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Impact of Hypertension on Health Care Costs Among Children

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Abstract

Objectives—Despite the significant prevalence of elevated blood pressure (BP) and body mass index (BMI) in children, few studies have assessed their combined impact on health care costs. This study estimates health care costs related to BP and BMI in children and adolescents.

Study Design—Prospective dynamic cohort study of 71,617 children age 3 to 17 with 208,800 child years of enrollment in integrated health systems in Minnesota or Colorado between January 1, 2007 and December 31, 2011.

Methods—Generalized linear models were used to calculate standardized annual estimates of total, inpatient, outpatient, and pharmacy costs, outpatient utilization, and receipt of diagnostic and evaluation tests associated with BP status and BMI status.

Results—Total annual costs were significantly lower in children with normal BP ($736, SE=$15) and pre-hypertension ($945, SE=$10) than children with hypertension ($1972, SE=$74) (P<0.001, each comparison), adjusting for BMI. Total annual cost for children below the 85th percentile of BMI ($822, SE=$8) was significantly lower than for children between the 85th and 95th percentiles ($954, SE=$45) and for children at or above the 95th percentile ($937, SE=$13) (P<0.001, each), adjusting for HT.

Conclusions—This study shows strong associations of pre-hypertension and hypertension, independent of BMI, with health care costs in children. Although BMI status was also statistically significantly associated with costs, the major influence on cost in this large cohort of children and adolescents was BP status. Costs related to elevated BMI may be systematically overestimated in studies that do not adjust for BP status.

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INTRODUCTION

The potential long-term adverse outcomes associated with pre-hypertension (Pre-HT) and hypertension (HT) in children and adolescents are well recognized.[1–3] Blood pressure (BP) in youth correlates with BP in early adulthood and may be associated with elevated cardiovascular (CV) risk later in life.[4–9] Moreover, elevated BP is associated with elevated BMI in children and adolescents,[1–3,10–15] thus compounding potential CV risk.

Because of the acknowledged increased CV risk associated with childhood Pre-HT or HT, it seems reasonable to suggest that health care costs would also increase with Pre-HT or HT as the result of increased testing and evaluation, increased follow-up, or increased CV related comorbidities. However, information on the cost related to elevated BP in children is scarce.[16–19] Studies of obese children suggest modestly elevated costs of care, but none of these prior studies consider the fact that elevated BMI is significantly related to elevated BP.[20–24]

Studies assessing the relation between BMI and health care costs, but failing to account for BP levels or other clinical conditions associated with elevated BMI, may overestimate the independent impact of BMI.[25] In this project, we model the association of elevated BP and costs, while taking into account detailed data on BMI and other comorbid conditions (including depression and other mental health conditions). Using this broader approach permits a more accurate assessment of health care costs in children and adolescents with elevated BP than data currently available in the literature.

METHODS

Electronic health records were used to identify a dynamic, longitudinal cohort of children and adolescents who were enrolled in two large, integrated health maintenance organizations in Colorado and Minnesota. Children and adolescents age 3 to 17 years were included in the study if they were continuously enrolled in the health plans for one or more years from January 1, 2007 to December 31, 2010, had measured height, weight, and BP, and had comprehensive insurance coverage including coverage for pharmaceuticals. Only BP measurements obtained in primary care outpatient clinics were included in this study; BP measurements obtained in the emergency room or urgent care centers were excluded.

Both health plans used an EpiCare (Verona, WI) electronic health record. Demographics including age, gender, and race/ethnicity, were derived from administrative eligibility data. Body mass index (BMI) and presence of Pre-HT and HT were ascertained from electronic health record vital sign data. Age and gender-specific BMI percentile was calculated for each visit where both height and weight were measured, and children and adolescents were assigned their maximum BMI percentile during the study period. Age, gender, and height specific BP percentiles were calculated for both systolic BP and diastolic BP measures obtained in outpatient settings (including emergency departments and urgent care clinics) using published equations.[26]

Children with three or more BP measurements over the study period were included. Normal BP was defined as having all systolic BP and diastolic BP measurements < 90th percentile;

Pre-HT was defined as having one or more BP measurements ≥90th percentile or ≥120/80 mmHG; HT was defined as either three consecutive BP measurements ≥95th percentile or one or more BP measurements ≥99th percentile. Children were also identified as having HT if they received a diagnosis of essential hypertension by their health care provider during the study period (ICD9 codes 401XX). In order to focus this study on essential hypertension, children diagnosed with secondary hypertension (ICD9 codes 405XX) or other cardiovascular conditions were excluded. Normal BMI was defined as <85th percentile, overweight as ≥85th–95th percentile, and obesity as ≥95th percentile.

Electronic health records accurately measure utilization, but do not directly measure resource use or costs. Therefore, we applied standard pricing methodologies to estimate annual inpatient, outpatient, and pharmacy costs.[27,28] Inpatient admissions were priced using nationally representative 2010 payment rates based on Diagnostic Related Groups. Costs for outpatient services including physician, outpatient hospital, and clinic services, as well as costs for all other outpatient services such as nursing services and laboratory and radiology were priced using the nationally representative 2010 payment rates per relative value unit. Costs for pharmaceuticals, including prescriptions for antihypertensive and other medications, were priced at 68% of their average wholesale prices in 2010.[27]

We examined utilization of outpatient services to determine whether Pre-HT and HT might be driving utilization and costs through increased diagnostic testing and evaluation. We used procedure codes to estimate the annual number of preventive, office, or outpatient medical visits and the number of outpatient psychiatry and psychology visits. We also identified the likelihood of emergency department services or specialist consultations. In addition, we identified the likelihood of receiving diagnostic procedures including urinalysis, laboratory testing, chest x-ray, electrocardiogram, renal ultrasound and echocardiogram.

We measured medical comorbidities using the Chronic Illness and Disability Payment System (CDPS).[29] CDPS is a combined diagnostic and pharmacy based risk adjustment model that is commonly used to measure illness burden and to adjust capitated payments to health plans. The CDPS algorithm assigns international classification of disease version 9 (ICD-9) diagnosis codes to 58 diagnostic categories including selected mental health conditions, and national drug codes to 15 pharmaceutical categories, and applies severity weights developed from a national database of medical claims. The resulting CDPS score provides a measure of illness burden based on expected future health care expenditure conditional on each person's diagnostic and pharmaceutical profile.

Statistical Analysis

We analyzed inpatient, outpatient, pharmacy, and total costs using generalized linear models. Generalized linear models are commonly used to estimate health care costs when the dependent variable is non-negative and when its distribution is noticeably skewed and kurtotic (with a heavy right hand tail).[30] Inpatient and pharmacy costs were estimated using two-part models: logistic regression was used to estimate the probability of any use of a service, and a generalized linear model based on a gamma family with a log link function was used to estimate costs conditional on receiving at least one service. Total and outpatient costs were estimated using a single generalized linear model. The number of preventive, office, or outpatient visits and the number of outpatient psychiatry and psychology visits were estimated using negative binomial regression, and the probability of receipt of each of the remaining measures of outpatient utilization were estimating using logistic regression. We selected these specific distributions based on standard tests for assessing alternative generalized linear and transformed models.[31–33] We assessed goodness of fit using a modified Hosmer-Lemeshow test and a Pregibon's link test.[34,35]

The primary predictor variables of interest were indicator variables for BMI ≥85th–95th percentile, BMI>=95th percentile, Pre-HT, and HT. Analyses of BMI were adjusted for HT, and analyses of HT were adjusted for BMI. Additional control covariates included age (specified as a set of indicator variables with one for each year), gender, race/ethnicity, site, and year. We conducted analyses with and without controlling for comorbidity using the CDPS score. Controlling for comorbidity may reduce confounding of the cost estimates if increased illness burden is correlated with BP or BMI status. However, it may be inappropriate to adjust for comorbidity if an increased illness burden is the result of BP or BMI status. Therefore, we conduct two sets of analysis to provide a range of estimates and to demonstrate the sensitivity of the estimates to medical comorbidities.

We calculated cost estimates associated with BMI, Pre-HT, and HT that were adjusted for age, sex, race/ethnicity, CDPS score, and either BMI or BP status. For example, the standardized costs of children with pediatric HT was calculated as the mean predicted values across all children assuming they all had pediatric HT. Standard errors were calculated using the nonparametric bootstrap, and P-values were computed using the percentile method from the empirical distributions of the results from 1000 replicates.[36] All analyses were conducted in STATA, version 12.[37] This project was reviewed in advance, approved, and monitored by the HealthPartners Institute for Education and Research Institutional Review Board.

RESULTS

The study sample included 71,617 children age 3 to 17 followed for 35.0 (SD=13.7) months and providing 208,800 child years of data. Study sample characteristics are shown in Table 1. The mean age was 10.3 (SD=4.4) years, and 51% were female. The majority (57%) were non-Latino white, 14% were Latino, 10% were African American, and 4% were Asian. Native American, Hawaiian / Pacific Islander, or multiple races were 1% or less, and 14% were of unknown race/ethnicity. BMI percentile was normal in 64%, 18% were overweight, and 18% were obese. BP percentile was normal in 55%, 42% were pre-hypertensive, and 3% had hypertension. Among children identified with hypertension, 83% were identified using only BP measures. Among the 17% with an ICD9 code for essential hypertension, 35% had BP measurements consistent with the diagnosis, while 65% did not have three consecutive BP measurements ≥95th percentile, and 31% filled prescriptions for antihypertensive medications. Among the 83% identified by BP only, 2% filled prescriptions for antihypertensive medications.

Table 2 shows the mean standardized annual costs among children by BMI and BP status without controlling for additional co-morbidity. Estimates of costs related to BMI were adjusted for HT, and estimates of costs related to HT were adjusted for BMI. There were no statistically significant interactions between BP and BMI status. As noted in Table 2, costs for children with Pre-HT ($945, SE=$10) were significantly higher than for children with normal BP ($736, SE=$15), and annual costs for children with HT ($1972, SE=$74) were significantly greater than for children with Pre-HT or normal BP (P<.001 each). Among children with hypertension, there was no difference in total costs between children who received a diagnosis of hypertension compared to children who were identified only by BP measures in the EMR review (P=.814). The largest cost component for all three BP groups was outpatient care, followed by pharmacy and inpatient care.

There were smaller cost differentials related to BMI. Total annual cost for children below the 85th percentile of BMI ($822, SE=$8) was significantly lower than for children between the 85th and 95th percentiles ($954, SE=$454) and for children at or above the 95th percentile ($937, SE=$13;) (P<.001 each). Total annual cost for children between the 85th and 95th percentiles of BMI was not statistically significantly different from the total cost for children above the 95th percentile (P=.754).

Table 3 shows that the standardized cost differentials between categories narrowed when controlling for additional comorbidity using the CDPS score. The differential in total costs between HT and normotensive children declined by $383 (SE=$90) to $852 (SE=$53), and the cost differential between PreHT and normotensive children declined by $67 (SE=$18) to $141 (SE=$9) (P<.001 each) when adjusting for additional comorbidity using CDPS. The differentials in total cost for children above the 95th percentile of BMI and children between the 85th and 95th percentiles compared to children below the 85th percentile declined by $67 (SE=$19, P<.001) and $64 (SE=$48, P=.192), respectively, to $48 (SE=$11, P<.001) and $68 (SE=$15, P<.001) when adjusting for additional comorbidity using CDPS.

Table 4 shows estimates of outpatient utilization associated with Pre-HT and HT. There were statistically significant increases in all measures of utilization except for laboratory testing. Utilization was at least 50% higher in HT than normal BP children in all categories, except for laboratory testing (P<.001 each), with the large percentage increases observed for renal ultrasound, echocardiogram and chest x-ray. However, these procedures were performed at a relatively low rates, and all diagnostic and evaluation procedures with the exception of urinalysis were conducted in fewer than 10% of children with HT. We reviewed the types of specialist consultations, but could not identify any specific pattern to differentiate visits among the BP categories.

DISCUSSION

The present study shows the strong incremental effects of both Pre-HT and HT, independent of BMI and comorbidity, on health care costs in children. Although BMI status also was significantly associated with cost, the major influence on cost in this large cohort of children was BP status. It should be noted that the percent of children with Pre-HT was higher than previously reported.[38] Because the definition for Pre-HT requires only a single BP measurement, the requirement of three separate clinic BP measurements for inclusion in this study increased the number with Pre-HT.

An important factor in this analysis is that hypertension was identified primarily from review of electronic medical records, with only 17% recognized by the clinic physicians. The lack of recognition of HT by providers using computerized medical record systems has been reported previously,[39] as has the extent of the under-recognition.[40] However, there was no significant difference in cost associated with the electronic medical record method, as opposed to physician recognition and diagnosis. Thus, there may be something inherent in the presence of hypertension or prehypertension that leads to increased outpatient and emergency department visits, specialist consultations, increased diagnostic and evaluation procedures, and their associated costs; or medical issues resulting in more frequent clinic visits with greater number of BP measurements resulting in a larger number of diagnoses of Pre-HT or HT; this may account for the significantly greater use of cardiac studies and chest x-rays in the subjects with hypertension

Elevated BP in adults has been shown to be associated with substantial increased costs in three national data sets.[41–43] Studies of adults have further shown that both obesity and hypertension are independent determinants of costs.[44] In contrast, little attention has been devoted to the costs or to strategies to address elevated BP in children or adolescents. Given the strong relationship between elevated BP and health care costs, a case could be made to health plans and payers to consider implementing strategies to manage health care utilization of children with elevated BP. These strategies might include improved primary care, case management, health behavior interventions, family education, or other interventions.[45–47]

In contrast to prior studies, costs of health care services in this study were not significantly different between overweight (BMI >= 85th percentile and < 95th percentile) and obese (BMI >= 95th percentile) children controlling for BP status. Studies assessing health care utilization and cost related to overweight or obesity previously have not been able to adjust for BP status due to lack of BP data. By including both BMI and BP status in the analyses, this study has been able to extend previous findings by showing that the effect of BMI is lower than previously reported and is confounded by the associated impact of Pre-HT and HT.

These findings are relevant to ongoing clinical and public policy discussions. First, they suggest that greater attention should be paid to elevated BP in children and adolescents as a driver of health care costs. Second, elevated BP has a significant effect on cost independent from elevated BMI and other comorbid conditions. Third, studies that do not account for the impact of BP level on utilization may over estimate the effect of BMI on utilization and costs.

There are limitations that should be considered in the interpretation of these data. First, despite the large, racially and ethnically diverse study population, these results may not be generalizable to costs of care in non-insurance driven health care systems. However, at the present time it is challenging to conduct this type of study and capture detailed clinical and cost data outside the highly integrated health care systems included in this study. Second, it is possible that some allopathic care was obtained outside the insurance system, although prior studies suggest that this is well under 5% of total allopathic care. Third, although we adjusted for comorbidity using CDPS, there may be some residual differences in comorbidities by BP status. Finally, the results from this study do not imply causality between hypertension and the increased cost of patient care. However, the data clearly show an association between BP and health care costs in youth.

In summary, this study provides for the first time an estimate of the impact of BP and BMI status on health care utilization and cost in children and adolescents. Results suggest that costs attributable to overweight or obesity may be systematically overestimated in studies that do not adjust for BP status, and that BP status has a major independent association with utilization and costs of health care in youth. While we do not have the data to examine whether lowering BP in those with elevated BP would reduce their health care cost, it seems reasonable to suggest this may occur.

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REFERENCES

1. Daniels SR. Cardiovascular sequelae of childhood hypertension. Am J Hypertens. 2002 Feb; 15(2 Pt 2):61S–63S. [PubMed: 11866233]
2. Mitchell P, Cheung N, de Haseth K, et al. Blood pressure and retinal arteriolar narrowing in children. Hypertension. 2007 May; 49(5):1156–1162. [PubMed: 17372033]
3. Raitakari OT, Juonala M, Kahonen M, et al. Cardiovascular risk factors in childhood and carotid artery intima-media thickness in adulthood: the Cardiovascular Risk in Young Finns Study. JAMA. 2003 Nov 5; 290(17):2277–2283. [PubMed: 14600186]
4. Donahue RP, Prineas RJ, Gomez O, Hong CP. Tracking of elevated systolic blood pressure among lean and overweight adolescents: the Minneapolis Children's Blood Pressure Study. J Hypertens. 1994 Mar; 12(3):303–308. [PubMed: 8021484]
5. Klumbiene J, Sileikiene L, Milasauskiene Z, Zaborskis A, Shatchkute A. The relationship of childhood to adult blood pressure: longitudinal study of juvenile hypertension in Lithuania. J Hypertens. 2000 May; 18(5):531–538. [PubMed: 10826554]
6. Elkasabany AM, Urbina EM, Daniels SR, Berenson GS. Prediction of adult hypertension by K4 and K5 diastolic blood pressure in children: the Bogalusa Heart Study. J Pediatr. 1998 Apr; 132(4):687–692. [PubMed: 9580771]
7. Lauer RM, Burns TL, Clarke WR, Mahoney LT. Childhood predictors of future blood pressure. Hypertens. 1991; 18(3 Suppl):174–181.
8. Yong LC, Kuller LH. Tracking of Blood Pressure from Adolescence to Middle Age: The Dormont High School Study. Prev Med. 1994; 23(4):418. [PubMed: 7971868]
9. Sinaiko AR, Donahue RP, Jacobs DR Jr, Prineas RJ. Relation of weight and rate of increase in weight during childhood and adolescence to body size, blood pressure, fasting insulin, and lipids in young adults : The Minneapolis Children's Blood Pressure Study. Circulation. 1999 Mar 23; 99(11): 1471–1476. 1999. [PubMed: 10086972]
10. Chiolero A, Bovet P, Paradis G, Paccaud F. Has Blood Pressure Increased in Children in Response to the Obesity Epidemic? Pediatrics. 2007 Mar 1; 119(3):544–553. 2007. [PubMed: 17332208]
11. Muntner P, He J, Cutler JA, Wildman RP, Whelton PK. Trends in Blood Pressure Among Children and Adolescents. JAMA. 2004 May 5; 291(17):2107–2113. 2004. [PubMed: 15126439]
12. National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and A. The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents. Pediatrics. 2004; 114(2):555–576. [PubMed: 15286277]
13. McNiece KL, Poffenbarger TS, Turner JL, Franco KD, Sorof JM, Portman RJ. Prevalence of hypertension and pre-hypertension among adolescents. J Pediatr. 2007 Jun; 150(6):640–644. 644 e641. [PubMed: 17517252]

14. Fuentes RM, Notkola IL, Shemeikka S, Tuomilehto J, Nissinen A. Tracking of systolic blood pressure during childhood: a 15-year follow-up population-based family study in eastern Finland. J Hypertens. 2002 Feb; 20(2):195–202. [PubMed: 11821703]
15. Vos LE, Oren A, Uiterwaal C, Gorissen WH, Grobbee DE, Bots ML. Adolescent blood pressure and blood pressure tracking into young adulthood are related to subclinical atherosclerosis: the Atherosclerosis Risk in Young Adults (ARYA) study. Am J Hypertens. 2003 Jul; 16(7):549–555. [PubMed: 12850388]
16. Wang YC, Cheung AM, Bibbins-Domingo K, et al. Effectiveness and cost-effectiveness of blood pressure screening in adolescents in the United States. J Pediatr. 2011 Feb; 158(2):257–264. e251–e257. [PubMed: 20850759]
17. Tran CL, Ehrmann BJ, Messer KL, et al. Recent trends in healthcare utilization among children and adolescents with hypertension in the United States. Hypertension. 2012 Aug; 60(2):296–302. [PubMed: 22710648]
18. Samuels J. The increasing burden of pediatric hypertension. Hypertension. 2012 Aug; 60(2):276–277. [PubMed: 22710647]
19. Elliott DJ, Weintraub WS. Population-based health requires population-based change. J Pediatr. 2011 Feb; 158(2):181–184. [PubMed: 21035817]
20. Hampl SE, Carroll CA, Simon SD, Sharma V. Resource utilization and expenditures for overweight and obese children. Arch Pediatr Adolesc Med. 2007 Jan; 161(1):11–14. [PubMed: 17199061]
21. Finkelstein EA, Fiebelkorn IC, Wang G. State-level estimates of annual medical expenditures attributable to obesity. Obes Res. 2004 Jan; 12(1):18–24. [PubMed: 14742838]
22. Thorpe KE, Florence CS, Howard DH, Joski P. The impact of obesity on rising medical spending. Health Aff (Millwood). 2004 Jul-Dec;(Suppl):W4-480–W4-486. Web Exclusives.
23. Wang G, Dietz WH. Economic burden of obesity in youths aged 6 to 17 years: 1979–1999. Pediatrics. 2002 May.109(5) E81-81.
24. O'Brien SH, Holubkov R, Reis EC. Identification, evaluation, and management of obesity in an academic primary care center. Pediatrics. 2004 Aug; 114(2):e154–e159. [PubMed: 15286251]
25. Finkelstein EA, Fiebelkorn IC, Wang G. National medical spending attributable to overweight and obesity: how much, and who's paying? Health Aff (Millwood). 2003 Jan-Jun;(Suppl):W3-219–W3-226. Web Exclusives. [PubMed: 14527256]
26. NHBPEPWG. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. Pediatrics. 2004 Aug; 114 Suppl(2):555–576. 4th Report. [PubMed: 15286277]
27. Gilmer TP, O'Connor PJ, Rush WA, et al. Predictors of health care costs in adults with diabetes. Diabetes Care. 2005 Jan; 28(1):59–64. [PubMed: 15616234]
28. Gilmer TP, O'Connor PJ, Rush WA, et al. Impact of office systems and improvement strategies on costs of care for adults with diabetes. Diabetes Care. 2006 Jun; 29(6):1242–1248. [PubMed: 16732003]
29. Kronick R, Gilmer T, Dreyfus T, Lee L. Improving health-based payment for Medicaid beneficiaries: CDPS. Health Care Financ Rev. 2000 Spring;21(3):29–64. [PubMed: 11481767]
30. Manning WG, Newhouse JP, Duan N, Keeler EB, Leibowitz A, Marquis MS. Health insurance and the demand for medical care: evidence from a randomized experiment. Am Econ Rev. 1987; 77(3):251–277. 1987. [PubMed: 10284091]
31. Blough DK, Madden CW, Hornbrook MC. Modeling risk using generalized linear models. J Health Econ. 1999 Apr; 18(2):153–171. [PubMed: 10346351]
32. Manning WG, Mullahy J. Estimating log models: to transform or not to transform? J Health Econ. 2001 Jul; 20(4):461–494. [PubMed: 11469231]
33. Buntin MB, Zaslavsky AM. Too much ado about two-part models and transformation? Comparing methods of modeling Medicare expenditures. J Health Econ. 2004 May; 23(3):525–542. [PubMed: 15120469]
34. Hosmer, DW.; Lemeshow, S. Applied Logistic Regression. New York: John Wiley and Sons; 1989.

35. Pregibon D. Goodness of link tests for generalized linear models. Applied Statistics. 1980; 29:15–24.
36. Efron, B. An Introduction to the Bootstrap. New York: Chapman & Hall; 1993.
37. Stata Statistical Software: Release 12. College Station, TX: StataCorp LP; 2011. [computer program].
38. Lo JC, Sinaiko A, Chandra M, et al. Prehypertension and hypertension in community-based pediatric practice. Pediatrics. 2013 Feb; 131(2):e415–e424. [PubMed: 23359583]
39. Brady TM, Solomon BS, Neu AM, Siberry GK, Parekh RS. Patient-, provider-, and clinic-level predictors of unrecognized elevated blood pressure in children. Pediatrics. 2010 Jun; 125(6):e1286–e1293. [PubMed: 20439598]
40. Daley MF, Sinaiko AR, Reifler LM, et al. Patterns of care and persistence after incident elevated blood pressure. Pediatrics. 2013 Aug; 132(2):e349–e355. [PubMed: 23821694]
41. Hodgson TA, Cai L. Medical care expenditures for hypertension, its complications, and its comorbidities. Med Care. 2001 Jun; 39(6):599–615. [PubMed: 11404643]
42. Balu S, Thomas J 3rd. Incremental expenditure of treating hypertension in the United States. Am J Hypertens. 2006 Aug; 19(8):810–816. discussion 817. [PubMed: 16876679]
43. Trogdon JG, Finkelstein EA, Nwaise IA, Tangka FK, Orenstein D. The economic burden of chronic cardiovascular disease for major insurers. Health promotion practice. 2007 Jul; 8(3):234–242. [PubMed: 17606951]
44. Wang G, Zheng ZJ, Heath G, Macera C, Pratt M, Buchner D. Economic burden of cardiovascular disease associated with excess body weight in U.S. adults. Am J Prev Med. 2002 Jul; 23(1):1–6. [PubMed: 12093416]
45. Neter JE, Stam BE, Kok FJ, Grobbee DE, Geleijnse JM. Influence of weight reduction on blood pressure: a meta-analysis of randomized controlled trials. Hypertension. 2003 Nov; 42(5):878–884. [PubMed: 12975389]
46. Kelley GA, Kelley KS, Tran ZV. The effects of exercise on resting blood pressure in children and adolescents: a meta-analysis of randomized controlled trials. Prev Cardiol. 2003 Winter;6(1):8–16. [PubMed: 12624556]
47. He FJ, MacGregor GA. Importance of salt in determining blood pressure in children: meta-analysis of controlled trials. Hypertension. 2006 Nov; 48(5):861–869. [PubMed: 17000923]

Table 1

Study Sample Characteristics (N=71,617)

	Mean	SD
Age	10.3	4.4
	N	**%**
Gender		
Male	35,094	49
Female	36,523	51
Race/Ethnicity		
Non-Latino White	40,470	57
African American	6,853	10
Latino	9,868	14
Asian	2,983	4
Native American	722	1
Hawaiian / Pacific Islander	168	0
Multiple Races	344	0
Unknown	10,209	14
BMI		
BMI below 85 percentile	45,655	64
BMI >=85 percentile and <95 percentile	13,089	18
BMI at or above 95 percentile	12,873	18
Blood Pressure		
Normal blood pressure	39,229	55
Pre-Hypertension	30,101	42
Hypertension	2,287	3
Utilization / Enrollment	**Mean**	**SD**
Annual Office Visits	2.2	2.5
Months Enrollment	35.0	13.7

Note: Normal BP was defined as having all systolic BP and diastolic BP measurements < 90^{th} percentile; Pre-HT was defined as having one or more BP measurements ≥90^{th} percentile or ≥120/80 mmHG; HT was defined as either three consecutive BP measurements ≥95^{th} percentile, one or more BP measurements ≥99^{th} percentile, or receiving a diagnosis of essential hypertension during the study period.

Table 2

Standardized Mean Annual Estimates of Costs in 2010 Dollars for Elevated BMI and Pediatric Hypertension Groups, without Controlling for Comorbidity (N=208,800 child-years)

	Inpatient Mean (SE)	Outpatient Mean (SE)	Pharmacy Mean (SE)	Total Mean (SE)
BMI percentile				
BMI < 85	75 (3)	547 (4)	201 (5)	822 (8)
85<= BMI<95[a]	81 (65)	599 (8)	251 (26)	954 (45)
BMI >= 95[b]	88 (5)	609 (8)	249 (8)	937 (13)
Pediatric Hypertension				
Normal BP	58 (3)	477 (4)	197 (10)	736 (15)
Pre Hypertension[c]	89 (4)	616 (5)	240 (7)	945 (10)
Hypertension[c]	247 (27)	1366 (47)	326 (16)	1972 (74)

Notes:

a) P-values associated with tests of statistical significance for differences in costs relative to enrollees with BMI under the 85th percentile are .314 for inpatient and <.001 for outpatient, pharmacy and total costs.

b) P-values associated with tests of statistical significance for differences in costs relative to enrollees with BMI under the 85th percentile are .022 for inpatient and <.001 for outpatient, pharmacy, and total costs.

c) P-values associated with tests of statistical significance for differences in costs relative to enrollees with normal BP are <.001 for inpatient, outpatient, pharmacy, and total costs.

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Table 3

Standardized Annual Estimates of Costs in 2010 Dollars for Elevated BMI and Pediatric Pre-Hypertension and Hypertension, Controlling for Comorbidity (N=208,800 child-years)

	Inpatient Mean (SE)	Outpatient Mean (SE)	Pharmacy Mean (SE)	Total Mean (SE)
BMI percentile				
BMI < 85	79 (3)	558 (4)	211 (5)	847 (10)
85<= BMI<95[a]	78 (5)	591 (7)	234 (11)	918 (20)
BMI >= 95[b]	79 (4)	579 (7)	235 (6)	897 (12)
Pediatric Hypertension				
Normal BP	64 (3)	498 (4)	208 (7)	772 (12)
Pre Hypertension[c]	82 (3)	594 (5)	231 (5)	913 (10)
Hypertension[c]	171 (17)	1158 (42)	262 (9)	1624 (54)

Notes:

a) P-values associated with tests of statistical significance for differences in costs relative to enrollees with BMI under the 85th percentile are .962 for inpatient and <.001 for outpatient, pharmacy, and total costs.

b) P-values associated with tests of statistical significance for differences in costs relative to enrollees with BMI under the 85th percentile are .870 for inpatient, .006 for outpatient and <.001 for pharmacy and total costs.

c) P-values associated with tests of statistical significance for differences in costs relative to enrollees with normal BP are <.001 for inpatient, outpatient, pharmacy, and total costs.

Table 4

Standardized Annual Utilization of Outpatient Services Associated with Pediatric Pre-Hypertension and Hypertension, without Controlling for Comorbidity (N=208,800 child-years)

	Normal BP Mean (SE)	Pre-HT Mean (SE)	Hypertension Mean (SE)	P-Value
Number of Annual Outpatient Visits				
Preventive or Office / Outpatient Visit	2.0 (.01)	2.5 (.01)	3.1 (.06)	<.001
Outpatient Psychiatry and Psychology	.4 (.01)	.5 (.01)	.6 (.07)	<.001
Annual Percent with Service Use				
Emergency Department	11.7% (.1%)	14.5% (.1%)	21.6% (.6%)	<.001
Specialist Consultation	6.5% (.1%)	8.4% (.1%)	10.9% (.4%)	<.001
Annual Percent with Diagnostic Testing				
Urinalysis	12.1% (.1%)	13.8% (.1%)	18.9% (.6%)	<.001
Laboratory Blood Testing	7.3% (.1%)	7.1% (.1%)	7.8% (.4%)	.895
Chest X-Ray	5.2% (.1%)	6.5% (.1%)	8.9% (.4%)	<.001
Electrocardiogram	1.9% (.1%)	2.3% (.1%)	4.0% (.3%)	<.001
Renal Ultrasound	1.0% (.1%)	1.3% (.1%)	2.6% (.2%)	<.001
Echocardiogram	.2% (.1%)	.3% (.1)	.8% (.1%)	.006

Note: The P-value tests the hypothesis that normal BP < PreHT < HT.