The Relationship of Education to Blood Pressure

Findings on 40,000 Employed Chicagoans

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RICHARD B. SHEKELLE, PH.D., AND JAMES SCHOENBERGER, M.D.

SUMMARY The relationship of education to both actual blood pressure and the prevalence of high blood pressure, based on a systolic pressure of 160 mm Hg or greater or a diastolic pressure of 95 mm Hg or greater, was analyzed among 27,033 men and women, white and black, age 25-44 and 45-64, from the Chicago Heart Association Detection Project in Industry. The educational status of each individual was categorized as not a high school graduate, high school graduate, some college, or college graduate. A statistically significant inverse association between education and high blood pressure was present in all groups of whites. This association could not be "accounted for" by differences in age, relative weight, and heart rate among the educational strata. Controlling for these variables did, however, lessen the association. Among black males a significant inverse association between education level and blood pressure was found for the younger group. For the older black males there was a clear inverse association although with the small numbers it did not achieve statistical significance. For black females there was no clear association.

THE EPIDEMIOLOGY OF HYPERTENSION and the correlates and risk factors for hypertension have been studied extensively. Factors examined as potential risk factors and correlates have included not only biological variables such as age, relative weight, heart rate, uric acid, plasma glucose, and serum cholesterol, but psychosocial and environmental factors as well.1-4 Studies that have investigated the relationship between education and hypertension have generally found a negative association — those with the greatest education have the lowest prevalence of hypertension and the lowest mortality rates from hypertensive disease.5-11 Only one of the studies in this country has examined this association with variables other than age or sex and race controlled. The current study examines both systolic and diastolic blood pressure by level of education among 27,033 screenees from the Chicago Heart Association Detection Project in Industry, controlling not only for age, but for relative weight* and heart rate as well. This relationship is examined among men and women, white and black, ages 25-64.

Methods

From the fall of 1967 until early 1973, the Chicago Heart Association Detection Project in Industry screened 39,665 young adult and middle-aged men and women, both white and black, employed by almost 100 firms in the greater Chicago area. The total labor force among these companies and institutions was about 80,000 persons. Thus, the volunteer rate for this screening effort was about 50%. In all facilities, all employees were encouraged to participate irrespective of type of job or shift worked.

Of the total group screened, 32,106 were whites or blacks in the age range 25-64; 28,606 of these men and women had complete data on the variables considered in this study. Of this group 1,573 were on hypertensive treatment at the time of screening and have therefore been excluded from the analysis. The remaining 27,033 (14,976 white males, 9,716 white females, 1,087 black males, 1,254 black females) are the subjects of this report.

At each site of employment the standardized tests were administered by two specially trained four-person teams of nurses and technicians. They included a self-administered questionnaire to collect demographic data and information about smoking habits; previous medical diagnoses; current treatment for chronic diseases; measurement of height and weight; a single casual supine blood pressure reading (standard mercury sphygmomanometer, fifth phase diastolic pressure); and venipuncture for determination of serum cholesterol and uric acid, and plasma glucose 1-hour after a 50 g oral load of glucose.

For purposes of analysis, each screenee was categorized by level of education into one of four groups: 1) not a high school graduate; 2) high school graduate; 3) some college; and 4) college graduate. The blood pressure comparisons among these four groups were based on actual blood pressure level, for both systolic and diastolic blood pressure, and on the presence or absence of high blood pressure based on a systolic reading of 160 mm Hg or greater or a diastolic reading of 95 mm Hg or greater. For each of eight age-sex-race groups, (i) white males 25-44, (ii) white males 45-64, (iii) white females 25-44, (iv) white females 45-64, (v) black males 25-44, (vi) black males 45-64, (vii) black females 25-44, and (viii) black females 45-64, the relationship between education and blood pressure was analyzed utilizing both mean blood pressure by education category and percent with high blood pressure by education category. The principal statistical methods were \( \chi^2 \) tests and analyses of variance and covariance.

*Relative weight is the ratio of actual weight to desirable weight \( \times 100 \), where desirable weight is the midpoint of the range of weight for an individual with a medium build, as computed from tables published by the Metropolitan Life Insurance Company.19

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Data from the Chicago Heart Association Detection Project in Industry.

This research has been supported by the Chicago Heart Association, the Illinois Regional Medical Program, and the National Heart and Lung Institute, National Institutes of Health, United States Public Health Service.

During the period of this work Dr. Dyer was an Established Investigator of the American Heart Association.

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Received December 8, 1975; revision accepted for publication June 11, 1976.
TABLE 1. Percent with High Blood Pressure (SBP ≥ 160 or DBP ≥ 95) by Level of Education—Whites and Blacks—Chicago Heart Association Detection Project in Industry—1967–1973—Excluding Hypertensives on Treatment

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Educ</th>
<th>White Males</th>
<th>White Females</th>
<th>Black Males</th>
<th>Black Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>25–44</td>
<td>1†</td>
<td>1005</td>
<td>18.4</td>
<td>611</td>
<td>8.8</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2655</td>
<td>14.5</td>
<td>2042</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1713</td>
<td>12.8</td>
<td>653</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>3536</td>
<td>10.5</td>
<td>831</td>
<td>3.7</td>
</tr>
<tr>
<td>x²</td>
<td></td>
<td>49.68***</td>
<td>20.59***</td>
<td>8.78*</td>
<td>4.02</td>
</tr>
<tr>
<td>45–64</td>
<td>1</td>
<td>1783</td>
<td>32.9</td>
<td>1794</td>
<td>23.7</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2038</td>
<td>31.2</td>
<td>2605</td>
<td>19.8</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>980</td>
<td>26.9</td>
<td>722</td>
<td>15.1</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1266</td>
<td>19.7</td>
<td>458</td>
<td>15.1</td>
</tr>
<tr>
<td>x²</td>
<td></td>
<td>73.85***</td>
<td>33.50***</td>
<td>4.67</td>
<td>1.11</td>
</tr>
</tbody>
</table>

*P <0.05
**P <0.01
***P <0.005
† not a high school graduate; 2 = high school graduate; 3 = some college; 4 = college graduate.

Results

Univariate Findings

Table 1 gives the percentages of individuals with high blood pressure by education category for the four groups of whites and blacks, based on a systolic pressure of 160 mm Hg or greater or a diastolic pressure of 95 mm Hg or greater. The x² test statistic for a test of the hypothesis that there is no difference in percent with high blood pressure among the four education categories is also presented. In all four age-sex groups of whites those with the least education have the highest percentage of high blood pressure. Among the white men the lowest prevalence of high blood pressure is among those who graduated from college. For white women, the lowest prevalence of high blood pressure also occurs among the college graduates. For all four groups of whites the differences among strata are statistically significant with P < 0.005. Thus, for whites the prevalence of high blood pressure appears to decrease with increasing education.

For the blacks the results are less definitive than for the whites, due to the substantially smaller numbers of blacks studied. The only statistically significant results are those for the black males 25–44. For this group of men the highest prevalence of high blood pressure is again among those in the lowest education category, with the lowest prevalence occurring in the highest education category. The data for the older black men also show an inverse association between high blood pressure and education, although the results are not statistically significant. For neither cohort of black women is there a significant association between high blood pressure and education.

Table 2 presents the mean systolic and diastolic blood pressures by education category for the whites and blacks along with the F-statistic results from testing the hypothesis of equal means among educational strata. For the four white age-sex groups the differences in mean systolic and diastolic blood pressure among the educational strata are statistically significant (P < 0.005). Mean systolic pressure decreases in all four groups with increasing education, while mean diastolic pressure decreases with increasing education for all but the group of older women, where the lowest mean pressure occurs among those with some college, rather than among the college graduates. The difference in mean diastolic pressure for these two categories in this group is, however, slight.

For the blacks, the younger group of men shows a significant inverse association between blood pressure and educational level. The differences in the means between the highest and lowest education categories for this group of blacks are similar to those for whites of the same age. For the older black men, although an inverse association between blood pressure and education is present, the highest mean pressures occur among the high school graduates, rather than among the least educated stratum. The differ-

TABLE 2. Mean Systolic and Diastolic Blood Pressure by Level of Education—Whites and Blacks

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Educ</th>
<th>White males</th>
<th>White females</th>
<th>Black males</th>
<th>Black females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>Mean SBP</td>
<td>Mean DBP</td>
<td>N</td>
</tr>
<tr>
<td>25–44</td>
<td>1</td>
<td>1005</td>
<td>138.3</td>
<td>81.7</td>
<td>611</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2655</td>
<td>136.0</td>
<td>80.0</td>
<td>2042</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1713</td>
<td>134.5</td>
<td>79.4</td>
<td>653</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>3536</td>
<td>132.8</td>
<td>78.0</td>
<td>831</td>
</tr>
<tr>
<td>F</td>
<td></td>
<td>41.31***</td>
<td>39.52***</td>
<td>21.72***</td>
<td>31.80***</td>
</tr>
<tr>
<td>45–64</td>
<td>1</td>
<td>1783</td>
<td>146.5</td>
<td>85.4</td>
<td>1794</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2038</td>
<td>144.6</td>
<td>85.1</td>
<td>2605</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>980</td>
<td>142.7</td>
<td>84.6</td>
<td>722</td>
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<tr>
<td></td>
<td>4</td>
<td>1266</td>
<td>137.3</td>
<td>82.1</td>
<td>438</td>
</tr>
<tr>
<td>F</td>
<td></td>
<td>54.52***</td>
<td>22.87***</td>
<td>25.04***</td>
<td>10.95***</td>
</tr>
</tbody>
</table>
ences between these two strata are, however, small. None of these results are statistically significant, given the small numbers in this group. For the black women no consistent association between actual blood pressure and education level can be noted.

**Multivariate Findings**

Other variables such as age, relative weight, and heart rate, which are now known to be related to the prevalence of hypertension,\(^4\) may confound these univariate analyses, if these variables are also inversely associated with education. Table 3 presents the means for age, relative weight, and heart rate by education category for the whites and blacks, respectively, along with the appropriate F-statistic.

For the whites, each of these three variables shows a significant inverse association with level of education. The gradient for relative weight is particularly marked for the younger women, while heart rate shows a large gradient for the younger men. Because blood pressure tends to increase with age, the differences in age among educational strata have practical import only insofar as they may account for the significant inverse association between blood pressure and education, whereas the findings with respect to heart rate and education and relative weight and education are additionally important in their own right.

For the blacks, the only important associations between these three variables and education are the inverse associations with age and heart rate in the younger black men, and the high relative weights among those with the least education in the two groups of black women.

The data in this table highlights the need for an analysis of the association between blood pressure and education with these other variables controlled. That analysis is presented below.

Table 4 presents the adjusted percentages with high blood pressure from the analysis of covariance and the ensuing multiple classification analysis for the four groups in both races. Three analyses of covariance were performed for each age-sex group, one with age as a covariate, a second with age and relative weight as covariates, and a third with age, relative weight, and heart rate as covariates. Three separate analyses were performed so that the relationship between high blood pressure and education might be examined with only age controlled, as was the procedure in most other studies, and with relative weight in addition to age controlled.

When the rates of high blood pressure are adjusted for age differences among the education categories, the significant inverse association between high blood pressure and education persists in all four groups of whites, with the association remaining significant with \(P < 0.005\) in three of the four groups. When the percentages of high blood pressure are further adjusted for differential relative weights among the education categories, the differences in percent with high blood pressure decrease but continue to be statistically significant for all groups but women 25–44. The addition of

### Table 3. Mean Age, Relative Weight, and Heart Rate by Level of Education—Whites and Blacks

<table>
<thead>
<tr>
<th>Age group</th>
<th>Education</th>
<th>White males</th>
<th>White females</th>
<th>Black males</th>
<th>Black females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Age (in years)</td>
<td>Relative Weight</td>
<td>Heart Rate (in beats per minute)</td>
<td>Age (in years)</td>
</tr>
<tr>
<td>25–44</td>
<td></td>
<td>35.7</td>
<td>121.5</td>
<td>79.6</td>
<td>35.2</td>
</tr>
<tr>
<td>45–64</td>
<td></td>
<td>54.2</td>
<td>124.9</td>
<td>77.8</td>
<td>53.1</td>
</tr>
</tbody>
</table>

*\(p < 0.05\)

**Table 4. Percent with High Blood Pressure by Level of Education, Adjusted for other Variables—Whites and Blacks**

<table>
<thead>
<tr>
<th>Age group</th>
<th>Education</th>
<th>White males</th>
<th>White females</th>
<th>Black males</th>
<th>Black females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Age (in years)</td>
<td>Relative Weight</td>
<td>Heart Rate (in beats per minute)</td>
<td>Age (in years)</td>
</tr>
<tr>
<td>25–44</td>
<td></td>
<td>17.6</td>
<td>17.3</td>
<td>15.6</td>
<td>8.0</td>
</tr>
<tr>
<td>45–64</td>
<td></td>
<td>31.7</td>
<td>31.0</td>
<td>29.7</td>
<td>22.3</td>
</tr>
</tbody>
</table>

*\(p < 0.005\)

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heart rate further reduces the differences among the four educational strata. Controlling for heart rate and relative weight "accounts for" 51% of the remaining difference in percent with high blood pressure between the highest and lowest education categories for the younger men, 100% for the younger women, 50% for the older men, and 63% for the older women, after controlling for the age differentials among the categories. Although controlling for age and in addition relative weight and heart rate substantially reduces the differences in percent with high blood pressure between the highest and lowest education categories, the overall differences among the four educational strata remain statistically significant for three of the four groups.

In the four groups of blacks, the only significant univariate association between high blood pressure and education occurred among the younger black men (table 1). In the analyses of covariance, this significant association did not persist when adjustment for age differentials among the educational strata was made. Although none of the results from the analyses of covariance are statistically significant for any of the groups of blacks, in both groups of black males, an inverse relationship between high blood pressure and education is clearly present, regardless of the set of adjusting variables. The fact that these associations are not statistically significant may be due to small numbers, rather than to the lack of a real association. If the magnitude of the differences are real, they represent an important biological phenomenon. No association between blood pressure and education can be noted among the black women of either age group. For the younger black men, controlling for heart rate and relative weight "accounts for" 17% of the difference between the highest and lowest education categories after controlling for age differentials. For the older black men the difference between these two education categories actually increases when heart rate and relative weight are included.

An important finding in table 4 is the similarity of the relative increase in the age-adjusted prevalence of high blood pressure between the highest and lowest education categories for the four groups of whites and the two groups of black males. The increased prevalence for the least educated when compared to the best educated is, in white males 25-44, 63%; white males 45-64, 54%; white females 25-44, 70%, white females 45-64, 47%; black males 25-44, 70%; and black males 45-64, 43%. Although the overall rate of high blood pressure differs substantially in these six groups, the relative effect of low education versus high education is remarkably consistent among these six groups. Among the whites better than half of this increased prevalence among the least educated is explainable by differences in relative weight and heart rate. Among blacks very little of this increase is explainable by differences in these two variables. Although the findings among the black males are not statistically significant, a result that may be due to the small numbers, the comparability of the differences among whites and blacks represents an important finding.

Analyses using the four blood pressure cut points, systolic $\geq 160$, systolic $\geq 140$, diastolic $\geq 95$, and diastolic $\geq 90$, were also performed on these data. The results were similar to those presented utilizing percent with high blood pressure, and are therefore not presented in detail. For the whites, although adjusting mean systolic and diastolic blood pressures for differences among education categories in age, relative weight, and heart rate substantially reduced the differences in the mean pressures among the categories, the differences remained statistically significant, although sometimes small. For the black males the differences in mean pressures among education categories were larger than those for the whites of the same age but were generally not statistically significant.

**Discussion**

Results of this study indicate that blood pressure is inversely related to education level in young adult and middle-aged white American men and women, and that this association persists when the data are adjusted for age, relative weight, and heart rate. These data also suggest that education may be inversely related to blood pressure among both young adult and middle-aged black males. The National Health Examination Survey in its 1960-62 sample found a trend toward lower prevalence of hypertension with increasing education, especially for white women. The only variable controlled in this analysis was age. The NHES also found in white children 6–11 years old a weak but significant association between blood pressure and parental education. The Framingham Study found that for men and women age 30–59 the mean systolic blood pressure of the most highly educated group in each of the three decades of age was less than that of the less well educated. The greatest differences were observed in the upper two decades (7 mm Hg in men and 12 mm Hg in women). The differences were statistically significant; no other possibly confounding factors were controlled. Data from the Chicago Peoples Gas Company study for men age 40–59 also suggest that men with the greatest education tend to have lower blood pressures than men with less education. Again, no other variables were controlled. The Hypertension Detection and Followup Program (HDFP) examined the relationship between hypertension and education in whites and blacks age 30–69. An inverse association between hypertension and education was found for both whites and blacks, males and females. It tended to persist after stratifying both for age and relative weight, although the relationship was stronger among the younger ages than the older. A further conclusion from the HDFP study was that differences in socio-economic status as measured by level of education could not explain the differences in the prevalence rates of hypertension between blacks and whites. Hauser and Kitagawa in a study on differential mortality based on a matching of death certificates to the 1960 population census schedules found among males and females age 25–64 decreasing mortality from hypertensive heart disease with increasing education. In contrast to these U.S. findings, in a study of 10,000 Israeli men age 40–60, multiple regression analysis showed no association between systolic blood pressure and years of education. A large number of variables were controlled in this analysis. Thus, the present findings are in agreement with the results of other U.S. studies suggesting an inverse association between level of education and blood pressure. This report both documents and quantitates this association while
controlling for three other variables known to be related to blood pressure, i.e., age, relative weight, and heart rate. When differences among education categories are adjusted for age, for all four white age-sex groups, there is a significant inverse association between the prevalence of high blood pressure and level of education. Those with the least education have from 47% to 70% more high blood pressure than those with the most education.

For both groups of black males, when differences among education categories are adjusted for age, there is a clear inverse association between blood pressure and education, but this association is not statistically significant, given the small numbers of blacks. The relative differences in the rates of high blood pressure for the lowest and highest education groups are comparable to the statistically significant results in the whites.

Because relative weight is known to be positively related to the development of hypertension, and because relative weight is also inversely related to education among the study group, analyses controlling for relative weight differences among the education categories were also performed. For the white females, the association that remains is no longer very large or important, the results among the older women being significant based on the sheer size of the numbers. Among white males, the sizes of the differences among the strata that remain are both statistically significant and important.

Heart rate has also been shown to be strongly related to blood pressure. However, it is unclear whether there is any cause-and-effect relationship, or whether the association is the result of a common influence on both (e.g., adrenergic activity). The finding that adjustment for heart rate further diminished blood pressure differences in educational strata should therefore be viewed with caution.

For the blacks, none of the results in the four groups were statistically significant when adjusted for all three variables. However, among the black males little of the important inverse association that remained after controlling for age could be “accounted for” by differences in relative weight and heart rate. Thus, for black males the differences remain biologically important, although not statistically significant, given the small numbers. For the black women the results remained inconsistent and inconclusive.

Hypertension is one of the three major risk factors for the atherosclerotic diseases. Therefore, it is reasonable to hypothesize that differences among educational strata in blood pressure and in the rate of high blood pressure will be paralleled by differences in the incidence and mortality rates from the atherosclerotic diseases. In this regard, Hauser and Kitagawa found for both white males and white females, age 25–64, decreasing cardiovascular mortality with increasing education. They also found for both whites and blacks, male and female, an inverse association between all causes of mortality and education. The only variable controlled in these analyses was age. In a five year study of male employees age 30–59 in the Bell System Operating Companies it was found that those categorized as high with respect to education had a significantly lower incidence of coronary heart disease (CHD) than those categorized low with respect to education. In this analysis no other variables were controlled. The Western Collaborative Group Study found a significant inverse association between level of education and CHD incidence among men 30–59. Men with a high school education or less had a significantly higher rate of coronary heart disease than those with more education. No other variables were controlled in this analysis. A study among whites and blacks based on cross-sectional data from Evans County, Georgia, showed that those with the most education had the highest prevalence of CHD, a finding directly opposite to those presented above. Again no other variables were controlled. Shekelle, Ostfield, and Paul, in a study of an industrial population in Chicago, found a significant inverse association between educational status and incidence of CHD among men age 40–57.

Educational status in this study was also a measure of social status since the coding on education also included the status of the schools attended. Although no other variables were controlled in this analysis, the authors did examine the means of several other variables by education category, and found that both systolic and diastolic blood pressure and relative weight were significantly different for the different strata. As educational status decreased, both systolic and diastolic blood pressure tended to increase.

Although these studies tend to indicate that education is related to the incidence of coronary heart disease, they do not answer the question as to whether or not education is independently related, i.e., apart from an association with other known cardiovascular risk factors. This point is particularly important in view of the large differences both in heart rate for white males by level of education and in relative weight for white females by level of education in the present study. The differences in blood pressure, heart rate, and relative weight by level of education found in the present study and elsewhere might well “explain” the previous findings suggesting an association between heart disease and low educational status. At the very least the differences should be much smaller when these other variables are controlled.

Although controlling for relative weight and heart rate did not completely eliminate the differences in blood pressure among the various educational strata, the inclusion of additional variables might eliminate such differences. An analysis was performed on these data with somewhat smaller numbers controlling for uric acid and plasma glucose in addition to the other three variables with similar findings. The differences among the educational strata continued to persist.

A further and more difficult question that cannot be answered by this study is the why of the inverse association between blood pressure and education. On a priori grounds there does not seem to be any reason for this finding, although as Fuchs indicates, the less educated tend to have more health problems generally than the better educated. What is the mechanism between blood pressure and education? Two possible and testable answers to this question are diet and factors which affect the central nervous system. For example, with respect to diet, do the less educated tend to have higher salt intakes than the better educated? While these and other explanations may be valid, at this time the mechanism that causes hypertension to be inversely related to education remains to be discovered.
Acknowledgment

It is a pleasure to express appreciation to the many Chicago companies and organizations giving invaluable cooperation in this effort. Acknowledgment is also gratefully extended to all those involved in the Chicago Heart Association Detection Project in Industry: Louis deBoer, Executive Director, and Kay Westfall, Program Director; the Chicago Heart Association Detection Project in Industry Staff: Pamela Beaumont, Thelma Black, Clarice Blanton, Joan Carothers, Arlene Dunca, Mary Ann Foelker, Susan Forkos, Carol Fulgenzi, Harold Gram, Jean Graver, Inger Hansen, Cherry Latimer, Karen Streintz, R.N. and Suzann Ward, R.N.; also to volunteer members of the Heart Disease Detection Committee of the Chicago Heart Association and its Subcommittees: Howard Adler, Ph.D., Rene Arcilla, M.D., Robert Arzoecher, Ph.D., Richard A. Carleton, M.D., Angelo Cottini, Edwin Duffin, Ph.D., Morton B. Epstein, Ph.D., Robert E. Fitzgerald, M.D., Philip Freedman, M.D., Burton J. Grossman, M.D., Mark M. Lepper, M.D., Robert R. J. Hilker, M.D., Robert S. Kassriel, M.D., Howard A. Lindberg, M.D., Clinton L. Lindo, M.D., Gerald Masek, Ph.D., Richard McNamara, Robert A. Miller, M.D., Robert Mosley, Jr., M.D., Milton H. Paul, M.D., Willie Reedus, R.N., Raymond Restivo, Wallace Salzman, M.D., Robert Sessions, Howard H. Sky-Peck, Ph.D., Donald Singer, M.D., Lachichida Sinha, M.D., Grace Smestad, Ralph Springer, J. Martin Stoker, M.D., Carl Vogel, Ira T. Whipple, M.S., Quentin D. Young, M.D.; also to the Chicago Board of Health and the Chicago Health Research Foundation for the research laboratory facilities, and Ika Tomaszewsky who was directly responsible for the laboratory analyses.

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The relationship of education to blood pressure: findings on 40,000 employed Chicagoans.
A R Dyer, J Stamler, R B Shekelle and J Schoenberger

Circulation. 1976;54:987-992
doi: 10.1161/01.CIR.54.6.987

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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