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Hypertension in Adult Survivors of Child Abuse: Observations from the Nurses' Health Study II

EH Riley¹, RJ Wright^{2,3}, HJ Jun², EN Hibert², and JW Rich-Edwards^{4,5}

¹Department of Medicine, Massachusetts General Hospital, Boston, MA

²Channing Laboratory, Brigham and Women's Hospital, Boston, MA

³Department of Environmental Health, Harvard School of Public Health

⁴Connors Center for Women's Health and Gender Biology, Brigham and Women's Hospital, Boston, MA

⁵Department of Epidemiology, Harvard School of Public Health

Abstract

Background—Limited research has shown a possible association between exposure to physical or sexual abuse prior to age 18 and the risk of developing hypertension as an adult. The factors mediating this relationship are unknown.

Methods—We analyzed questionnaire data from 68 505 female participants in the Nurses' Health Study II regarding exposure to physical and sexual abuse prior to age 18. Cox proportional hazards regression was used to assess the relationship between abuse exposure and hypertension.

Results—Sixty-four percent of the participants (n = 41 792) reported physical and/or sexual abuse prior to age 18; 17% reported hypertension. All forms of abuse had a dose-response relationship with hypertension. Adjustments for smoking, alcohol, family history of hypertension, exercise, and oral contraceptives did not alter risk estimates. Adjustment for body mass index (BMI) significantly attenuated the associations between abuse and risk of hypertension and accounted for approximately 50% of the observed association between abuse exposure and hypertension. Women experiencing forced sexual activity as a child *and* as an adolescent had a 20% increased risk for developing hypertension (95% CI 8–32%) that was independent of BMI. Similarly, women reporting severe physical abuse in childhood and/or adolescence had risk estimates ranging from 14% (95% CI 5–24%) to 22% (95% CI 11–33%).

Conclusion—Early interpersonal violence may be a widespread risk factor for the development of hypertension in women. BMI is a significant mediator in the relationship between early abuse and adult hypertension.

Keywords

domestic violence; child abuse; hypertension

Correspondence to: E.H. Riley, 165 Cambridge Street, Suite 501, Boston, MA 02114. ehriley@partners.org.

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BACKGROUND

The global burden of hypertension is extensive, affecting an estimated 972 million adults worldwide.^{1,2} Exposure to certain types of violence may increase the risk of developing hypertension.^{3,4} Community-wide violence (gunshot wounds, fractures, stabbings, burns, and rape) has been shown to triple rates of hypertension in exposed populations.⁵ Exposure to terrorist violence, such as the September 11th attack on the United States (US), has been shown to increase rates of hypertension and stroke in adults for up to 3 years following the event.⁶

Exposure to interpersonal violence, particularly during childhood, may also be a risk factor for hypertension. The scope of this violence is staggering; in 2007 nearly 1 million cases of child abuse were verified by authorities in the US.^{7,8} Early life exposure to violence has been shown to be a possible risk factor for a number of health conditions including chronic pain⁹, autoimmune disease¹⁰, ischemic heart disease¹¹, headache¹², fibromyalgia,¹³ and asthma.¹⁴ Findings from a small number of studies suggest that exposure to violence in childhood may also be a risk factor for the development of hypertension. One early study evaluated childhood trauma (parental death, parental psychosis, separation from a parent, or being beaten by a parent) in 35 men, 17 of whom had a diagnosis of hypertension; 64% of the hypertensive men reported childhood trauma compared to 27% of the normotensives.¹⁵

The association of specific types of interpersonal violence with hypertension has not been clearly established. In a community-based study of 323 women evaluating the impact of psychosocial factors on health, childhood psychological and sexual abuse, but not physical abuse, were associated with hypertension.¹⁶ In 2009, the association between blood pressure, adverse environment (exposure to physical abuse, verbal abuse, sexual abuse, or harsh parenting), and expression of negative emotions (depression, anxiety, or anger) was measured in a group of 2739 adults. Only an indirect association, via the presence of negative emotions in study participants, was found between adverse environment and elevated blood pressure.¹⁷ Finally, when Nomura and colleagues prospectively followed 1704 children with a history of low birth weight, they found no significant relationship between a history of child abuse and adult onset hypertension.¹⁸

Established risk factors for the development of hypertension include age, race, family history of hypertension, inactivity, overweight or obesity, tobacco use, and alcohol use. Among these risk factors there is evidence that weight, alcohol use,¹⁹ and smoking²⁰ may be influenced by violence exposure. In particular, research on body mass index (BMI) indicates that adults with a history of child abuse are more likely to be overweight than adults with no abuse history.^{21,22,23} Although research has shown an association between child abuse and adult onset hypertension, little is known about the magnitude of this association or the factors that may mediate it. We hypothesized that exposure to physical and sexual violence prior to age 18, relative to being unexposed, would be associated with increased risk of developing hypertension in adulthood. In addition, we hoped to identify if established risk factors for hypertension, particularly smoking, alcohol use, and weight explained any observed association between abuse and hypertension.

METHODS

We studied participants in the Nurses' Health Study II (NHS II), a prospective cohort of 116 686 female nurses age 25 to 44 years at baseline, from fourteen US states.²⁴ The purpose of the NHS II was to investigate long-term effects of oral contraceptive use, diet, and lifestyle. Since the inception of the cohort in 1989, participants were mailed biennial questionnaires, including sociodemographic, behavioral, comorbidity, and dietary domains.

A violence questionnaire designed to ascertain abuse across the lifecourse was mailed to 91 286 study participants in 2001. Questionnaires were returned by 68 505 participants (75%). This study was approved by both the Institutional Review Board at Brigham and Women's Hospital in Boston, Massachusetts and the Human Subjects Committee at the Harvard School of Public Health. Completion and return of the supplementary questionnaire was an indicator of consent.

The violence questionnaire included assessments of abuse in childhood, adolescence, and adulthood. For this analysis, we examined physical and sexual abuse exposures reported for childhood (up to age 11 years) and adolescence (11–17 years).

Questions from the Revised Conflict Tactics Scale (CTS)²⁵ were used to measure physical abuse. Participants were asked to indicate the type of abuse sustained from a parent, step-parent, or adult guardian, as well as the frequency of abuse (never, once, a few times, or more than a few times). Physical abuse was categorized as: no abuse; mild to moderate abuse (hit, pushed, grabbed, or shoved); severe abuse as child or adolescent (kicked, bitten, punched, choked, burned, or physically attacked as a child or adolescent); and severe abuse as child and adolescent (kicked, bitten, punched, choked, burned, or physically attacked as a child and as an adolescent).

Sexual abuse was measured using questions from a national telephone survey conducted by the Gallup Organization in 1995.²⁶ We included a question on forced sexual touching, “Were you ever touched in a sexual way by an adult or an older child or were you forced to touch an adult or an older child in a sexual way when you did not want to?” and a question on forced sexual activity, “Did an adult or older child ever force you or attempt to force you into any sexual activity by threatening you, holding you down, or hurting you in some way when you did not want to?” Participants answered “No, this never happened”, “Yes, this happened once”, or “Yes, this happened more than once”. Sexual abuse was categorized as: no abuse, mild to moderate abuse (touched in a sexual way as child and/or adolescent), severe child or adolescent abuse (forced sexual activity as a child or adolescent), and severe child and adolescent abuse (forced sexual activity as a child and as an adolescent).

As the co-occurrence of physical and sexual abuse is highly correlated in the literature²⁷ we derived a cumulative abuse indicator which combined subtypes of physical and sexual abuse across childhood and adolescent periods. Categorization of cumulative abuse, combining exposure type, severity, number of events, and timing of abuse in either childhood or adolescence, are detailed in Table 1.

Hypertension diagnosis by a physician was self-reported biennially. The validity of self-reported hypertension was assessed by obtaining medical records from samples of women in the original Nurses' Health Study.^{28,29} Of 51 women who reported hypertension for whom we obtained medical records, hypertension (blood pressure greater than 140/90) was confirmed in all cases. In a second validation survey, blood pressure was measured in a sample of Boston-area NHS II participants; among the 161 participants who did not report hypertension, none had a blood pressure greater than 160/95 mm Hg and 6.8% had values between 140/70 and 160/95.

Covariates were considered for analysis based on their established association with hypertension and their role as potential confounders of the relationship between abuse and hypertension.^{30,31,32,33} Race/ethnicity was categorized as Caucasian, African-American, Hispanic, Asian, and other. We measured alcohol use in grams consumed per day (no alcohol, 0.1- < 5 grams/day, 5- <15 grams/day, and >15 grams/day). Metabolic equivalents of exercise per week were calculated from self-reported activity.³⁴ BMI (kg/m²) was calculated from height reported in 1989 and weight reported on each biennial questionnaire.

We included a childhood somatogram score, derived from nine female body figures. Participants chose the diagram that best depicted their body type at age 5 (scored from 1 (very thin) to 9 (extremely obese)).³⁵ Family history of hypertension in any first degree relative was assessed at baseline and was updated in 2003. Smoking, age, and oral contraceptive use were updated biennially. For a subset of 29 100 nurses (45%) whose mothers reported parental occupations at the time of the participant's birth, we were able to adjust for socioeconomic status.

68 505 women completed the violence questionnaire. We excluded 3772 women who were diagnosed with hypertension prior to 1989. Women were followed from 1989 until 2003, or until they developed hypertension, died, or were lost to follow-up.

We used missing indicators to model missing covariate status. Cox proportional hazards regression was used to estimate hazard ratios and 95% CI for the relationship between abuse and hypertension. Covariates were added to the models based on their established relationship with hypertension. We examined BMI as a continuous covariate as well as in categories (<18.5 kg/m², 18.5–24.9 kg/m², 25–29.9 kg/m², 30+ kg/m²). The effect of BMI on the association of abuse with hypertension was evaluated using BMI as a continuous variable. We estimated the proportion and 95% CI of the abuse association that was explained by adult BMI using the SAS mediation macro of Spiegelman and colleagues.³⁶

We examined the years 2001–2003 separately, following administration of the 2001 violence questionnaire. We re-ran all models excluding the 45 635 women who reported physical or sexual abuse exposure as adults.

RESULTS

Sixty-four percent of the participants (n = 41 792) reported any abuse prior to age 18. Thirty-three percent reported sexual abuse and 53% reported physical abuse. There were 4328 women (7%) who reported severe physical abuse by a parent, step-parent or guardian and 11% who reported forced sexual activity.

There was very little difference across cumulative levels of abuse with respect to age, race/ethnicity, parity, exercise, and family history of hypertension (Table 2). Women exposed to violence prior to age 18 were less likely to use oral contraceptives or drink alcohol compared to those with no abuse. Women reporting exposure to violence were more likely to smoke cigarettes, had slightly increased mean BMI at age 18, and larger increases in BMI at baseline (Table 2).

Between 1989 and 2003, 17.4% of the cohort reported incident hypertension. Sexual abuse had a dose-response relationship with risk of incident adult hypertension (age and race adjusted) ranging from a 5% (95% CI 0–9%) increased risk associated with forced sexual touching to 47% (95% CI 33–62%) with forced sexual activity as a child *and* adolescent (Table 3). Findings were similar for physical abuse, ranging from a 6% (95% CI 2–10%) increased risk among those reporting mild to moderate physical abuse, to a 27% increased risk (95% CI 17–38%) among women reporting severe physical abuse (Table 3).

Adjustments for smoking, alcohol use, family history of hypertension, somatogram score, exercise, and oral contraceptive use made no difference to the risk estimates associated with hypertension (Table 3). Further adjustment for parental occupation made no difference to these estimates (data not shown).

Inclusion of adult BMI in the models attenuated associations of child and adolescent abuse with risk of adult hypertension (Table 3); the results were similar whether BMI was

parameterized as continuous or categorical. After adjustment for BMI, only severe physical abuse and forced sexual activity remained associated with statistically significant increases in the risk of hypertension (ranging from 14% to 20%) compared to women with no history of abuse.

The findings for cumulative abuse were similar to those for physical and sexual abuse. Compared to women who reported no abuse, the risk of hypertension (age and race adjusted) rose in a dose-response fashion with cumulative abuse exposure, from 4% (95% CI 1–8%) among women reporting Level 2 abuse, to 59% (95% CI 42–78%) among women reporting Level 6 abuse (Table 3). BMI adjustment attenuated the estimates considerably, with increased risk of hypertension remaining significant for only Level 5 (16% (95% CI 5–28%)) and Level 6 (28% (95% CI 14–44%)) cumulative abuse.

Adult BMI accounted for 48% of the association of severe physical abuse with hypertension and for 60% of the association of severe sexual abuse with hypertension. The effects of BMI on cumulative abuse and risk of hypertension were similar, accounting for 59% (range 42–76%) of the association between cumulative abuse levels 3 through 6 and hypertension.

In the two years of follow-up after the administration of the 2001 abuse questionnaire there were 2283 incident reports of hypertension. We observed the same associations in this group of prospectively detected cases as we did in the cases reported between 1989 and 2001 (data not shown). Associations of abuse restricted to childhood and/or adolescence with risk of hypertension were similar to associations reported for the entire cohort (data not shown).

DISCUSSION

The results of our study suggest that women exposed to severe physical and/or sexual abuse prior to age 18 are more likely to develop hypertension than women with no abuse history or less severe forms of abuse exposure. Although adult adiposity mediated a large part of the association between early abuse and adult hypertension, there remained a 20% increased risk with the most severe abuse that was independent of BMI.

This study is by far the largest of its kind, including over 68 000 women from fourteen US states. Notably, the prevalence of physical and sexual abuse reported by this cohort is similar to the prevalence reported in national surveys.^{37,38}

Abuse exposure was recalled on a questionnaire administered in 2001, and hypertension was self-reported on questionnaires from 1991–2003. If administration of the violence questionnaire influenced patients' subsequent reporting of hypertension, we would likely have seen a difference in the relationship between abuse and hypertension in the subset of women diagnosed with hypertension after 2001. This was not the case, as the relationship between abuse and hypertension was similar in the women with hypertension occurring after the violence questionnaire was administered.

We did not have data on depression or antidepressant medications for the entire follow-up period. In women with a history of abuse, depression is more common than in women with no abuse history.³³ Certain antidepressants can cause hypertension. Given that depression itself has been shown to be associated with lower blood pressure,³⁹ it is unclear what impact, if any, the measurement of depression may have had on our analysis. This warrants consideration in future research.

Our results may not be generalizable to other groups, given our cohort of nurses had a higher than average level of education and was 95% Caucasian.

Women with hypertension prior to the start of the NHS II were excluded from this analysis. These women could have developed hypertension earlier as a result of their exposure to violence prior to age 18. While we are unable to address this issue, this suggests that the reported results may be a conservative estimate of the association between early abuse and adult hypertension.

We estimated the impact of the co-occurrence of physical and sexual abuse via the cumulative abuse variable. Children who experience one type of maltreatment are at increased risk of other types of violence, with reported co-existence of physical and sexual abuse ranging from 43% to 71%.^{27,40} Moreover, research suggests that experiencing multiple forms of abuse, compared to any one abuse subtype, may be more detrimental to health.⁴¹ This is corroborated in our analysis as there was no significant difference between cumulative abuse estimates and those analyzed separately for physical and sexual abuse, suggesting that abuse severity and frequency, and not subtype, may have the greatest impact on adult health.

Overweight and obesity are strong intermediate factors driving the association of child/adolescent abuse and risk of hypertension in our cohort. Data in Table 2 suggest that early abuse sets women on different weight trajectories in adulthood: while there was little difference in BMI at age 18 by abuse categories, there was a sizeable trend in increasing BMI with increasing abuse history by 1989, when the participants were age 25 to 44. In support of the proposition that abuse precedes weight gain, Noll and colleagues examined prospectively collected data on weight to report that the obesity rates of girls with and without sexual abuse histories were similar in childhood, began to diverge in adolescence, and were greater among young adults who had suffered sexual abuse as girls.⁴² Bentley et al reported that children with a history of physical abuse were more likely to have higher BMI as adults than those who experienced no physical abuse; this association remained despite adjustment for age, race, smoking, and alcohol use.²³ Thus, it seems plausible that child and adolescent abuse exposure increases the risk of overweight and obesity among young adult women, increasing their risk for hypertension.

After adjustment for BMI, an association of severe physical and/or sexual abuse with hypertension remained, suggesting that abuse prior to age 18 may affect the risk of adult hypertension through a mechanism independent of BMI. One possible mechanism for the development of hypertension in women with a history of abuse is fear-induced alterations to the developing hypothalamic-pituitary-adrenal (HPA) axis.⁴³ Serum cortisol levels in patients placed in stressful situations correlate with blood pressure, obesity, and other markers of cardiometabolic risk.⁴⁴ Several studies have reported altered cortisol or diurnal patterns among children exposed to violence.^{45,46,47,48} Others have reported increased cardiac output, stroke volume, and peripheral resistance among children exposed to community and/or interpersonal violence.⁴⁹ Importantly, altered HPA axis function has been shown to persist long after abuse has ceased.⁵⁰ In women with a history of child abuse, peak adrenocorticotropin levels and urinary cortisol levels are higher than levels in non-abused controls in response to stressful situations. These findings are consistent among populations suffering from mental illness or substance abuse.⁵¹

One in 4 women has experienced domestic violence at some point in her lifetime.³⁸ Our findings, that severe physical and sexual abuse prior to age 18 are associated with increased risk of hypertension in adulthood, independent of BMI, suggest that early interpersonal violence is a risk factor for the development of hypertension in women. Roughly half of the association between early abuse and hypertension was explained by greater adiposity among women who had been abused as girls. This suggests that the prompt detection of early abuse,

followed by psychological counseling, stress and weight management, may help to prevent adult hypertension.

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What is already known on the subject?

There have been a small number of studies in the past 10 years evaluating the possible role of violence exposure in the development of hypertension. These studies suggest that exposure to childhood and adolescent interpersonal violence may increase the risk for developing hypertension in adulthood.

The number of participants in these studies has been small and the population characteristics vary widely. In addition, the types of violence and methods of documenting the violence exposure have been inconsistent.

What does this study add to the current literature?

This study is by far the largest of its kind, including over 67 000 women from fourteen US states. Its measurement of physical and sexual abuse, as well as severity and frequency of abuse, offers a greater level of detail than any prior analyses.

This study emphasizes the role of BMI as a mediator in the relationship between abuse and risk of hypertension. Despite the mediating effect of BMI, a statistically significant increase in the risk of developing adult onset hypertension remains in women with the most severe physical and/or sexual abuse exposures prior to age 18.

Combined physical and sexual abuse in childhood and/or adolescence: distribution of women in Cumulative Abuse levels 1–6.

Table 1

		No abuse (N, %)	Sexual Abuse**		Forced sex as child <u>and</u> adolescent (N, %)
			Touched only (N, %)	Forced sex as child <u>or</u> adolescent (N, %)	
Physical Abuse*	No abuse	Level 1 (22 327, 35)	Level 2 (5796, 9)	Level 3 (1579, 2)	Level 4 (287, <1)
	Mild to Moderate	Level 2 (18 215, 28)	Level 3 (7080, 11)	Level 4 (2791, 4)	Level 5 (710, 1)
	Severe as child <u>or</u> adolescent	Level 3 (1154, 2)	Level 4 (649, 1)	Level 5 (492, 1)	Level 6 (154, <1)
	Severe as child <u>and</u> adolescent	Level 4 (1189, 2)	Level 5 (689, 1)	Level 6 (547, 1)	Level 6 (584, 1)

* Physical abuse severity: mild to moderate abuse (hit, pushed, grabbed, or shoved); severe abuse as child or adolescent (kicked, bitten, punched, choked, burned, or physically attacked as a child or adolescent); and severe abuse as child and adolescent (kicked, bitten, punched, choked, burned, or physically attacked as a child and as an adolescent).

** Sexual abuse severity: mild to moderate abuse (touched in a sexual way as child and/or adolescent), severe child or adolescent abuse (forced sexual activity as a child or adolescent), and severe child and adolescent abuse (forced sexual activity as a child and as an adolescent).

Table 2
Population characteristics at baseline (1989) by cumulative early life abuse scale, Nurses Health Study II

	Cumulative abuse scale					
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Baseline characteristics in 1989						
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Study population	22 327 (35)	24 011 (37)	9813 (15)	4916 (8)	1891 (3)	1285 (2)
	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)
Age	34.4 (4.8)	35.0 (4.7)	34.7 (4.6)	34.6 (4.6)	34.9 (4.6)	35.1 (4.4)
BMI[*] at age 18	21.0 (3.0)	21.1 (3.1)	21.3 (3.1)	21.2 (3.2)	21.4 (3.5)	21.7 (3.7)
Current BMI[*]	23.3 (4.3)	23.6 (4.5)	24.0 (4.6)	24.1 (4.9)	24.3 (5.0)	24.9 (5.4)
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Current smoker	2172 (10)	2845 (12)	1339 (14)	835 (17)	330 (18)	255 (20)
Alcohol use						
None	8311 (38)	8521 (36)	3506 (36)	1829 (37)	732 (39)	528 (41)
0.1–<5 grams/day	9580 (43)	10 280 (43)	4086 (42)	2023 (41)	755 (40)	507 (40)
5–<15 grams/day	3717 (17)	4281 (18)	1818 (19)	872 (18)	327 (17)	193 (15)
15 grams/day	523 (2)	760 (3)	322 (3)	156 (3)	59 (3)	43 (3)
Exercise once per week	18 731 (85)	20 203 (86)	8240 (85)	4080 (85)	1579 (85)	1073 (86)
Oral contraceptive use	3109 (14)	2985 (12)	1187 (13)	563 (12)	208 (12)	127 (11)
Family history of HTN^{**}	11 554 (52)	12 473 (52)	5151 (52)	2559 (52)	1001 (52)	691 (53)
Race/Ethnicity						
White	20 995 (96)	22 407 (95)	9009 (93)	4556 (94)	1740 (93)	1168 (92)
Black	148 (1)	260 (1)	166 (2)	59 (1)	31 (2)	17 (1)
Latina	165 (1)	308 (1)	192 (2)	76 (2)	40 (2)	31 (2)
Asian	291 (1)	356 (2)	157 (2)	69 (1)	27 (2)	26 (2)
Other	371 (2)	366 (2)	170 (2)	90 (2)	27 (1)	28 (2)
Parous	15 118 (68)	16 798 (70)	7018 (71)	3482 (71)	1368 (71)	928 (70)

* BMI: body mass index, measured in kg/m².

** HTN: hypertension. Family history of hypertension in any first degree relative.

Table 3

Sexual abuse, physical abuse, and cumulative physical and sexual abuse in childhood and/or adolescence and the multivariate hazard ratios (HR) and 95% confidence intervals (CI) for adult hypertension.

	Number of cases (person-years)	Age and race- adjusted model	Full model without BMI*	Full model with BMI**
		HR (95% CI)	HR (95% CI)	HR (95% CI)
Sexual Abuse				
No sexual abuse	7130 (544 875)	1.00 (referent)	1.00 (referent)	1.00 (referent)
Touched as a child <u>or</u> teen	2556 (179 304)	1.05 (1.00, 1.09)	1.03 (0.99, 1.08)	0.97 (0.93, 1.01)
Forced sex as child <u>or</u> teen	1041 (68 047)	1.15 (1.07, 1.22)	1.14 (1.06, 1.21)	1.02 (0.98, 1.09)
Forced sex as child <u>and</u> teen	421 (21 184)	1.47 (1.33, 1.62)	1.44 (1.31, 1.59)	1.20 (1.08, 1.32)
Physical Abuse				
No physical abuse	4948 (382 503)	1.00 (referent)	1.00 (referent)	1.00 (referent)
Mild to moderate abuse	5057 (365 642)	1.06 (1.02, 1.10)	1.07 (1.03, 1.11)	1.02 (0.98, 1.06)
Severe abuse as child <u>or</u> teen	541 (30 522)	1.34 (1.22, 1.46)	1.35 (1.24, 1.48)	1.22 (1.11, 1.33)
Severe abuse as child <u>and</u> teen	653 (37 602)	1.27 (1.17, 1.38)	1.30 (1.19, 1.41)	1.14 (1.05, 1.24)
Cumulative Abuse***				
Level 1	3595 (284 067)	1.00 (referent)	1.00 (referent)	1.00 (referent)
Level 2	4055 (304 470)	1.04 (0.99, 1.08)	1.04 (1.00, 1.09)	0.99 (0.94, 1.03)
Level 3	1829 (123 380)	1.12 (1.06, 1.19)	1.13 (1.06, 1.19)	1.02 (0.96, 1.08)
Level 4	901 (61 805)	1.13 (1.05, 1.21)	1.13 (1.05, 1.22)	0.99 (0.92, 1.07)
Level 5	418 (23 297)	1.35 (1.22, 1.50)	1.36 (1.23, 1.51)	1.16 (1.05, 1.28)
Level 6	337 (15 621)	1.59 (1.42, 1.78)	1.60 (1.43, 1.80)	1.28 (1.14, 1.44)

* Full model is adjusted for age in years, race (Caucasian, African-American, Hispanic, Asian, and other), smoking (current, past, and never), alcohol use (no alcohol, 0.1–< 5 gms/day, 5–<15 gms/day, and >15 gms/day), history of hypertension (in any first degree relative), exercise (in metabolic equivalents per week), oral contraceptive use (current, past, or never) and child somatogram score.

** Full model with body mass index (BMI) is adjusted for the variables above, as well as continuous BMI.

*** See table 1 for detailed explanation of cumulative abuse levels.