Higher Blood Pressure in Adults With Less Education
Some Explanations From INTERSALT

An inverse association between social class and disease has frequently been reported; education, an indicator of social class, was negatively related to blood pressure in several studies. Reasons are not clear. INTERSALT, an international study on electrolytes and blood pressure, obtained data on years of education for 10,079 adults in 52 centers in 32 countries. Data presented here are for 47 centers, omitting five where the population in the sample had no education or no differences in educational level. Regression coefficients were calculated for the education-blood pressure association in each center. An inverse association was found for men in 28 centers and for women in 38. Center coefficients were combined to give a studywide estimate of that association. When adjusted only for age, systolic pressure in men was 1.3 mm Hg higher for 10 fewer years of education ($p<0.05$) and for women 4.5 mm Hg higher ($p<0.001$). However, when adjusted also for five lifestyle factors (24-hour sodium and potassium excretion, body mass index, alcohol intake, and smoking), these estimates were reduced by about one half, and the inverse association was no longer significant for men. Similar findings were obtained for diastolic pressure. Those with less education had on average higher sodium excretion, lower potassium excretion, greater body mass, and higher alcohol intake, all factors tending to increase blood pressure. Improvement of these factors, which help explain the differences in blood pressure related to years of education, has the potential to reduce the blood pressure disadvantage associated with lower socioeconomic status. (Hypertension 1992;19:237–241)

KEY WORDS • population studies • blood pressure • educational status • socioeconomic status

That persons in lower socioeconomic strata have higher rates of disease and mortality at all ages has been known quantitatively at least since public health records have been kept and known qualitatively for even longer.1–7 In recent years, several population studies have reported that persons of higher education tended, on average, to have lower blood pressure as well as lower prevalence rates of hypertension than those with less education.8–11 It is unlikely that the mere act of sitting in a classroom for more years would in itself produce lower average blood pressure; a more credible explanation is that education, a marker of socioeconomic status, is associated with habits of lifestyle that help account for differences in blood pressure. Certainly, in the past, differing patterns of nutrition, of sanitation, and of housing and work conditions were major contributors to social differentials in disease and health.1,12,13

Could lifestyle differences, particularly nutritional ones, also help explain the reported social differences in blood pressure levels? Is this social difference in blood pressure a common phenomenon shared by many populations? These two questions were examined using data from INTERSALT, an international collaborative study on the relation of electrolytes and other factors to blood pressure.

Methods

The methods and main findings of the INTERSALT study have been extensively reported.14–18 This cross-sectional study was the largest of its type; 10,079 men and women aged 20–59 years participated at 52 centers in 32 countries, covering a wide range of cultures and lifestyles, including dietary patterns. A detailed standardized protocol formed the basis of prestudy training of local investigators by the study's two coordinating centers (London and Chicago) and of ongoing quality control during the study. Electrolyte intake was assessed (with analysis in a central laboratory in Leuven, Belgium) through measurement of excretion in timed 24-hour urine collections. Blood pressure was measured
with a random zero sphygmomanometer by trained and certified observers. The mean of two measurements was used for these analyses. Other variables likely to be related to blood pressure were also measured using standardized methods (e.g., alcohol intake in the previous 7 days ascertained through a questionnaire, and body mass index [kg/m²]). In addition, information on demographic and social factors was obtained from participants, including reported number of years of education completed, as an indicator of socioeconomic status.

**Statistical Methods**

The size and standardization of procedures in INTERSALT resulted in effect in 52 simultaneous studies, each of approximately 200 persons randomly selected from defined populations. These features permitted the analysis of relations both across populations and within populations. For the present report, linear regression analyses were performed within each center for the relation between blood pressure and years of education; age-adjusted coefficients were computed separately for men and women. To obtain a studywide estimate of the relation between individual pressure and education, these five centers could not be included. Within and across the remaining 47 centers, there was considerable variation in number of years of education. Mean number of years ranged across centers from 2.6 to 17.4.

Coefficients of variation within centers averaged 36.6% for men and 39.6% for women. The number of participants in the 47 centers totaled 9,125 when all persons were included in the analysis and 8,477 when those currently on antihypertensive medication were excluded.

### Results

INTERSALT found an inverse association between years of education and both systolic and diastolic blood pressures in a majority of the populations studied (Table 1). Age-adjusted regression coefficients for the education–systolic blood pressure relation in men were negative in 28 of the 47 centers, significantly so in three of them. There were 19 centers where this coefficient was positive, with two of them significant. The within-center coefficients were pooled to give studywide estimates of the education–blood pressure association. The pooled coefficients for the relation of years of education to individual systolic pressure in men gave a significant studywide negative coefficient of \(-0.13\) (95% CI, \(-0.25\) to \(-0.01\)). This coefficient indicates that for every additional year of education, systolic pressure was approximately 0.13 mm Hg lower; when men on medication were excluded, this was reduced to 0.09 mm Hg lower, a difference no longer statistically significant. In women, the inverse association of education with systolic blood pressure was stronger than for men, with 38 of 47 centers having negative regression coefficients.

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**Table 1. Relation of Education to Blood Pressure in INTERSALT: Within-Center Regression of Blood Pressure on Years of Education, Adjusted for Age**

<table>
<thead>
<tr>
<th>Centers and coefficients</th>
<th>Systolic BP</th>
<th>Diastolic BP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>Centers with negative coefficient (No.)</td>
<td>28</td>
<td>38</td>
</tr>
<tr>
<td>Centers with (p&lt;0.05) (No.)</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Centers with positive coefficient (No.)</td>
<td>19</td>
<td>9</td>
</tr>
<tr>
<td>Centers with (p&lt;0.05) (No.)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Pooled coefficient (standard error)</td>
<td>-0.130 (-0.061)</td>
<td>-0.447 (-0.071)</td>
</tr>
<tr>
<td>(z=)</td>
<td>-2.13* (-0.046)</td>
<td>-6.32* (-0.046)</td>
</tr>
<tr>
<td>Pooled coefficient, excluding persons on antihypertensive therapy (standard error)</td>
<td>-0.093 (-0.060)</td>
<td>-0.324 (-0.070)</td>
</tr>
<tr>
<td>(z=)</td>
<td>-1.55 (-0.045)</td>
<td>-4.60* (-0.050)</td>
</tr>
</tbody>
</table>

Values for coefficients and standard errors are millimeters of mercury per year of education. BP, blood pressure.

\(*p<0.05, \text{ } ?p<0.01, \text{ } \textcolor{red}{p}<0.001\).
In this multivariate analysis, although the negative education–blood pressure relation was still present, its magnitude was diminished (Table 3). The effect of these education-related lifestyle variables on the inverse education–blood pressure association is demonstrated in Table 4. The coefficients are expressed as the differences in blood pressure (in mm Hg) associated with 10 more years of education, first when adjusted only for age, and then also for the foregoing lifestyle variables. For the education–systolic blood pressure relation in men, with multivariate adjustment compared with adjustment for age only, the inverse association is reduced by almost one half and is no longer statistically significant. A reduction is also seen with multivariate adjustment among women, but there is still a significant inverse association of years of education and systolic blood pressure. For diastolic pressure, multivariate adjustment reduces the negative association for both sexes, and this association is not statistically significant for either sex.

To determine whether, in repeat analyses, exclusion of the 648 persons on antihypertensive medication introduced bias, their educational level was compared with the remaining 8,477. The age-adjusted difference in years of education in the treated versus untreated men and women was less than one third year (not significant) (data not shown).

**Discussion**

INTERSALT, based on a large population sample from 29 countries, found higher blood pressure for those with less education in a variety of social settings, including both highly industrialized and less industrialized populations. A key finding is that close to one half of the education-related differences in blood pressure can be explained by differences in lifestyle, particularly in nutrition and nutrition-related factors, along the gradient of educational level. Those with fewer years of education had, on average, higher intake of sodium, lower intake of potassium, greater body mass, and higher alcohol consumption. These factors help explain differences in blood pressure related to years of educa-

### Table 2. Partial Correlation Coefficients Between Lifestyle Variables and Years of Education, Age-Adjusted

<table>
<thead>
<tr>
<th>Variable</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass index (kg/m²)</td>
<td>-0.036*</td>
<td>-0.137†</td>
</tr>
<tr>
<td>24-hr sodium excretion (mmol)</td>
<td>-0.037*</td>
<td>-0.068†</td>
</tr>
<tr>
<td>24-hr potassium excretion (mmol)</td>
<td>0.041†</td>
<td>0.030</td>
</tr>
<tr>
<td>Cigarette smoking (1=smoker, 0=nonsmoker)</td>
<td>-0.116†</td>
<td>-0.062†</td>
</tr>
<tr>
<td>Alcohol (milliliters per week)</td>
<td>-0.066†</td>
<td>0.036*</td>
</tr>
</tbody>
</table>

* p<0.05, † p<0.001.

(nine of them significant) and nine having positive regression coefficients (two significant). The combined studywide coefficient (−0.45, with 95% CI from −0.59 to −0.31) indicates that for each additional year of education, systolic pressure in women was 0.45 mm Hg lower. When women currently on antihypertensive medication were excluded, this coefficient was reduced (to −0.32) but remained significant (p<0.01). There was also an inverse association between years of education and diastolic pressure; this association was weaker than for systolic pressure.

Education was also found to be associated with several other variables previously reported in INTERSALT and in other studies to be related significantly to blood pressure: body mass, alcohol intake, 24-hour urinary sodium, and (inversely) potassium excretion. In the present age-adjusted analysis (Table 2), it was found that the higher the education, the lower the sodium excretion, body mass index, and alcohol intake (in men) and the higher the potassium excretion. These findings therefore made it important to determine the degree to which these lifestyle factors accounted for the inverse education–blood pressure association. The regression analyses were repeated with control not only for age but also for 24-hour urinary excretion of sodium and potassium, for body mass index, and for reported alcohol intake. To remove its possible confounding effect, smoking was also included in the multivariate analysis, since it too is related to education (inversely) (Table 2).

### Table 3. Multivariate Regression of Blood Pressure on Years of Education in INTERSALT: Within Centers and Combined for 47 Centers, by Sex

<table>
<thead>
<tr>
<th>Centers and coefficients</th>
<th>Systolic BP</th>
<th>Diastolic BP</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>Centers with negative coefficient (No.)</td>
<td>27</td>
<td>33</td>
</tr>
<tr>
<td>Centers with p&lt;0.05 (No.)</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Centers with positive coefficient (No.)</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>Centers with p&lt;0.05 (No.)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Pooled coefficient</td>
<td>-0.069</td>
<td>-0.289</td>
</tr>
<tr>
<td>(standard error)</td>
<td>(0.062)</td>
<td>(0.073)</td>
</tr>
<tr>
<td>z=</td>
<td>-1.10</td>
<td>-3.97*</td>
</tr>
<tr>
<td>Pooled coefficient, excluding persons on antihypertensive therapy</td>
<td>-0.050</td>
<td>-0.191</td>
</tr>
<tr>
<td>(standard error)</td>
<td>(0.061)</td>
<td>(0.073)</td>
</tr>
<tr>
<td>z=</td>
<td>-0.82</td>
<td>-2.62†</td>
</tr>
</tbody>
</table>

Analysis was adjusted for age, body mass index, 24-hour excretion of sodium and potassium, smoking, and alcohol intake. Values for coefficients and standard errors are millimeters of mercury per year of education. BP, blood pressure.

† p<0.01, * p<0.001.
verse education–blood pressure association may lie with psychosocial factors not measured in the study but related to these. It is also possible that other factors (e.g., nutritional, social) could narrow to some degree the education-related blood pressure differences. Long-term population studies have demonstrated that differences in average population systolic pressure predicts a 4–6% lower cardiovascular risk.

Multivariate analyses are adjusted for age, body mass index, 24-hour excretion of sodium and potassium, smoking, alcohol intake. Values for differences and standard errors are millimeters of mercury per 10 years of education (standard error of the difference). BP, blood pressure; SE, standard error of the difference.

*p<0.05, *p<0.01, tp<0.001.

### Acknowledgments

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References

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