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Cost-Effectiveness of a Hypertension Control Intervention in Three Community Health Centers in China

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Abstract

Background—Hypertension and associated chronic diseases impose enormous and growing health and economic burdens worldwide. The objective of this study was to investigate the cost-effectiveness (CE) of a hypertension control program in China.

Methods—We collected information on program costs and health outcomes in three community health centers over a 1-year period. The participants were 4902 people with hypertension (systolic blood pressure [SBP] ≥140 mm Hg and/ or diastolic blood pressure [DBP] ≥90 mm Hg, or on hypertension medication) aged 18 years and older. The SBP and DBP changes in the populations were estimated from a random sample of 818 participants by conducting face-to-face interviews and physical examinations. We derived CE measures based on the costs and effects on health outcomes.

Findings—The total cost of implementing the intervention was Renminbi (RMB) 240 772 yuan (US$35 252), or 49 yuan (US$7.17) per participant in 2009. On average, SBP decreased from 143 to 131 mm Hg ($P < .001$) and DBP decreased from 84 to 78 mm Hg ($P < .001$), the SBP decreases ranged from 7.6 to 17.8 mm Hg and DBP decreases ranged from 3.9 to 8.3 mm Hg. CE ratios ranged from RMB 3.6 to 5.0 yuan (US$0.53-US$0.73) per person per mm Hg SBP decrease, and from RMB 6.3 to 9.7 yuan (US$0.92-US$1.42) per person per mm Hg DBP decrease.

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Authors' note

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Disclaimer: The opinions and conclusions in this study are those of the authors and do not necessarily represent the official position of the US Centers for Disease Control and Prevention (CDC) YaminBai and Yanfang Zhao share senior authorship.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Interpretation—Per capita costs varied widely across the communities, as did changes in SBP and DBP, but CE was similar. The findings suggest (*a*) a positive correlation between per capita costs and program effectiveness, (*b*) differences in intervention levels, and (*c*) differences in health status. CE results could be helpful to policy makers in making resource allocation decisions.

Keywords

economic evaluation; blood pressure; community; intervention; China

Introduction

Hypertension, a major risk factor for heart disease and stroke, is a growing public health problem as its prevalence is high and increasing worldwide.[1–3] In China, for example, about 29% of men and 26% of women in 2000 were hypertensive (systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, and/or use of antihypertension medications). Only 9 years later, the prevalence of hypertension had increased to more than 39% among adults older than 35 years.[4,5] More than 62% of strokes and 49% of ischemic heart disease were attributable to hypertension.[6] The morbidity and mortality due to these chronic conditions have been increasing rapidly in recent decades.[7,8]

In addition, hypertension and associated chronic diseases, such as heart disease and stroke, impose an enormous economic burden in China. For example, in 2002, the direct medical costs of hypertension exceeded Renminbi (RMB) 20 billion yuan. Additionally, the direct medical costs of coronary heart disease and stroke were RMB 15.7 billion yuan and 24.3 billion yuan, respectively, and more than 47% (RMB 19.1 billion yuan) of the total medical costs of the 2 chronic diseases were attributable to hypertension.[9] Therefore, prevention and control of hypertension is a public health priority for improving population health and containing the economic burden of chronic diseases. It is a pressing need to develop and implement cost-effective strategies to combat the hypertension epidemic in China.

Many intervention programs have been developed and implemented for hypertension control and prevention around the world. Some studies have conducted analyses to demonstrate cost savings and cost-effectiveness of strategies intended to ameliorate hypertension. For example, strategies shown to be cost-effective include a nurse-administered, tailored behavioral intervention in the United States,[10–12] a national hypertension prevention and control program in Israel,[13] a national hypertension treatment program in Germany,[14] an elderly health examination program including hypertension screening in Taiwan,[15] an adherence-improving program (the Medication Events Monitoring System) in hypertensive patients in the Netherlands,[16] guidelines for antihypertensive care in Finland,[17] and ambulatory blood pressure monitoring in Spain.[18]

In China, however, no studies have documented cost savings or cost-effectiveness of programs intended to prevent and control hypertension. Given the enormous health and economic burden of hypertension, such information could have important implications for public health in China. Policy makers and public health officials could use scientific evidence of cost and cost-effectiveness to make wise decisions about resource allocation. This study attempts to fill the gap by investigating the cost-effectiveness of hypertension control programs implemented in community health centers as part of an integrated project sponsored by China Ministry of Health to control chronic diseases.

Methods

Intervention

The integrated project “Central Government’s Transfer Payments to Local Governments for Chronic Disease Intervention and Control” covers 64 communities across China. The project is implementing an intervention consisting of the following components: (*a*) classify the patients into 4 groups (ie, low, moderate, high, very high risk), based on their blood pressure, number of comorbidities, and risk factors (eg, smoking and drinking); (*b*) conduct diet, exercise, smoking, and drinking interventions consisting of educational sessions, supervision, and face-to-face consultation as necessary; (*c*) standardize drug therapies according to 2005 Chinese national guidelines for hypertension prevention and control; (*d*) conduct follow-up visits on a regular basis—once every 3 months for low-risk group, once every 2 months for moderate-risk group, and once a month for high- and very-high-risk groups; and (*e*) provide other services, such as physician recommendations, if necessary.

For this study, we selected 3 community health centers that are receiving the implementation based on geographic location, demographic characteristics, and availability and/ or feasibility of data collection. All three are located in urban settings: one community health center is located in Beijing city, representing regions of north and north central China; one is in Hangzhou city of Zhejiang Province, representing regions of south and southeast China; and one is located in Chengdu city of Sichuan Province, representing the region of southwest China. The 3 community health centers served 192 000 residents in the regions (Beijing 72 000, Hangzhou 42 000, and Chengdu 78 000) with a total of 286 employees (Beijing 119, Hangzhou 122, and Chengdu 45), including physicians (37%), nurses (26%), prevention specialists (9%), pharmacists (11%), and others (17%).

Eligibility for this cost-effectiveness study was based on age (18 years or older) and hypertension status (at least 3 months of receiving hypertension interventions at one of the community health centers) during the period September 2008 to August 2009. Hypertension was defined as systolic blood pressure (SBP) ≥140 mm Hg, diastolic blood pressure (DBP) ≥90 mm Hg, or with a past medical history of hypertension but with normal blood pressure when taking antihypertensive drug therapy. We excluded those with serious complications and comorbidities such as stroke and diabetes, physical limitations, and mental disorders.

A sample of 860 patients at the 3 centers was selected randomly for this study. Participants provided informed consent and voluntarily agreed to take part in the cost-effectiveness study. From the 860 participants, 818 valid questionnaires were received. Of the 818 respondents, 336 were men (41.1%) and 482 were women (58.9%); the mean age was 66.3 ± 10.6 years.

Calculation of Intervention Costs

We derived the costs of the hypertension intervention funded by the program “Central Government’s Transfer Payments to Local Governments for Chronic Disease Intervention and Control" by estimating the labor costs, variable costs, and fixed costs of the intervention. Calculations were based on recommendations from China's Fudan University and the World Health Organization.[19,20] Medication costs were not included as intervention costs because they were normally paid for by the participants' insurance or other sources and because the government's integrated project did not cover the medications. We determined that this was appropriate for the cost-effectiveness analysis from a public health care perspective.

Costs of labor were based on the annual income data prorated by the proportion of time that workers at the community health centers devoted to the intervention program. Annual income figures included salary, bonus, welfare allowance, and social security income. The hours working on the hypertension intervention were estimated using medical records for all hypertension intervention activities. The costs of labor were usually categorized as variable costs. However, most health care workers were permanent government employees. Their annual income might account for a significant proportion, for example, nearly half, of the intervention costs. Thus, we keep the costs of labor as a stand-alone category.

Variable costs included the costs of printing materials, health education and promotion sessions, low-value consumable goods, utility expenses, and other costs related to the hypertension intervention.

Fixed costs included the cost of depreciation on fixed assets such as buildings, vehicles, and equipment of various kinds relevant to the hypertension intervention. The straight-line depreciation method was used to assess depreciation cost for fixed assets. First, the service life and the purchase price of the construction, equipment, and fixtures used in the hypertension intervention program were obtained, and then the annual depreciation cost was calculated by dividing the total cost (price) by the expected life of the asset. Second, the engaged time of these equipment and fixtures on hypertension intervention were determined by an apportionment ratio (percentage of time used for hypertension control).

Outcome Measures

The outcomes were measured SBP and DBP of the participants, estimated from the random sample of 818 patients at the 3 community health centers. For each participant in the sample, the blood pressure was measured 3 times before the intervention and 3 times after the intervention. The average of the 3 measures at each time point was used for the data analysis. Detailed characteristics of the participants are presented in Table 1.

Statistical Methods

The cost data collected were numbered, sorted, validated, and processed with Excel 2003 software. Epidata3.1 was adopted to establish a database for the questionnaire survey and its subsequent data input, whereas SPSS 13.0 was used for data cleaning and statistical analysis. The statistical methods used were descriptive analysis, *t* test, and variance analysis.

Results

Intervention Costs

The total program costs were RMB 240 772 yuan (US$35 252) for the hypertension intervention at the 3 community health centers; 59 091 yuan (US$8652) in Beijing, 108 353 yuan (US$15 864) in Hangzhou, and 73 328 yuan (US$10 736) in Chengdu (Table 2). Overall, the biggest component of the cost was variable costs, which accounted for more than half of the total costs. In Beijing, the variable cost accounted for 75% of the intervention costs. In Hangzhou, the labor costs were the main component of the program cost. Across the 3 community health centers, labor costs ranged from 13.8% to 49.4% of total program cost, variable cost from 43.7% to 74.6%, and fixed cost from 6.9% to 11.6%.

From September 2008 to August 2009, the 3 community health centers served a total of 4902 hypertensive patients: Beijing 1603, Hangzhou 1358, and Chengdu 1941. The annual per capita cost of the hypertension intervention at all the community health centers was RMB 49 yuan (US$7.17), ranging from 37 yuan (US$5.42) in Beijing to 80 yuan (US $11.71) in Hangzhou.

Health Outcome Effects

After the 1-year intervention, mean SBP dropped by 12.3 mm Hg, with the drop ranging from 7.6 mm Hg in Chengdu to 17.8 mm Hg in Hangzhou. Mean DBP decreased by 6.2 mm Hg, ranging from 3.9 mm Hg in Chengdu to 8.3 mm Hg in Hangzhou. All reductions of the blood pressure were statistically significant (Table 3).

Cost-Effectiveness Ratio

The cost-effectiveness ratio for the intervention across all three sites was RMB 4.0 yuan (US $0.59) per mm Hg SBP decrease and, at the same time DBP decreased by about 0.5 mm Hg (Table 4). The cost-effectiveness ratios ranged from RMB 3.6 yuan (US$0.53) in Beijing to 5 yuan (US$0.73) in Chengdu per mm Hg SBP decrease. Using DBP measures, the cost-effectiveness ratio ranged from RMB 6.3 yuan (US$0.92) in Beijing to 9.7 yuan (US$1.42) in Chengdu. In extreme cases, the cost could be as low as RMB 2.1 yuan (US$0.31) or as high as 10.5 yuan (US$1.54) for a 1 mm Hg reduction in SBP, or RMB 4.5 yuan (US$0.66) to 20.5 yuan (US$3.00) for 1 mm Hg DBP reduction.

Discussion

In this study, we examined the costs and effectiveness of an intervention for hypertension control in 3 community health centers. As far as we know, this is the first empirical analysis of costs and cost-effectiveness of interventions for hypertension control at community levels in China. Our results showed that there was a large variation in per capita program costs and a large variation in average SBP and DBP reductions across communities. The large variations suggest a great potential in reducing cost and increasing SBP and DBP reductions in some communities.

More than 54% of the program cost was variable cost, which presents the best opportunity for reducing costs and improving cost-effectiveness of the intervention. However, in one center (Hangzhou), nearly half (49.4%) of the program cost was labor cost. This suggests that labor cost was also an important factor affecting the cost-effectiveness of the intervention in some areas.

In addition, the components of program cost varied greatly from site to site; for example, only 13.8% of the intervention cost was labor cost in Beijing, but it comprised 49.4% of total cost in Hangzhou. The differences in the cost components may reflect the differences in intervention intensity or contents. For example, patient assessment reports were mostly printed in color in Beijing to improve patient compliance with the intervention. This subsequently increased the variable costs in this center. In Hangzhou, the follow-up visits were mainly (about 80%) home visits. In-home visits usually took longer time than other forms of follow-up visits such as telephone and outpatient visits. Thus, the labor cost was much higher in Hangzhou than in other 2 centers. These variations signal a need to explore the reasons behind such differences.

We also found that the blood pressure reductions attributable to the program were significant. On average, the SBP decreased by 12.3 mm Hg ($P < .001$) from 143 mm Hg before the intervention to 131 mm Hg after the intervention. And the reduction was as great as 17.8 mm Hg in Hangzhou. The DBP decreased by 6.2 mm Hg ($P < .001$), ranging from 3.9 mm Hg in Chengdu to 8.3 mm Hg in Hangzhou. These reductions were larger than many interventions in other countries where many interventions had SBP reduction of less than 10 mm Hg regardless of the duration of the interventions.[21–23] Therefore, the interventions implemented at the community health centers were very effective in China. In Hangzhou, both SBP and DBP decreased the most among the 3 intervention sites. This might be because of poor health status at the beginning of the intervention such as having higher blood pressure than patients in other 2 sites. This might also explain the fact that the costs of labor were higher in Hangzhou than in other sites. The significant blood pressure reduction is likely to have a substantial impact on public health because even a small decrease in population blood pressure is likely to result a substantial reduction in cardiovascular disease and mortality.[24] This is further supported by the fact that the morbidity and mortality due to the chronic diseases have been high and becoming more prevalent in China.[7,8]

Finally, we found that the community with the highest per capita program costs also had the best health outcomes, that is, largest decreases in SBP and DBP. For example, the per capita cost in Hangzhou was RMB 80 yuan (US$11.71), more than twice that in Beijing (37 yuan, US$5.42) or Chengdu (38 yuan, US$5.56). In terms of health outcome effect, participants in Hangzhou had a mean reduction of 17.8 mm Hg SBP and 8.3 mm Hg DBP, and the reductions were nearly double those achieved in Beijing, and more than double those in Chengdu. Therefore, the cost-effectiveness ratios did not vary greatly, as the cost per mm Hg reduction ranged from RMB 3.6 yuan (US$0.53) in Beijing to 5.0 yuan (US$0.73) in Chengdu for SBP, and Hangzhou was in between, with a cost-effectiveness ratio of 4.5 yuan (US$0.66). The patterns were similar for DBP. The mean DBP reduction in Hangzhou was 8.3 mm Hg, compared with 5.9 mm Hg in Beijing, and 3.9 mm Hg in Chengdu. The cost-effectiveness ratio for DBP ranged from RMB 6.3 yuan (US$0.92) in Beijing to 9.7 yuan (US$1.42) in Chengdu per mm Hg reduction in DBP. As was the case with SBP, the cost-effectiveness ratio of Hangzhou was 9.6 yuan (US$1.41), between that of the other 2 sites.

These findings suggest a positive correlation between program investment and program impact. Program investment might be a good indicator of program intensity, quality, or both. Because we have not noted any such information in the literature for comparisons, we cannot make any claims about whether the cost-effectiveness ratios indicated that the intervention investments for hypertension control were better or worse uses of government funds compared with other various government programs.

The costs and cost-effectiveness information presented in this study could be used by policy makers and public health officials in developing government policies and making resource allocation decisions to promote population health. We hope our study will convince more researchers to explore program cost and cost-effectiveness information in public health areas.

Limitations

Our study had several limitations that should be considered in interpreting our findings. First, we used data from only 3 community health centers. Although they were located in different geographic regions, all 3 were in urban areas. The small number of community centers and the relatively small sample size may limit the generalization of the results to the national level or rural areas. Many studies have explored issues of growing health burden associated with hypertension in rural China.[25–28] There is a pressing need to conduct economic evaluation studies focusing on rural residents. Second, we did not include socioeconomic factors, such as household income, age, sex, education, or employment status in the data analysis. All these characteristics differed greatly across the community health centers and affected the cost, health outcomes, and cost-effectiveness of the interventions. Incorporating these variables into cost-effectiveness analysis should provide more insightful information to policy makers and public health practitioners. Third, the China Ministry of Health sponsored the intervention, which was a continuous project for several years. We arbitrarily selected a 1-year period for this study (September 2008 to August 2009.) This might affect the cost calculation since government investment may not be spent evenly over the project years. A follow-up study is needed to validate the cost-effectiveness results.

Finally, we only used blood pressure as a health outcome. We were unable to evaluate the effect of the intervention on behavioral outcomes such as antihypertensive medication adherence and health consequences of hypertension such as cardiovascular disease, stroke or quality-adjusted life years, which likely would be relevant information for policy makers working on public health policies. Further investigations of the intervention’s effects on these outcomes should strengthen the policy implications of the information on cost and cost-effectiveness.

Conclusions

This study examined detailed information on cost and cost-effectiveness of an intervention for hypertension control using data collected in 3 community health centers located in 3 different regions of China. This was the first empirical study, as far as we know, to examine the costs and cost-effectiveness of a hypertension control intervention in China. Our results showed that the hypertension intervention at community health centers was effective in reducing blood pressures although per capita costs of the intervention varied widely across communities. Because China is a developing country and resources for public health are extremely limited, careful choices must be made in allocating scarce resources. This study provided much-needed cost and cost-effectiveness information that should be helpful to policy makers and public health professionals as they make decisions about allocating resources and developing cost-effective interventions for hypertension control.

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Table 1

Sample Characteristics of Participants With Blood Pressure Measured (n = 818).

	Male		Female		Total	
	n	%	n	%	n	%
Total	336	100	482	100	818	100
Age (years)						
<55	43	12.8	76	15.8	119	14.5
55–64	78	23.2	145	29.0	223	27.3
65–74	127	37.8	156	32.4	283	34.6
≥75	88	26.2	105	21.8	193	23.6
Education (years)						
<7	73	21.7	165	34.2	238	29.1
7–12	216	64.3	282	58.5	498	60.9
>12	47	14.0	35	7.3	82	10.0
Employment status						
Employed	130	38.7	168	34.9	298	36.4
Housework	97	28.9	201	41.7	298	36.4
Unemployed	109	32.4	113	23.4	222	27.1

Table 2

One-Year Intervention Costs of the Community Health Centers, September 2008 to August 2009, Renminbi Yuan (US$).[a]

	Beijing		Hangzhou		Chengdu		Overall	
	Cost	%	Cost	%	Cost	%	Cost	%
Labor cost	8140 (1192)	13.8	53 480 (7830)	49.4	27 115 (3970)	37	88 735 (1299)	36.9
Variable cost	44 094 (6456)	74.6	47 392 (6939)	43.7	39 040 (5716)	53	130 526 (19 111)	54.2
Fixed cost	6857 (1004)	11.6	7481 (1095)	6.9	7173 (1050)	10	21 510 (3149)	8.9
Total	59 091 (8652)	100	108 353 (15 864)	100	73 328 (10 736)	100	240 772 (35 252)	100
Number of patients served	1603		1358		1941		4902	
Cost per patient	37 (5.42)		80 (11.71)		38 (5.56)		49 (7.17)	

[a]Based on average rate of exchange of US$1 = Renminbi 6.8307 yuan in 2009. Source: http://www.federalreserve.gov/release/g5a.

Table 3

Mean Blood Pressures (mm Hg) Before and After 1-Year Intervention (N = 818).

	Before	After	Difference	Summary Statistics
Systolic blood pressure	143.3 ± 16.6	131.0 ± 12.4	12.3 ± 14.8	t = 23.69 (P < .001); F = 39.33 (P < .001)
Beijing	140.7 ± 10.1	130.4 ± 11.4	10.3 ± 10.8	
Hangzhou	154.0 ± 16.1	136.2 ± 14.1	17.8 ± 15.9	
Chengdu	132.6 ± 14.4	125.0 ± 7.5	7.6 ± 15.0	
Diastolic blood pressure	84.4 ± 10.1	78.3 ± 8.0	6.2 ± 10.2	t = 17.38 (P < .001); F = 13.08 (P < .001)
Beijing	85.5 ± 8.9	79.6 ± 8.6	5.9 ± 9.2	
Hangzhou	88.1 ± 10.0	79.8 ± 8.4	8.3 ± 11.0	
Chengdu	78.8 ± 8.9	74.9 ± 5.4	3.9 ± 9.7	

Table 4

Cost-Effectiveness of the Community Health Centers in Hypertension Control.

	Cost per mm Hg SBP Reduction, Renminbi yuan (US $)[a]	Cost per mm Hg DBP Reduction, Renminbi yuan (US$)
Overall	4.0 (0.59)	7.9 (1.16)
Beijing	3.6 (0.53)	6.3 (0.92)
Hangzhou	4.5 (0.66)	9.6 (1.41)
Chengdu	5.0 (0.73)	9.7 (1.42)
Extreme cases		
Best case scenario[b]	2.1 (0.31)	4.5 (0.66)
Worst case scenario[c]	10.5 (1.54)	20.5 (3.00)

Abbreviations: SBP, systolic blood pressure; DBP, diastolic blood pressure.

[a]Based on average rate of exchange of US$1 = Renminbi 6.8307 yuan in 2009. Source: http://www.federalreserve.gov/release/g5a.

[b]Based on the lowest per capita cost and greatest blood pressure reduction of the community health centers.

[c]Based on the highest per capita cost and smallest blood pressure reduction of the community health centers.