How Often Do Office Blood Pressure Measurements Fail to Identify True Hypertension?

An Exploration of White-Coat Normotension

Christopher Selenta, BA; Brenda E. Hogan, MA; Wolfgang Linden, PhD

Background: The often-observed differences between ambulatory (ABP) and office blood pressure (OBP) measurements have brought attention to the problem of misdiagnoses. Although there has been much focus on white-coat hypertension (elevated OBP with normal ABP means), few studies have examined “white-coat normotension” (WCN; normal OBP with elevated ABP means).

Objectives: To describe patients with WCN in terms of prevalence and quantitative differences between ABP and OBP; to identify psychological and demographic features that discriminate them from true normotensive patients; and to offer possible corrections for diagnostic limitations of OBP measurements in clinical practice.

Design and Methods: Five OBP measurements and 10- to 12-hour daytime ABP monitoring in 319 presumed healthy participants.

Results: Prevalence rates of WCN were 23% for systolic BP and 24% for diastolic BP. Participants with WCN were more often male, past smokers, and older and consumed more alcohol. Increasing the number of office readings and discarding the first office reading did not improve the accuracy of OBP measurements. Participants with BP of 10 mm Hg above or below the 140/90 office reading cutoff showed the lowest accuracy, with more than 50% of normotensive diagnoses being incorrect.

Conclusions: Office measures of BP lack sensitivity, missing a sizable portion of individuals who have hypertensive mean ABP measurements. Subjects with WCN differ from true normotensive subjects on several demographic and lifestyle variables. Only those office readings averaging 20 points above or below the 140/90 cut-off represent safe diagnostic information.

Arch Fam Med. 2000;9:533-540
SUBJECTS, MATERIALS, AND METHODS

PARTICIPANTS

Three hundred nineteen participants (154 male and 165 female; aged 17-86 years [average age, 27 years]; 5 did not specify age) were recruited for a 2-phase study of BP reactivity. Of these, 208 were healthy students (aged 17-50 years [average age, 21 years]) and 111 were community participants (aged 19-68 years [average age, 39 years]); 9 did not specify student or community member status and were considered under the more global label of community member. The only exclusion criterion for this study was use of cardioactive medication. The ethnic composition of the sample was approximately 70% white and 30% Asian. Twenty-one percent of the sample were past smokers, and 7% were current smokers. The reported average number of cigarettes smoked by active smokers was 12.1 per day. Forty-six percent of the sample consumed alcohol; for the entire sample, the average number of drinks per week was 0.8. Ninety-six percent of the sample exercised; on average, the sample exercised 2.6 times per week.

PROCEDURE

Participants came to the laboratory between 7 and 9 AM. They completed a demographic questionnaire package, and then were fitted with an ABP monitor on the nondominant arm, which they wore for the next 8 to 12 hours. The following week, participants returned for a laboratory session. During a 15-minute adaptation period, 5 baseline office measurements were taken at minutes 0, 4, 8, 12, and 14, respectively, in the seated position. Participants then performed a counterbalanced set of stress tasks while having their BP monitored. During this session, participants completed a psychological test battery, which included measures of daily stress (Daily Stress Inventory25), self-deception and other deception (Balanced Inventory of Desirable Responding [Delroy L. Paulhus, PhD, unpublished data, 1991]), hostility (Cook Medley Hostility Questionnaire26), depression (Beck Depression Inventory27), anger expression (Spielberger Anger Expression Scale28), and social support (Social Support Questionnaire29). All psychological inventories were chosen because they measure constructs that are related to cardiovascular disease. Each test has satisfactory psychometric properties and available norms.

Additional protocol details are published elsewhere30 (we used a more complete version of the data set than is used in the referenced study).

BP INSTRUMENTATION

Office BP was measured using a monitor (Dinamap 845 Vital Signs Monitor; Critikon Corporation, Tampa, Fla) that uses the oscillometric principle for pressure determinations. We used commercially available monitors for ABP readings (Model 90207; Spacelabs, Redmond, Washington). Use of this monitor is supported by validation work.31 Monitoring was performed on typical workdays or school days without specific stressors, and participants were encouraged to pursue their usual activities and to relax their arm at their side when the cuff inflated. A standard and a large cuff were available to provide best fit with the participant’s arm. The first 5 ABP readings were taken in the laboratory to determine proper cuff placement. Blood pressure recordings were taken automatically every 20 minutes for the entire monitoring period.

DIAGNOSTIC CATEGORIES

There is no clear consensus as to what constitutes a reference range or cutoff for ABP.32-36 Most researchers have recommended upper limits of daytime ABP (above which hypertension is suspected) ranging from 135/85 to 146/91 mm Hg.32-36 O'Brien et al35 have recommended using different reference values for men and women categorized by age group (suggested reference values based on the 95th percentile for daytime ABP). However, the International Society of Hypertension Scientific Committee,36 the Blood Pressure Monitoring Committee of the American Society of Hypertension,37 and the JNC-VI report1 have recommended 135/85 mm Hg as a provisional cutoff level between a normal and a high daytime ABP. Although we explicitly acknowledge that any difference in cutoff value will affect the resulting prevalence rates for misdiagnosis, we have adopted the latter guidelines in our study. We defined hypertension as daytime ambulatory SBP averages of 135 mm Hg or diastolic BP (DBP) averages of 85 mm Hg and greater, and office SBP averages of 140 mm Hg or DBP averages of 90 mm Hg and greater. Conversely, normotension was defined as values falling below these cutoffs. Participants with WCN therefore were defined as those with ambulatory hypertension and office normotension.

ond, ABP is not likely to be measured on a seemingly healthy individual. The result is that WCN patients are undetectable in standard medical practice, at least until the sequelae of chronically high BP develop. As such, few studies have examined this false-negative phenomenon.

Reported prevalence rates of WCN are 14%38 and 31%.17 Until recently, the existing studies on WCN17-21 have not examined or have been inconclusive with regard to stable psychological characteristics, demographics, cardiovascular structure and functioning, or prognosis. More recently, Liu et al10 found WCN patients to be similar to true hypertensive patients in terms of left ventricular characteristics, carotid artery wall thickness, and prevalence of discrete atherosclerotic plaques. Patients with WCN were older, had higher body mass index, serum creatinine concentrations, and plasma glucose elevated.
cose levels; and were more likely to be current smokers than normotensive patients. These research findings underscore the importance of early detection and aggressive treatment of WCN.

Considering how little is known about WCN, our overall goals were 3-fold. Using a presumably healthy sample of students and older community members, our first objective was to describe WCN in terms of prevalence and quantitative differences between ABP and OBP readings. Second, we were interested in whether any psychological or demographic feature would emerge to characterize these false-negative findings to facilitate identification of these patients in daily practice. Third, we sought to identify diagnostic limitations of OBP readings in a normotensive sample that may be corrected readily in clinical practice, thus reducing misdiagnoses.

Ambulatory BP was used as the criterion standard for diagnosing BP status throughout this study. Given that OBP readings are inherently unreliable because they are isolated estimates of daily BP, and that systolic BP (SBP) values have been shown to drop enough during a single visit to alter the diagnosis of hypertension, we examined to what extent OBP accuracy would improve by simply increasing the number of measurements. We also investigated the effect of eliminating the first OBP measurement. Since 5 OBP measurements were taken, we had the chance to examine the correctness of diagnoses based on different numbers of readings and the exclusion of the first reading. We hypothesized that the full 5 OBP readings would result in more accurate diagnoses compared with the 2 readings that are more typical of routine clinical practice. In addition, we speculated that accounting for habituation by discarding the first office reading would result in OBP measurements closer to ABP measurements.

Finally, we sought to determine whether physicians should be wary of diagnostic accuracy only within a narrow BP range that extends just above and below the traditional office cutoff of 140/90 mm Hg. Inden et al24 used a similar approach, but included only hypertension diagnoses classified into stages 1 to 3 (based on JNC-VI criteria4), and reported that OBP readings were not necessarily associated with the severity of ambulatory hypertension, although correspondence did improve with stage advancement. In contrast to the sample choice of Inden et al,24 our approach included the lower end of the BP range given the available sample of mostly young, presumed normotensive individuals.

## RESULTS

Except where otherwise indicated, the analyses used OBP measurements based on the average of 5 office readings. Although not reported herein, all analyses were conducted separately using OBP measurements based on the average of 2 office readings. Because of the similarity of the results of these approaches, we report only the results of analyses based on the more conservative average of 5 office readings.

### ACCURACY OF OBP DIAGNOSES

To clearly illustrate the discrepancy between obtained OBP and ABP readings, raw means, SDs, and histograms of the difference scores (daytime ambulatory average minus average of 5 office readings) are presented in Table 1, Figure 1, and Figure 2.

For SBP and DBP, daytime ambulatory readings were higher than OBP readings. Paired-samples t tests were conducted for SBP and DBP to detect differences between measurement techniques. The SBP and DBP data revealed higher ABP than OBP ($t_{318}=23.20$ [P < .001]; $t_{318}=27.84$ [P < .001]).

Figures 1 and 2 illustrate the often wide disparities between both modes of BP determination, overestimating in some and underestimating in others the observed

Table 1. Daytime Ambulatory and 5 Office Readings for Systolic and Diastolic Blood Pressure

<table>
<thead>
<tr>
<th></th>
<th>Daytime Ambulatory Readings, mm Hg</th>
<th>Five Office Readings, mm Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic</td>
<td>129.2 (11.2)</td>
<td>117.1 (11.6)</td>
</tr>
<tr>
<td>Diastolic</td>
<td>80.0 (8.6)</td>
<td>68.8 (9.4)</td>
</tr>
</tbody>
</table>

*N = 319. Values are expressed as mean (SD).
ABP. The percentage of prevalence of WCN (SBP/DBP) was 23%/4%, whereas the prevalence for true normotension was 73%/72%.

DESCRIPTIVE FEATURES OF WCN

Next, we examined whether there were any identifying characteristics of WCN. The SBP and DBP means of participants with WCN and normotension for the variables of age, sex, history of smoking, current smoking, frequency of smoking, frequency of exercise, and amount of alcohol consumption were compared. In addition, the SBP and DBP means were compared for the psychological variables of stress, self- and other deception (self-deception refers to response biases that are honestly held by the individual, whereas other deception refers to intentionally distorted self-reports [Delroy L. Paulhus, PhD, unpublished data, 1991]), hostility, depression, anger expression (the following 3 forms of anger expression were examined: anger in [how often angry feelings are experienced but not expressed], anger out [aggressive physical or verbal behavior when angry], and anger control [a tendency to acknowledge angry feelings but make efforts to control their expression]),28 and perceived social support.

Participants with WCN and normotension differed on several variables, but different patterns were observed for SBP and DBP diagnoses. For SBP-based diagnoses, WCN participants consumed more alcohol than normotensive participants. In addition, the proportion of male subjects in the WCN group was larger than in the normotensive group. For DBP-based diagnoses, WCN participants were older than normotensive participants and included a larger proportion of past smokers. Other differences approached but did not reach statistical significance; there was a tendency for WCN participants to smoke currently more than normotensive participants (DBP diagnoses) and to have higher levels of anger control (SBP diagnoses).

These findings were established by conducting separate \( \chi^2 \) analyses for SBP and DBP diagnoses on the 3 dichotomous variables (sex, history of smoking, and current smoking) and 2 multivariate analyses of variance (MANOVA) (one for SBP and one for DBP diagnoses) for the remaining 13 dependent variables to determine differences among categories. Specifically, the \( \chi^2 \) analyses revealed that for SBP diagnoses, there was a greater proportion of male subjects in the WCN than in the normotensive group (\( \chi^2=22.74, P<.001 \)). Approximately 70% of the WCN group was male compared with only 40% of the normotensive group. For DBP diagnoses, there was a significantly greater proportion of participants with a history of smoking in the WCN group than in the normotensive group (\( \chi^2=6.95 \left[ P=.007 \right] \)); approximately 37% of the WCN group had a history of smoking, compared with only 17% of the normotensive group.

For SBP and DBP diagnoses, a multivariate effect (\( F_{13,288}=1.99 \left[ P=.02 \right] \) and \( F_{13,292}=2.72 \left[ P=.008 \right] \), respectively) emerged from the MANOVA analyses. Bonferroni-corrected univariate tests (corrected for violations of the assumption of homogeneity of variance when necessary) revealed that for SBP diagnoses, the WCN group consumed more alcohol than the normotensive group (\( t_{93.28}=2.70 \left[ P<.008 \right] \)). For DBP diagnoses, WCN participants were older than normotensive participants (\( t_{107}=4.97 \left[ P<.001 \right] \)). Other variables approached but did not meet the requirement for statistical significance. For SBP diagnoses, there was a tendency for WCN participants to have higher levels of anger control than normotensive participants (\( t_{130}=2.44 \left[ P=.01 \right] \)). For DBP diagnoses, there was a tendency for WCN participants to smoke more than normotensive participants (\( t_{100.09}=1.93 \left[ P=.05 \right] \)). No other differences were observed between WCN and normotensive participants.

CAN WE IMPROVE DIAGNOSTIC ACCURACY?

Increasing the Number of Office Readings

We predicted that increasing the number of office readings would improve diagnostic accuracy, but accuracy was almost identical for diagnoses based on 2 office readings and those based on 5 office readings. The \( \chi^2 \) analyses confirmed this. In an effort to allow for habituation to the office setting, the effect of eliminating the first OBP reading was examined. To do this, the second office read-
ing alone, the average of the first 2 office readings, the average of the second through the fifth office readings, and the average of the first 5 office readings were each correlated with ambulatory SBP and DBP and compared using a procedure that accounts for nonindependent correlation coefficients described by Rosenthal and Rosnow (Table 2). The correlation of the second office reading with daytime ambulatory DBP was significantly lower than all other correlations. No differences were observed for SBP.

Are Any OBP Values Safe?

Although the correlations between ABP and OBP (Table 3) were quite strong, the percentage receiving a misdiagnosis as healthy based on OBP measurements (SBP/DBP, 23%/24%) is indicative of deeper discrepancies. Therefore, we broke down the full range of OBP measurements for each study into blocks of 10–mm Hg increments. Within each increment, we determined the percentage of participants actually hypertensive with the use of ABP measures as the criterion. This information is displayed in Table 3. For 10–mm Hg increments above 140/90, the percentage of participants actually hypertensive is an accuracy rate, but for 10–mm Hg increments below 140/90, the percent of participants actually hypertensive is an inaccuracy rate. Correlations between ABP and OBP measures within each increment were not calculated because of the small and uneven numbers inherent in these divisions.

Dividing the BP data into such incremental blocks clearly demonstrates that diagnoses falling in the borderline range (10 mm Hg above and below 140/90) are particularly inaccurate. Most participants in the 10–mm Hg range below 140/90 have hypertensive ABP. Diagnoses in the more extreme ranges (ie, SBP <119 and DBP <69) have a much higher accuracy rate.

**Table 2. Intercorrelations Between Ambulatory and Office Systolic and Diastolic Blood Pressures***

<table>
<thead>
<tr>
<th>Office Blood Pressure Measurements</th>
<th>Second Reading</th>
<th>1-2 Readings</th>
<th>2-5 Readings</th>
<th>1-5 Readings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic</td>
<td>0.64</td>
<td>0.66</td>
<td>0.65</td>
<td>0.67</td>
</tr>
<tr>
<td>Diastolic</td>
<td>0.64</td>
<td>0.67†</td>
<td>0.68†</td>
<td>0.68†</td>
</tr>
</tbody>
</table>

* N = 319. †Significantly greater than second reading (P < .05).

**Table 3. Participants With Actual Hypertension by the Use of Daytime Ambulatory Blood Pressure Measurements as a Function of 10–mm Hg Increments of Office Measurements***

<table>
<thead>
<tr>
<th>Office Blood Pressure Readings</th>
<th>No. (% With Actual Hypertension</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥160 SBP</td>
<td>1/1 (100)</td>
</tr>
<tr>
<td>≥110 DBP</td>
<td>1/1 (100)</td>
</tr>
<tr>
<td>150–159 SBP</td>
<td>5/5 (100)</td>
</tr>
<tr>
<td>100–109 DBP</td>
<td>2/2 (100)</td>
</tr>
<tr>
<td>140–149 SBP</td>
<td>6/6 (75)</td>
</tr>
<tr>
<td>90–99 DBP</td>
<td>7/7 (100)</td>
</tr>
<tr>
<td>130–139 SBP</td>
<td>12/20 (60)</td>
</tr>
<tr>
<td>80–89 DBP</td>
<td>23/28 (82)</td>
</tr>
<tr>
<td>120–129 SBP</td>
<td>37/85 (44)</td>
</tr>
<tr>
<td>70–79 DBP</td>
<td>33/74 (45)</td>
</tr>
<tr>
<td>110–119 SBP</td>
<td>21/109 (19)</td>
</tr>
<tr>
<td>60–69 DBP</td>
<td>21/164 (13)</td>
</tr>
<tr>
<td>≥109 SBP</td>
<td>3/91 (3)</td>
</tr>
<tr>
<td>≥59 DBP</td>
<td>1/43 (2)</td>
</tr>
</tbody>
</table>

* N = 319. Actual hypertension is defined as at least 135 mm Hg for systolic (SBP) and at least 85 mm Hg for diastolic blood pressure (DBP) readings.

Our results clearly demonstrate that even in a presumed healthy sample, WCN is a genuine entity. When considering inconsistencies between OBP and ABP readings, a possible comparison is across overall means (using mean score data and simple correlations for each modality). These simple comparisons, however, are of limited value because misdiagnosis is largely caused by variability that is hidden when only means or correlation coefficients are reported. Correlations between ABP and OBP readings (Table 3) reveal highly interrelated values that mistakenly may lead practitioners to treat the methods as comparable. The differences in ABP and OBP means (Table 1) would cause little concern if mean difference were a constant around which the distribution of differences clustered narrowly. However, the histograms displaying ABP and OBP differences (Figures 1 and 2) show that these differences distribute widely along a spectrum of roughly −15 and +20 points and that large distortions are unfortunately frequent. In fact, most individuals exhibited ABP/OBP discrepancies of more than 5 points above or below the cutoff.

**PREVALENCE OF WCN**

A disturbing observation is that in this large sample of presumably healthy individuals, approximately 23% have truly high BP as defined by ABP measurements, and these subjects with true hypertension were missed by OBP measurements. Because this study included only daytime BP measures, which are higher than nighttime measures, the rate of WCN in our study may be somewhat inflated. However, the prevalence of WCN seen herein is comparable
to the rates based on 24-hour ABP measurements reported elsewhere that ranged from 14% to 31%. Nonetheless, the fact that daytime BP levels were used should be kept in mind when interpreting results.

The observed high misdiagnosis rate calls for the use of ABP in place of OBP measurements. Of course, we recognize that the cost and inconvenience of ABP measurements, as well as a likely reluctance to deviate from the established acceptability of OBP measurements, form a joint force that impedes large-scale use of ABP measurements in the immediate future. Consequently, our remaining objectives sought to buttress the efficacy of OBP measurements. By identifying characteristics of subjects with WCN, physicians could focus on potential cases of misdiagnoses within the office setting and then conduct ambulatory monitoring on these select subgroups. Our results at best support a restricted use of OBP measurements.

SEARCH FOR DEMOGRAPHIC, LIFESTYLE, AND PSYCHOLOGICAL MARKERS

The results do not draw a simple picture and vary according to SBP or DBP diagnoses. The WCN group included a greater proportion of male participants who consumed more alcohol than the normotensive group (for SBP diagnoses). When diagnoses were based on DBP, WCN participants were older and included a greater proportion of past smokers. Other differences were noted that approached, but did not reach, statistical significance, ie, a tendency for WCN participants to be current smokers more than normotensive participants (DBP diagnoses) and to have higher levels of anger control (SBP diagnoses).

What do these findings tell us? Altogether, it appears that WCN subjects tend to engage (or have engaged in the past) in more risk factors for cardiovascular disease—smoking and alcohol consumption—more frequently than normotensive subjects. In addition, they tend to be older and to include a greater proportion of male subjects, both of which are considered characteristics that increase the risk of cardiovascular disease. These findings overlap those of Liu et al., who reported that WCN subjects were more likely to be older and be current smokers than normotensive subjects. If further research corroborates and strengthens these findings, physicians may want to consider using ABP measurements as a diagnostic tool when patients present with these characteristics but do not have hypertensive OBP levels. However, these characteristics are still quite broad, lack specificity, and do not narrow down the potential pool of candidates for ABP monitoring by a substantial amount.

Aside from these demographic and lifestyle characteristics, we failed to find definitive psychological traits that distinguished WCN subjects from normotensive ones. Our analysis of potential psychological and demographic characteristics of WCN subjects, however, was not exhaustive, and further research still should pursue a psychological or behavioral profile of these subjects with false-negative findings to facilitate their identification and to decrease the risk of misdiagnoses.

PRACTICE IMPLICATIONS

Our results show that increasing the number of OBP measurements from 2 to 5 did not improve diagnostic accuracy, nor did discarding the first office reading improve correlations with ABP measurements. Five OBP readings in a single visit are unlikely to be obtained in actual clinical practice. Rather, 2 or more readings per visit averaged across 2 or more visits are more likely, and this is in fact recommended by the JNC-VI report. Despite this recommendation, however, Pearce et al. found that important discrepancies existed between OBP and ABP readings, even when 2 readings per visit were averaged across 6 visits. Furthermore, Newlove and Linden also found that OBP readings did not habituate, ie, OBP did not drop significantly on a second visit, although 9 readings had been taken during every visit.

The question for clinical practice, then, is how to achieve an increase in the number of BP readings (short of the 24-hour ABP measurement ideal) that would improve diagnostic accuracy without being onerous for physician and patient. One possible solution would involve the patient arriving in advance of a physician appointment, being hooked up to an ambulatory device, leaving, and then performing typical activities before returning a short period later. In this light, Sheps et al. statistically evaluated the feasibility of using only 6 hours of ABP measurement to approximate the awake period. Despite the positive results of their study, the use of minimal ABP measurements needs to be studied further. A second possibility is home BP monitoring by the patient; it is less expensive than ABP monitoring and received some support regarding usefulness, but there are 2 considerations that limit home monitoring. First, the number of readings is usually much smaller than with ABP monitoring, thus reducing reliability and representativeness. Second, because the patient has control over the measurements, we doubt that a patient would bother, or be able, to take BP measurements during certain stressful situations (eg, an argument, heavy traffic) that are otherwise typical of that individual’s daily life.

IDENTIFICATION OF RELIABLE DIAGNOSTIC BP RANGES

In regard to identifying BP ranges in which a health care practitioner could assume safely that the OBP values cor-

(Reprinted) Arch Fam Med/Vol. 9, June 2000 www.archfammed.com

Downloaded from www.archfammed.com at STANFORD Univ Med Center, on November 8, 2009
©2000 American Medical Association. All rights reserved.
respond with ABP values, we found some, albeit limited comfort. Unfortunately, the distributions of discrepancies between ABP and OBP readings indicate that OBP readings are reasonably accurate only if they are at least 20 points above or below the recommended office BP cutoff for definition of hypertension (140/90 mm Hg15). The inaccuracy rate of OBP readings is highest 10 mm Hg above and below the cutoff, thus ensuring a substantial proportion of misdiagnoses within SBP ranges of 130 to 150 mm Hg and DBP ranges of 80 to 100 mm Hg. Although using a hypertensive sample, Inden et al24 noted a similar pattern in stages 1 through 3 and isolated systolic hypertension; the misdiagnosis rate was lower as hypertension stages advanced in severity. Our study mirrored these results for BPs above and below the 140/90 mm Hg cutoff. For a practitioner, correct diagnoses appear to lie more toward the extremes of the OBP continuum. The latter is alarming because the preponderance of hypertension-related mortality occurs in the borderline hypertensive-normotensive range as a result of the large number of persons (ie, high base rate) included in this band of BPs.44

Thus, our attempts to identify methods of improving the accuracy of OBP readings served mostly to cast further doubts on the usefulness of office measurements. Even worse, the question of OBP accuracy ultimately needs to be tackled by studying white-coat hypertension and WCN. Given the apparently high prevalence rates of both types of misdiagnoses, practitioners need to consider seriously that somewhere between one third and one half of all OBP-based diagnoses may be wrong. In light of our research and the existing literature, we believe that there is little that can be done within the medical setting that can eliminate OBP measurement problems. If the exclusive use of OBP measurements continues, critical diagnostic errors will also be unavoidable, given the current state of knowledge.

LIMITATIONS AND CONSIDERATIONS

One of the drawbacks of this study is that OBP measurements were taken in the laboratory rather than in a physician’s office. The inherent differences between these measurement situations reduce generalizability somewhat. However, at least 1 study has shown that OBP measurements taken by nurses did not differ significantly from standardized readings taken by a research assistant. Furthermore, very similar prevalence rates of WCN have been reported when OBP was measured by a physician or nurse.9

A second point is that a presumed normotensive sample was used. This had the advantage of demonstrating the existence of WCN in persons who were assumed to be healthy, and it had the potential to reveal the troubling discrepancy between ABP and OBP measurements, but the sample is also somewhat younger than patient samples usually used in hypertension studies.

A further consideration is that we used daytime (approximately 10- to 12-hour) ABP means. Most researchers would agree that more BP readings also lead to more reliable diagnoses; thus, 24-hour ABP measurement would be considered the superior method. Unfortunately, the recurrent theme of cost and inconvenience continues to prevent physicians from routinely using 24-hour ABP measurements. Limiting ambulatory monitoring to the 12-hour day cuts down on cost and inconvenience, and as our study demonstrates, will still identify many patients in whom OBP readings lead to misdiagnosis. Of course, 24-hour ABP measurements should be considered the criterion standard, but it is our view that for ABP readings to replace OBP readings as the status quo, some compromises may be necessary. Use of home BP monitoring may circumvent some of the difficulties of ABP monitoring, but until more research on its use is conducted, ABP monitoring is a more meaningful alternative. Future research should work to identify the most cost-effective diagnostic procedure that does not compromise the health of patients.

White-coat normotension is an understudied problem that deserves much more attention from researchers and clinicians, as this silent hypertension may go unnoticed and thus untreated for indefinite periods of time. In addition to further defining patients with WCN in terms of personality and demographic characteristics, researchers should further examine this group in terms of physiological variables. Further questions concern whether WCN treatment and prognosis are the same as for established patients with hypertension, although findings by Liu et al19 suggest that they are likely similar. Meanwhile, health care practitioners must be wary of WCN and its hidden costs.

Accepted for publication January 14, 2000.

This study was financially supported by the Heart and Stroke Foundation of British Columbia and Yukon, Vancouver, British Columbia, and the Medical Research Council of Canada, Ottawa, Ontario.

We appreciate the helpful comments of Bill Gerin, PhD; Mark Gelfer, MD; and David Paul for an earlier version of this manuscript.

Corresponding author: Wolfgang Linden, PhD, Department of Psychology, University of British Columbia, 2136 West Mall, Vancouver, British Columbia, Canada V6T 1Z4 (e-mail: wlinden@cortex.psych.ubc.ca).
REFERENCES


42. Kriesand T, Cohen IM. Home blood pressure monitoring. Am Fam Phy-