Economics

Incremental Expenditure of Treating Hypertension in the United States

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Background: This study determined incremental direct expenditures of treating hypertension in the United States population.

Methods: Analysis of the 2001 Medical Expenditure Panel Survey (MEPS), a national probability sample survey of the civilian noninstitutionalized U.S. population, was conducted. Hypertensive patients were identified as those with a medical diagnosis for hypertension based on International Classification of Diseases (ICD)–9 codes; patients who were consumers of hypertension-related medical care services including inpatient and outpatient visits, emergency room visits, home health visits, office-based medical provider visits, and other medical expenses; patients who self-reported being diagnosed with hypertension by their physicians; and patients who were prescribed antihypertensive medication. Incremental expenditure of treating hypertension was estimated through least-squares regression adjusting for age, sex, ethnicity, education, and comorbidities using the D'Hoore et al version of the Charlson comorbidity index. Sample data were projected to the U.S. population and 95% confidence limits for estimates were calculated using the Taylor expansion method.

Results: Sample estimates projected to the population indicated that approximately 17.4% of individuals ≥18 years of age in the ambulatory population have hypertension. Total incremental annual direct expenditures for hypertension patients were estimated to be more than $US 54.0 billion in 2001 after adjusting for demographics and comorbidities. Mean incremental annual direct expenditures for an individual with hypertension was $US 1,131. Prescription medicines, inpatient visits, and outpatient visits constituted >90% of overall incremental expenditures.

Conclusions: With incremental direct medical expenditures estimated at nearly $US 55.0 billion, hypertension expenditures represent a significant amount of health care resource use. Am J Hypertens 2006;19:810–816 © 2006 American Journal of Hypertension, Ltd.

Key Words: Hypertension, cost-of-treatment, direct cost.

Hypertension being the most commonly diagnosed disease in the United States,[1] is an important health problem, as the relationship between high blood pressure and risk of cardiovascular, cerebrovascular, and peripheral vascular diseases is well established.[2–4] As a modifiable risk factor, treatment of hypertension through lifestyle changes and medication is a vital approach to preventing these diseases and has immense public health implications. Despite its benefits, treatment of hypertension is costly, and estimating the cost of hypertension treatment is of significant importance to determine the monetary impact of disease treatment on the society.

The total health care costs of treating hypertension and its complications are estimated to be quite significant, ranging from approximately $US 15.0 billion to approximately $60.0 billion.[5–10] A study estimating the expenditures attributed to treating hypertension-related complications found that cardiovascular complications accounted for approximately $US 30.0 billion and other comorbidities contributed approximately $US 57.0 billion.[7] These reported expenditures reflect the magnitude of the illness and its epidemiologic, public health, and economic impact on society, thus showing the importance of rational use of resources in health care. These estimates were obtained by analyses using the primary diagnosis approach,[11–13] which included expenditures when hypertension was the primary reported diagnosis or reason for a health care encounter, disability, or cause of death, or considered treatment expenditures related to hypertension using the attributable risk approach,[14,15] popular approaches used in cost of treatment studies but having the potential for not estimating the precise spending related to hypertension. Having knowledge of precise disease treatment estimates helps in allocating scarce resources efficiently, thereby maximizing the potential for improved clinical and economic outcomes by improving cost savings while maintaining or improving health quality.

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Incremental cost approach, used since the mid-1990s,[16–22] estimates the incremental or excess expenditures of treating a particular disease by comparing the expenditures associated in treating patients diagnosed with the study disease with a group of patients not diagnosed with the study disease. Incremental expenditure approach measures expenditures solely attributable to that particular disease, as it adjusts for differences in variables deemed to have a bearing on the overall expenditure estimate.[11,16]

Evaluation of the precise hypertension treatment expenditures can provide important information to guide policies that simultaneously encourage cost-effectiveness and improved treatment while maintaining equity. Given the clinical importance of hypertension, suboptimal state of treatment, and magnitude of associated health care costs, estimating incremental expenditure of treating hypertension using the incremental expenditure approach by comparing hypertensive patients with nonhypertensive patients is useful to understand effectively both the clinical impact and more precisely the economic impact of hypertension treatment.

The specific objectives of this study were 1) toestimate the prevalence of hypertension in the United States in 2001; 2) to estimate consumption of medical resources by hypertensive individuals in the United States in 2001; and 3) to estimate incremental direct expenditure of treating hypertension in 2001.

Methods

The 2001 Medical Expenditure Panel Survey (MEPS), based on a nationally representative sample of the ambulatory population in the United States, was the source of data used in all analyses. The 2001 portion was the latest version that had full and updated information at the time of the study. The dataset contained variables and frequency distributions associated with 33,556 individuals and provided data that can be used to obtain estimates regarding health care use, expenditures, payment sources, and insurance coverage for the civilian, noninstitutionalized population in the United States.[23] The survey comprised of three component surveys: the Household Component (HC), the Medical Provider Component (MPC) linked to the household survey, and the Insurance Component (IC) that includes a subset that links to the household survey. The MPC was used to obtain information on medical care events from medical providers provided by respondents in the HC, whereas IC provided information on the type of insurance provided to respondents through their insurance firms and employers. These data were used to validate and supplement the data provided by respondents in the Household Component. Ten data files from the MEPS–2001 including the job file, full year consolidated data file, medical conditions file, and the seven medical event files including prescribed medicines, inpatient visits, outpatient visits, office-based medical provider visits, home health visits, emergency room visits, and other medical expenses were used in the analysis.

Expenditures can be analyzed in terms of sum of charges, sum of payments, or sources of payments. The 2001 MEPS defined expenditures as sum of direct payments for care provided during the year and charges for care provided. Although sum of direct payments may help to provide an accurate measure of reimbursement received by providers, sum of charges may provide a more accurate measure of total resources consumed. However, as charges include uncollected liability, bad debt, charitable care, and discounting, sum of payments was included for expenditure analyses. Total direct expenditure was calculated as sum of expenditures for each of the seven medical event files for treating hypertension.

Identification of Hypertension Patients

Respondents ≥18 years of age with ICD-9 codes 401.xx to 405.xx in the medical conditions file or in any of the seven medical events files were included as hypertensive patients. ICD-9 codes in the MEPS are collapsed into three digit codes to protect patient confidentiality. The ICD-9 codes 401.xx to 405.xx include essential hypertension, hypertensive heart disease, hypertensive renal disease, hypertensive heart and renal disease, and secondary hypertension. Respondents self-reporting hypertension in the full-year consolidated file and respondents receiving antihypertensive medication were also included. These were the patients who were likely to have high blood pressure but were not coded for hypertension. Antihypertensive medications listed in the seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7) were considered for the study. These included thiazide diuretics, β-blockers, calcium channel blockers, angiotensin converting enzyme (ACE) inhibitors, α-blockers, aldosterone antagonists, and angiotensin receptor blockers. Respondents who were prescribed a combination drug comprising of a thiazide diuretic with another antihypertensive were classified as respondents who were prescribed a thiazide diuretic. Because antihypertensive medications can be prescribed for medical conditions other than hypertension,[3] exclusion criteria included respondents who were prescribed an antihypertensive medication for a medical condition other than hypertension. For example, respondents who were prescribed an ACE inhibitor for congestive heart failure (428.xx) or myocardial infarction (410.xx, 412.xx) were not considered to be hypertensive. Respondents who were prescribed an antihypertensive medication and did not show a code for either hypertension or other medical conditions for which such medications are prescribed were considered to be hypertensive.

Statistical Methods

Least-squares regression was used to estimate the incremental expenditure of hypertension. Dependent variable in

Table 1. Seventeen comorbidities listed in D'Hoore comorbidity version[27]

Comorbidity	Relative weight
Myocardial infarction	1
Congestive heart failure	1
Peripheral vascular disease	1
Dementia	1
Cerebrovascular disease	1
Chronic pulmonary disease	1
Connective tissue disease	1
Ulcer disease	1
Mild liver disease	1
Diabetes	1
Hemiplegia	2
Moderate or severe renal disease	2
Any tumor	2
Leukemia	2
Lymphoma	2
Moderate or severe liver disease	3
Metastatic solid tumor	6

the regression model was total direct expenditure while the main independent variable was hypertension. Other covariates were demographics including age, sex, ethnicity, and education along with and the Charlson Comorbidity Index adaptation by D'Hoore et al.[24] As the MEPS database reported medical diagnoses based on three-digit ICD-9 codes, the D'Hoore et al version, which uses three-digit ICD-9 codes for disease identification in the comorbidity index, was considered. Table 1 lists the 17 comorbidities listed in this adaptation. For estimating individual incremental expenditure centers, the dependent variable in each of the individual regression models was total direct expenditure of that particular medical event, whereas the independent variables were hypertension, age, sex, ethnicity, education, and Charlson Comorbidity Index. Incremental expenditures were calculated from the respective regression coefficients. Normal probability plot and Modified Levene test were used to assess normality and heteroscedasticity of the data. Tests for linearity confirmed the linear relationship between total direct expenditures and the independent variables including age and Charlson Comorbidity Index score. Because expenditure data were found to be skewed to the right, a logarithmic transformation of total direct expenditure was used as the dependent variable. For statistical analyses the SAS version 8.1 (SAS Institute, Cary, NC) and SUDAAN 9.0 programs were used. An a priori α value of 0.05 was used for all statistical tests. Because of the complex sample design of the Medical Expenditure Panel Survey, proc surveymeans and proc surveyreg procedures in SAS 8.1 were used to calculate sampling errors of estimates. Adjusted mean expenditures were calculated by exponentiating the least-squares means, and then multiplying the result by a "smearing" coefficient, the sum of the exponentiated residuals divided by the sample size, to produce unbiased estimates of the mean expenditures.[25]

Results

Hypertension Prevalence

Prevalence of patients with hypertension was estimated by sum of the person-level weights of identified hypertension patients. Prevalence of hypertension in individuals aged ≥18 years was estimated to be 17.4% (49,048,231 persons) in 2001 in United States. The remaining 82.6% (232,738,726 persons) were considered to be nonhypertensive.

Demographics of Study Sample

Table 2 compares demographic characteristics of study patients with hypertension and without hypertension. Among hypertensive individuals, the percentage of individuals who were ≥31 years of age was approximately 95%. Similarly approximately 55% of hypertensive individuals were female and 83% of individuals who were diagnosed with hypertension were of white ethnicity.

Diabetes was the most prevalent comorbid condition among hypertensive patients at 8.50%. Only 1.12% of nonhypertensive respondents had diabetes as one of their comorbid conditions. Of the hypertensive respondents, 5.4% had chronic pulmonary disease as a comorbid condition, compared with 2.6% of nonhypertensive respondents. In addition 4.3% of hypertensive respondents had any tumor as a comorbidity, compared with 1.0% of nonhypertensive respondents. The Charlson Comorbidity Index score for hypertensive respondents was 0.44 (95% confidence interval [CI] = 0.40 to 0.47) compared with 0.09 (95% CI = 0.08 to 0.10) for nonhypertensive respondents.

Resource use was greater among hypertensive individuals in each of the seven medical events analyzed as compared with use by nonhypertensive individuals ($P <$ .0001). Office-based medical provider visits and prescription medications were the two most highly used medical resources among both hypertensive and nonhypertensive individuals, with approximately 92% of hypertensive individuals showing at least one office-based medical provider visit as compared with approximately 77% of nonhypertensive individuals. Approximately 78% of hypertensive individuals were prescribed prescription medicines at least once as compared with approximately 72% of nonhypertensive individuals ($P <$ .0001).

Total Incremental Expenditure of Hypertension Treatment

After adjusting for age, ethnicity, sex, education, and Charlson Comorbidity Index, mean incremental expenditure of treating patients diagnosed with hypertension was estimated to be $US 1,130.7. This estimate was multiplied by prevalence of hypertension in 2001 that was 49,048,231 individuals to arrive at overall incremental expenditure of treating hypertension in the United States of $US 55,458,834,792 in the year 2001

Table 2. Comparison of demographic characteristics between hypertensive and nonhypertensive subjects

	Hypertensive*		Nonhypertensive†		
Characteristic	**%**	**95% CI‡**	**%**	**95% CI**	***P* value**
Age (y)					
18–30	5.1	4.4–5.9	51.6	50.8–52.4	<.0001
31–60	49.6	48.0–51.2	39.6	38.9–40.3	<.0001
≥61	45.3	43.6–46.9	8.8	8.3–9.4	<.0001
Sex					
Male	45.0	43.7–46.3	49.6	48.9–50.2	<.0001
Female	55.0	53.7–56.3	50.4	49.8–51.1	<.0001
Ethnicity					
African American	13.3	12.0–14.6	12.5	11.4–13.5	.0432
White	82.8	81.3–84.3	82.2	81.0–83.4	.2763
Other	3.9	3.0–4.7	5.3	4.6–6.1	<.0001
Education					
No degree	20.4	18.9–21.9	19.0	17.5–19.5	<.0001
GED	4.7	4.0–5.3	3.7	3.4–4.0	.0743
High school diploma	44.3	42.6–45.9	40.4	39.6–42.1	<.0001
Bachelor's degree	12.6	11.5–13.6	9.9	9.4–10.5	.0137
Master's degree	6.1	5.2–7.0	4.7	3.4–5.0	<.0001
Doctorate degree	1.6	1.2–2.1	0.8	0.7–0.9	.0238
Other degree	6.5	5.7–7.4	5.0	3.6–5.3	<.0001
Age <16 years, nonapplicable	0.0	0.0–0.0	0.8	0.6–0.9	<.0001
Charlson Comorbidity Index score	0.44	0.40–0.47	0.09	0.08–0.10	<.0001

CI = confidence interval; GED = graduation equivalence degree.
* Stratified sample estimates projected to a population of 49,048,231 hypertensive persons.
† Stratified sample estimates projected to a population of 232,738,726 non-hypertensive persons.

(Table 3). There was a significant relationship between log of total direct expenditure and demographic characteristics, prevalence of hypertension, and comorbidities ($F = 265.45$, $P < .0001$).

Table 3. Results of regression analysis to estimate incremental direct cost of treating hypertension*

Parameter	Estimate†	SE	*P* value
Intercept	525.1	148.7	.0012
Hypertension	1130.7	184.8	<.0001
Age	48.1	3.7	<.0001
Male	−508.2	83.9	<.0001
Female‡	0.0	0.0	—
Black	−283.1	110.3	.0180
White‡	0.0	0.0	—
Other	−491.2	173.9	.0092
No degree	−198.1	126.8	.1488
GED	−2310.8	76.9	<.0001
High school diploma‡	0.0	0.0	—
Bachelor's degree	33.3	141.1	.8274
Master's degree	−703.9	114.5	<.0001
Doctorate degree	−449.9	120.6	.0006
Other degree	365.7	129.1	.0091
Age <16 years	−222.7	191.8	.2829
Charlson Comorbidity Index score	3314.8	227.8	<.0001

GED = graduation equivalency degree; SE = standard error.
* Based on 29,581 respondents.
† Stratified sample estimates projected to a population of 281,786,957 persons.
‡ Reference category.

Incremental Expenditure of Hypertension Treatment by Individual Expenditure Categories

Table 4 shows the results of regression models of incremental expenditure of prescription medicines, inpatient visits, outpatient visits, office-based medical provider visits, emergency room visits, home health visits, and other

Table 4. Results of regression analysis to estimate incremental cost of hypertension by service categories*

Parameter†	Estimate‡	SE	*P* value
Prescription medications	546.8	29.4	<.0001
Inpatient visits	343.0	146.3	.0305
Outpatient visits	114.5	36.7	.0040
Emergency room visits	57.9	13.7	.0001
Office-based medical visits	37.9	45.3	.0209
Home health visits	16.7	14.8	<.0001
Other medical expenses	13.8	8.3	.1235

SE = standard error.
* Based on 29,581 respondents.
† Generalized least-squares regression model (only the hypertension estimate is reported): log of total medical event cost = intercept + age + gender + ethnicity + education + Charlson Comorbidity index + error.
‡ Stratified sample estimates projected to a population of 281,786,957 persons.

medical expenses. The dependent variable in each regression model was the log of total individual medical event expenditure as the dependent variable, whereas the main independent variable was hypertension. Other independent variables used as covariates in the model were age, sex, ethnicity, education, and comorbidities. Mean incremental prescription medicine expenditure, inpatient visit expenditure, and outpatient visit expenditure by hypertension patients was estimated to be $US 546.8, $343.0, and $114.5 respectively. These three categories constituted >90% of the overall incremental expenditure for treating hypertension, which are similar to approximately 87% contributions estimated by the 2005 heart and stroke statistics from the American Heart Association (AHA).[27]

Discussion

The percentage of individuals ≥18 years of age with hypertension was estimated to be approximately 17.4% in 2001 in the United States using the MEPS data. This estimate is comparable to the prevalence estimate of approximately 20% of individuals ≥18 years of age obtained from the results of the third National Health and Nutrition Examination Survey (NHANES III).[26] However, our prevalence estimate is lower than the AHA estimate (32.3%) because of potential underestimation resulting from missed diagnoses and the self-reported nature of the responses.[27] Generally the prevalence of hypertension increases with age; this pattern was similar in our study population, as was the fact that a higher percentage of hypertensive individuals were female. This study gives insight into the structure of incremental expenditure caused by hypertension and shows that the estimate of approximately $US 55.0 billion obtained indicated a significant financial burden to society. This estimate is higher than the estimated $US 44.2 billion of the AHA in 1997, which excluded emergency room visits as part of direct medical expenditures.[27] It was hypothesized that our incremental expenditure estimate would be in the range between previous under-reported and over-reported hypertension cost estimates. Our estimate seems to be more precise as compared with the above estimate and other direct expenditure estimates obtained in previous studies, which have ranged from approximately $US 15.0 billion to $60.0 billion and may have been conservative or overestimated.[5–10] Our results are more likely to be unbiased estimates as significant variables associated with hypertension such as age, sex, ethnicity, education. More importantly the clinical comorbidities were adjusted for in the regression model, which was not the case in earlier studies.

To our knowledge, this is the first study that estimates the incremental direct expenditures for treating hypertension in the US. Some studies have estimated the incremental expenditures for treating other diseases using the regression approach.[17,19–22] However, because our estimate is believed to be the first incremental estimate for hypertension, we have compared our estimates with previous hypertension estimates from studies that have used other estimating methodologies. Because the sample size in this study is very large, the issue of statistical significance becomes somewhat trivial for variables that have a significant impact on expenditures.

Prescription medicines, inpatient visits, and outpatient visits comprised approximately 90% of the overall expenditure of treating hypertension. This finding is comparable to those in previous studies in which prescription medications were found to constitute >50% of the overall treatment expenditure.[5–8] According to the AHA, prescription medicines accounted for 45% of the total direct cost of hypertension treatment.[28]

The model used in our study included age, sex, ethnicity, Charlson Comorbidity Index, and education. The variables were selected based on the JNC-7.[3] Education was used as a proxy for income as there is a strong correlation between these two variables. Other important covariates that were not considered because the inability of the MEPS database to capture them included smoking status, obesity, dyslipidemia, and history of hypertension among responding individuals. An estimate of incremental cost of treating hypertension using a commercial database that provides information on the above risk factors would be more precise.

Our study estimated incremental direct expenditures and not indirect expenditures. Indirect expenditures of hypertension have been estimated to be in the range of approximately $US 14 billion to $18.0 billion.[6,29] If these expenditures have to be considered, then total incremental expenditure for hypertension would be much higher than the estimated $US 55 billion.

The principal limitation of this study was the fact that hypertension patients were identified using ICD-9 codes. Also, the comorbidities used for the Charlson Comorbidity Index were identified using ICD-9 codes. Identification of patients through ICD-9 codes from claims databases have their own limitations including errors in coding and documentation.[30] Because hypertension is a “silent” disease in which affected individuals do not experience symptoms, it is likely that there were some respondents who had high blood pressure but in whom hypertension was not diagnosed. This might have resulted in underreporting of the percentage of hypertensive individuals.

Medical conditions reported by respondents in the MEPS were collapsed from fully specified four-digit and five-digit codes to three-digit codes to preserve respondent confidentiality. Three-digit ICD-9 codes are less finely grained than four-digit or five-digit codes in accurately identifying a medical condition. This can be a potential factor for the possibility of underestimation of the prevalence of hypertension and incremental cost estimates obtained in our study.

As the study focused on only direct expenditures of treating hypertension, overall incremental expenditure associated with hypertension is underreported. A more detailed analysis capturing both direct as well as expenditures associated with unpaid care providers, lost productivity, premature mortality, or pain and suffering will provide a more precise overall incremental expenditure for hypertension. Even though hypertension is not common among children and adolescents, not including these individuals from the analyses might result in our estimate being conservative. The results are specific to hypertensive individuals identified through medications, ICD-9 codes, and self-reported responses. Persons with milder cases might have been more likely to have forgone treatment that might possibly underestimate our expenditures. The MEPS database contained no objective measures of disease severity. Such data could have enhanced our ability to stratify and quantify the effects of hypertension on expenditures and describe drug-prescribing patterns. We might also have underestimated expenditures because of potential under-reporting of all medical conditions in the MEPS database. Underestimation could also have occurred because of unknown hypertension costs before diagnosis.

Incremental direct expenditure estimates can be included in cost–benefit analyses to justify expenditures for programs appropriately to reduce risk of hypertension in the population thereby improving efficiency in resource allocation. Strategies to change physician-prescribing behavior to increase use of the lower expenditure but effective medications may lower the overall expenditure of treating hypertension. Switching and discontinuation of antihypertensive agents have significant cost implications. More aggressive hypertension management with cost-effective medications may effectively reduce the need for subsequent physician visits and the need for complicated therapeutic regimens, thereby potentially improving patient compliance. Estimating incremental medical cost savings associated with hypertension control (avoiding strokes and heart attacks) would be of interest. The impact of patient cost-sharing and insurance coverage on overall hypertension resource use and health care expenditures should be further explored.

Data on distribution of expenses show that relatively few individuals with hypertension incur high levels of expenditures. Interventions that can reduce frequency of high expenditures such as hypertension action plans, following JNC guidelines for prevention including Dietary Approaches to Stop Hypertension (DASH) diet and more effective self-management strategies can have a profound impact on the national economic impact of hypertension, by preventing hospitalizations and emergency room visits. Until that time, hypertension will continue to have a substantial impact on the national economy.

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