, 2014).

In industrialized nations, most of the advantages of height operate through the fact that taller people are better educated and thus have higher incomes (Deaton & Arora, 2009). Given that the majority of Roma women are traditionally housewives, rarely working outside their homes, how does 'life at the top' manifest for tall Roma women? The tallest Roma women in the sample had the most education, and they were married with the highest bride price – a proximate cue for investment – in comparison with women with less schooling, consistent with other studies (Ashraf *et al*., 2016). Thus, a higher level of education of Roma women, even just a few years spent in school, serves to their advantage for prospective marriage, as their (husband's family's) SES was higher and they also had the least child mortality, when compared with women with less schooling. Taller Roma women with more schooling marry into richer Roma families – either 'old' families with good reputations or economically wealthier – both signalling social prestige and better economic provisioning in Roma culture. The role of height in the marriage market is well-established, as greater height signals better health (Gottfredson & Deary, 2004; Whitley *et al*., 2013; Yamamura & Tsutsui, 2017), whereas the shortest women are at a distinct disadvantage (Baten & Murray, 1998). In turn, even low levels of education increase children's well-being and survival prospects (Sandiford *et al*., 1997; Gage *et al*., 2013), as increasing levels of education lead to different thinking and decision-making patterns (Cutler & Lleras-Muney, 2010). Additionally, marrying well allows these women increased access to resources (Dickemann, 1979) and, given the widespread Roma poverty, makes a substantial difference to their own lives and those of their children. By marrying well, a smarter, more educated wife is able to learn to use her extra resources to improve the health and survival of her offspring (Charlton, 2010).

In this study, taller, more educated Roma women rated their parents' support towards formal schooling higher than did women of average or short height. And although parental support was

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not significant in the regression model, it is likely that Roma parents might have selectively invested in and supported girls who had the greatest potential to survive into adulthood and reproduce successfully, thus making the parents into grandparents, or, in other words, enhancing the parents' reproductive success (Bereczkei, 2001). For instance, poor child health, which is associated with poverty, may reduce the long-term returns on investment in education (Lawson *et al.*, 2014). In evolutionary models, payoffs are measured as reproductive success, but outcomes such as mating or economic competition may serve as salient substitutions guiding behaviours (Hopcroft & Martin, 2014; Hedges *et al.*, 2016). Given that the Roma kinship system is sustained largely through marriage, Roma parents from both sides may have recognized the benefits of combining female maternal and male economic investment capability. Variation in height across social classes is greater in poorer societies (Silventoinen, 2003; Deaton, 2007), and this form of assortative mating (Charlton, 2010; Keller *et al.*, 2013), where fitter, taller Roma females of higher than average schooling are chosen for marriage by socially/economically successful Roma males, may have influenced heterogeneity in height in Roma females, as arranged marriages, when combined with bride price, may serve as a form of social selection (Čvorović & Coe, 2019). In turn, this may create gradients in their offspring (Blane *et al.*, 1993; Čvorović, 2018).

While this study has a number of advantages, including a never-before studied topic and assessment of different variables influencing educational outcomes for Roma females, it also has a number of limitations. One possible limitation of the research is the use of cross-sectional data: the main exposure of interest (height) was measured in a standardized manner, but all other variables relied on women's self-report, and could have been affected by recall and other biases. In addition, height may also be positively associated with the acquisition of social skills, such as adaptability, confidence and abilities in social interactions, which may lead to better educational attainment (Magnusson *et al.*, 2006; Cinnirella *et al.*, 2011), but these were not accounted for in the study. Another limitation is the lack of data on Roma women's natal families, which prevented assessment of the potential influence and cross-generational patterns of investment in education. For instance, recent epidemiological and genetic studies have shown that genetics plays an important role in the achievement of education. These studies have estimated that the genetic component of educational achievement can explain as much as 40% of the trait variance (Rietveld *et al.*, 2013; Kong *et al.*, 2017). Future studies should assess these conditions and both the costs and benefits of education in terms of reproductive success among the Roma.

Given the Roma's isolated traditions and social segregation, including endogamy, any intervention aimed at improving Roma women's situation should consider not only their level of education, but also the meaning they attach to it. Traditional Roma marriage practices play an important role in the education of Roma females, and may thus represent an example of how culture actually 'works' (Kagawa Singer *et al.*, 2016). Contrary to the established perception that formal education is 'irrelevant' to the Roma way of life, this study shows that female education is a valued mate characteristic in Roma society, which is nevertheless in scarce supply. Height may affect not only female educational achievement but also their lifetime prospects, including their marital and socioeconomic status.

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