Hypertension in Rural India: The Contribution of Socioeconomic Position

Amanda G. Thrift, BSc(Hons), PhD; Rathina Srinivasa Ragavan, BBiomedSc(Hons); Michaela A. Riddell, BA(Sci), Biostats, PhD; Rohina Joshi, MBBS, MPH, PhD; K. R. Thankappan, MD, PhD; Clara Chow, MBBS, PhD; Brian Oldenburg, BSc, MSc, PhD; Ajay S. Mahal, MA, MPhil, PhD; Kartik Kalyanram, MBBS, MD; Kamakshi Kartik, MBBS, MD; Oduru Suresh, BSc, MSc, PostGradDipClinRes; G. K. Mini, PhD; Jordan Ismail, BSc(Hons); Dilan Giguruwa Gamage, MBBS(Hons), BMEdSc(Hons); Aniqa Hasan, BSc(Hons); Velandai K. Srikanth, MBBS, PhD; Nihal Thomas, MBBS, MD, PhD; Pallab K. Maulik, MD, PhD, MSc; Rama K. Guggilla, MBBS, MMed; Roger G. Evans, BSc(Hons), PhD

Background—Various indicators of socioeconomic position (SEP) may have opposing effects on the risk of hypertension in disadvantaged settings. For example, high income may reflect sedentary employment, whereas greater education may promote healthy lifestyle choices. We assessed whether education modifies the association between income and hypertension in 3 regions of South India at different stages of epidemiological transition.

Methods and Results—Using a cross-sectional design, we randomly selected villages within each of rural Trivandrum, West Godavari, and Rishi Valley. Sampling was stratified by age group and sex. We measured blood pressure and anthropometry and administered a questionnaire to identify lifestyle factors and SEP, including education, literacy, and income. Logistic regression was used to assess associations between various components of SEP and hypertension, and interaction analyses were used to determine whether educational attainment modified the association between income and hypertension. Trivandrum, the region of highest SEP, had the greatest prevalence of hypertension, whereas Rishi Valley, the lowest SEP region, had the least. Overall, greater income was associated with greater risk of hypertension. In interaction analyses, there was no evidence that educational attainment modified the association between income and hypertension.

Conclusions—Education is widely considered to ameliorate the risk of hypertension in high-income countries. Why this effect is absent in rural India merits investigation. (J Am Heart Assoc. 2020;9:e014486. DOI: 10.1161/JAHA.119.014486.)

Key Words: education • lifestyle • low-to-middle income • risk factors • socioeconomic position

Recently, the prevalence of hypertension in low- to middle-income countries has been estimated to exceed that in high-income countries (HICs). Socioeconomic position (SEP), generally measured using indicators such as education, income, and occupation, is strongly associated with the presence of hypertension in HICs, with individuals of higher SEP less likely to have hypertension than those of lower SEP. The association between SEP and hypertension in HICs may be attributable to a greater awareness of hypertension and associated risk factors in those with high SEP, and greater...
Clinical Perspective

What Is New?

• We found that the risk of hypertension was positively associated with higher socioeconomic position (SEP) in rural India.
• We also found that modifiable risk factors, such as greater adiposity, may collectively mediate the increased risk of hypertension in individuals from higher socioeconomic backgrounds.

What Are the Clinical Implications?

• Health education and prevention strategies that are targeted at those who are at high risk of hypertension, such as retirees and older unemployed people, may provide an important means to reduce the emergence of hypertension in rural India.

Study Region

The 3 study regions have differing levels of educational attainment, income, and occupations. A rural region in the northern part of the District of Trivandrum (herein referred to as Trivandrum) in Kerala is the most socioeconomically advanced region, West Godavari District (herein referred to as Godavari) in Northern Andhra Pradesh is less advanced, and Rishi Valley region (Chittoor District) in Southern Andhra Pradesh is the least socioeconomically advanced (Data S1).

Study Design

Villages (clusters) were randomly selected within Rishi Valley, Godavari, and Trivandrum for inclusion. This involved dividing each of the 3 sites into primary sampling units (villages, wards, or hamlets) by computer-generated random selection. In each primary sampling unit, a full list of residents was obtained and then individuals were sampled into 12 categories by age (18–24, 25–34, 35–44, 45–54, 55–64, and ≥65 years) and sex. In an effort to reduce bias, eligible participants were revisited when unavailable on the first or second visit to the village. Using this method, 11,657 participants were recruited between January 2014 and December 2015 (Figure 1).

Our sample size was based on outcomes for a cluster randomized controlled trial (registered with the Clinical Trials Registry–India, CTRI/2016/02/006678), nested within this cross-sectional study. This meant that the sample size was larger than required for the primary hypothesis outlined in our Introduction. For example, estimating that 20% of people would have completed high school, and 25% of people would have hypertension, provides adequate power (99%) to detect a difference between groups in those completing high school of as little as 4.1%.

Ethics

This project was approved by each institutional ethics committee (Data S1) and the Health Ministry’s Screening Committee of the Government of India (58/4/1F/CHR/2013/NCD II). Written informed consent was obtained from all participants before inclusion.

Training

To ensure standardization, all field workers and supervisors were trained to measure anthropometric parameters and blood pressure (BP) and administer questionnaires, according to the World Health Organization STEPwise Approach to Surveillance protocol. Follow-up training occurred
1 month after initial training to ensure consistency in data collection within and between sites.

Clinical Measurements

Clinical measurements were made during the working day, mostly in the morning. Systolic BP (SBP) and diastolic BP were assessed using a digital automatic BP monitor (HEM–907; OMRON, Kyoto, Japan). Before measurement, participants sat quietly for 15 minutes, with legs uncrossed. BP was measured using the right upper arm, resting at the level of the heart, with a 3-minute rest period between readings. At least 3 readings were recorded, with a fourth or fifth measurement taken when the final 2 measurements varied by \( \geq 10 \) mm Hg SBP or \( \geq 6 \) mm Hg diastolic BP. The mean of the last 2 measurements was used to determine BP.

Height was measured to the nearest 0.1 cm using a stadiometer (213; Seca, Hamburg, Germany), and weight to the nearest 0.1 kg using a digital weight scale (9000SV3R; Salter, Kent, UK). Waist circumference was measured horizontally at the midpoint between the iliac crest and the floating rib (after expiration), and hip circumference was measured at the fullest point of the buttocks, using a spring-loaded tension tape (Gulick M-22C; Patterson Medical, IL).

Self-Reported Data

Questionnaires were used to obtain information on lifestyle and SEP, the latter including education and household income. Annual household income in Indian rupees was obtained using a general question about estimated household income, supplemented by specific questions about income from rent of house, land, or equipment, as well as income from inheritance, investments, and gifts. The sum of these measures was then divided by the number of adults in the household to obtain an average individual income. Income was categorized into quartiles, with approximately similar number of participants in each group (Data S1). Participants also reported whether they held ration cards, and the type of ration card held.

Participants self-reported their highest level of education completed and whether they could read and write. Educational attainment was categorized into 4 groups: no formal education, class 1 to 6, class 7 to 11, and completed class 12 or more.

Alcohol intake was recorded according to whether individuals had consumed any alcohol in the previous 30 days. Hypertension was defined as having SBP \( \geq 140 \) mm Hg, diastolic BP \( \geq 90 \) mm Hg, and/or self-reported use of BP-lowering medication. Body mass index (BMI) was categorized as being overweight or obese \( (\geq 23 \text{ kg/m}^2) \) or normal \( (<23 \text{ kg/m}^2) \).\(^{15}\) Waist/hip ratio (WHR) was defined as being above normal when \( \geq 0.8 \) for women and \( \geq 0.9 \) for men. Regularity of physician visits and ease of access to healthcare were also documented (Data S1).

Data Management

Hard copies of the questionnaires were scanned into tagged image files and distributed to the research group digitally. TeleForm Elite Version 9 software (Cardiff, San Jose, CA) was used to capture and verify the data in the tagged image files.
and export the data to a Microsoft Access database. All data were cleaned before analyses (Data S1).

Statistical Analyses

All analyses were performed in Stata (Stata 15.0; College Station, TX). For continuous variables, we report means (SDs). Proportions were calculated for all categorical variables, and are presented as percentages. When variables were missing for a participant, that participant was excluded from any analyses involving that variable.

ANOVA was used to determine whether baseline characteristics of continuous variables differed between regions and by sex. Tukey’s test was applied to determine which regions differed. Student unpaired t test was used to detect whether differences existed between women and men in each of the 3 regions. A Bonferroni correction was applied to protect against increased risk of type 1 error. Differences in categorical variables between regions and sex were analyzed using χ² tests with Bonferroni correction to account for multiple comparisons between and within regions. Two-tailed P values are reported.

Univariable and multivariable logistic regression analyses were used to measure the association between socioeconomic factors and hypertension. Multivariable analyses were initially adjusted for age, with age categorized into 3 groups, each group having approximately one third of the participants with hypertension. We then adjusted for income and education, both of which were dichotomized into the upper and lower 2 groups (as outlined above), to determine whether education modified the association between self-reported income and hypertension. In these analyses, age was included as a continuous variable. To determine the interaction on an additive scale, we further assessed the relative excess risk caused by interaction, the attributable proportion, and the Synergy Index, using the technique described by VanderWeele and Knol.16 We also conducted sensitivity analyses of these associations, stratified by sex, age, and region. We further used logistic regression, adjusted for age and sex, to assess the association between SEP factors and having a WHR and BMI above normal, and consumption of alcohol in the past 30 days, and undertook similar analyses for relative excess risk caused by interaction, attributable proportion, and the Synergy Index as described above.

Results

Among 16 949 people approached, 11 657 (68.8%) agreed to participate. The response rate was greatest in West Godavari (99%), least in Rishi Valley (45%), and intermediate in Trivandrum (77%). There were some differences in those who were recruited. For example, in the Rishi Valley region, the region with the poorest response rate, 30.5% of men aged 18 to 34.9 years agreed to participate, compared with 60.2% of men aged at least 65 years. In this same region, participation was also greater in women (50.3%) than in men (40.7%).

Participants in Trivandrum had a higher SEP, as indicated by the greater proportion of women and men who were able to read or write, and had completed at least class 12, than those in Godavari and Rishi Valley (Table 1). Overall, the proportion of men who could read and write was similar between Godavari and Rishi Valley, whereas women from Rishi Valley had the least educational attainment, with less than one third being able to read or write (Table 1).

The proportion of men with hypertension in Trivandrum was 3.7% greater than in Godavari and 7.9% greater than in Rishi Valley (Table 1). Women followed similar trends to men on mean SBP, and the proportion of people with hypertension (Table 1). A greater proportion of women had hypertension than men in both Godavari and Trivandrum, whereas a lesser proportion had hypertension in Rishi Valley (Table 1).

Residing in the higher SEP regions of Godavari or Trivandrum was associated with greater odds of hypertension than residing in the lowest SEP region, Rishi Valley (Table 2), with or without adjustment for age. This association remained when the analyses were stratified by 3 age groups (Table 2). Greater educational attainment appeared to be associated with lesser odds of hypertension (Table 2). However, people who were older tended to have lesser educational attainment than those who were younger, with age confounding the association between education and hypertension (Figure S1). When adjusted for the confounding effects of age, having some level of educational attainment was associated with greater odds of hypertension compared with having no formal education (Table 2), an association that remained when the analyses were stratified by age group. Compared with agricultural workers, nonagricultural workers were 53% more likely to have hypertension, whereas unemployed participants were 104% more likely to have hypertension, and retirees were 64% more likely to have hypertension. In analyses that were stratified by age group, it appeared that older unemployed people and all age categories of retirees were particularly vulnerable to having hypertension. Those in the highest quartile income bracket had 47% greater odds of hypertension than those in the lowest quartile (Table 2), although there was a large number of missing observations for income, particularly for those in Trivandrum (36.4%), and the characteristics of people with and without details on income were different for all variables (Table S1). The associations between these characteristics and hypertension were largely stronger for women than for men, although directionally similar (Tables S2 and S3).
Table 1. Age, BP, and Socioeconomic Characteristics of Participants in 3 Rural Regions in India, by Sex, 2014 to 2015

| Characteristics          | Rishi Valley | Godavari | Trivandrum | \( P_{\text{region}} \) | \( P_{\text{sex}} \) | \( P_{\text{region} \times \text{sex}} \) |
|--------------------------|-------------|----------|------------|--------------------------|-------------------|----------------------------------|
| **Age, mean (SD), y**    |             |          |            |                          |                   |                                  |
| Women (n=1700)           | 45.7 (16.5) | 44.6 (17.1) | 44.9 (17.5) | 46.2 (17.4)              | 45.8 (18.0)       | 0.001<sup>AC</sup> 0.60 0.54    |
| Men (n=1700)             | 46.2 (16.7) | 47.3 (33.3) | 44.9 (17.5) | 45.8 (18.0)              |                   |                                  |
| **Age group, y**         |             |          |            |                          |                   |                                  |
| 18 to 34.9               | 500 (29.4)  | 752 (33.5) | 739 (33.1)  | 604 (31.7)               | 615 (33.2)        | 0.003<sup>AB</sup> 0.89         |
| 35 to 54.9               | 600 (35.3)  | 744 (33.1) | 749 (33.6)  | 666 (35.0)               | 640 (34.5)        |                                  |
| ≥55                      | 600 (35.3)  | 744 (33.1) | 749 (33.6)  | 666 (35.0)               | 640 (34.5)        |                                  |
| **SBP, mean (SD), mm Hg**|             |          |            |                          |                   |                                  |
| Women (n=1904)           | 119.3 (20.0)<sup>†</sup> | 119.2 (19.7)<sup>†</sup> | 124.6 (17.3) | 127.3 (16.5)             |                   | <0.001<sup>BC</sup> >0.18      |
| Men (n=1853)             | 124.7 (19.3)| 123.2 (20.1)<sup>†</sup> | 127.3 (16.5) |                   |                   |                                  |
| **DBP, mean (SD), mm Hg**|             |          |            |                          |                   |                                  |
| Women (n=1904)           | 72.7 (10.8)<sup>†</sup> | 75.3 (12.0)<sup>†</sup> | 72.8 (11.5)<sup>†</sup> | 74.5 (11.5)       |                   | <0.001<sup>AB</sup> <0.18      |
| Men (n=1853)             | 76.2 (11.9) | 71.7 (11.6)<sup>†</sup> | 74.5 (11.5) |                   |                   |                                  |
| **SBP ≥140 mm Hg or DBP ≥90 mm Hg** | 263 (15.5)<sup>‡</sup> | 351 (15.6)<sup>‡</sup> | 383 (20.1) | 375 (20.3)<sup>‡</sup> |                   | <0.001<sup>BC</sup> 0.002      |
| **Hypertension**         | 365 (21.5)<sup>‡</sup> | 740 (32.9)<sup>‡</sup> | 637 (28.6) | 705 (37.0)<sup>‡</sup> |                   | <0.001<sup>DC</sup> 0.005      |
| **Literacy**             |             |          |            |                          |                   |                                  |
| Ability to read          | 534 (31.9)<sup>‡</sup> | 1102 (65.8)<sup>‡</sup> | 1317 (58.6)<sup>‡</sup> | 1432 (64.3)<sup>‡</sup> | 1656 (87.0)<sup>‡</sup> | 1777 (95.9)<sup>‡</sup> <0.001<sup>DC</sup> <0.001 |
| Ability to write         | 502 (30.0)<sup>‡</sup> | 1040 (62.1)<sup>‡</sup> | 1432 (64.3)<sup>‡</sup> | 1656 (87.0)<sup>‡</sup> | 1777 (95.9)<sup>‡</sup> | 1755 (94.8)<sup>‡</sup> <0.001<sup>DC</sup> <0.001 |
| **Highest level of schooling** | <sup>†</sup> | <sup>‡</sup> | <sup>‡</sup> | <sup>‡</sup> | <sup>‡</sup> | <sup>‡</sup>                                  |
| No formal education      | 853 (53.7)  | 703 (31.4) | 501 (22.5)  | 291 (13.5)               | 107 (5.8)         | <0.001<sup>DC</sup> <0.001      |
| Class 1 to 6             | 319 (20.1)  | 854 (38.2) | 789 (35.5)  | 233 (12.2)               | 283 (15.3)        |                                  |
| Class 7 to 11            | 315 (19.8)  | 535 (23.9) | 559 (25.2)  | 778 (40.9)               | 908 (49.0)        |                                  |
| Class ≥12                | 101 (6.4)   | 146 (6.5)  | 602 (31.6)  | 555 (30.0)               |                   |                                  |
| **Above poverty line or no ration card** | 113 (6.8)<sup>‡</sup> | 233 (10.4) | 209 (9.4)<sup>‡</sup> | 1191 (62.6) | 1111 (60.0)<sup>‡</sup> | <0.001<sup>DC</sup> 0.007      |
| **People in household**  |                   |           |            |                          |                   |                                  |
| Mean (SD)                | 4.4 (3.1)   | 4.6 (3.1)  | 4.0 (2.1)   | 4.4 (1.9)                | 4.4 (1.9)<sup>‡</sup> | <0.001<sup>AC</sup> <0.001 0.07 |
| ≥5 People                | 692 (41.4)  | 620 (27.6) | 636 (30.8)  | 811 (42.6)               | 761 (41.1)<sup>‡</sup> | <0.001<sup>AC</sup> 0.61       |
| **Income per adult per month** | <sup>†</sup> | <sup>‡</sup> | <sup>‡</sup> | <sup>‡</sup> | <sup>‡</sup> | <sup>‡</sup>                                  |
| Quartile 1, Rs 0 to 1000 | 1107 (66.2) | 744 (44.4) | 206 (9.8)   | 301 (13.6)               | 416 (36.9)        | 368 (29.2)<sup>‡</sup> <0.001<sup>DC</sup> <0.001 |
| Quartile 2, Rs >1000 to 1900 | 199 (11.9) | 447 (21.2) | 591 (26.8)  | 252 (22.3)               | 275 (21.8)        |                                  |
| Quartile 3, Rs >1900 to 3000 | 184 (11.0) | 803 (38.1) | 199 (17.6)  | 274 (21.7)               |                   |                                  |
| Quartile 4, Rs >3000     | 182 (10.9)  | 653 (31.0) | 477 (21.6)  | 262 (23.2)               | 344 (27.3)        |                                  |
| **Type of employment**   |             |          |            |                          |                   |                                  |
| Agricultural             | 754 (45.2)  | 411 (18.3) | 1198 (53.7) | 13 (0.7)                 | 200 (10.8)<sup>‡</sup> | <0.001<sup>DC</sup> <0.001      |
| Nonagricultural          | 225 (13.5)  | 224 (10.0) | 758 (34.0)  | 401 (21.1)               | 1220 (66.1)       |                                  |
| Unemployed               | 457 (27.4)  | 1612 (71.7) | 312 (11.7)  | 1176 (61.9)              | 143 (7.7)         |                                  |
| Retired                  | 234 (14.0)  | 138 (8.3)  | 13 (0.6)    | 311 (16.4)               | 284 (15.4)        |                                  |

Continued
Table 1. Continued

| Characteristics                        | Rishi Valley | Godavari | Trivandrum |
|----------------------------------------|-------------|----------|------------|
|                                        | Women (n=1700) | Men (n=1700) | Women (n=2248) | Men (n=2231) | Women (n=1904) | Men (n=1853) | Region | Sex |
| Visits to physician                    |             |          |            |             |               |              |        |     |
| Never                                  | 1135 (67.8) | 1119 (66.8) | 427 (19.0) | 834 (37.4) | 253 (13.3) | 875 (47.3) | <0.001 | D   |
| Regular visits to physician            | 74 (4.4)    | 74 (4.4)    | 225 (10.0) | 154 (6.9)  | 422 (22.2) | 302 (16.3) | <0.001 | D   |
| Irregular, but visited within past year | 285 (17.0) | 283 (16.9) | 1004 (44.7) | 831 (37.3) | 895 (47.0) | 477 (25.8) | <0.001 | D   |
| Not visited in past 1 y                | 179 (10.7) | 199 (11.9) | 591 (26.3) | 409 (18.4) | 334 (17.5) | 198 (10.7) |                |     |
| Self-reported difficulty in accessing health care | 770 (46.0) | 677 (40.4) | 796 (35.5) | 504 (22.6) | 201 (10.6) | 130 (7.0) | <0.001 | D   |

Hypertension refers to those with SBP \( \geq 140 \) mm Hg, DBP \( \geq 90 \) mm Hg, and/or self-reported use of BP-lowering medications. Data are presented as number (percentage) unless otherwise stated. \( P \) values were determined using ANOVA for continuous variables and \( \chi^2 \) test for categorical variables. For continuous variables, if \( P_{\text{region}} \leq 0.05 \), Tukey’s test was used to determine which regions differed at \( P \leq 0.05 \). For categorical variables, \( \chi^2 \) test was used with a Bonferroni correction for multiple comparisons (3 regions). This is shown by subscript (A=Rishi Valley vs Godavari, B=Rishi Valley vs Trivandrum, C=Godavari vs Trivandrum, D=all differ). BP indicates blood pressure; DBP, diastolic BP; Rs, Indian rupee; SBP, systolic BP.

\( P \leq 0.01 \), \( P \leq 0.001 \) for differences in \( P_{\text{region}} \) or \( P_{\text{sex}} \) between men and women, derived using Student unpaired \( t \) test, with Bonferroni correction for specific contrasts in each of the 3 regions. Class \( \geq 12 \) includes individuals who graduated from secondary schooling, completed technical college, or completed university. Income level above the poverty line was assessed using self-reported data for use of a government issued ration card.

† There are 1 to 15 missing observations.
‡ There are 16 to 34 missing observations.
§ There are 123 to 139 missing variables.
¶ There are 212 missing observations.
# There are 592 to 775 missing observations.

The association between income and hypertension was similar when adjusting for age alone, or with an additional adjustment for education (Table S3). This pattern was similar for BMI. However, there was no evidence of an interaction (Table S4). A similar pattern was seen for education, although there may have been a threshold above class 6 education level for trend (Table S5).

The association between income and hypertension was similarly seen when adjusting for age alone, or with an additional adjustment for education (Table S6). This pattern persisted when adjusting for age and education (Table S7). There was no evidence of an interaction (Tables S8, S9), and no pattern was again observed for education modified the association between income and hypertension (Table S10).

The association between education and hypertension was consistent across the 3 regions (Figure S2). Interestingly, there was evidence of an interaction across the 3 regions (Figure S2). Interestingly, education was positively associated with WHR, with each increasing category of educational attainment and income (Figure 2, Table S12). For each increasing category of education and income, there was an increased likelihood of having a WHR above normal (Table S4). This finding appeared similar for men and women (Tables S4, S5, and S14) and were consistent across the 3 regions (Table S15).

The association between income and hypertension was consistent when using the point of 130/80 mm Hg to define hypertension (Table S10), or when stratified by region (Tables S6, S7). With an additional adjustment for region, the odds ratios were reduced toward the null (Table S11).

Similarly, the association between income and hypertension did not appear to be modified by income in the model. When using the cutoff of 130/80 mm Hg for defining hypertension (Table S3, S4, and S5) or when stratified by region (Tables S6, S7), the pattern was similar when using the cutoff of 130/80 mm Hg for defining hypertension (Table S3, S4, and S5) or when stratified by region (Tables S6, S7).
Table 2. Factors Associated With Hypertension in 3 Rural Regions in India, 2014 to 2015: All Ages and Stratified by Age Group

| Characteristics          | Univariable Adjusted for Age | Adjusted for Age |
|--------------------------|------------------------------|------------------|
|                          | All Ages (N=11,652)          | All Ages (N=11,652) | 18 to 34.9 y (N=3716) | 35 to 54.9 y (N=3932) | ≥55 y (N=4004) |
|                          | OR 95% CI P Value            | OR 95% CI P Value | OR 95% CI P Value | OR 95% CI P Value | OR 95% CI P Value |
| Age, y                   | 1.07 1.07 to 1.07 <0.001     |                  |                  |                  |                  |
| Age group, y             |                              |                  |                  |                  |                  |
| 18 to 34.9               | 1.00                         |                  |                  |                  |                  |
| 35 to 54.9               | 5.40 4.65 to 6.28 <0.001     |                  |                  |                  |                  |
| ≥55                      | 17.7 15.3 to 20.5 <0.001     |                  |                  |                  |                  |
| Women*                   | 1.12 1.04 to 1.21 0.005      | 1.18 1.08 to 1.29 <0.001 | 0.58 0.44 to 0.76 <0.001 | 1.18 0.97 to 1.29 0.14 | 1.43 1.26 to 1.62 <0.001 |
| Region                   |                              |                  |                  |                  |                  |
| Rishi Valley             | 1.00                         | 1.00             | 1.00             | 1.00             | 1.00             |
| Godavari                 | 1.49 1.35 to 1.65 <0.001     | 1.75 1.56 to 1.96 <0.001 | 2.08 1.40 to 3.10 <0.001 | 1.92 1.59 to 2.32 <0.001 | 1.58 1.35 to 1.84 <0.001 |
| Trivandrum               | 1.79 1.61 to 1.98 <0.001     | 2.01 1.79 to 2.26 <0.001 | 2.69 1.81 to 4.00 <0.001 | 1.81 1.49 to 2.20 <0.001 | 2.11 1.80 to 2.48 <0.001 |
| Literate: ability to write† | 0.70 0.64 to 0.76 <0.001   | 1.34 1.22 to 1.47 <0.001 | 1.59 1.06 to 2.38 0.03 | 1.24 1.07 to 1.44 0.005 | 1.44 1.27 to 1.63 <0.001 |
| Education‡               |                              |                  |                  |                  |                  |
| No formal education      | 1.00                         | 1.00             | 1.00             | 1.00             | 1.00             |
| Class 1 to 6             | 0.87 0.78 to 0.97 0.01       | 1.20 1.07 to 1.36 0.003 | 1.16 0.56 to 2.42 0.69 | 1.25 1.02 to 1.53 0.03 | 1.17 1.00 to 1.36 0.05 |
| Class 7 to 11            | 0.60 0.53 to 0.66 <0.001     | 1.48 1.30 to 1.67 <0.001 | 1.78 0.91 to 3.47 0.09 | 1.34 1.10 to 1.62 0.003 | 1.58 1.33 to 1.89 <0.001 |
| Class ≥12                | 0.32 0.28 to 0.37 <0.001     | 1.43 1.21 to 1.69 <0.001 | 1.91 0.97 to 3.76 0.06 | 1.31 1.01 to 1.70 0.04 | 2.01 1.46 to 2.77 <0.001 |
| Above poverty line       |                              |                  |                  |                  |                  |
| or no ration card†       | 1.45 1.32 to 1.58 <0.001     | 1.48 1.33 to 1.63 <0.001 | 1.29 0.96 to 1.73 0.09 | 1.31 1.11 to 1.54 0.001 | 1.71 1.48 to 1.99 <0.001 |
| At least 5 people living in household† | 0.87 0.80 to 0.95 0.001 | 0.95 0.86 to 1.04 0.3 | 0.90 0.69 to 1.18 0.44 | 0.97 0.83 to 1.13 0.71 | 1.00 0.88 to 1.15 0.95 |
| Type of employment§      |                              |                  |                  |                  |                  |
| Agricultural             | 1.00                         | 1.00             | 1.00             | 1.00             | 1.00             |
| Nonagricultural          | 0.91 0.81 to 1.02 0.12       | 1.53 1.35 to 1.74 <0.001 | 1.69 1.19 to 2.41 0.003 | 1.53 1.27 to 1.84 <0.001 | 1.51 1.22 to 1.87 <0.001 |
| Unemployed               | 2.14 1.93 to 2.37 <0.001     | 2.04 1.82 to 2.28 <0.001 | 1.21 0.82 to 1.80 0.33 | 2.05 1.71 to 2.44 <0.001 | 2.66 2.26 to 3.15 <0.001 |
| Retired                  | 5.74 4.93 to 6.69 <0.001     | 1.64 1.39 to 1.94 <0.001 | 2.75 0.32 to 23.6 0.36 | 2.08 1.15 to 3.77 0.02 | 2.32 1.91 to 2.81 <0.001 |
| Income per adult per month§ |                      |                  |                  |                  |                  |
| Quartile 1, Rs 0 to 1000 | 1.00                         | 1.00             | 1.00             | 1.00             | 1.00             |
| Quartile 2, Rs >1000 to 1900 | 0.96 0.85 to 1.09 0.6 | 1.22 1.06 to 1.39 0.005 | 1.71 1.11 to 2.64 0.02 | 1.30 1.04 to 1.61 0.02 | 1.01 0.84 to 1.22 0.93 |

Continued
### Table 2. Continued

| Characteristics                  | Univariable Adjusted for Age |
|----------------------------------|-----------------------------|
|                                  | All Ages (N=11,652)         | 18 to 34.9 y (N=3766) | 35 to 54.9 y (N=3932) | ≥55 y (N=4004) |
|                                  | OR 95% CI P Value           | OR 95% CI P Value     | OR 95% CI P Value     | OR 95% CI P Value |
| Quartile 3, Rs >1900 to 3000     | 0.90 0.80 to 1.01 0.08      | 1.23 1.08 to 1.40 0.002 | 1.24 0.80 to 1.90 0.34 | 1.28 1.04 to 1.58 0.002 | 0.98 to 1.41 0.09 |
| Quartile 4, Rs >3000             | 1.03 0.92 to 1.16 0.6       | 1.47 1.29 to 1.69 <0.001 | 1.76 1.16 to 2.65 0.007 | 1.29 1.04 to 1.61 0.02 1.62 1.33 to 1.98 <0.001 |
| Visits to physician †            |                             |                       |                       |                       |
| Never                            | 1.00                        | 1.00                   | 1.00                   | 1.00                   |
| Regular visits to physician      | 15.8 13.6 to 18.3 <0.001    | 8.05 6.68 to 9.44 <0.001 | 3.07 1.51 to 6.25 0.002 | 8.41 6.45 to 11.0 <0.001 8.10 6.52 to 10.1 <0.001 |
| Irregular, but visited within past year | 3.55 3.19 to 3.94 <0.001 2.61 2.33 to 2.92 <0.001 1.79 1.31 to 2.44 <0.001 2.61 2.17 to 3.16 <0.001 2.74 2.32 to 3.24 <0.001 |
| Not visited in past 1 y          | 1.91 1.67 to 2.18 <0.001    | 1.55 1.34 to 1.79 <0.001 1.56 1.09 to 2.23 0.02 1.66 1.31 to 2.10 <0.001 1.44 1.17 to 1.77 0.001 |
| Self-reported difficulty in accessing health care ‡ | 1.01 0.93 to 1.11 0.79 0.87 0.79 to 0.97 0.01 0.76 0.55 to 1.07 0.11 1.03 0.87 to 1.21 0.74 0.81 0.71 to 0.93 0.003 |

Data are presented as odds ratio (95% CI). P values were generated using univariable and multivariable logistic regression. Hypertension is defined as a systolic blood pressure ≥140 mm Hg, a diastolic blood pressure ≥90 mm Hg, and/or taking blood pressure–lowering medication(s). Difficulty in accessing health care was defined as those reporting that access was fairly difficult or very difficult. Unemployed includes homemakers. Retired includes retirees and pensioners, regardless of whether they still report undertaking some agricultural activities. Nonagricultural indicates all forms of employment unrelated to agricultural work. N=11,652. OR indicates odds ratio; Rs, Indian rupee.

*There are 21 missing observations.
†There are 53 to 55 missing observations.
‡There are 250 missing observations.
§There are 67 missing observations.
kThere are 1579 missing observations.
Table 3. Association Between Income and/or Education and Hypertension and Its Risk Factors, 3 Rural Regions in India, 2014 to 2015

| SEP Variable                      | Hypertension OR (95% CI) | P Value | WHR Above Normal* OR (95% CI) | P Value | BMI ≥23 kg/m² OR (95% CI) | P Value |
|-----------------------------------|--------------------------|---------|--------------------------------|---------|---------------------------|---------|
| Income per adult per month, adjusted for age |                          |         |                                |         |                           |         |
| Quartile 1, Rs 0 to 1000          | 1.00                     | 1.00    | 1.00                           | 1.00    |                           | 1.00    |
| Quartile 2, Rs >1000 to 1900      | 1.21                     | 1.06 to 1.39 | 0.006                        | 1.73    | 1.53 to 1.94             | <0.001  |
| Quartile 3, Rs >1900 to 3000      | 1.23                     | 1.08 to 1.40 | 0.002                        | 2.13    | 1.90 to 2.40             | <0.001  |
| Quartile 4, Rs >3000              | 1.44                     | 1.26 to 1.66 | <0.001                       | 2.41    | 2.13 to 2.73             | <0.001  |
| Income per adult per month, adjusted for age and education |                          |         |                                |         |                           |         |
| Quartile 1, Rs 0 to 1000          | 1.00                     | 1.00    | 1.00                           | 1.00    |                           | 1.00    |
| Quartile 2, Rs >1000 to 1900      | 1.19                     | 1.03 to 1.37 | 0.02                         | 1.66    | 1.47 to 1.88             | <0.001  |
| Quartile 3, Rs >1900 to 3000      | 1.21                     | 1.06 to 1.38 | 0.005                        | 2.10    | 1.87 to 2.36             | <0.001  |
| Quartile 4, Rs >3000              | 1.36                     | 1.18 to 1.55 | <0.001                       | 2.22    | 1.96 to 2.51             | <0.001  |
| Education, adjusted for age       |                          |         |                                |         |                           |         |
| No formal education               | 1.00                     | 1.00    | 1.00                           | 1.00    |                           | 1.00    |
| Class 1 to 6                      | 1.20                     | 1.06 to 1.37 | 0.005                        | 1.79    | 1.58 to 2.02             | <0.001  |
| Class 7 to 11                     | 1.41                     | 1.23 to 1.61 | <0.001                       | 2.23    | 1.97 to 2.52             | <0.001  |
| Class ≥12                         | 1.52                     | 1.27 to 1.82 | <0.001                       | 2.22    | 1.91 to 2.57             | <0.001  |
| Education, adjusted for age and income |                         |         |                                |         |                           |         |
| No formal education               | 1.00                     | 1.00    | 1.00                           | 1.00    |                           | 1.00    |
| Class 1 to 6                      | 1.16                     | 1.02 to 1.32 | 0.025                        | 1.63    | 1.44 to 1.84             | <0.001  |
| Class 7 to 11                     | 1.36                     | 1.18 to 1.55 | <0.001                       | 2.11    | 1.86 to 2.39             | <0.001  |
| Class ≥12                         | 1.40                     | 1.16 to 1.69 | <0.001                       | 1.98    | 1.70 to 2.31             | <0.001  |

- There are 62 additional missing observations.
- There are 24 additional missing observations.

In 3 diverse rural sites across southern India, we found that higher SEP was associated with hypertension. Comparing between the sites, the prevalence of hypertension was greater in sites with higher average SEP. Overall, there was a positive association between measures of SEP and risk factors for hypertension, such as BMI and WHR, but not for alcohol consumption. These findings demonstrate that the positive association between SEP and hypertension may be fueled by adiposity in regions of higher SEP.

Education, and specifically health education, has been shown in some settings to mitigate the association between low SEP and hypertension, potentially by modifying health behaviors. Our inability to detect a mitigating effect consuming alcohol (Figure 2; Table S16; P<0.001). Comprising any form of education was associated with reduced odds of consuming alcohol, whereas completing class 12+ was associated with 62% reduced likelihood of consuming alcohol in the previous month (P<0.001). There did not appear to be an association between indicators of income, such as possession of a below poverty line ration card or individual income per month, and alcohol consumption. Indeed, people in the highest categories of income appeared to consume alcohol at similar levels to those in the lowest quartiles (Figure 2; Table S16), although there did appear to be a difference by region (Figure S2). However, it does appear that, in men, education may modify the association between income and alcohol consumption, with a relative reduced risk caused by the interaction of 0.23, although this apparent effect was not statistically significant at conventional levels (Table S17).

People with hypertension were more likely to report taking medications for hypertension for each increasing category of educational attainment and income (P<0.001; Figure S3). This association was similar for women and men.

Discussion

In 3 diverse rural sites across southern India, we found that higher SEP was associated with hypertension. Comparing between the sites, the prevalence of hypertension was greater in sites with higher average SEP. Overall, there was a positive association between measures of SEP and risk factors for hypertension, such as BMI and WHR, but not for alcohol consumption. These findings demonstrate that the positive association between SEP and hypertension may be fueled by adiposity in regions of higher SEP.

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People with hypertension were more likely to report taking medications for hypertension for each increasing category of educational attainment and income (P<0.001; Figure S3). This association was similar for women and men.
### Table 4. Association of Hypertension With Income and Education for Women and Men Combined, for All Age Groups and Stratified by Age, 3 Rural Regions in India, 2014 to 2015

| Income per Adult per Month | Education Level | Measure of Effect Modification |
|---------------------------|-----------------|---------------------------------|
|                           | No Education to Class 6 | Class ≥7 |
|                           | N +/− Hypertension | OR | 95% CI | P Value | N +/− Hypertension | OR | 95% CI | P Value | Index | OR | 95% CI | P Value |
| All ages                  |                 |    |      |        |       |                 |    |      |        |       |    |      |        |
| Rs 0 to 1900             | 1016/1905       | 1.00 |    | <0.001 | 468/1785 | 1.38 | 1.19 to 1.60 | <0.001 | RERI | −0.12 | −0.40 to 0.15 | 0.38 |
| Rs >1900                 | 763/1535        | 1.28 | 1.12 to 1.45 | <0.001 | 552/1845 | 1.53 | 1.33 to 1.77 | <0.001 | AP | −0.08 | −0.26 to 0.10 | 0.39 |
|                           |                 |    |      |        |       |                 |    |      |        |       |    |      |        |
| Age group 18 to 34.9 y   |                 |    |      |        |       |                 |    |      |        |       |    |      |        |
| Rs 0 to 1900             | 15/324          | 1.00 |    |        | 72/1103 | 1.72 | 0.97 to 3.05 | 0.07 | SI | 0.81 | 0.52 to 1.27 | 0.36 |
| Rs >1900                 | 25/444          | 1.21 | 0.63 to 2.34 | 0.56 | 90/1093 | 1.98 | 1.13 to 3.47 | 0.02 | RERI | 0.05 | −0.86 to 0.97 | 0.91 |
|                           |                 |    |      |        |       |                 |    |      |        |       |    |      |        |
| Age group 35 to 54.9 y   |                 |    |      |        |       |                 |    |      |        |       |    |      |        |
| Rs 0 to 1900             | 259/804         | 1.00 |    |        | 197/521 | 1.28 | 1.03 to 1.60 | 0.03 | AP | 0.02 | −0.44 to 0.49 | 0.92 |
| Rs >1900                 | 248/673         | 1.25 | 1.01 to 1.54 | 0.04 | 214/606 | 1.29 | 1.04 to 1.60 | 0.02 | SI | 1.05 | 0.39 to 2.89 | 0.92 |
|                           |                 |    |      |        |       |                 |    |      |        |       |    |      |        |
| Age group ≥55 y          |                 |    |      |        |       |                 |    |      |        |       |    |      |        |
| Rs 0 to 1900             | 742/777         | 1.00 |    |        | 199/161 | 1.44 | 1.14 to 1.83 | 0.002 | RERI | −0.24 | −0.63 to 0.16 | 0.24 |
| Rs >1900                 | 490/418         | 1.27 | 1.07 to 1.50 | 0.005 | 248/146 | 1.90 | 1.51 to 2.40 | <0.001 | AP | −0.18 | −0.49 to 0.13 | 0.25 |
|                           |                 |    |      |        |       |                 |    |      |        |       |    |      |        |

Data are presented as odds ratio (95% CI), and all analyses are adjusted for age. n=9869 for all ages (1788 missing observations for education or income), n=3166 for those aged 18 to 34.9 years (551 missing observations for education or income), n=3522 for those aged 35 to 44.9 years (411 missing observations for education or income), n=3181 for those aged ≥55 years (824 missing observations for education or income). AP indicates attributable proportion; OR, odds ratio; Rs, Indian rupee; RERI, relative excess risk caused by interaction; SI, Synergy Index.
of education on the association between high income and hypertension in the setting of rural India may reflect a relative lack of health education within the curricula. Thus, targeted health education, in schools and in workplaces, may provide a pathway for controlling hypertension in regions that are rapidly undergoing urbanization and industrialization. Importantly, targeted health education in the community at large is also an important pathway that could be used to engage with the retirees and older unemployed people who appeared to be at particularly high risk of hypertension. Potentially, this strategy may be effective not only in India, but also in other settings where health education is suboptimal. Thus, randomized controlled trials of educational interventions, tailored to local cultural and socioeconomic conditions, are warranted. Notably, a recently completed cluster-randomized controlled trial of educational interventions, tailored to local cultural and socioeconomic conditions, are warranted. Notably, a recently completed cluster-randomized controlled trial, conducted in the same 3 sites as the current study, demonstrated the effectiveness of a scalable group-based education and monitoring program delivered by health workers for improving control of hypertension.13

The 3 regions of the study were at very different stages of the epidemiological transition, as shown by each measurement of SEP. Trivandrum was the most socioeconomically advanced, with almost all individuals able to read and write, fewer individuals in possession of a below poverty line ration card, and more individuals reporting income levels in the highest bracket. In contrast, in Rishi Valley, few did not possess a below poverty line ration card, and few had an income in the highest quartile, whereas the relative lack of education was largely limited to women. In all measures of SEP, Godavari was intermediate to Rishi Valley and Trivandrum. These data validate our use of region as a proxy measure of SEP.

When using region as a proxy for SEP, the proportion of people with hypertension was greater with each increasing level of SEP. Similar findings were evident when classifying SEP according to income, albeit in a slightly reduced sample size, and education. These findings are consistent with those of studies previously conducted in other sites of India and other low- to middle-income countries, such as Uganda and China,20–22 but are in contradistinction to the findings from HICs, where greater educational attainment has been associated with a reduced risk of hypertension.1,23

The difference in the association between SEP and hypertension in HICs versus low- to middle-income countries may at least partly be attributable to the effects of epidemiological transition.7,24 As transition progresses toward urbanization and industrialization, diets include a higher content of fat, and sedentary lifestyles are more common.25,26 In these instances, socioeconomic factors play an important role in

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**Figure 2.** Socioeconomic factors associated with waist/hip ratio, body mass index, and alcohol consumption, 3 rural regions in India, 2014 to 2015. Data are presented as age- and sex-adjusted odds ratios, and error bars indicate 95% CIs. Waist/hip ratio above normal is defined as ≥0.8 for women and ≥0.9 for men. Rs, Indian rupee.
influencing the risk and outcome of noncommunicable conditions, such as hypertension, by affecting individuals’ ability to access and afford health care, lead healthy lifestyles, and take preventative measures.24

In HICs, at latter stages of the epidemiological transition, where sedentary lifestyles and access to high-energy processed food persist, education may offer a mitigating effect on the risk of hypertension.9,27 With increased educational attainment, there is increased knowledge about the risk factors for hypertension and measures to prevent high BP,23,26 potentially influencing individuals to adopt healthier lifestyles.7,28,29 In the sample we studied, the relationships between education, risk factors for hypertension, and the risk of hypertension are not entirely clear. Although we found that higher SEP was associated with indicators of unhealthy lifestyle, such as greater BMI and greater WHR, higher educational attainment was associated with reduced odds of consuming alcohol in the past month. Therefore, it is likely that the positive relationship between SEP and hypertension may partly be fueled by some unhealthy lifestyle practices that are associated with SEP, although alcohol consumption does not appear to be among these. The fact that we did not find evidence for a mitigating effect of education on the association between income and hypertension or measures of adiposity, in our rural populations, leads us to speculate that people with higher SEP in rural India may lack health literacy.

Agricultural workers were less likely to be hypertensive than either nonagricultural workers or those who were unemployed or retired, even after adjustment for physical activity, sex, BMI, WHR, and age (data not shown). This indicates that there may be fundamental differences between agricultural workers and those who are nonagricultural workers or unemployed/retired, and that these differences may protect agricultural workers from the risk of hypertension. The precise nature of these differences remains to be determined.

Our finding that people with hypertension who had higher educational attainment were more likely to report taking antihypertensive medications may indicate better health literacy among this group than those with lower educational attainment. However, the fact that this trend for increasing use of medications was also observed with each greater level of income more likely points to greater access to health care and greater affordability of medications in those with more education and a higher income. As rural India is fast advancing along the epidemiological spectrum,30 the burden of hypertension in these populations is likely to increase substantially, so access to affordable medications will be critical to managing this increased burden.

A limitation of our study was the large proportion of people who refused to participate, particularly in one of the regions. Potentially, this may have biased the sample to those who were not working, as shown by the poorer response rates in men of working age than in those aged ≥65 years, or there may be other systematic biases that cannot be accounted for in the analysis. It is unclear whether this would have resulted in odds ratios that overestimated or underestimated the effect size. Importantly, the large proportion of people refusing to participate in the Rishi Valley region may have reduced the generalizability of our findings in this region. However, the fact that the findings are similar between the West Godavari region, the region with a 99% response rate, and the regions with poorer response rates somewhat mitigates this concern. A further limitation is the large proportion of missing data for participants’ income, with 13.6% of participants opting not to report their income, mostly in the highest SEP region. More important, we observed less educational attainment, lower levels of SBP, and lesser adiposity in those who chose to report their income than in those who refused. Thus, our data on income are not representative of the population sampled. This is likely to have biased the findings toward the null and may have reduced the likelihood of identifying potential modifications of education on the association of income and hypertension. Income was derived using self-reported household income as well as details of additional rental and other income, and the sum of which was then divided by the number of adults in the household. Self-reported income levels are potentially subject to serious measurement error, so the levels of income obtained may be inaccurate. The fact that we categorized income into quartiles somewhat reduces this potential bias. Furthermore, as income is a critical indicator of SEP, assessing the relationship between income, education, and hypertension in a more generalizable sample may provide clearer and more conclusive findings.

A major strength of our study is the large sample size of 11,657 participants from 3 diverse rural regions of India. This allowed collection of a relatively representative sample and enabled some generalizability to the population of interest. We also used rigorous training for all data collectors and research staff to ensure standardization of methods for data collection across the 3 sites. The questionnaires we administered were read aloud to participants to allow inclusion of participants irrespective of their ability to read or write. Together, these measures optimized the validity and generalizability of our findings.

In conclusion, the risk of hypertension was positively associated with higher SEP in rural India. In addition, modifiable risk factors, such as greater adiposity, were exacerbated with higher SEP. These modifiable risk factors may contribute to the increased risk of hypertension in people with higher SEP. In future studies, careful ascertainment of income, potentially by using a wealth index or determining what people spend and own rather than earn, and identifying
where and how people learn about health, may provide further clarity about the relationship between SEP and hypertension in rural Indian populations, particularly if collected prospectively. In addition, comparing sites of higher SEP from urban regions with those from rural regions may also provide more information about the factors that influence the relationship between SEP and hypertension.

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References

1. Mills KT, Bundy JD, Kelly TN, Reed JE, Kearney PM, Reynolds K, Chen J, He J. Global disparities of hypertension prevalence and control: a systematic analysis of population-based studies from 90 countries. Circulation. 2016;134:441–450.
2. Galobardes B, Shaw M, Lawlor DA, Lynch JW, Davey Smith G. Indicators of socioeconomic position (part 1). J Epidemiol Community Health. 2006;60:7–12.
3. Leng B, Jin Y, Li G, Chen L, Jin N. Socioeconomic status and hypertension: a meta-analysis. J Hypertens. 2015;33:221–229.
4. Mielck A, Vogelmann M, Leidl R. Health-related quality of life and socioeconomic status: inequalities among adults with a chronic disease. Health Qual Life Outcomes. 2014;12:58.
5. Grotto I, Huerta M, Sharabi Y. Hypertension and socioeconomic status. Curr Opin Cardiol. 2006;23:335–339.
6. Thrift AG, Evans RG, Kalyanram K, Kartik K, Fitzgerald SM, Srikanth V. Gender-specific effects of caste and salt on hypertension in poverty: a population-based study. J Hypertens. 2011;29:443–450.
7. Busingye D, Arashbashi S, Subasinghe AK, Evans RG, Riddell MA, Thrift AG. Do the socioeconomic and hypertension gradients in rural populations of low- and middle-income countries differ by geographical region? A systematic review and meta-analysis. Int J Epidemiol. 2014;43:1563–1577.
8. Amegah AK, Nayia S. Educational attainment modifies the association of wealth status with elevated blood pressure in the Ghanaian population. Helyon. 2018;4:e00711.
9. Tedesco MA, Di Salvo G, Caputo S, Natale F, Ratti G, larussi D, Iacono A. Educational level and hypertension: how socioeconomic differences condition health care. J Hum Hypertens. 2001;15:727–731.
10. Li X, Ning N, Hao Y, Sun H, Gao L, Jiao M, Wu Q, Quan H. Health literacy in rural areas of China: hypertension knowledge survey. Int J Environ Res Public Health. 2013;10:1125–1138.
11. Anchala R, Kannuri NK, Pant H, Khan H, Franco OH, Di Angelantonio E, Prabhakaran D. Hypertension in India: a systematic review and meta-analysis of prevalence, awareness, and control of hypertension. J Hypertens. 2014;32:1170–1177.
12. Riddell MA, Joshi R, Oldenburg B, Chow C, Thanhkappan KR, Mahal A, Thomas N, Srikanth VK, Evans RG, Kalyanram K, Kartik K, Maulik PK, Arashbashi S, Varma RP, Guggilla RK, Suresh O, Mini G, D’Esposito F, Sathish T, Alim M, Thrift AG. Cluster randomised feasibility trial to improve the Control of Hypertension In Rural India (CHIRI): a study protocol. BMJ Open. 2016;6:e102140.
13. Gamage DG, Riddell MA, Joshi R, Thanhkappan KR, Chow CK, Oldenburg B, Evans RG, Mahal AS, Kalyanram K, Kartik K, Suresh O, Thomas N, Mini G, Maulik PK, Srikanth VK, Arashbashi S, Varma RP, Guggilla RK, D’Esposito F, Sathish T, Alim M, Thrift AG. Effectiveness of a scalable group-based education and monitoring program, delivered by health workers, to improve control of hypertension in rural India: a cluster randomised controlled trial. PLOS Med. 2020;17:e1002997.
14. World Health Organization. WHO STEPS: surveillance manual—update: June 2008. 2008. http://www.who.int/nchs/surveillance/steps/STEPS_Manual. pdf. Accessed October 10, 2018.
15. Misra A, Choweby P, Kakkam BR, Vikram NK, Wasir JS, Chadha D, Joshi SR, Sadikot S, Gupta R, Gulati S, Munjal YP; Consensus Group. Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. J Assoc Physicians India. 2009;57:163–170.
16. VanderWeele TJ, Knol MJ. A tutorial on interaction. Epidemiol Methods. 2014;3:33–72.
17. Whelton PK, Carey RM, Aronow WS, Casey DE JR, Collins KJ, Dennison Himmelfarb C, DePalma SM, Gidding S, Jamerson KA, Jones DW, MacLaughlin EJ, Muntner P, O'Dea B, Smith SC Jr, Spencer CC, Stafford RS, Taler SJ, Thomas RJ, Williams KA Sr, Williamson JD, Wright JT Jr. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Hypertension. 2018;72:1269–1324.
18. Levine DM, Green LW, Deeds SG, Chawal J, Russell RP, Finlay J. Health education for hypertensive patients. JAMA. 1979;241:1700–1703.
19. Zaman MJ, Patel A, Jan S, Hill MN, Raju PK, Neal B, Chow CK. Socioeconomic distribution of cardiovascular risk factors and knowledge in rural India. Int J Epidemiol. 2012;41:1302–1314.
20. Lu Y, Wang P, Zhou T, Lu J, Spatz E, Nasir K, Jiang L, Krumholz H. Comparison of prevalence, awareness, treatment, and control of cardiovascular risk factors in China and the United States. J Am Heart Assoc. 2018;7:e007462. DOI: 10.1161/JAHA.117.007462.
21. Raja VR, Abiona T, Guroje O. Awareness of hypertension and its impact on blood pressure control among elderly Nigerians: report from the Ibadan study of aging. Pan Afr Med J. 2017;27:190.
22. Corsi DJ, Subramanian SV. Socioeconomic gradients and distribution of diabetes, hypertension, and obesity in India. JAMA Netw Open. 2019;2:e190411.
23. Oliveira SA, Chen RS, McCarthy BD, Davis CC, Hill MN. Hypertension knowledge, awareness, and attitudes in a hypertensive population. J Gen Intern Med. 2005;20:219–223.
24. Reddy KS, Naik N, Prabhakaran D. Hypertension in the developing world: a consequence of progress. Curr Cardio] Rep. 2006;8:399–404.
25. Yusuf S, Reddy S, Quanpu S, Anand S. Global burden of cardiovascular diseases: part II: variations in cardiovascular disease by specific ethnic groups and geographic regions and prevention strategies. Circulation. 2001;104:2855–2864.
26. Psaltopoloul T, Hatzis G, Papageorgiou N, Androulakis E, Briasoulis A, Toussoulis D. Socioeconomic status and risk factors for cardiovascular disease: impact of dietary mediators. Hellenic J Cardiol. 2017;58:32–42.
27. Dyer AR, Stamler J, Shekelle RB, Schoenberger J. The relationship of education to blood pressure: findings on 40,000 employed Chicagoans. Circulation. 1976;54:987–992.

28. Wang W, Lee ET, Fabsitz RR, Devereux R, Best L, Wally TK, Howard BV. A longitudinal study of hypertension risk factors and their relation to cardiovascular disease: the Strong Heart Study. Hypertension. 2006;47:403–409.

29. Brummett BH, Babyak MA, Siegler IC, Shanahan M, Harris KM, Elder GH, Williams RB. Systolic blood pressure, socioeconomic status, and biobehavioral risk factors in a nationally representative US young adult sample. Hypertension. 2011;58:161–166.

30. Yadav S, Arokiasamy P. Understanding epidemiological transition in India. Glob Health Action. 2014;7:23248.
SUPPLEMENTARY MATERIAL
Data S1. Supplementary Methods

Regions of the study

Trivandrum, located in Kerala is one of the most socioeconomically advantaged regions of India. Seventy four percent of the population in Kerala reside in rural settings, yet changing patterns of employment and shifts towards the cultivation of cash crops have rendered Kerala the least agriculturally focused state in India. Constituents of the District of Trivandrum often have access to healthcare and incomes in this region are high by Indian standards. The study site is within the Chirayinkeezhu Taluk, a rural region on the northern edge of the District of Trivandrum.

The West Godavari region (herein termed Godavari), located in northern Andhra Pradesh comprises 45 villages. Healthcare is less accessible in Godavari than Trivandrum. Average monthly household income is lower than in Trivandrum, with the majority of the residents of these regions working in agriculture or aquaculture.

The Rishi Valley region, located near the south-western border of Andhra Pradesh, encompasses approximately 240 hamlets. It is one of the poorest regions of India. Most inhabitants of the Rishi Valley are subsistence farmers. Average household income is below internationally defined thresholds for poverty.

Village leaders were contacted and informed about the proposed study, prior to commencement of the study.

Ethics

This project was approved by the Health Ministry’s Screening Committee of the Government of India (58/4/1F/CHR/2013/NCD II), the Sree Chitra Tirunal Institute of Medical Sciences and Technology (SCT/IEC-484/July-2013), the Centre for Chronic Disease Control (CCDC-IEC-09-2012), Christian Medical College Vellore, and Monash University (CF13/2516 – 2013001327). Written informed consent was obtained from all participants prior to inclusion. When participants could not read or write, the patient information statement was read aloud to them, and consent recorded via a thumb print.

Questions on income, access to healthcare and employment

Income, in Indian Rupees, was recorded as household income. Household income was then divided by the number of adults in each household to generate income per person per month. Income was then categorized into four groups. The four categories were Rs 0 to 1000, Rs > 1000 to 1900, Rs > 1900 to 3000, Rs > 3000. The categories had approximately equal number of participants in the top
three quartiles. There were slightly more people in the bottom quartile because of the large number of people with an estimated income of Rs 1000.

Participants were asked how regularly they visited a doctor, with visits categorized as being regular, irregular but within the past 12 months, no visit within the previous year, or never. Access to healthcare was assessed by a general question about the ease of visiting a doctor according to five levels; difficulty comprised those reporting access to health care as being fairly difficult or very difficult.

Unemployed indicates those without employment, those seeking employment, beggars and homemakers. Retired includes retirees, ex-servicemen and pensioners. When individuals stated that they were a pensioner, but also undertook other activities, e.g. tending cattle, we deemed them as retired. Agricultural indicates farmers, farmhands, sericulture, aquaculture and farm machinery operators. People who indicated that they undertook both agricultural and nonagricultural activities were preferentially categorized as “agricultural” workers. Non-agricultural indicates all forms of employment unrelated to agricultural work including business owners, office workers, healthcare workers, manual laborers, students, and others.

**Data cleaning**

Data cleaning was performed in Stata (Stata 11.2, College Station, Texas, United States), with cleaned points corrected in two database locations as well as an audit trail. Data points were inspected for inconsistencies, such as extreme values, greatly variant blood pressure readings, or values inconsistent with adjacent parameters. Suspect data points were verified manually against the questionnaire and if necessary against on-site clinical records in India. Erroneous data points were replaced with correct values, or excluded where verified values were not available. Each parameter was inspected thoroughly before inclusion in analyses.
Table S1. Baseline Characteristics According to Whether or Not Details of Income Were Provided, Three Rural Regions of India, 2014–2015.

| Characteristics                                      | Details provided on Income | No Details provided on Income | P     |
|------------------------------------------------------|----------------------------|--------------------------------|-------|
| Age (years), mean (SD)                               | n = 10,075                 | n = 1,582                      | <0.001|
| SBP (mmHg), mean (SD)                                | 45.3 (16.8)                | 47.1 (19.9)                    |       |
| DBP (mmHg), mean (SD)                                | 122.7 (18.8)               | 125.0 (20.5)                   | <0.001|
| Hypertension                                         | 74.1 (11.7)                | 72.1 (11.6)                    | <0.001|
| Body Mass Index (kg/m²), mean (SD)                   | 2,886 (28.7)               | 580 (36.7)                     | <0.001|
| Female                                               | 4,910 (48.8)               | 942 (59.6)                     | <0.001|
| Body Mass Index (kg/m²), mean (SD)                   | 23.1 (5.2)                 | 23.8 (5.6)                     | <0.001|
| Site                                                  |                            |                                |       |
| Rishi Valley                                         | 3,348 (33.2)               | 52 (3.3)                       | <0.001|
| Godavari                                             | 4,337 (43.1)               | 163 (10.3)                     |       |
| Trivandrum                                           | 2,390 (23.7)               | 1,367 (86.4)                   |       |
| Literacy rates                                       |                            |                                |       |
| Read                                                 | 6,502 (64.6)               | 1,328 (86.6)                   | <0.001|
| Write                                                | 6,181 (61.4)               | 1,286 (83.9)                   | <0.001|
| Highest level of schooling                           |                            |                                |       |
| No formal education                                   | 2,536 (25.7)               | 233 (15.2)                     | <0.001|
| Class 1 to 6                                         | 2,684 (27.2)               | 275 (17.9)                     |       |
| Class 7 to 11                                        | 3,048 (30.9)               | 568 (37.1)                     |       |
| Class 12+                                            | 1,603 (16.2)               | 457 (29.8)                     |       |
| Above poverty line or no ration card                 | 2,039 (20.3)               | 893 (58.3)                     | <0.001|
| People in household                                  |                            |                                |       |
| Mean (SD)                                            | 4.2 (2.5)                  | 4.3 (1.9)                      | 0.03  |
| ≥ 5 people                                           | 3,635 (36.1)               | 624 (40.8)                     | <0.001|
| Visits to doctor                                     |                            |                                |       |
| Never                                                | 4,214 (41.9)               | 442 (28.8)                     | <0.001|
| Regular visits to doctor                             | 960 (9.5)                  | 292 (19.0)                     |       |
| Irregular, but visited within past year              | 3,189 (31.7)               | 591 (38.5)                     |       |
| Not visited in past 1 year                           | 1,702 (16.9)               | 210 (13.7)                     |       |
| Self-reported difficulty in accessing health care     | 2,913 (28.9)               | 172 (11.2)                     | <0.001|

Abbreviations: DBP, diastolic blood pressure; Rs, Indian rupees; SBP, systolic blood pressure; SD, standard deviation.

Data are presented as number (%) unless otherwise stated. Income was missing for 36.4% of participants in Trivandrum, 3.6% in Godavari, and 1.5% in the Rishi Valley.

* 1-15 missing observations;
† 20-53 missing variables
‡ 104 missing variables
Table S2. Factors Associated with Hypertension in Women, Three Rural Regions in India, 2014–2015.

| Characteristic                      | Univariable | Adjusted for Age |
|-------------------------------------|-------------|------------------|
|                                     | OR          | 95% CI           | P     | OR             | 95% CI           | P    |
| Age, years                          | 1.08        | 1.08, 1.09       | <0.001| 1.00           |                   |      |
| Age Group, years                    |             |                  |       |                |                  |      |
| 18-34.9                             | 1.00        |                  |       |                |                  |      |
| 35-54.9                             | 7.50        | 5.94, 9.49       | <0.001| 2.32           | 1.96, 2.75       | <0.001|
| ≥55                                 | 28.0        | 22.2, 35.2       | <0.001| 2.62           | 2.20, 3.12       | <0.001|
| Region                              |             |                  |       |                |                  |      |
| Rishi Valley                        | 1.00        |                  |       |                |                  |      |
| Godavari                            | 1.79        | 1.55, 2.07       | <0.001| 2.32           | 1.96, 2.75       | <0.001|
| Trivandrum                          | 2.15        | 1.85, 2.49       | <0.001| 2.62           | 2.20, 3.12       | <0.001|
| Literate: Ability to Write *        | 0.64        | 0.57, 0.71       | <0.001| 1.56           | 1.36, 1.79       | <0.001|
| Education †                         |             |                  |       |                |                  |      |
| No Formal Education                 | 1.00        |                  |       |                |                  |      |
| Class 1 to 6                        | 0.90        | 0.78, 1.04       | 0.16  | 1.61           | 1.36, 1.90       | <0.001|
| Class 7 to 11                       | 0.56        | 0.48, 0.64       | <0.001| 1.88           | 1.57, 2.25       | <0.001|
| Class 12+                           | 0.19        | 0.15, 0.24       | <0.001| 1.26           | 0.96, 1.67       | 0.1   |
| Above poverty line or no ration card * | 1.31        | 1.16, 1.48       | <0.001| 1.39           | 1.20, 1.61       | <0.001|
| At least 5 people living in household * | 0.95        | 0.84, 1.06       | 0.4   | 1.03           | 0.90, 1.18       | 0.7   |
| Type of employment*                 |             |                  |       |                |                  |      |
| Agricultural                        | 1.00        |                  |       |                |                  |      |
| Non-agricultural                    | 1.30        | 1.03, 1.65       | 0.03  | 1.85           | 1.42, 2.40       | <0.001|
| Unemployed                          | 3.15        | 2.63, 3.76       | <0.001| 2.81           | 2.32, 3.40       | <0.001|
| Retired                             | 10.1        | 7.95, 12.8       | <0.001| 2.06           | 1.58, 2.68       | <0.001|
| Income per adult per month ‡        |             |                  |       |                |                  |      |
| Q1, Rs 0 to 1000                    | 1.00        |                  |       |                |                  |      |
| Q2, Rs >1000 to 1900                | 1.03        | 0.86, 1.23       | 0.7   | 1.31           | 1.07, 1.61       | 0.009|
| Q3, Rs >1900 to 3000                | 1.00        | 0.85, 1.18       | >0.9  | 1.54           | 1.27, 1.87       | <0.001|
| Q4, Rs >3000                        | 1.04        | 0.88, 1.23       | 0.7   | 1.61           | 1.32, 1.96       | <0.001|
| Visits to doctor *                  |             |                  |       |                |                  |      |
| Never                               | 1.00        |                  |       |                |                  |      |
| Regular visits to doctor            | 22.1        | 17.7, 27.5       | <0.001| 13.2           | 10.4, 16.8       | <0.001|
| Irregular, but visited within past year | 4.25        | 3.60, 5.02       | <0.001| 3.62           | 3.01, 4.35       | <0.001|
| Not visited in past 1 year          | 1.97        | 1.61, 2.41       | <0.001| 1.91           | 1.53, 2.40       | <0.001|
| Self-reported difficulty in accessing health care * | 1.04         | 0.92, 1.17       | 0.5   | 0.94           | 0.81, 1.08       | 0.4   |

Abbreviations: CI, confidence interval; OR, odds ratio; Q1-4, quartiles 1-4; Rs, rupees

N= 5,851. Data are presented as odds ratio (95% confidence interval). P values were generated using univariable and multivariable logistic regression. Hypertension is defined as a systolic blood pressure ≥ 140 mmHg and/or a diastolic blood pressure ≥ 90 mmHg and/or taking BP lowering medication(s). For difficulty in accessing healthcare, participants reported their level of difficulty according to five levels; difficulty comprised those reporting access to health care as being fairly difficult or very difficult. Unemployed indicates those without employment, those seeking employment, and homemakers. Retired refers to retirees, and pensioners. Agricultural indicates farmers, farmhands, and farm machinery operators. Non-agricultural indicates all forms of employment unrelated to agricultural work including business owners, office workers, healthcare workers, manual laborers, students, and others.

* 24-39 missing observations; † 121 missing observations; ‡ 941 missing observations.
Table S3. Factors Associated with Hypertension in Men, Three Rural Regions in India, 2014–2015.

| Characteristic                                | Univariable |          |          | Adjusted for Age |          |
|-----------------------------------------------|-------------|----------|----------|-----------------|----------|
|                                               | OR          | 95% CI   | P        | OR              | 95% CI   | P       |
| Age, years                                    | 1.06        | 1.07, 1.07 | <0.001   | 1.00            |          |         |
| Age Group, years                              |             |          |          |                 |          |         |
| 18-34.9                                       | 1.00        |          |          |                 |          |         |
| 35-54.9                                       | 4.11        | 3.37, 5.00 | <0.001   |                 |          |         |
| ≥55                                           | 11.9        | 9.80, 14.3 | <0.001   |                 |          |         |
| Region                                        |             |          |          |                 |          |         |
| Rishi Valley                                  | 1.00        |          |          |                 |          |         |
| Godavari                                      | 1.24        | 1.07, 1.43 | 0.004    | 1.36            | 1.16, 1.59 | <0.001 |
| Trivandrum                                    | 1.48        | 1.28, 1.72 | <0.001   | 1.59            | 1.35, 1.87 | <0.001 |
| Literate: Ability to Write *                  | 0.80        | 0.70, 0.90 | <0.001   | 1.32            | 1.15, 1.51 | <0.001 |
| Education †                                   |             |          |          |                 |          |         |
| No Formal Education                           | 1.00        |          |          |                 |          |         |
| Class 1 to 6                                  | 0.89        | 0.75, 1.06 | 0.2      | 1.06            | 0.88, 1.28 | 0.5     |
| Class 7 to 11                                 | 0.68        | 0.57, 0.80 | <0.001   | 1.40            | 1.16, 1.69 | 0.001   |
| Class 12+                                     | 0.46        | 0.38, 0.56 | <0.001   | 1.65            | 1.31, 2.08 | <0.001   |
| Above poverty line or no ration card *        | 1.60        | 1.41, 1.82 | <0.001   | 1.57            | 1.36, 1.81 | <0.001   |
| At least 5 people living in household *       | 0.80        | 0.71, 0.90 | 0.001    | 0.87            | 0.76, 0.99 | 0.03     |
| Type of employment *                          |             |          |          |                 |          |         |
| Agricultural                                  | 1.00        |          |          |                 |          |         |
| Non-agricultural                              | 0.78        | 0.68, 0.89 | <0.001   | 1.31            | 1.13, 1.52 | <0.001 |
| Unemployed                                    | 3.16        | 2.60, 3.85 | <0.001   | 1.71            | 1.37, 2.13 | <0.001 |
| Retired                                       | 4.27        | 3.45, 5.29 | <0.001   | 1.50            | 1.19, 1.90 | 0.001   |
| Income per adult per month ‡                  |             |          |          |                 |          |         |
| Q1, Rs 0 to 1000                              | 1.00        |          |          |                 |          |         |
| Q2, Rs >1000 to 1900                          | 0.91        | 0.77, 1.07 | 0.3      | 1.14            | 0.95, 1.38 | 0.2     |
| Q3, Rs >1900 to 3000                          | 0.82        | 0.70, 0.97 | 0.02     | 1.04            | 0.87, 1.25 | 0.7     |
| Q4, Rs >3000                                  | 1.02        | 0.86, 1.22 | 0.8      | 1.38            | 1.14, 1.67 | 0.001   |
| Visits to doctor *                            |             |          |          |                 |          |         |
| Never                                         | 1.00        |          |          |                 |          |         |
| Regular visits to doctor                      | 11.8        | 9.53, 14.5 | <0.001   | 5.51            | 4.41, 6.89 | <0.001 |
| Irregular, but visited within past year       | 3.20        | 2.78, 3.70 | <0.001   | 2.16            | 1.85, 2.52 | <0.001 |
| Not visited in past 1 year                    | 2.07        | 1.73, 2.49 | <0.001   | 1.48            | 1.22, 1.80 | <0.001 |
| Self-reported difficulty in accessing health care * | 0.95        | 0.83, 1.09 | 0.45     | 0.78            | 0.67, 0.91 | 0.001   |

Abbreviations: CI, confidence interval; OR, odds ratio; Q1-4, quartiles 1-4; Rs, rupees

N= 5,780. Data are presented as odds ratio (95% confidence interval). P values were generated using univariable and multivariable logistic regression. Hypertension is defined as a systolic blood pressure > 140 mmHg and/or a diastolic blood pressure > 90 mmHg and/or taking BP lowering medication(s). For difficulty in accessing healthcare, participants reported their level of difficulty according to five levels; difficulty comprised those reporting access to health care as being fairly difficult or very difficult. Unemployed indicates those without employment, those seeking employment, and homemakers. Retired refers to retirees, and pensioners. Agricultural indicates farmers, farmhands, and farm machinery operators. Non-agricultural indicates all forms of employment unrelated to agricultural work including business owners, office workers healthcare workers, manual laborers, students, and others.

* 23-46 missing observations; † 129 missing observations; ‡ 637 missing observations.
Table S4. Association Between Income and/or Education and Hypertension and its Risk Factors in Women, Three Rural Regions in India, 2014–2015.

| SEP variable                  | Hypertension OR 95% CI | P       | WHR above Normal * OR 95% CI | P       | BMI ≥ 23 kg/m²† OR 95% CI | P       |
|-------------------------------|------------------------|---------|------------------------------|---------|--------------------------|---------|
| **Income per adult per month,** |                        |         |                              |         |                          |         |
| **Adjusted for Age**          |                        |         |                              |         |                          |         |
| Q1, Rs 0 to 1000              | 1.00                   | 1.00    | 1.00                         | 1.00    |
| Q2, Rs >1000 to 1900          | 1.31 1.06, 1.61        | 0.01    | 1.77 1.48, 2.10              | <0.001  | 1.77 1.50, 2.09          | <0.001  |
| Q3, Rs >1900 to 3000          | 1.55 1.28, 1.88        | <0.001  | 2.13 1.80, 2.50              | <0.001  | 2.28 1.96, 2.66          | <0.001  |
| Q4, Rs >3000                  | 1.59 1.30, 1.93        | <0.001  | 2.39 2.02, 2.83              | <0.001  | 2.88 2.46, 3.38          | <0.001  |
| **Income per adult per month,** |                        |         |                              |         |                          |         |
| **Adjusted for Age and**      |                        |         |                              |         |                          |         |
| Education                     |                        |         |                              |         |                          |         |
| Q1, Rs 0 to 1000              | 1.00                   | 1.00    | 1.00                         | 1.00    |
| Q2, Rs >1000 to 1900          | 1.23 1.00, 1.52        | 0.05    | 1.66 1.39, 1.99              | <0.001  | 1.63 1.38, 1.93          | <0.001  |
| Q3, Rs >1900 to 3000          | 1.48 1.22, 1.80        | <0.001  | 2.12 1.79, 2.50              | <0.001  | 2.22 1.90, 2.61          | <0.001  |
| Q4, Rs >3000                  | 1.44 1.18, 1.77        | <0.001  | 2.13 1.79, 2.53              | <0.001  | 2.46 2.09, 2.91          | <0.001  |
| **Education, Adjusted for Age** |                        |         |                              |         |                          |         |
| No Formal Education           | 1.00                   | 1.00    | 1.00                         | 1.00    |
| Class 1 to 6                  | 1.60 1.34, 1.92        | <0.001  | 1.79 1.52, 2.11              | <0.001  | 2.52 2.15, 2.95          | <0.001  |
| Class 7 to 11                 | 1.78 1.46, 2.18        | <0.001  | 2.55 2.14, 3.05              | <0.001  | 3.62 3.06, 4.29          | <0.001  |
| Class 12+                     | 1.26 0.92, 1.74        | 0.2     | 3.57 2.82, 4.50              | <0.001  | 4.01 3.22, 5.00          | <0.001  |
| **Education, Adjusted for Age** |                        |         |                              |         |                          |         |
| and Income                    |                        |         |                              |         |                          |         |
| No Formal Education           | 1.00                   | 1.00    | 1.00                         | 1.00    |
| Class 1 to 6                  | 1.49 1.23, 1.79        | <0.001  | 1.58 1.33, 1.87              | <0.001  | 2.19 1.86, 2.57          | <0.001  |
| Class 7 to 11                 | 1.70 1.39, 2.09        | <0.001  | 2.40 2.00, 2.87              | <0.001  | 3.37 2.83, 4.00          | <0.001  |
| Class 12+                     | 1.16 0.84, 1.61        | 0.4     | 3.30 2.60, 4.19              | <0.001  | 3.60 2.87, 4.51          | <0.001  |

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio; Q1-4, quartiles 1-4; WHR, waist-hip ratio; Rs, rupees; SEP, socioeconomic position

n = 4,815 (1,037 missing observations for education or income); Data are presented as odds ratios (95% confidence interval). P values were generated using logistic regression adjusted for age alone, or adjusted for age and education/income.

* 42 additional missing observations; † 12 additional missing observations.
Table S5. Association Between Income and/or Education and Hypertension and its Risk Factors in Men, Three Rural Regions in India, 2014–2015.

| SEP variable | Hypertension | WHR above Normal | BMI ≥ 23 kg/m² | Alcohol in Past 30 Days |
|--------------|--------------|------------------|----------------|------------------------|
|              | OR 95% CI P  | OR 95% CI P      | OR 95% CI P    | OR 95% CI P            |
| Income per adult per month, Adjusted for Age | | | | |
| Q1, Rs 0 to 1000 | 1.00 1.00 | 1.00 | 1.00 | 1.00 |
| Q2, Rs >1000 to 1900 | 1.14 0.94, 1.38 0.2 | 1.76 1.49, 2.09 <0.001 | 1.41 1.20, 1.66 <0.001 | 0.90 0.75, 1.07 0.2 |
| Q3, Rs >1900 to 3000 | 1.04 0.86, 1.25 0.7 | 2.18 1.84, 2.57 <0.001 | 1.69 1.45, 1.97 <0.001 | 1.06 0.90, 1.25 0.5 |
| Q4, Rs >3000 | 1.35 1.12, 1.64 0.002 | 2.45 2.06, 2.93 <0.001 | 2.68 2.28, 3.16 <0.001 | 0.94 0.79, 1.12 0.5 |
| Income per adult per month, Adjusted for Age and Education | | | | |
| Q1, Rs 0 to 1000 | 1.00 1.00 | 1.00 | 1.00 | 1.00 |
| Q2, Rs >1000 to 1900 | 1.14 0.94, 1.38 0.2 | 1.78 1.50, 2.11 <0.001 | 1.42 1.21, 1.67 <0.001 | 0.90 0.75, 1.07 0.2 |
| Q3, Rs >1900 to 3000 | 1.03 0.86, 1.24 0.7 | 2.21 1.87, 2.62 <0.001 | 1.72 1.47, 2.02 <0.001 | 1.06 0.90, 1.25 0.5 |
| Q4, Rs >3000 | 1.24 1.01, 1.51 0.04 | 2.43 2.03, 2.91 <0.001 | 2.47 2.09, 2.92 <0.001 | 1.07 0.90, 1.29 0.4 |
| Education, Adjusted for Age | | | | |
| No Formal Education | 1.00 1.00 | 1.00 | 1.00 | 1.00 |
| Class 1 to 6 | 1.05 0.86, 1.27 0.65 | 1.77 1.47, 2.13 <0.001 | 1.72 1.43, 2.05 <0.001 | 0.78 0.64, 0.93 0.007 |
| Class 7 to 11 | 1.32 1.08, 1.61 0.006 | 2.03 1.68, 2.44 <0.001 | 2.47 2.06, 2.95 <0.001 | 0.81 0.67, 0.97 0.02 |
| Class 12+ | 1.72 1.35, 2.19 <0.001 | 1.74 1.41, 2.16 <0.001 | 2.92 2.37, 3.59 <0.001 | 0.36 0.29, 0.45 <0.001 |
| Education, Adjusted for Age and Income | | | | |
| No Formal Education | 1.00 1.00 | 1.00 | 1.00 | 1.00 |
| Class 1 to 6 | 1.04 0.86, 1.26 0.7 | 1.72 1.43, 2.08 <0.001 | 1.67 1.40, 2.00 <0.001 | 0.77 0.64, 0.93 0.006 |
| Class 7 to 11 | 1.30 1.06, 1.58 0.01 | 2.01 1.66, 2.43 <0.001 | 2.37 1.98, 2.84 <0.001 | 0.80 0.67, 0.96 0.02 |
| Class 12+ | 1.63 1.27, 2.09 <0.001 | 1.58 1.27, 1.97 <0.001 | 2.52 2.04, 3.12 <0.001 | 0.35 0.28, 0.45 <0.001 |

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio; WHR, waist-hip ratio; Q1-4, quartiles 1-4; Rs, rupees; SEP, socioeconomic position.

n = 5,034 (750 missing observations for education or income); Data are presented as odds ratios (95% confidence interval). P values were generated using logistic regression adjusted for age alone, or adjusted for age and education/income. * 12-15 additional missing observations.
Table S6. Association Between Income and/or Education and Hypertension as defined by a cut-off of 130/80 mmHg as per the American College of Cardiology / American Heart Association guidelines for hypertension; Three Rural Regions in India, 2014–2015.

| SEP variable                  | Three Sites Combined | Rishi Valley | Godavari | Trivandrum |
|-------------------------------|----------------------|-------------|----------|------------|
|                               | OR  95% CI  | P    | OR  95% CI  | P    | OR  95% CI  | P    | OR  95% CI  | P    |
| Income per adult per month,   |                      |           |          |            |            |          |            |          |
| Adjusted for Age              |                      |           |          |            |            |          |            |          |
| Q1, Rs 0 to 1000              | 1.00                 | 1.00      | 1.00     | 1.00       |
| Q2, Rs >1000 to 1900          | 1.23, 1.08, 1.39    | 0.001     | 1.18, 0.95, 1.47 | 0.13  | 0.91, 0.72, 1.15 | 0.44  | 1.17, 0.92, 1.49 | 0.20  |
| Q3, Rs >1900 to 3000          | 1.30, 1.16, 1.46   | <0.001    | 1.29, 1.01, 1.65 | 0.04  | 1.00, 0.80, 1.24 | 0.97  | 1.08, 0.84, 1.39 | 0.54  |
| Q4, Rs >3000                  | 1.44, 1.27, 1.63   | <0.001    | 1.28, 1.01, 1.61 | 0.04  | 1.09, 0.86, 1.37 | 0.48  | 1.34, 1.06, 1.69 | 0.02  |
| Income per adult per month,   |                      |           |          |            |            |          |            |          |
| Adjusted for Age and          |                      |           |          |            |            |          |            |          |
| Education                     |                      |           |          |            |            |          |            |          |
| No Formal Education           | 1.00                 | 1.00      | 1.00     | 1.00       |
| Class 1 to 6                  | 1.27, 1.13, 1.43   | <0.001    | 1.16, 0.95, 1.42 | 0.14  | 1.28, 1.08, 1.51 | 0.004 | 0.80, 0.54, 1.18 | 0.25  |
| Class 7 to 11                 | 1.42, 1.26, 1.61   | <0.001    | 1.19, 0.96, 1.49 | 0.11  | 1.31, 1.07, 1.59 | 0.009 | 1.08, 0.77, 1.52 | 0.65  |
| Class 12+                     | 1.68, 1.44, 1.95   | <0.001    | 1.40, 1.03, 1.90 | 0.03  | 1.50, 1.16, 1.93 | 0.002 | 1.23, 0.84, 1.79 | 0.29  |
| Education, Adjusted for Age   |                      |           |          |            |            |          |            |          |
| and Income                    |                      |           |          |            |            |          |            |          |
| No Formal Education           | 1.00                 | 1.00      | 1.00     | 1.00       |
| Class 1 to 6                  | 1.23, 1.09, 1.38   | <0.001    | 1.13, 0.93, 1.39 | 0.10  | 1.27, 1.07, 1.50 | 0.005 | 0.78, 0.53, 1.16 | 0.22  |
| Class 7 to 11                 | 1.38, 1.22, 1.56   | <0.001    | 1.15, 0.92, 1.44 | 0.23  | 1.29, 1.06, 1.58 | 0.01  | 1.04, 0.74, 1.46 | 0.83  |
| Class 12+                     | 1.58, 1.35, 1.85   | <0.001    | 1.33, 0.98, 1.81 | 0.07  | 1.47, 1.14, 1.90 | 0.003 | 1.12, 0.76, 1.66 | 0.57  |

Abbreviations: CI, confidence interval; OR, odds ratio; Q1-4, quartiles 1-4; Rs, rupees; SEP, socioeconomic position

n = 9,869 (1,788 missing observations for education or income); n = 3,160 Rishi Valley, n = 4,320 Godavari, n = 2,389 Trivandrum (missing observations for education or income: 236 Rishi Valley, 180 Godavari, 1,367 Trivandrum); Data are presented as odds ratios (95% confidence interval). P values were generated using logistic regression adjusted for age alone, or adjusted for age and education/income.
Table S7. Association Between Income and/or Education and Hypertension by Region, Three Rural Regions in India, 2014–2015.

| SEP variable                  | Rishi Valley |              |              | Godavari |              |              | Trivandrum |              |              |
|-------------------------------|--------------|--------------|--------------|----------|--------------|--------------|------------|--------------|--------------|
|                               | OR           | 95% CI       | P            | OR       | 95% CI       | P            | OR         | 95% CI       | P            |
| **Income per adult per month,** |              |              |              |          |              |              |            |              |              |
| Adjusted for Age              |              |              |              |          |              |              |            |              |              |
| Q1, Rs 0 to 1000              | 1.00         |              |              | 1.00     |              |              | 1.00       |              |              |
| Q2, Rs >1000 to 1900          | 1.00         | 0.77, 1.31   | 0.97         | 1.01     | 0.78, 1.30   | 0.97         | 1.20       | 0.92, 1.56   | 0.18         |
| Q3, Rs >1900 to 3000          | 0.96         | 0.71, 1.31   | 0.80         | 1.06     | 0.83, 1.35   | 0.65         | 1.01       | 0.77, 1.34   | 0.93         |
| Q4, Rs >3000                  | 0.87         | 0.64, 1.19   | 0.38         | 1.28     | 0.99, 1.66   | 0.037        | 1.27       | 0.99, 1.64   | 0.06         |
| **Income per adult per month,** |              |              |              |          |              |              |            |              |              |
| Adjusted for Age and Education|              |              |              |          |              |              |            |              |              |
| Q1, Rs 0 to 1000              | 1.00         |              |              | 1.00     |              |              | 1.00       |              |              |
| Q2, Rs >1000 to 1900          | 1.00         | 0.77, 1.31   | 0.99         | 1.01     | 0.78, 1.30   | 0.95         | 1.17       | 0.90, 1.52   | 0.24         |
| Q3, Rs >1900 to 3000          | 0.95         | 0.70, 1.30   | 0.76         | 1.06     | 0.83, 1.35   | 0.65         | 0.99       | 0.74, 1.31   | 0.92         |
| Q4, Rs >3000                  | 0.84         | 0.61, 1.16   | 0.29         | 1.28     | 0.99, 1.66   | 0.055        | 1.22       | 0.93, 1.59   | 0.15         |
| **Education, Adjusted for Age**|              |              |              |          |              |              |            |              |              |
| No Formal Education           | 1.00         |              |              | 1.00     |              |              | 1.00       |              |              |
| Class 1 to 6                  | 1.01         | 0.80, 1.27   | 0.95         | 1.23     | 1.03, 1.46   | 0.023        | 0.81       | 0.55, 1.18   | 0.27         |
| Class 7 to 11                 | 0.91         | 0.69, 1.20   | 0.53         | 1.32     | 1.06, 1.65   | 0.014        | 1.20       | 0.86, 1.67   | 0.29         |
| Class 12+                     | 1.30         | 0.88, 1.93   | 0.19         | 1.22     | 0.90, 1.66   | 0.19         | 1.21       | 0.83, 1.78   | 0.33         |
| **Education, Adjusted for Age and Income** |              |              |              |          |              |              |            |              |              |
| No Formal Education           | 1.00         |              |              | 1.00     |              |              | 1.00       |              |              |
| Class 1 to 6                  | 1.02         | 0.80, 1.28   | 0.90         | 1.21     | 1.01, 1.44   | 0.037        | 0.80       | 0.54, 1.17   | 0.25         |
| Class 7 to 11                 | 0.93         | 0.70, 1.23   | 0.62         | 1.28     | 1.02, 1.60   | 0.032        | 1.16       | 0.83, 1.62   | 0.39         |
| Class 12+                     | 1.36         | 0.91, 2.03   | 0.13         | 1.16     | 0.85, 1.58   | 0.35         | 1.13       | 0.76, 1.69   | 0.55         |

Abbreviations: CI, confidence interval; OR, odds ratio; Q1-4, quartiles 1-4; Rs, rupees; SEP, socioeconomic position

n = 3,160 Rishi Valley, n = 4,320 Godavari, n = 2,389 Trivandrum (missing observations for education or income: 236 Rishi Valley, 180 Godavari, 1,367 Trivandrum); P values were generated using logistic regression adjusted for age alone, or adjusted for age and education/income.
Table S8. Association Between Income and/or Education and Hypertension and its Risk Factors, Three Rural Regions in India, 2014–2015.

| SEP variable | Hypertension | WHR Above Normal * | BMI ≥ 23 kg/m² † |
|--------------|--------------|--------------------|------------------|
|              | OR | 95% CI | P  | OR | 95% CI | P  | OR | 95% CI | P  |
| Income per adult per month, Adjusted for Age and Region |
| Q1, Rs 0 to 1000 | 1.00 | 1.00 | 1.00 | 1.00 |
| Q2, Rs >1000 to 1900 | 1.09 | 0.95, 1.26 | 0.23 | 1.33 | 1.18, 1.52 | <0.001 | 1.28 | 1.14, 1.44 | <0.001 |
| Q3, Rs >1900 to 3000 | 1.10 | 0.96, 1.26 | 0.18 | 1.59 | 1.40, 1.79 | <0.001 | 1.58 | 1.42, 1.77 | <0.001 |
| Q4, Rs >3000 | 1.26 | 1.10, 1.45 | 0.001 | 1.81 | 1.59, 2.06 | <0.001 | 2.26 | 2.01, 2.54 | <0.001 |
| Income per adult per month, Adjusted for Age, Region and Education |
| Q1, Rs 0 to 1000 | 1.00 | 1.00 | 1.00 | 1.00 |
| Q2, Rs >1000 to 1900 | 1.09 | 0.94, 1.25 | 0.25 | 1.31 | 1.16, 1.49 | <0.001 | 1.27 | 1.13, 1.43 | <0.001 |
| Q3, Rs >1900 to 3000 | 1.10 | 0.96, 1.26 | 0.19 | 1.56 | 1.38, 1.76 | <0.001 | 1.60 | 1.43, 1.79 | <0.001 |
| Q4, Rs >3000 | 1.25 | 1.08, 1.44 | 0.002 | 1.77 | 1.55, 2.02 | <0.001 | 2.16 | 1.92, 2.43 | <0.001 |
| Education, Adjusted for Age and Region |
| No Formal Education | 1.00 | 1.00 | 1.00 | 1.00 |
| Class 1 to 6 | 1.11 | 0.97, 1.26 | 0.12 | 1.50 | 1.32, 1.69 | <0.001 | 1.65 | 1.47, 1.86 | <0.001 |
| Class 7 to 11 | 1.12 | 0.97, 1.30 | 0.11 | 1.44 | 1.26, 1.64 | <0.001 | 1.89 | 1.67, 2.13 | <0.001 |
| Class 12+ | 1.16 | 0.96, 1.41 | 0.12 | 1.19 | 1.01, 1.39 | 0.04 | 1.94 | 1.67, 2.25 | <0.001 |
| Education, Adjusted for Age, Region and Income |
| No Formal Education | 1.00 | 1.00 | 1.00 | 1.00 |
| Class 1 to 6 | 1.09 | 0.95, 1.24 | 0.22 | 1.42 | 1.25, 1.61 | <0.001 | 1.56 | 1.39, 1.75 | <0.001 |
| Class 7 to 11 | 1.10 | 0.96, 1.28 | 0.18 | 1.41 | 1.23, 1.61 | <0.001 | 1.83 | 1.62, 2.07 | <0.001 |
| Class 12+ | 1.11 | 0.91, 1.34 | 0.30 | 1.14 | 0.96, 1.34 | 0.13 | 1.77 | 1.52, 2.07 | <0.001 |

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio; Q1-Q4, quartiles 1-4; Rs, Indian rupees; WHR, waist-hip ratio. 

n = 9,869 (1,788 missing observations for education or income); Data are presented as odds ratios (95% confidence interval). P values were generated using logistic regression adjusted for age and region, or adjusted for age, region and education/income. WHR above normal is defined as ≥0.8 for women and ≥0.9 for men. 

* 62 additional missing observations; † 24 additional missing observations
Table S9. Modification of the Effect of Education on Hypertension by Income Level, Three Rural Regions in India, 2014–2015: by Sex.

| Income per adult per month | Education Level | Measure of Effect Modification on Additive Scale |
|----------------------------|----------------|-----------------------------------------------|
|                            | No Education to Class 6 |                                           |
|                            | N +/- HTN | OR 95% CI | P            | N +/- HTN | OR 95% CI | P            |
| Women                      |            |            |               |            |            |               |
| Rs 0 to 1900               |            |            |               |            |            |               |
|                            | 570 / 1,062 | 1.00      | < 0.001       | 174 / 772 | 1.49      | 1.18, 1.87   | <0.001       |
| Rs >1900                   | 451 / 817  | 1.53      | 1.28, 1.83    | 193 / 776 | 1.78      | 1.42, 2.24   | <0.001       |
| Men                        |            |            |               |            |            |               |
| Rs 0 to 1900               |            |            |               |            |            |               |
|                            | 442 / 838  | 1.00      |               | 294 / 1,011 | 1.37     | 1.12, 1.67   | 0.002        |
| Rs >1900                   | 312 / 716  | 1.07      | 0.88, 1.29    | 358 / 1,063 | 1.48     | 1.22, 1.79   | <0.001       |

Abbreviations: AP, Attributable proportion; CI, confidence interval; HTN, hypertension; OR, odds ratio; RERI, Relative Excess Risk due to Interaction; Rs, rupees; SI, Synergy Index

Data are presented as odds ratios (95% confidence interval), and all analyses are adjusted for age.

n = 4,815 for women (1,037 missing observations for education or income)

n = 5,034 for men (750 missing observations for education or income)
Table S10. Modification of the Effect of Education on Hypertension (130/80 mmHg) by Income Level, Three Rural Regions in India, 2014–2015: Overall and by Sex.

| Income per adult per month | Education Level | Measure of Effect Modification on Additive Scale |
|----------------------------|----------------|-----------------------------------------------|
|                            | No Education to Class 6 | Class 7 and Above|
|                            | N +/- HTN  | OR | 95% CI | P  | N +/- HTN  | OR | 95% CI | P  |
| **Women and Men Combined** |                |                |                |    |                |                |    |
| Rs 0 to 1900               | 1,443 / 1,478 | 1.00 |        |     | 803 / 1,450 | 1.37 | 1.20, 1.56 | <0.001 |
| Rs >1900                   | 1,129 / 1,169 | 1.31 | 1.16, 1.47 | <0.001 | 953 / 1,444 | 1.59 | 1.40, 1.81 | <0.001 |
|                            |                |                |                |    |                |                |    |
| **Women**                  |                |                |                |    |                |                |    |
| Rs 0 to 1900               | 775 / 857     | 1.00 |        |     | 277 / 669    | 1.47 | 1.20, 1.81 | <0.001 |
| Rs >1900                   | 614 / 654     | 1.52 | 1.29, 1.80 | <0.001 | 286 / 683    | 1.54 | 1.26, 1.89 | <0.001 |
|                            |                |                |                |    |                |                |    |
| **Men**                    |                |                |                |    |                |                |    |
| Rs 0 to 1900               | 663 / 617     | 1.00 |        |     | 526 / 779    | 1.23 | 1.04, 1.47 | 0.02  |
| Rs >1900                   | 513 / 515     | 1.13 | 0.95, 1.35 | 0.16 | 664 / 757    | 1.54 | 1.30, 1.82 | <0.001 |

Abbreviations: AP, Attributable proportion; CI, confidence interval; HTN, hypertension; OR, odds ratio; RERI, Relative Excess Risk due to Interaction; Rs, Rupees; SI, Synergy Index

Data are presented as odds ratios (95% confidence interval), and all analyses are adjusted for age.

n = 9,869 for women and men combined (1,788 missing observations for education or income)
n = 4,815 for women (1,037 missing observations for education or income)
n = 5,034 for men (750 missing observations for education or income)
Table S11. Modification of the Effect of Education on Hypertension by Income Level for Women and Men Combined, 2014–2015: by Region.

| Income per adult per month | Education Level No Education to Class 6 | Measure of Effect Modification on Additive Scale |
|---------------------------|----------------------------------------|-----------------------------------------------|
|                           | N +/- HTN OR 95% CI P                  | Index OR 95% CI P                             |
| **Rishi Valley**           |                                        |                                               |
| Rs 0 to 1900               | 451 / 1,080 1.00                       | RERI 0.17 -0.28, 0.62 0.46                   |
| Rs >1900                   | 81 / 339 0.85 0.64, 1.14 0.29          | AP 0.17 -0.26, 0.60 0.43                      |
|                           |                                        | SI – – –                                       |
| **Godavari**               |                                        |                                               |
| Rs 0 to 1900               | 384 / 633 1.00                         | RERI -0.27 -0.72, 0.19 0.25                   |
| Rs >1900                   | 611 / 1,124 1.22 1.02, 1.46 0.03       | AP -0.21 -0.56, 0.15 0.26                      |
|                           |                                        | SI 0.52 0.20, 1.39 0.19                       |
| **Trivandrum**             |                                        |                                               |
| Rs 0 to 1900               | 181 / 192 1.00                         | RERI 0.18 -0.30, 0.66 0.46                   |
| Rs >1900                   | 71 / 72 0.91 0.59, 1.39 0.65           | AP 0.13 -0.22, 0.48 0.47                      |
|                           |                                        | SI 1.93 0.13, 28.4 0.63                       |

Abbreviations: AP, Attributable proportion; CI, confidence interval; HTN, hypertension; OR, odds ratio; RERI, Relative Excess Risk due to Interaction; Rs, Rupees; SI, Synergy Index.

Data are presented as odds ratios (95% confidence interval), and all analyses are adjusted for age.

n = 3,160 for the Rishi Valley (236 missing observations for education or income)
n = 4,320 for Godavari (180 missing observations for education or income)
n = 2,389 for Trivandrum (1,367 missing observations for education or income)
Table S12. Association between SEP and Waist Hip Ratio Above Normal, Three Rural Regions in India, 2014–2015.

| Characteristic                              | Univariable | Adjusted for Age and Sex |
|---------------------------------------------|-------------|--------------------------|
|                                             | OR 95% CI   | P            | OR 95% CI   | P            |
| Region                                      |             |              |             |              |
| Rishi Valley                                | 1.00        | 1.00         | 1.00        | 1.00         |
| Godavari                                    | 2.83 2.58, 3.11 | <0.001 | 3.20 2.91, 3.54 | <0.001 |
| Trivandrum                                  | 5.13 4.62, 5.71 | <0.001 | 5.80 5.19, 6.48 | <0.001 |
| Education *                                 |             |              |             |              |
| No Formal Education                         | 1.00        | 1.00         | 1.00        | 1.00         |
| Class 1 to 6                                | 1.37 1.23, 1.53 | <0.001 | 1.94 1.72, 2.18 | <0.001 |
| Class 7 to 11                               | 1.32 1.19, 1.46 | <0.001 | 2.73 2.41, 3.08 | <0.001 |
| Class 12+                                   | 0.90 0.80, 1.02 | 0.09 | 2.69 2.33, 3.11 | <0.001 |
| Above poverty line or no ration card †      | 2.42 2.19, 2.68 | <0.001 | 2.47 2.23, 2.74 | <0.001 |
| At least 5 people living in household †     | 0.91 0.84, 0.99 | 0.03 | 0.97 0.89, 1.05 | 0.40 |
| Income per adult per month ‡                |             |              |             |              |
| Q1, Rs 0 to 1000                            | 1.00        | 1.00         | 1.00        | 1.00         |
| Q2, Rs >1000 to 1900                        | 1.53 1.36, 1.71 | <0.001 | 1.76 1.56, 1.98 | <0.001 |
| Q3, Rs >1900 to 3000                        | 1.76 1.58, 1.96 | <0.001 | 2.10 1.87, 2.36 | <0.001 |
| Q4, Rs >3000                                | 2.00 1.78, 2.25 | <0.001 | 2.40 2.13, 2.71 | <0.001 |

Abbreviations: CI, confidence interval; OR, odds ratio; Q1-4, quartiles 1-4; Rs, rupees; SEP, socioeconomic position

n =11,576 for univariable and n=11,563 for adjusted analyses. Waist hip ratio above normal is defined as ≥0.8 for women and ≥0.9 for men. P values were generated using univariable and multivariable logistic regression. Class 12+ includes individuals who graduated from secondary schooling, completed technical college or completed university. Income level above the poverty line was assessed using self-reported data for use of a government issued ration card.

* 238 missing observations. † 37-43 missing observations. ‡ 1,564-1,565 missing observations.
Table S13. Association between SEP and BMI \( \geq 23 \text{ kg/m}^2 \), Three Rural Regions in India, 2014–2015.

| Characteristic                                      | Univariable | Adjusted for Age and Sex |
|-----------------------------------------------------|-------------|--------------------------|
|                                                     | OR 95% CI   | P            | OR 95% CI   | P            |
| **Region**                                          |             |              |             |              |
| Rishi Valley                                        | 1.00        |              | 1.00        |              |
| Godavari                                            | 2.91        | 2.65, 3.20   | <0.001      | 2.97         | 2.70, 3.27   | <0.001      |
| Trivandrum                                          | 3.45        | 3.13, 3.81   | <0.001      | 3.48         | 3.15, 3.84   | <0.001      |
| **Education**                                       |             |              |             |              |
| No Formal Education                                 | 1.00        |              | 1.00        |              |
| Class 1 to 6                                        | 1.62        | 1.46, 1.80   | <0.001      | 2.00         | 1.79, 2.23   | <0.001      |
| Class 7 to 11                                       | 1.99        | 1.80, 2.21   | <0.001      | 2.97         | 2.65, 3.33   | <0.001      |
| Class 12+                                           | 1.84        | 1.64, 2.06   | <0.001      | 3.28         | 2.86, 3.76   | <0.001      |
| Above poverty line or no ration card †              | 2.21        | 2.03, 2.41   | <0.001      | 2.19         | 2.01, 2.39   | <0.001      |
| At least 5 people living in household †             | 0.94        | 0.87, 1.01   | 0.09        | 0.95         | 0.88, 1.02   | 0.20        |
| **Income per adult per month ‡**                    |             |              |             |              |
| Q1, Rs 0 to 1000                                    | 1.00        |              | 1.00        |              |
| Q2, Rs >1000 to 1900                                | 1.48        | 1.32, 1.66   | <0.001      | 1.57         | 1.40, 1.76   | <0.001      |
| Q3, Rs >1900 to 3000                                | 1.81        | 1.62, 2.01   | <0.001      | 1.91         | 1.72, 2.13   | <0.001      |
| Q4, Rs >3000                                        | 2.63        | 2.35, 2.94   | <0.001      | 2.78         | 2.48, 3.11   | <0.001      |

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio; Q1-4, quartiles 1-4; Rs, rupees; SEP, socioeconomic position

n =11,616 for univariable and n=11,595 for adjusted analyses. P values were generated using univariable and multivariable logistic regression. Class 12+ includes individuals who graduated from secondary schooling, completed technical college or completed university. Income level above the poverty line was assessed using self-reported data for use of a government issued ration card.

* 240 missing observations. † 41-45 missing observations. ‡ 1,567 – 1,568 missing observations.
Table S14. Modification of the Effect of Education on Waist Hip Ratio Above Normal Levels, by Income Level, Three Rural Regions in India, 2014–2015: Overall and by Sex.

| Income per adult per month | Education Level | Measure of Effect Modification on Additive Scale |
|----------------------------|-----------------|-----------------------------------------------|
|                            | No Education to Class 6 | | |
|                            | Education Level | OR | 95% CI | P | |
| N +/- WHR above normal     | N +/- WHR above normal | OR | 95% CI | P | |
| Women and Men Combined     | Rs 0 to 1900    | 1,734 / 1,160 | 1.00 | | 1,314 / 920 | 1.82 | 1.60, 2.07 | <0.001 |
|                            | Rs >1900        | 1,631 / 662  | 2.07 | 1.83, 2.34 | <0.001 | 1,648 / 738  | 2.82 | 2.48, 3.21 | <0.001 |
| Women                      | Rs 0 to 1900    | 925 / 686  | 1.00 | | 600 / 334  | 2.53 | 2.09, 3.06 | <0.001 |
|                            | Rs >1900        | 893 / 372  | 2.20 | 1.87, 2.60 | <0.001 | 694 / 269  | 3.69 | 3.03, 4.49 | <0.001 |
| Men                        | Rs 0 to 1900    | 805 / 472  | 1.00 | | 714 / 586  | 1.41 | 1.18, 1.69 | <0.001 |
|                            | Rs >1900        | 737 / 290  | 1.90 | 1.58, 2.29 | <0.001 | 950 / 468  | 2.30 | 1.92, 2.75 | <0.001 |

Abbreviations: AP, Attributable proportion; CI, confidence interval; OR, odds ratio; RERI, Relative Excess Risk due to Interaction; Rs, Rupees; SI, Synergy Index; WHR, waist to hip ratio

Data are presented as odds ratios (95% confidence interval), and all analyses are adjusted for age.

n = 9,805 for women and men combined (1,850 missing observations for education, income or WHR)

n = 4,773 for women (1,079 missing observations for education, income, or WHR)

n = 5,022 for men (762 missing observations for education, income, or WHR)
Table S15. Women and Men Combined: Modification of the Effect of Education on BMI ≥ 23 kg/m² by Income Level, Three Rural Regions in India, 2014–2015.

| Income per adult per month | No Education to Class 6 | Class 7 and Above | Measure of Effect Modification on Additive Scale |
|----------------------------|-------------------------|------------------|-----------------------------------------------|
|                            | N +/- BMI ≥ 23 kg/m²    | OR 95% CI P      | Index OR 95% CI P                            |
| **Women and Men Combined** |                         |                  |                                               |
| Rs 0 to 1900               | 1,045 / 1,863           | 1.00             |                                               |
|                            | 1,159 / 1,137           | 1.96 1.75, 2.20  | <0.001                                        |
| Rs >1900                   | 1,030 / 1,215           | 1.94 1.72, 2.19  | <0.001                                        |
|                            | 1,440 / 956             | 3.42 3.03, 3.86  | <0.001                                        |
|                            |                         |                  |                                               |
| **Women**                  |                         |                  |                                               |
| Rs 0 to 1900               | 610 / 1,013             | 1.00             |                                               |
|                            | 488 / 457               | 2.69 2.24, 3.23  | <0.001                                        |
| Rs >1900                   | 707 / 559               | 2.39 2.05, 2.79  | <0.001                                        |
|                            | 629 / 340               | 4.72 3.91, 5.68  | <0.001                                        |
|                            |                         |                  |                                               |
| **Men**                    |                         |                  |                                               |
| Rs 0 to 1900               | 432 / 844               | 1.00             |                                               |
|                            | 541 / 757               | 1.66 1.40, 1.97  | <0.001                                        |
| Rs >1900                   | 451 / 577               | 1.61 1.36, 1.91  | <0.001                                        |
|                            | 809 / 611               | 3.04 2.57, 3.59  | <0.001                                        |

Abbreviations: AP, Attributable proportion; BMI, body mass index; CI, confidence interval; OR, odds ratio; RERI, Relative Excess Risk due to Interaction; Rs, Rupees; SI, Synergy Index

Data are presented as odds ratios (95% confidence interval), and all analyses are adjusted for age.

n = 9,845 for women and men combined (1,812 missing observations for education, income or WHR)

n = 4,803 for women (1,049 missing observations for education, income, or BMI)

n = 5,022 for men (762 missing observations for education, income, or BMI)
Table S16. Association between SEP and Alcohol Consumption in the Preceding 30 days, Three Rural Regions in India, 2014–2015.

| Characteristic                           | Univariable OR | 95% CI     | P  | Adjusted for Age and Sex OR | 95% CI     | P  |
|-----------------------------------------|----------------|------------|----|----------------------------|------------|----|
| Region                                   |                |            |    |                            |            |    |
| Rishi Valley                             | 1.00           | 1.00       |    |                            | 1.00       |    |
| Godavari                                 | 1.24           | 1.08, 1.42 | 0.003 | 1.27                       | 1.09, 1.47 | 0.002 |
| Trivandrum                               | 1.84           | 1.61, 2.11 | <0.001 | 2.12                       | 1.82, 2.46 | <0.001 |
| Education *                              |                |            |    |                            |            |    |
| No Formal Education                      | 1.00           | 1.00       |    |                            | 1.00       |    |
| Class 1 to 6                             | 1.40           | 1.20, 1.64 | <0.001 | 0.76                       | 0.64, 0.91 | 0.003 |
| Class 7 to 11                            | 1.71           | 1.48, 1.98 | <0.001 | 0.82                       | 0.69, 0.98 | 0.03  |
| Class 12+                                | 1.02           | 0.85, 1.22 | 0.80  | 0.38                       | 0.30, 0.47 | <0.001 |
| Above poverty line or no ration card †   | 0.97           | 0.86, 1.10 | 0.70  | 1.06                       | 0.93, 1.21 | 0.40  |
| At least 5 people living in household †  | 1.11           | 1.00, 1.24 | 0.05  | 1.11                       | 0.98, 1.25 | 0.09  |
| Income per adult per month ‡             |                |            |    |                            |            |    |
| Q1, Rs 0 to 1000                         | 1.00           | 1.00       |    |                            | 1.00       |    |
| Q2, Rs >1000 to 1900                     | 1.23           | 1.05, 1.44 | 0.01  | 0.89                       | 0.75, 1.06 | 0.20  |
| Q3, Rs >1900 to 3000                     | 1.32           | 1.14, 1.53 | <0.001 | 1.07                       | 0.90, 1.26 | 0.40  |
| Q4, Rs >3000                             | 1.13           | 0.97, 1.33 | 0.10  | 0.96                       | 0.81, 1.14 | 0.70  |

Abbreviations: CI, confidence interval; OR, odds ratio; Q1-4, quartiles 1-4; Rs, rupees; SEP, socioeconomic position

n =11,568 for univariable and n=11,547 for adjusted analyses. P values were generated using univariable and multivariable logistic regression. Class 12+ includes individuals who graduated from secondary schooling, completed technical college or completed university. Income level above the poverty line was assessed using self-reported data for use of a government issued ration card.

* 201 missing observations. † 1-5 missing observations. ‡ 1,526-1,527 missing observations.
Table S17. Men: Modification of the Effect of Education on Alcohol Use in the Past 30 Days by Income Level, Three Rural Regions in India, 2014–2015.

| Income per adult per month | No Education to Class 6 | Class 7 and Above |
|---------------------------|-------------------------|-------------------|
|                           | N = 2,301               | N = 2,718         |
|                           | N +/- Alcohol in past 30 days | OR | 95% CI | P | N +/- Alcohol in past 30 days | OR | 95% CI | P |
| Rs 0 to 1900              | 349 / 927               | 1.00              | 1.00, 1.44 | 0.05 | 349 / 951               | 0.84 | 0.70, 1.02 | 0.07 |
| Rs >1900                  | 328 / 697               | 1.20              | 0.81, 1.44 | 0.05 | 367 / 1,051             | 0.81 | 0.68, 0.98 | 0.03 |

Abbreviations: CI, confidence interval; OR, odds ratio; Rs, rupees
n = 5,019 (765 missing observations for education, income, or alcohol consumption); Data are presented as odds ratios (95% confidence interval), and all analyses are adjusted for age.
Measure of effect modification on additive scale:
Relative Excess Risk due to Interaction (RERI) and (95% CI) = -0.23 (-0.49, 0.03), P = 0.09
Attributable proportion (AP) and (95% CI) = -0.28 (-0.60, 0.03), P = 0.08
Figure S1. Proportion of people in each category of age and education.

Class 12+ includes individuals who graduated from secondary schooling, completed technical college or completed university.

Age confounds the association between education and hypertension, as it is associated with both the outcome (hypertension) and the variable of interest (education):

- Association between age group and hypertension: OR 1.27 (95% CI 1.26 to 1.28); and
- Association between age group and education: OR 0.93 (95% CI 0.92 to 0.94).
Figure S2. Association between Different Measures of SEP and Waist-Hip Ratio Above Normal, Body Mass Index $\geq 23\text{kg/m}^2$ and Alcohol Consumption at least once a month in Three Rural Regions in India, 2014–2015: A) Rishi Valley; B) Godavari; and C) Trivandrum.

Abbreviations: Q1-4, quartiles 1-4; Rs, rupees

Error bars indicate 95% confidence intervals. Class 12+ includes individuals who graduated from secondary schooling, completed technical college or completed university. $P$ values are the outcomes of logistic regression with hypertension as the dependent variable and the categorized terms for education (and income) introduced as a continuous independent variable.
Figure S3. Proportion of people with hypertension reporting use of medications for hypertension in: A) women and men (n = 3,310); B) women (n = 1,687); and C) men (n = 1,618).

Abbreviations: Q1-4, quartiles 1-4; Rs, rupees

Error bars indicate 95% confidence intervals. Class 12+ includes individuals who graduated from secondary schooling, completed technical college or completed university. P values are the outcomes of logistic regression with hypertension as the dependent variable and the categorized terms for education (and income) introduced as a continuous independent variable.
Supplemental References:

1. State Planning Board, Government of Kerala. Human Development Report 2005. 2005. [http://planningcommission.nic.in/plans/stateplan/sdr_pdf/shdr_kerala05.pdf](http://planningcommission.nic.in/plans/stateplan/sdr_pdf/shdr_kerala05.pdf) (accessed 9 November, 2018)

2. Government of India. Census 2011. 2015. [http://www.census2011.co.in/district.php](http://www.census2011.co.in/district.php) (accessed 9 November, 2018)

3. Thrift AG, Evans RG, Kalyanram K, Kartik K, Fitzgerald SM, Srikanth V. Gender-specific effects of caste and salt on hypertension in poverty: a population-based study. *J. Hypertens.* 2011;29:443-450

4. Banerjee AV, Duflo E. The Economic Lives of the Poor. *J. Econ. Perspect.* 2007;21:141-167

5. Whelton PK, Carey RM, Aronow WS, Casey DE, Jr., Collins KJ, Dennison Himmelfarb C, DePalma SM, Gidding S, Jamerson KA, Jones DW, MacLaughlin EJ, Muntner P, Ovbiagele B, Smith SC, Jr., Spencer CC, Stafford RS, Taler SJ, Thomas RJ, Williams KA, Sr., Williamson JD, Wright JT, Jr. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APHA/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Hypertension.* 2018;71:1269-1324
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Author/s:
Thrift, AG; Ragavan, RS; Riddell, MA; Joshi, R; Thankappan, KR; Chow, C; Oldenburg, B; Mahal, AS; Kalyanram, K; Kartik, K; Suresh, O; Mini, GK; Ismail, J; Gamage, DG; Hasan, A; Srikanth, VK; Thomas, N; Maulik, PK; Guggilla, RK; Evans, RG

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