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Early determinants of blood pressure among adults of the 1982 birth cohort, Pelotas, Southern Brazil

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Abstract

OBJECTIVE: To evaluate the effects of exposure occurring during pregnancy or the first years of life on blood pressure.

METHODS: Cohort study on all children born in 1982 in maternity hospitals in the city of Pelotas, Southern Brazil. The mothers living in the urban area were interviewed and the children were followed up on different occasions. In 2004-5, all the individuals in the cohort were sought for monitoring. Their blood pressure was measured twice, at the start and end of the interview, using a digital wrist sphygmomanometer. Associations between blood pressure and the following variables were evaluated: skin color; maternal schooling level; family income at birth; change in income between birth and 23 years of age; birth weight; and duration of breastfeeding. Analysis of variance was used to compare the means and a generalized linear model was used in the adjusted analysis.

RESULTS: Blood pressure measurements were obtained from 4,291 individuals: 2,208 males and 2,083 females. The mean systolic blood pressure was 117.5 ± 15.0 mmHg and the mean diastolic was 73.6 ± 11.5 mmHg. Among the men, systolic blood pressure was higher among those of black or brown skin color and among those who were never considered poor. Diastolic pressure was only associated with birth weight. Among the women, systolic blood pressure was greater among those of black or brown skin color whose mothers' schooling level was greater than or equal to 12 years or whose birth weight was less than 4,000 g.

CONCLUSIONS: For both sexes, only skin color was associated with blood pressure. Breastfeeding did not have any long-term effect on blood pressure and the associations for birth weight and socioeconomic level were inconsistent.

Keywords

Adult; Hypertension; epidemiology; Prenatal Exposure; delayed effects; Maternal Exposure; Socioeconomic Factors; Health Inequalities; Cohort Studies; Brazil

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The authors declare that there are no conflicts of interest.

INTRODUCTION

Hypertension is an important risk factor for ischemic cardiopathy and stroke.¹² The World Health Organization⁴ has estimated that around seven million deaths attributable to hypertension occur every year. This is responsible for 62% of the deaths due to stroke and 49% of those due to ischemic cardiopathy. Among the main risk factors for hypertension are obesity, excessive sodium intake, abusive consumption of alcoholic drinks, sedentarism and inadequate intake of fruits, vegetables and potassium.^{16,17} Epidemiological studies conducted in several countries have suggested that occurrences of chronic diseases such as ischemic cardiopathy,^{6,15} diabetes¹⁴ and hypertension^{8,10} may be programmed by exposure that occurs during gestation or the first years of life. Birth weight and breastfeeding are factors possibly associated with arterial pressure levels in adulthood.^{7,10} Some authors have suggested that socioeconomic adversity during childhood may also program risk factors for chronic diseases.¹¹

The objective of the present paper was to evaluate the effects of exposure that occurred during pregnancy or the first years of life on blood pressure.

METHODS

All the children who were born in maternity hospitals in the city of Pelotas in 1982 were identified and their mothers were interviewed. Those children whose families lived in the urban area of the city were followed up on different occasions. The detailed methodology for the cohort has been published in another paper.²

In 2004-5, 4,291 members of the cohort (2,208 men and 2,083 women) had their blood pressures measured using a digital wrist sphygmomanometer (Omron HEM-629). Two measurements were made, at the start and end of the interview, with the interviewee seated and the arm supported at the level of the breast region. The blood pressure measurements were made by trained interviewers.

The systolic and diastolic blood pressure values were treated as continuous variables in the data analysis, using the mean of the two measurements. High blood pressure was defined as mean systolic pressure ≥ 140 mmHg and/or mean diastolic pressure ≥ 90 mmHg, in accordance with the definitions of the seventh American Consensus.⁵

Analysis of variance was used to compare means and generalized linear model in the adjusted analysis. The multivariable analysis followed a hierarchical model with the following levels: sex, skin color, maternal schooling and family income at birth in the first level; birth weight in the second level; and breastfeeding in the third level.

The variable of income change was constructed from the family income distribution in tertiles in 1982 and 2004-5. The interviewees were classified according to the following categories: always poor (individuals in the lowest tertile of family income both in 1982 and in 2004-5); poor \rightarrow non-poor (lowest tertile in 1982 and middle or highest tertile in 2004-5); non-poor \rightarrow poor (middle or highest tertile in 1982 and lowest tertile in 2004-5); and never poor (middle or highest tertile both in 1982 and in 2004-5).

Verbal informed consent was obtained from the adult responsible for the children during the early phase of the study (from 1982 to 1986), as was the common practice at that time, when there was no ethics committee at the *Universidade Federal de Pelotas*. For the more recent phases, the university's research ethics committee, which is affiliated to the National Council for Research Ethics (*Conselho Nacional de Ética em Pesquisa*, CONEP), approved the study and written informed consent was obtained from the participants.

RESULTS

The mean of the systolic blood pressure measurements was 117.5 ± 15.0 mmHg and, of the diastolic measurements, 73.6 ± 11.5 mmHg. The mean blood pressure (both systolic and diastolic), was higher among the men. The frequency of high blood pressure values was greater among the men (16.4%) than among the women (5.3%).

Table 1 shows the crude analyses for the men and women. Unadjusted analyses expressed as regression coefficients are presented in Tables 2 and 3 for the men and women, respectively.

Among the men, the systolic blood pressure was higher among those of Black or Mixed skin color, and this association was still observed after controlling for possible confounding factors. Income change was also associated with systolic blood pressure, which was lower among men who changed from poor during childhood to non-poor during adulthood. A similar result was observed for diastolic pressure, but without statistical significance. Low birth weight was only associated with higher diastolic pressure, and this result was maintained after adjusting for the socioeconomic variables and skin color. Lower means for systolic and diastolic pressure were observed among the men who had been breastfed for three to five months (Table 2).

Among the women, Black or Mixed skin color, low birth weight and intermediate duration of breastfeeding (one to eight months) were associated with systolic pressure. These associations were still observed after controlling for the socioeconomic variables. On the other hand, an inverse association between maternal schooling and systolic pressure was only observed after adjusting for skin color. Lower maternal schooling and intermediate duration of breastfeeding were associated with lower diastolic pressure values. Women whose income changed between 1982 and 2004-5, going from non-poor to poor, presented the lowest means for blood pressure, but this association was not significant after adjusting for skin color and maternal schooling (Table 3).

DISCUSSION

This cohort has been followed up since birth. It was observed that blood pressure was higher among the men. In analyses stratified according to sex, it was observed that white skin color and intermediate durations of breastfeeding were associated with lower blood pressure levels at 23 years of age among both the men and the women. In addition, low birth weight was related to greater diastolic pressure among the men and greater systolic pressure among the women. On the other hand, among these young adults' socioeconomic conditions during childhood did not have any effect on their blood pressure. Regarding the effect of birth weight on blood pressure, Adair & Dahly¹ reviewed the evidence relating to factors with long-term action on blood pressure and concluded that low birth weight was associated with a small increase in blood pressure. Most of the studies were carried out in developed countries, and they reported that for each 1 kg increase in birth weight, there was a reduction of 1 to 4 mmHg in blood pressure. In the present study, an increase of 1 kg in birth weight was associated with a reduction of 0.91 mmHg (95% CI: -2.07; 0.25) in systolic pressure among the men and 0.63 mmHg (95% CI: -1.76; 0.51) among the women, i.e. similar to observations in the literature.¹ On the other hand, among the individuals with low birth weight, the blood pressure was higher, but no linear trend was observed.

Contrary to what had been observed in relation to height at the age of 19 years,³ blood pressure did not present any association with socioeconomic conditions during childhood. Moreover, the similarity in mean blood pressure between individuals who were born and remained poor and those who were born and remained in the higher socioeconomic strata suggests that the cumulative exposure to low socioeconomic conditions also did not present

any effect on arterial pressure. Because the information on family income was collected in infancy, the possibility of information bias is small. Therefore, the absence of effect from socioeconomic conditions on arterial pressure at 23 years of age is not expected to result from such bias.

Since the incidence of breastfeeding was nearly universal among the population studied, it was not possible to replicate the analysis performed in other studies,¹³ in which the blood pressure of the subjects who had never been breastfed was compared with the pressure among those who had been breastfed. In a paper on data gathered from previous follow-ups of this cohort, we did not observe any effect relating to the duration of predominant breastfeeding on blood pressure.⁹ In a meta-analysis, it was shown that breastfeeding presented a small effect on blood pressure.⁷

In conclusion, blood pressure at 23 years of age was not only determined by the individuals' skin color but also was associated with low birth weight. This implies that intrauterine growth stimulation may have long-term effects with regard to preventing the development of chronic diseases.

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Table 1

Mean systolic and diastolic blood pressure according to birth weight, skin color, family income at birth, maternal schooling and duration of breastfeeding, according to sex. Pelotas, Southern Brazil, 1982 to 2004-5.

Variable	Men			Women		
	n	Systolic mmHg (standard deviation)	Diastolic mmHg (standard deviation)	n	Systolic mmHg (standard deviation)	Diastolic mmHg (standard deviation)
Skin color ^{***}		0.02 ^{***}	0.28 ^{***}		0.02 ^{***}	0.56 ^{***}
White	1654	123.1 (14.2)	75.6 (11.3)	1580	110.8 (12.8)	71.3 (10.5)
Black or Mixed	470	124.8 (14.6)	76.2 (12.5)	437	112.5 (14.0)	71.6 (12.0)
Maternal schooling (years) ^{**}		0.49 ^{***}	0.57 ^{***}		0.30 ^{****}	0.02 ^{****}
0 - 4	717	123.7 (14.8)	75.8 (12.1)	688	110.9 (13.3)	70.7 (11.4)
5 - 8	956	123.0 (14.2)	75.4 (11.6)	870	111.1 (13.1)	71.3 (10.5)
9 - 11	239	124.4 (13.6)	76.3 (10.8)	234	111.4 (12.6)	72.0 (11.2)
12	292	123.9 (14.4)	76.1 (11.2)	289	111.8 (12.5)	72.2 (9.8)
Family income in 1982 (MW) ^{**}		0.87 ^{***}	0.22 ^{***}		0.55 ^{****}	0.49 ^{***}
1	438	123.2 (14.4)	75.9 (12.0)	414	111.1 (14.0)	71.2 (11.9)
1.1 - 3	1092	123.7 (14.5)	75.6 (11.8)	1031	111.3 (13.0)	71.0 (10.8)
3.1 - 6	416	123.2 (14.3)	75.3 (11.2)	383	111.2 (12.0)	72.2 (9.7)
6.1 - 10	129	124.4 (13.9)	77.9 (11.1)	122	110.4 (12.8)	70.9 (10.2)
>10	123	123.0 (14.1)	75.0 (11.3)	121	110.6 (12.9)	71.3 (10.3)
Income change (1982 → 2004-5) ^{**}		0.08 ^{***}	0.15 ^{****}		0.38 ^{****}	0.20 ^{****}
Always poor	335	123.2 (15.0)	76.0 (12.7)	373	111.9 (14.1)	71.3 (12.1)
Non-poor → poor	339	121.8 (14.1)	74.4 (11.6)	374	110.3 (12.7)	70.3 (10.3)
Poor → non-poor	359	123.6 (14.9)	75.8 (12.2)	305	111.4 (13.6)	71.2 (11.6)
Never poor	1175	124.0 (14.0)	76.0 (11.1)	1031	111.1 (12.6)	71.7 (10.2)
Birth weight (g) ^{**}		0.37 ^{****}	0.05 ^{****}		0.25 ^{****}	0.38 ^{****}
< 2500	136	124.7 (14.5)	76.8 (12.9)	165	111.3 (13.2)	71.3 (12.1)
2500 - 2999	451	123.0 (13.6)	75.5 (10.9)	570	111.4 (13.5)	71.2 (11.4)
3000 - 3499	847	124.0 (14.7)	76.2 (11.8)	785	111.2 (12.9)	71.4 (10.6)
3500 - 3999	609	123.0 (14.3)	75.4 (11.6)	486	111.3 (12.8)	71.6 (10.2)

Variable	Men			Women		
	Mean blood pressure in mmHg (standard deviation)			Mean blood pressure in mmHg (standard deviation)		
	n	Systolic	Diastolic	n	Systolic	Diastolic
4000	165	122.9 (14.2)	73.6 (11.8)	76	107.8 (11.2)	68.9 (9.8)
Duration of breastfeeding (months)**		0.05***	0.18***		0.03***	0.06***
< 1.0	482	124.1 (15.4)	75.8 (12.3)	417	111.4 (12.5)	71.8 (10.5)
1.0 - 2.9	544	123.6 (13.8)	75.5 (11.5)	529	110.6 (13.1)	70.8 (11.1)
3.0 - 5.9	484	121.8 (14.2)	74.8 (11.0)	469	110.2 (12.7)	70.9 (10.4)
6.0 - 8.9	202	123.2 (13.4)	75.9 (11.5)	191	110.1 (13.5)	69.9 (11.1)
9.0 - 11.9	83	122.7 (13.8)	74.9 (12.0)	76	114.2 (14.0)	73.7 (11.7)
12.0	334	124.9 (14.5)	77.0 (11.7)	345	112.5 (13.3)	71.9 (10.9)
Total****	2208	123.5 (14.3)	75.7 (11.7)	2083	111.1 (13.0)	71.3 (10.8)

MW: Minimum wages

* 150 interviewees classified themselves as Asian or indigenous

** Out of the 4297 subjects interviewed in 2004-5, there was missing information in the cases of 141 individuals (3.3% of the interviewees)

Test for heterogeneity

Test for linear trend

For six of the interviewees in 2004-5, there was no information on systolic and diastolic pressure

Table 2

Crude and adjusted analyses on the effect of the independent variables on systolic and diastolic blood pressure among the men. Pelotas, Southern Brazil, 1982 to 2004-5.

Variable	Systolic pressure in mmHg		Diastolic pressure in mmHg	
	Crude	Adjusted*	Crude	Adjusted*
Skin color	0.02**	0.02**	0.28**	0.23**
White	0	0	0	0
Black or Mixed	1.67 (0.23;3.17)	1.90 (0.36;3.44)	0.66 (-0.54;1.85)	0.76 (-0.49;2.00)
Maternal schooling (years)	0.49**	0.45**	0.57***	0.59***
0 - 4	-0.15 (-2.11;1.80)	-0.64 (-3.15;1.87)	-0.30 (-1.88;1.29)	-0.40 (-2.44;1.64)
5 - 8	-0.85 (-2.74;1.03)	-1.23 (-3.56;1.10)	-0.68 (-2.21;0.85)	-0.65 (-2.54;1.25)
9 - 11	0.54 (-1.92;3.00)	0.29 (-2.37;2.95)	0.21 (-1.79;2.20)	0.27 (-1.89;2.43)
12	0	0	0	0
Family income in 1982 (MW)	0.87**	0.80**	0.55***	0.27**
1	0.14 (-2.74;3.02)	0.18 (-3.28;3.63)	0.90 (-1.43;3.23)	1.07 (-1.73;3.88)
1.1 - 3	0.65 (-2.03;3.34)	0.98 (-2.20;4.16)	0.59 (-1.59;2.76)	0.85 (-1.73;3.43)
3.1 - 6	0.21 (-2.68;3.11)	0.59 (-2.56;3.75)	0.31 (-2.03;2.66)	0.52 (-2.04;3.08)
6.1 - 10	1.42 (-2.13;4.98)	1.51 (-2.08;5.09)	2.89 (0.02;5.77)	2.93 (0.02;5.83)
>10	0	0	0	0
Income change (1982 → 2004-5)	0.08**	0.05**	0.15**	0.27**
Always poor	-0.82 (-2.56;0.92)	-1.76 (-3.79;0.27)	0.03 (-1.38;1.45)	-0.10 (-1.74;1.55)
Non-poor → poor	-2.26 (-3.99;-0.53)	-2.33 (-4.11;-0.55)	-1.60 (-3.01;-0.19)	-1.43 (-2.87;0.02)
Poor → non-poor	-0.43 (-2.12;1.27)	-1.38 (-3.34;0.59)	-0.13 (-1.51;1.24)	-0.26 (-1.86;1.33)
Never poor	0	0	0	0
Birth weight (g)	0.37***	0.30***	0.05***	0.04***
<2500	1.77 (-1.49;5.03)	1.91 (-1.38;5.21)	3.13 (0.49;5.77)	3.17 (0.50;5.84)
2500 - 2999	0.14 (-2.43;2.70)	0.12 (-2.46;2.70)	1.92 (-0.16;3.99)	1.97 (-0.12;4.06)
3000 - 3499	1.10 (-1.29;3.50)	1.07 (-1.34;3.49)	2.61 (0.67;4.55)	2.61 (0.66;4.57)
3500 - 3999	0.09 (-2.38;2.56)	-0.02 (-2.51;2.46)	1.80 (-0.20;3.81)	1.77 (-0.24;3.78)
4000	0	0	0	0
Duration of breastfeeding (months)	0.05**	0.42**	0.18**	0.50**
<1.0	-0.75 (-2.76;1.25)	-0.62 (-2.64;1.41)	-1.22 (-2.84;0.41)	-1.24 (-2.88;0.40)
1.0 - 2.9	-1.33 (-3.29;0.62)	-1.17 (-3.15;0.80)	-1.45 (-3.03;0.14)	-1.48 (-3.08;0.12)
3.0 - 5.9	-3.06 (-5.06;-1.06)	-3.04 (-5.06;-1.02)	-2.21 (-3.83;-0.59)	-2.28 (-3.92;-0.65)
6.0 - 8.9	-1.72 (-4.23;0.78)	-1.78 (-4.31;0.76)	-1.11 (-3.14;0.92)	-1.21 (-3.26;0.85)
9.0 - 11.9	-2.23 (-5.67;1.22)	-2.46 (-6.00;1.07)	-2.09 (-4.88;0.71)	-2.64 (-5.50;0.23)
12.0	0	0	0	0

MW: Minimum wages

* The variables in the first level (skin color, maternal schooling and family income in 1982) were adjusted between each other and maintained in the analysis model if $p < 0.2$. Income change was adjusted for skin color. Birth weight was adjusted for skin color, maternal schooling and family income in 1982. Breastfeeding was adjusted for skin color, maternal schooling, income in 1982 and birth weight

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Test for heterogeneity

Test for linear trend.

Table 3

Crude and adjusted analyses on the effect of the independent variables on systolic and diastolic blood pressure among the women. Pelotas, Southern Brazil, 1982 to 2004-5.

Variable	Systolic pressure in mmHg		Diastolic pressure in mmHg	
	Crude	Adjusted*	Crude	Adjusted*
Skin color	0.02**	0.01**	0.56**	0.39**
White	0	0	0	0
Black or Mixed	1.70 (0.32;3.07)	1.79 (0.36;3.21)	0.35 (-0.80;1.49)	0.53 (-0.66;1.71)
Maternal schooling (years)	0.30***	0.05***	0.02***	0.02***
0 - 4	-0.92 (-2.71;0.87)	-2.40 (-4.73;-0.07)	-1.53 (-3.01;-0.04)	-2.11 (-4.05;-0.18)
5 - 8	-0.72 (-2.46;1.01)	-1.96 (-4.13;0.20)	-0.94 (-2.38;0.50)	-1.46 (-3.26;0.34)
9 - 11	-0.41 (-2.66;1.84)	-1.24 (-3.64;1.16)	-0.23 (-2.09;1.63)	-0.67 (-2.66;1.32)
12	0	0	0	0
Family income in 1982 (MW)	0.55***	0.36***	0.49**	0.36***
1	0.49 (-2.15;3.13)	1.82 (-1.41;5.04)	-0.08 (-2.27;2.11)	1.45 (-1.23;4.13)
1.1 a 3	0.70 (-1.76;3.15)	2.03 (-0.93;4.99)	-0.29 (-2.32;1.75)	1.02 (-1.43;3.48)
3.1 a 6	0.52 (-2.14;3.19)	1.44 (-1.46;4.35)	0.88 (-1.33;3.08)	1.68 (-0.72;4.09)
6.1 a 10	-0.25 (-3.53;3.03)	0.21 (-3.12;3.54)	-0.41 (-3.13;2.30)	-0.04 (-2.80;2.72)
>10	0	0	0	0
Income change (1982 → 2004-5)	0.38**	0.38**	0.20**	0.16**
Always poor	0.78 (-0.76;2.32)	1.17 (-0.71;3.03)	-0.37 (-1.65;0.91)	0.44 (-1.11;1.99)
Non-poor → poor	-0.84 (-2.38;0.70)	-0.64 (-2.23;0.94)	-1.40 (-2.68;-0.12)	-1.13 (-2.45;0.19)
Poor → non-poor	0.31 (-1.35;1.98)	0.59 (-1.32;2.51)	-0.45 (-1.83;0.93)	0.22 (-1.37;1.80)
Never poor	0	0	0	0
Birth weight (g)	0.25**	0.38**	0.38**	0.38**
<2500	3.56 (0.03;7.10)	3.71 (0.15;7.26)	2.39 (-0.55;5.32)	2.54 (-0.41;5.49)
2500 - 2999	3.60 (0.48;6.71)	3.60 (0.47;6.72)	2.24 (-0.34;4.83)	2.28 (-0.31;4.88)
3000 - 3499	3.42 (0.35;6.48)	3.51 (0.43;6.58)	2.46 (-0.09;5.00)	2.48 (-0.07;5.03)
3500 - 3999	3.55 (0.40;6.70)	3.76 (0.61;6.92)	2.67 (0.06;5.28)	2.68 (0.06;5.29)
4000	0	0	0	0
Duration of breastfeeding (months)	0.03**	0.02**	0.18**	0.03**
<1.0	-1.14 (-2.99;0.72)	-1.14 (-3.02;0.74)	-0.10 (-1.64;1.44)	-0.16 (-1.72;1.40)
1.0 - 2.9	-1.88 (-3.65;-0.12)	-1.96 (-3.74;-0.18)	-1.06 (-2.52;0.41)	-1.19 (-2.67;0.29)
3.0 - 5.9	-2.27 (-4.08;-0.46)	-2.31 (-4.14;-0.48)	-1.01 (-2.51;0.49)	-1.18 (-2.70;0.34)
6.0 - 8.9	-2.45 (-4.75;-0.15)	-2.52 (-4.85;-0.19)	-1.97 (-3.88;-0.06)	-2.14 (-4.08;-0.21)
9.0 - 11.9	1.69 (-1.54;4.92)	2.03 (-1.25;5.31)	1.83 (-0.85;4.52)	2.03 (-0.70;4.75)
12.0	0	0	0	0

MW: Minimum wages

* The variables in the first level (skin color, maternal schooling and family income in 1982) were adjusted between each other and maintained in the analysis model if $p < 0.2$. Income change was adjusted for skin color. Birth weight was adjusted for skin color, maternal schooling and family income in 1982. Breastfeeding was adjusted for skin color, maternal schooling, income in 1982 and birth weight.

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Test for heterogeneity

Test for linear trend