Impact of Hypertension on Healthcare Costs Among Children

Todd P. Gilmer, PhD; Patrick J. O'Connor, MD, MPH; Alan R. Sinaiko, MD; Elyse O. Kharbanda, MD, MPH; David J. Magid, MD, MPH; Nancy E. Sherwood, PhD; Kenneth F. Adams, PhD; Emily D. Parker, MD, PhD; and Karen L. Margolis, MD, MPH

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 healthcare costs. This study estimates healthcare costs related to BP and BMI in children and adolescents.

Study Design

Prospective dynamic cohort study of 71,617 children aged 3 to 17 years with 208,800 child years of enrollment in integrated health systems in Colorado or Minnesota 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 prehypertension ($945, SE = $10) than children with hypertension ($1972, SE = $74) ($P$ <.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$ <.001, each), adjusting for HT.

Conclusions

This study shows strong associations of prehypertension and hypertension, independent of BMI, with healthcare 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.

Am J Manag Care. 2014;20(8):622-628

The potential long-term adverse outcomes associated with prehypertension (preHT) 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 body mass index (BMI) in children and adolescents,[1-3,10-15] thus compounding potential CV risk.

Because of the acknowledged increased CV risk associated with childhood preHT or HT, it seems reasonable to suggest that healthcare costs would also increase with preHT 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 healthcare 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 healthcare costs in children and adolescents with elevated BP than data currently available in the literature.

METHODS

Electronic health records (EHRs) were used to identify a dynamic, longitudinal cohort of children and adolescents who were enrolled in 2 large integrated health maintenance organizations in Colorado and Minnesota. Children and adolescents aged 3 to 17 years were included in the study

if they were continuously enrolled in the health plans for 1 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 department (ED) or urgent care centers were excluded.

Take-Away Points

Prehypertension and hypertension have strong effects on healthcare costs in children, independent of body mass index (BMI).

- This study examines the combined impact of blood pressure (BP) and BMI on healthcare costs.
- Although BMI status was 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.

Both health plans used an EpiCare (Verona, Wisconsin) EHR. Demographics, including age, gender, and race/ethnicity, were derived from administrative eligibility data. BMI and presence of preHT and HT were ascertained from EHR vital signs data. Age and gender-specific BMI percentiles were calculated for each visit in which 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.[12]

Children who had 3 or more BP measurements taken during the study period were included. Normal BP was defined as having all systolic BP and diastolic BP measurements < 90th percentile; preHT was defined as having 1 or more BP measurements ≥90th percentile or ≥120/80 mm Hg; HT was defined as either 3 consecutive BP measurements ≥95th percentile or 1 or more BP measurements ≥99th percentile. Children were also identified as having HT if they received a diagnosis of essential hypertension from their healthcare provider during the study period (*International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9-CM*] codes 401.xx). To focus this study on essential hypertension, children diagnosed with secondary hypertension (*ICD-9-CM* codes 405.xx) or other cardiovascular conditions were excluded. Normal BMI was defined as <85th percentile, overweight as ≥85th to <95th percentile, and obesity as ≥95th percentile.

EHRs 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.[26,27] 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; costs for all other outpatient services such as nursing services, 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.[26]

We examined utilization of outpatient services to determine whether preHT 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 ED 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).[28] CDPS is a combined diagnostic and pharmacy-based risk adjustment model commonly used to measure illness burden and to adjust capitated payments to health plans. The CDPS algorithm assigns *ICD-9-CM* 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 healthcare 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 healthcare costs when the dependent variable is non-negative and when its distribution is noticeably skewed and kurtotic (with a heavy right-hand tail).[29] Inpatient and pharmacy costs were estimated using 2-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 1 service. Total and outpatient

Table 1. Study Sample Characteristics (N = 71,617)

	Mean	SD
Age (years)	10.3	4.4
	N	**%**
Gender		
Male	35,094	49
Female	36,523	51
Race/ethnicity		
Non-Latino white	40,470	57
Latino	9868	14
African American	6853	10
Asian	2983	4
Native American	722	1
Hawaiian / Pacific Islander	168	0
Multiple races	344	0
Unknown	10,209	14
BMI		
BMI below 85th percentile	45,655	64
BMI ≥85th percentile and <95th percentile (overweight)	13,089	18
BMI at or above 95th percentile (obese)	12,873	18
Blood pressure		
Normal blood pressure	39,229	55
Prehypertension	30,101	42
Hypertension	2287	3
Utilization/enrollment	**Mean**	**SD**
Annual office visits	2.2	2.5
Months enrollment	35.0	13.7

BMI indicates body mass index.
Normal blood pressure (BP) was defined as having all systolic BP and diastolic BP measurements <90th percentile; prehypertension was defined as having 1 or more BP measurements ≥90th percentile or ≥120/80 mm Hg; hypertension was defined as either 3 consecutive BP measurements ≥95th percentile, 1 or more BP measurements ≥99th percentile, or receiving a diagnosis of essential hypertension during the study period.

costs was 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.[30-32] We assessed goodness of fit using a modified Hosmer-Lemeshow test and a Pregibon's link test.[33,34]

The primary predictor variables of interest were indicator variables for BMI ≥85th to <95th percentile, BMI ≥ 95th percentile, preHT, 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 1 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 conducted 2 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, preHT, 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 were calculated as the mean predicted values across all children assuming they all had pediatric HT. Standard errors were calculated using the nonparametric bootstrap,

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				
<85th	75 (3)	547 (4)	201 (5)	822 (8)
85th ≤BMI <95th[a]	81 (65)	599 (8)	251 (26)	954 (45)
≥ 95th[b]	88 (5)	609 (8)	249 (8)	937 (13)
Pediatric hypertension				
Normal BP	58 (3)	477 (4)	197 (10)	736 (15)
Prehypertension[c]	89 (4)	616 (5)	240 (7)	945 (10)
Hypertension[c]	247 (27)	1366 (47)	326 (16)	1972 (74)

BMI indicates body mass index; BP, blood pressure.
[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.

and *P* values were computed using the percentile method from the empirical distributions of the results from 1000 replicates.[35] All analyses were conducted in STATA, version 12.[36] 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 aged 3 to 17 years followed for 35.0 (SD = 13.7) months and provided 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 prehypertensive, and 3% had hypertension. Among children identified with hypertension, 83% were identified using only BP measures. Among the 17% with an *ICD-9-CM* code for essential hypertension, 35% had BP measurements consistent with the diagnosis, while 65% did not have 3 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 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 preHT ($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 preHT 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 with children who were identified only by BP measures in the EMR review (*P* = .814). The largest cost component for all 3 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

Table 3. Standardized Annual Estimates of Costs in 2010 Dollars for Elevated BMI and Pediatric Prehypertension 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 <85th	79 (3)	558 (4)	211 (5)	847 (10)
85th ≤BMI <95th[a]	78 (5)	591 (7)	234 (11)	918 (20)
BMI ≥95th[b]	79 (4)	579 (7)	235 (6)	897 (12)
Pediatric hypertension				
Normal BP	64 (3)	498 (4)	208 (7)	772 (12)
Prehypertension[c]	82 (3)	594 (5)	231 (5)	913 (10)
Hypertension[c]	171 (17)	1158 (42)	262 (9)	1624 (54)

BMI indicates body mass index; BP, blood pressure.
[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.

and children between the 85th and 95th percentiles compared with 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 preHT 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 rate, 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 preHT and HT, independent of BMI and comorbidity, on healthcare 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 preHT was higher than previously reported.[37] Because the definition for preHT requires only a single BP measurement, the requirement of 3 separate clinic BP measurements for inclusion in this study increased the number with preHT.

An important factor in this analysis is that hypertension was identified primarily from review of EHRs, 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,[38] as has the extent of the underrecognition.[39] However, there was no significant difference in cost associated with the EHR 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 ED visits, specialist consultations, increased diagnostic and evaluation procedures, and their associated costs; or medical issues resulting in more frequent clinic visits with a greater number of BP measurements resulting in a larger number of diagnoses of preHT 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 3 national data sets.[40-42] Studies of adults have further shown that both obesity and hypertension are independent determinants of costs.[43] 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 healthcare costs, a case could be made to health plans and payers to consider implementing strategies to manage healthcare utilization of children with elevated BP. These strategies might include improved primary care, case management, health behavior interventions, family education, or other interventions.[44-46]

In contrast to prior studies, costs of healthcare services in this study were not significantly different between over-

■ **Table 4.** Standardized Annual Utilization of Outpatient Services Associated With Pediatric Prehypertension and Hypertension, Without Controlling for Comorbidity (N = 208,800 child-years)

	Normal BP Mean (SE)	PreHT Mean (SE)	Hypertension Mean (SE)	*P*
Number of annual outpatient visits				
Preventive or office / outpatient visit	2.0 (0.01)	2.5 (0.01)	3.1 (0.06)	<.001
Outpatient psychiatry and psychology	.4 (0.01)	.5 (0.01)	.6 (0.07)	<.001
Annual percent with service use				
Emergency department	11.7% (0.1%)	14.5% (0.1%)	21.6% (0.6%)	<.001
Specialist consultation	6.5% (0.1%)	8.4% (0.1%)	10.9% (0.4%)	<.001
Annual percent with diagnostic testing				
Urinalysis	12.1% (0.1%)	13.8% (0.1%)	18.9% (0.6%)	<.001
Laboratory blood testing	7.3% (0.1%)	7.1% (0.1%)	7.8% (0.4%)	.895
Chest x-ray	5.2% (0.1%)	6.5% (0.1%)	8.9% (0.4%)	<.001
Electrocardiogram	1.9% (0.1%)	2.3% (0.1%)	4.0% (0.3%)	<.001
Renal ultrasound	1.0% (0.1%)	1.3% (0.1%)	2.6% (0.2%)	<.001
Echocardiogram	.2% (0.1%)	.3% (0.1)	.8% (0.1%)	.006

The *P* value tests the hypothesis that normal BP <PreHT <HT.

weight (BMI ≥85th percentile to < 95th percentile) and obese (BMI ≥95th percentile) children controlling for BP status. Studies assessing healthcare 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 preHT 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 healthcare 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 overestimate 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 healthcare systems. However, it is currently challenging to conduct this type of study and capture detailed clinical and cost data outside the highly integrated healthcare 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 total 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 healthcare costs in youth.

In summary, this study provides for the first time an estimate of the impact of BP and BMI status on healthcare 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 healthcare in youth. While we do not have the data to examine whether lowering BP in those with elevated BP would reduce their healthcare cost, it seems reasonable to suggest this may occur.

Author Affiliations: Department of Family and Preventive Medicine, University of California, San Diego (TPG); HealthPartners Institute for Education and Research, Minneapolis, MN (PJO, EOK, NES, KFA, KLM); Department of Pediatrics, University of Minnesota, Minneapolis (ARS); Institute for Health Research, Kaiser Permanente Colorado, Denver (DJM).

Funding Source: Funding was provided by the National Institutes of Health grant R01HL093345 from the National Heart, Lung, and Blood Institute.

Author Disclosures: The authors report no relationship or financial interest with any entity that would pose a conflict of interest with the subject matter of this article.

Authorship Information: Concept and design (TPG, PJO, ARS, EOK, KLM); acquisition of data (PJO, KLM); analysis and interpretation of data (TPG, PJO, ARS, EOK, DJM, NES, KFA, EDP, KLM); drafting of the manuscript (TPG, PJO, ARS); critical revision of the manuscript for important intellectual content (TPG, PJO, ARS, EOK, DJM, NES, KFA, EDP, KLM); statistical analysis (TPG); provision of study materials or patients (PJO); obtaining funding (PJO, ARS, NES); administrative, technical, or logistic support (TPG); supervision (TPG, POC).

Address correspondence to: Todd Gilmer, PhD, Department of Family and Preventive Medicine, University of California, San Diego, 9500 Gilman Dr, La Jolla, CA 92092-0622. E-mail: tgilmer@ucsd.edu.

REFERENCES

1. Daniels SR. Cardiovascular sequelae of childhood hypertension. *Am J Hypertens.* 2002;15(2, pt 2):61S-63S.
2. Mitchell P, Cheung N, de Haseth K, et al. Blood pressure and retinal arteriolar narrowing in children. *Hypertension.* 2007;49(5):1156-1162.
3. Raitakari OT, Juonala M, Kähönen 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;290(17): 2277-2283.
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;12(3): 303-308.
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;18(5): 531-538.
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;132(4):687-692.
7. Lauer RM, Burns TL, Clarke WR, Mahoney LT. Childhood predictors of future blood pressure. *Hypertension.* 1991;18(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): 418-426.
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;99(11):1471-1476.
10. Chiolero A, Bovet P, Paradis G, Paccaud F. Has blood pressure increased in children in response to the obesity epidemic? *Pediatrics.* 2007;119(3):544-553.
11. Muntner P, He J, Cutler JA, Wildman RP, Whelton PK. Trends in blood pressure among children and adolescents. *JAMA.* 2004;291(17): 2107-2113.
12. National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics.* 2004;114(suppl 4th Report): 555-576.
13. McNiece KL, Poffenbarger TS, Turner JL, Franco KD, Sorof JM, Portman RJ. Prevalence of hypertension and pre-hypertension among adolescents. *J Pediatr.* 2007;150(6):640-644, 644.e1.
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; 20(2):195-202.
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;16(7): 549-555.
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;158(2):257-264.
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;60(2):296-302.
18. Samuels J. The increasing burden of pediatric hypertension. *Hypertension.* 2012;60(2):276-277.
19. Elliott DJ, Weintraub WS. Population-based health requires population-based change. *J Pediatr.* 2011;158(2):181-184.
20. Hampl SE, Carroll CA, Simon SD, Sharma V. Resource utilization and expenditures for overweight and obese children. *Arch Pediatr Adolesc Med.*2007;161(1):11-14.
21. Finkelstein EA, Fiebelkorn IC, Wang G. State-level estimates of annual medical expenditures attributable to obesity. *Obes Res.* 2004;12(1): 18-24.
22. Thorpe KE, Florence CS, Howard DH, Joski P. The impact of obesity on rising medical spending. *Health Aff (Millwood).* 2004;Suppl Web Exclusives:W4-480-486.
23. Wang G, Dietz WH. Economic burden of obesity in youths aged 6 to 17 years: 1979-1999. *Pediatrics.* 2002;109(5):E81.
24. O'Brien SH, Holubkov R, Reis EC. Identification, evaluation, and management of obesity in an academic primary care center. *Pediatrics.* 2004;114(2):e154-e159.
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;Suppl Web Exclusives:W3-219-226.
26. Gilmer TP, O'Connor PJ, Rush WA, et al. Predictors of health care costs in adults with diabetes. *Diabetes Care.* 2005;28(1):59-64.
27. 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;29(6):1242-1248.
28. Kronick R, Gilmer T, Dreyfus T, Lee L. Improving health-based payment for Medicaid beneficiaries: CDPS. *Health Care Financ Rev.* 2000; 21(3):29-64.
29. 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.
30. Blough DK, Madden CW, Hornbrook MC. Modeling risk using generalized linear models. *J Health Econ.*1999;18(2):153-171.
31. Manning WG, Mullahy J. Estimating log models: to transform or not to transform? *J Health Econ.* 2001;20(4):461-494.
32. Buntin MB, Zaslavsky AM. Too much ado about two-part models and transformation? comparing methods of modeling Medicare expenditures. *J Health Econ.* 2004;23(3):525-542.
33. Hosmer DW, Lemeshow S. *Applied Logistic Regression*. New York: John Wiley and Sons; 1989.
34. Pregibon D. Goodness of link tests for generalized linear models. *Applied Statistics.* 1980; 29:15-24.
35. Efron B, Tibshirani RJ. *An Introduction to the Bootstrap*. New York, NY: Chapman & Hall; 1993.
36. *Stata Statistical Software* [computer program]. Version 12. College Station, TX: StataCorp LP; 2011.
37. Lo JC, Sinaiko A, Chandra M, et al. Prehypertension and hypertension in community-based pediatric practice. *Pediatrics.* 2013;131(2): e415-e424.
38. 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;125(6):e1286-e1293.
39. Daley MF, Sinaiko AR, Reifler LM, et al. Patterns of care and persistence after incident elevated blood pressure. *Pediatrics.* 2013;132(2): e349-e355.
40. Hodgson TA, Cai L. Medical care expenditures for hypertension, its complications, and its comorbidities. *Med Care.* 2001;39(6):599-615.
41. Balu S, Thomas J III. Incremental expenditure of treating hypertension in the United States. *Am J Hypertens.* 2006;19(8):810-816; discussion 817.
42. Trogdon JG, Finkelstein EA, Nwaise IA, Tangka FK, Orenstein D. The economic burden of chronic cardiovascular disease for major insurers. *Health Prom Pract.* 2007;8(3):234-242.
43. 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;23(1):1-6.
44. 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;42(5):878-884.
45. 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;6(1):8-16.
46. He FJ, MacGregor GA. Importance of salt in determining blood pressure in children: meta-analysis of controlled trials. *Hypertension.* 2006;48(5):861-869. ■