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

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Abstract

Background: Of the 1 billion people with hypertension globally, two-thirds reside in low- and middle-income countries (LMICs). The risk of hypertension in LMICs is thought to be positively associated with socioeconomic status (SES). However, recent studies have provided data inconsistent with this concept. Thus, we assessed the association between SES and hypertension in rural populations of LMICs. Further, we explored whether this association differs according to geographical region.

Methods: Through a search of databases we identified population-based studies that presented risk estimates for the association between SES, or any of its proxies, and hypertension. Meta-analyses were conducted using a random effects model.

Results: Overall, no association was detected between educational status and hypertension, whereas a positive association was observed with income. Interestingly, educational status was inversely associated with hypertension in East Asia (effect size [95% confidence interval (CI) 0.78, 0.87]) but positively associated in South Asia (95% CI 1.14, 1.43). Higher income, household assets or social class were positively associated with hypertension in South Asia whereas no association was detected in East Asia and Africa. Compared with other occupations, farmers or manual labourers were associated with a lower risk for hypertension. Further, in regions such as Latin America, few studies were identified that fulfilled our inclusion criteria.

Conclusions: We provide evidence that the association between hypertension and SES in rural populations of LMICs in Asia varies according to geographical region. This
has important implications for targeting intervention strategies aimed at high-risk populations in different geographical regions.

**Key words:** Hypertension, socioeconomic status, educational status, income, occupation, low-and-middle-income countries, rural, meta-analysis, review

**Key Messages**
- Overall, there is no significant association between educational status and hypertension in rural populations of some LMICs whereas a positive association exists with income.
- When stratified by geographical region, educational status is inversely associated with hypertension in rural East Asian populations whereas in South Asian populations a positive association is observed.
- Large multi-site collaborative studies employing uniform methodology are necessary to assess the association between SES and hypertension in rural settings of LMICs. These studies may help reduce the problem of bias associated with the use of disparate methodology.

**Introduction**

Hypertension is the leading risk factor for the global burden of disease, accounting for 9.4 million deaths and 7% of the global disability-adjusted life-years (DALYs, 2010). More specifically, hypertension is a major risk factor for coronary heart disease, heart failure, cerebrovascular disease, and chronic renal failure.2-5 Of the 1 billion people globally who have hypertension, two-thirds reside in low- and middle-income countries (LMICs).6 Moreover, most of the increase in the global prevalence of hypertension over the next decade is predicted to be in LMICs.6

The increase in the prevalence of hypertension in LMICs in recent years is generally thought to be attributable to the adoption of unhealthy behaviours as a result of globalization as well as an increase in human longevity.7,8 The percentage of people aged at least 65 years has increased from about 5% in 1950 to about 8% in 2010 and is expected to increase to approximately 15% in 2040; most of this increase is occurring in LMICs.9 This increase in the population age structure is one of the factors that are likely to be driving the rising prevalence of hypertension in these regions.

There is good evidence that adoption of unhealthy behaviours as a result of globalization is a major driver of cardiovascular disease in urban and semi-urban areas of LMICs.7,10 However, the extent to which this concept can be applied to rural areas of these countries, where uptake of unhealthy behaviours might be less than in urban areas, remains to be firmly established. Furthermore, our examination of published reports from population-based studies suggests that knowledge of the association between socioeconomic status (SES) and hypertension in rural populations of LMICs is scanty. An improved understanding of the nature of this association in rural areas of LMICs will assist in the implementation of strategies to control and prevent hypertension.

Socioeconomic status is a strong predictor of cardiovascular disease.11 However, the nature of the relationship between SES and hypertension (the ‘SES-hypertension gradient’) appears to differ by setting. In high-income countries (HICs), SES is inversely associated with hypertension.12 However in LMICs, SES is often seen to be positively associated with hypertension.12 Regardless of whether education, income or occupation is used to measure SES, there has been mostly a positive association between SES and hypertension in LMICs and a negative association in HICs.12

The positive association between SES and hypertension in LMICs has been explained by the theory that economic prosperity and urbanization increase the prevalence of risk factors for hypertension such as obesity, a sedentary lifestyle and excessive salt intake.7,12 Similarly, the negative association observed in HICs can be explained by the reversal of the risk factors as development increases.7,12 However, some recent studies have generated conflicting results regarding the relationship between SES and hypertension in LMICs.13-18 In some LMICs, such as China, inverse associations between SES and hypertension are increasingly being observed. This may indicate that these countries have reached an advanced development stage.13,19-21 Nevertheless, most rural areas of LMICs are still at an early stage of the epidemiological transition. Thus, we would expect the association between SES and hypertension in these settings to be positive. This hypothesis is the focus of the current meta-analysis.
We conducted a systematic review and meta-analysis of population-based studies, in which the effects of SES on hypertension in rural areas of LMICs were evaluated. The objective of this meta-analysis was to systematically quantify the association between SES and hypertension in rural populations of LMICs. We also explored whether the association between SES and hypertension in these settings differs according to geographical region.

Methods
Selection of articles
A comprehensive literature search using MeSH terms and text words was conducted in PubMed (including Medline), Web of Science, Scopus and EMBASE until 15 September 2013. The following keywords were used: ‘poverty areas’ or ‘vulnerable populations’ or ‘rural population’ or ‘rural health’ or ‘rural’ or ‘disadvantaged areas’ or ‘disadvantaged population(s)’ or ‘developing countries’ or ‘low-income countries’ or ‘middle-income countries’ or ‘low income countries’ or ‘low- and middle-income countries’; and ‘risk factor(s)’ or ‘blood pressure determination(s)’ or ‘determinant(s)’ or ‘predictor(s)’ or ‘social class’ or ‘socioeconomic status’ or ‘socio-economic status’ or ‘socioeconomic’ or ‘education status’ or ‘education level’ or ‘education’ or ‘income level’ or ‘income’ or ‘wealth’ or ‘assets’ or ‘occupation type’ or ‘occupation’ or ‘profession’ or ‘work’; and ‘hypertension’ or ‘high blood pressure’ or ‘blood pressure’ or ‘WHO STEPs’. The search was limited to articles written in English, Spanish, Portuguese and French.

Studies were eligible for inclusion if they conformed to the following criteria: (i) population-based studies that presented risk estimates for the association between socioeconomic status or any of its proxies such as education, income, assets ownership, social class or occupation, and hypertension; (ii) studies from rural populations (defined according to the country of origin of the study) of LMICs; (iii) a multivariable analysis (that is, with adjustment for age with or without other relevant confounding factors); (iv) results expressed as odds ratios (ORs), relative risks (RRs), hazards ratios (HRs) or prevalence ratios (PRs); (v) studies in which hypertension was defined based on measurement of both systolic blood pressure (SBP) and diastolic blood pressure (DBP) and information regarding prescription of antihypertensive medication; (vi) blood pressure was measured in the study rather than reported or taken from medical records; and (vii) a cross-sectional, case-control or cohort study design.

The World Bank’s country classification was used to define the LMICs. Studies in which only univariable associations were reported were excluded from the analysis. We excluded studies in only young (<24 years of age) or old (≥64 years of age) individuals, as well as studies where only genetic analyses were performed. In instances where there were multiple publications based on the same data source/study population, the most recent or the most complete publication was used; that is, no data were used more than once. We excluded studies from HICs, those from urban populations of LMICs, those that combined rural and urban populations of LMICs and those that did not include SES or any of its proxies.

Definition of hypertension
Hypertension was defined as a SBP ≥140 mmHg and/or DBP ≥90 mmHg and/or prescription of antihypertensive medication, as well as the older definition of SBP ≥160 mmHg and/or DBP ≥95 mmHg and/or prescription of antihypertensive medication.

Extraction of data
A list of retrieved articles was reviewed and data extraction performed independently by three investigators (D.B., S.A., and A.K.S.). Disagreement was resolved by consensus. Using a standardized data extraction form, the following information was extracted for each relevant study: (i) type of study; (ii) region and country; (iii) year(s) of data collection; (iv) the total population included in the study; (v) age range and mean age of participants; (vi) definition of hypertension; (vii) prevalence of hypertension; (viii) categories of SES, social class, educational status, income level, assets ownership and occupation type; (ix) point estimates (ORs, RRs, PR, or HRs) and 95% confidence intervals (CIs); and (x) the confounding factors that were adjusted for in the analyses (Table 1; Supplementary Table 1, available as Supplementary data online). In cases where several risk estimates were presented, those arising from adjustment of the greatest number of potential confounding variables were used.

Categorization of the studies based on SES
Studies were divided into three groups based on the measures of SES reported; that is those of the association between hypertension and: (i) level of education; (ii) income, social class or household assets; and (iii) type of occupation. For the education and income groups, studies were further separated based on whether educational status or income was treated as continuous or categorical variables. When educational status, income or occupation was presented as a categorical variable, we assessed this based on
<table>
<thead>
<tr>
<th>Location/reference</th>
<th>Survey year</th>
<th>Study population</th>
<th>Age range (years)</th>
<th>Mean age (SD)</th>
<th>HPN definition</th>
<th>SES measure</th>
<th>Hypertension prevalence (%)</th>
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<tr>
<td></td>
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<td>Zhangqiu, China</td>
<td>1991</td>
<td>8359</td>
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<td>_</td>
<td>A</td>
<td>D</td>
<td>20.4</td>
</tr>
<tr>
<td></td>
<td>2002</td>
<td>18922</td>
<td>35–74</td>
<td>_</td>
<td>A</td>
<td>D</td>
<td>24.5</td>
</tr>
<tr>
<td></td>
<td>2007</td>
<td>20167</td>
<td>35–74</td>
<td>_</td>
<td>A</td>
<td>D</td>
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<td>Rajasthan, India</td>
<td>1994</td>
<td>3148</td>
<td>20–80</td>
<td>_</td>
<td>A</td>
<td>D</td>
<td>21</td>
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<tr>
<td>Evoduola, Cameroon</td>
<td>1994</td>
<td>717</td>
<td>24–74</td>
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<td>A</td>
<td>F</td>
<td>13.8 (9.9, 17.6)</td>
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<td>415</td>
<td>24–74</td>
<td>M: 47.0 (14.6)</td>
<td>A</td>
<td>F</td>
<td>44 (36.8, 50.9)</td>
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<td>2559</td>
<td>16–70</td>
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<td>D, E</td>
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<td>60–84</td>
<td>_</td>
<td>B</td>
<td>E</td>
<td>–</td>
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<td>Moradabad, India</td>
<td>1995</td>
<td>1935</td>
<td>&gt;25</td>
<td>_</td>
<td>B</td>
<td>E</td>
<td>20.8</td>
</tr>
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<td>Muradbye, Turkey</td>
<td>2001</td>
<td>F: 207</td>
<td>&gt;45</td>
<td>62.3 (9.9)</td>
<td>A</td>
<td>F</td>
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<td>2002</td>
<td>14280</td>
<td>≥20</td>
<td>_</td>
<td>A</td>
<td>D</td>
<td>–</td>
</tr>
<tr>
<td>Fuxin, China</td>
<td>2004–06</td>
<td>≥35</td>
<td>51.2 (11.8)</td>
<td>A</td>
<td>D</td>
<td>42</td>
<td>41.7</td>
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<td>Mongolian Han</td>
<td>36154</td>
<td>36.7</td>
<td>35.8</td>
<td>37.7</td>
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<tr>
<td>Fuxin, China</td>
<td>2004–06 to 2008</td>
<td>24360</td>
<td>≥35</td>
<td>M: 48.2 (10.4)</td>
<td>A</td>
<td>D, E</td>
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<td>40–75</td>
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<td>D, E</td>
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<td>1984</td>
<td>25–64</td>
<td>_</td>
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<td>D, E, F</td>
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<td>25–64</td>
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<td>D</td>
<td>17.1 (15.5, 18.8)</td>
</tr>
<tr>
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<td>2005</td>
<td>–</td>
<td>25–64</td>
<td>_</td>
<td>A</td>
<td>D</td>
<td>24.1 (22.2, 26)</td>
</tr>
<tr>
<td>WATCH, Bangladesh</td>
<td>2005</td>
<td>–</td>
<td>25–64</td>
<td>_</td>
<td>A</td>
<td>D</td>
<td>9.3 (8, 10.6)</td>
</tr>
<tr>
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<td>2005</td>
<td>–</td>
<td>25–64</td>
<td>_</td>
<td>A</td>
<td>D</td>
<td>16.8 (15.2, 18.5)</td>
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<tr>
<td>Chilbab, Vietnam</td>
<td>2005</td>
<td>–</td>
<td>25–64</td>
<td>_</td>
<td>A</td>
<td>D</td>
<td>18.3 (16.7, 20)</td>
</tr>
<tr>
<td>Filabavi, Vietnam</td>
<td>2005</td>
<td>–</td>
<td>25–64</td>
<td>_</td>
<td>A</td>
<td>D</td>
<td>15.1 (13.5, 16.6)</td>
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<tr>
<td>Kanchanaburi, Thailand</td>
<td>2005</td>
<td>–</td>
<td>25–64</td>
<td>_</td>
<td>A</td>
<td>D</td>
<td>27.7 (25.8, 29.6)</td>
</tr>
<tr>
<td>Vadu, India</td>
<td>2005</td>
<td>–</td>
<td>25–64</td>
<td>_</td>
<td>A</td>
<td>D</td>
<td>23.6 (21.7, 25.4)</td>
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<th>Location/reference</th>
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<td>Total</td>
</tr>
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<td>Fuxin, China&lt;sup&gt;13&lt;/sup&gt;</td>
<td>2005–06</td>
<td>29970</td>
<td>35–85</td>
<td>51.3 (11.9)</td>
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<td>D</td>
<td>36.2</td>
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<td>Tamil Nadu, India&lt;sup&gt;35&lt;/sup&gt;</td>
<td>2005–07</td>
<td>10463</td>
<td>25–64</td>
<td>–</td>
<td>A</td>
<td>D, F</td>
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<td>Amasaman, Ghana&lt;sup&gt;28&lt;/sup&gt;</td>
<td>&lt;2006</td>
<td>362</td>
<td>18–99</td>
<td>42.4 (18.6)</td>
<td>A</td>
<td>D, F</td>
<td>25.4</td>
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<tr>
<td>Rishi Valley, India&lt;sup&gt;57&lt;/sup&gt;</td>
<td>2006</td>
<td>1474</td>
<td>≥18</td>
<td>39.7 (15.6)</td>
<td>A</td>
<td>D, E</td>
<td>–</td>
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<td>Sub-Saharan Africa&lt;sup&gt;31&lt;/sup&gt; including Mwandama (Malawi), Mayange (Rwanda) and Mbola (Tanzania)</td>
<td>2006–07</td>
<td>1485</td>
<td>≥18</td>
<td>41.4 (17.1)</td>
<td>A</td>
<td>E</td>
<td>22</td>
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<td>Sarlahi, Nepal&lt;sup&gt;56&lt;/sup&gt;</td>
<td>2006–08</td>
<td>15934</td>
<td>16–71</td>
<td>34.2 (5.9)</td>
<td>B</td>
<td>E, F</td>
<td>–</td>
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<td>Mysore, India&lt;sup&gt;57&lt;/sup&gt;</td>
<td>2007–08</td>
<td>1423</td>
<td>&gt;18</td>
<td>40.9 (16.3)</td>
<td>A</td>
<td>D, F</td>
<td>15.0</td>
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<td>Maharashatra, India&lt;sup&gt;52&lt;/sup&gt;</td>
<td>2007–08</td>
<td>3591</td>
<td>≥40</td>
<td>54.4 (11.4)</td>
<td>A</td>
<td>D</td>
<td>28.2</td>
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<td>West Bengal, India&lt;sup&gt;14&lt;/sup&gt;</td>
<td>2007–11</td>
<td>F: 1186</td>
<td>18–65</td>
<td>43 (median)</td>
<td>A</td>
<td>D, E</td>
<td>–</td>
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<td>Nandan, China&lt;sup&gt;18&lt;/sup&gt;</td>
<td>&lt;2008</td>
<td></td>
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<td>Bui Ku Yao</td>
<td></td>
<td>485</td>
<td>40–85</td>
<td>54 (11)</td>
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<td>21.9</td>
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<td>40–89</td>
<td>55 (11)</td>
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<td>Yunnan, China&lt;sup&gt;21&lt;/sup&gt;</td>
<td>2008–09</td>
<td>11061</td>
<td>≥35</td>
<td>–</td>
<td>A</td>
<td>D, E</td>
<td>32.8</td>
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<td>South western, Uganda&lt;sup&gt;38&lt;/sup&gt;</td>
<td>2009</td>
<td>6678</td>
<td>≥13</td>
<td>M: 31.8 (18.4)</td>
<td>B</td>
<td>D, E</td>
<td>22&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Hubei, China&lt;sup&gt;20&lt;/sup&gt;</td>
<td>&lt;2010</td>
<td>2438</td>
<td>&gt;35</td>
<td>51.4 (12.2)</td>
<td>A</td>
<td>D</td>
<td>26.9</td>
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<tr>
<td>Gudjig, Thailand&lt;sup&gt;16c&lt;/sup&gt;</td>
<td>2010</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>Cases</td>
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<td>72</td>
<td>–</td>
<td>64.3 (11.4)</td>
<td>A</td>
<td>D, F</td>
<td>–</td>
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<tr>
<td>Controls</td>
<td></td>
<td>72</td>
<td>–</td>
<td>48.5 (10.0)</td>
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<td></td>
<td>–</td>
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<tr>
<td>Jamkhed, India&lt;sup&gt;29&lt;/sup&gt;</td>
<td>2010</td>
<td>224</td>
<td>40–85</td>
<td>56.8 (11.8)</td>
<td>B</td>
<td>E, F</td>
<td>30.3</td>
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<td>Gansu, China&lt;sup&gt;52&lt;/sup&gt;</td>
<td>2010</td>
<td>3000</td>
<td>18–85</td>
<td>46.3 (14.2)</td>
<td>A</td>
<td>D</td>
<td>36.7</td>
</tr>
<tr>
<td>Zhejiang, China&lt;sup&gt;30&lt;/sup&gt;</td>
<td>2010</td>
<td>10525</td>
<td>≥18</td>
<td>49.3 (15.1)</td>
<td>A</td>
<td>D</td>
<td>27.0</td>
</tr>
<tr>
<td>Dali, China&lt;sup&gt;33&lt;/sup&gt;</td>
<td>2010</td>
<td>2133</td>
<td>≥50</td>
<td>–</td>
<td>A</td>
<td>D</td>
<td>42.1</td>
</tr>
<tr>
<td>Vitoria da Conquista, Brazil&lt;sup&gt;55&lt;/sup&gt;</td>
<td>2011</td>
<td>797</td>
<td>≥18</td>
<td>44 (17.9)</td>
<td>A</td>
<td>D, E</td>
<td>45.4 (41.9, 48.9)</td>
</tr>
</tbody>
</table>

HPN, hypertension; SES, socioeconomic status; SD, standard deviation; M, males; F, females; A, SBP ≥140 mmHg and/or DBP ≥90 mmHg or using antihypertensive medication; B, SBP ≥140 mmHg and/or DBP ≥90 mmHg; C, SBP ≥160 mmHg and/or DBP ≥95 mmHg or using antihypertensive medication; D, education; E, income, household assets or social class; F, occupation.

<sup>a</sup>Age-adjusted prevalence.

<sup>b</sup>Cohort study and case-control study, whereas the rest are cross-sectional studies.
the reported reference group. For example, separate analyses were performed for studies where higher educational status or income was considered as a reference group and studies where low educational status or income was considered as a reference group.

Additionally, for educational status, we considered three groups: low education (those who did not complete primary school, including those who had no education); completed primary school; and high education (those who completed more than primary school). The educational levels from each study were assigned to one of these three groups. For example, if a study had two levels in the high education group, both educational levels were included in the high educational group with their exact effect sizes as reported. For reports where subjects were grouped as illiterate and literate, those who were illiterate were considered to be in the low education group and those who were literate were considered as a separate group. Similarly, income (including household assets or social class) was re-categorized into three groups: low income; middle income; and high income. Some of the published reports included separate data from different study sites in a single article. In this paper, ‘studies’ represent each single study site whereas ‘articles’ represent each single published paper.

Statistical analysis
The outcome measurement was hypertension. Data were pooled separately based on the measure of SES that was reported and whether educational status or income was assessed as a continuous or a categorical variable. Meta-analyses of the categorical variables of educational status, income or occupation were compared with the reported reference category. Additionally, where possible the meta-analyses were stratified by sex and geographical region. For all meta-analyses, a random effects model was preferred over a fixed model because of the expected heterogeneity across studies arising from the differences in samples and designs of the studies, different risk estimates measured, and populations. Random effects estimates were calculated using the DerSimonian and Laird method. Summary estimates from the fixed effects model were also presented in the forest plots for comparison.

Heterogeneity of each pooled estimate was assessed using Cochrane’s Q test and quantified with the I² statistic, a quantitative estimate of the percentage of variation between studies that is attributable to heterogeneity. Publication bias was assessed using funnel plots and Begg’s tests. Sensitivity analyses were performed to examine whether the estimates varied by the design of the study and definition of hypertension used, and also to identify studies that may have had considerable influence on the pooled estimate.

Where data were given in a way that could not be used in the meta-analysis, but the study qualified for inclusion, the findings of these studies are only listed in the tables and the Results section of this review. For the association between SES and hypertension, ‘positive association’ means that high SES was associated with hypertension, whereas ‘inverse association’ means that low SES was associated with hypertension. Analyses were performed using STATA (version 12; StataCorp, College Station, TX, USA).

Results
The search of databases yielded 10 785 articles. Of these, 5230 duplicates were excluded (Figure 1). After reviewing the titles and abstracts, 436 articles were identified as potentially eligible for inclusion. After full review, 36 articles were deemed eligible and were included in the current paper. Of the 36 articles included in this review, 11 described studies conducted in China, 13-18,20,21,32, 44,45,51,53,54 10 in India, 14,15,29,35,37,39,42,43,47,52 three in Vietnam, 34,40,46 and one each in Thailand, 16 Nepal, 36 Iran, 17 Turkey, 41 Mexico, 30 Brazil, 55 Cameroon, 33 Gambia, 48 Ghana, 28 and Uganda. 38 Two of the articles presented results of multi-site studies, one from Asia and the other from sub-Saharan Africa. The countries involved in
the multi-site studies were Bangladesh, Vietnam, Thailand, Indonesia, India, Malawi, Rwanda and Tanzania. Nearly all the studies included were cross-sectional studies except two: one cohort study\textsuperscript{14} and one case-control study.\textsuperscript{16}

There were 29 reports\textsuperscript{13–18,20,21,28,30,32–35,37–40,45–55} on the association between education and hypertension, 11 on occupation,\textsuperscript{16,28,29,34–37,40,41,46,48,56} and 15 on either income, household assets or social class.\textsuperscript{14,17,21,29,31,34,36,38–40,42–44,47,55} Note that in some articles, the association between hypertension and SES was assessed with more than one of the SES proxies. The definition of hypertension used in the studies varied. For the majority of the articles,\textsuperscript{13–18,20,21,28,30,32–35,37–39,44–47,55} hypertension was defined as SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg and/or prescription of antihypertensive medication. In five articles,\textsuperscript{29,36,38,42,43} hypertension was defined as SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg, and in one article\textsuperscript{18} it was defined as SBP ≥ 160 mmHg and/or DBP ≥ 95 mmHg and/or prescription of antihypertensive medication. Although the figures show estimates from both the random and the fixed effects models, the results presented and discussed are based on the random effects model.

### Association between educational status and hypertension

The association between educational status and hypertension was reported as a continuous variable in two of the articles\textsuperscript{15,18} and as categorical in the remaining 27 articles. For 11 articles\textsuperscript{14,16,30,2,34,38–40,50,52,55} consisting of 11 studies, higher educational status (>primary school) or being literate was the reference category. In the remaining 16 articles\textsuperscript{13,15,17,18,20,21,28,33,35,37,45–49,51,53,54} consisting of 24 studies, lower educational status (<primary school) or being illiterate was the reference category.

Generally, a meta-analysis of data from 24 studies showed no association between higher educational status and hypertension [ES 0.98 (95% CI 0.91, 1.04)] (Figure 2; and Supplementary Figure 1, available as Supplementary data at IJE online). However, for the three studies in which subjects were categorized as being either literate or illiterate, being literate was associated with a lower risk for hypertension [ES 0.82 (95% CI 0.72, 0.93)] (Figure 2; and Supplementary Figure 2, available as Supplementary data at IJE online). Furthermore, having no or lower educational status (≤primary school, 11 studies) was associated with a greater risk of hypertension [ES 1.24 (95% CI 1.09,
Figure 3. Meta-analysis of the association between educational status and hypertension with low education (<primary school) as a reference group stratified by geographical region. Only studies from Evodoula, Tamil Nadu and Rishi Valley presented separate results for males and females, the rest of the studies presented combined results for both males and females. HPN, hypertension; ES, effect size; CI, confidence interval; Sch, school; Uni, university; Educ, education; yrs, years; D+L subtotal, random effects meta-analysis; I-V subtotal, fixed effects meta-analysis.
The association between hypertension and educational status was contradictory in the studies in which education was detected between educational status and hypertension (Figure 2; and Supplementary Figures 4 and 5, available as Supplementary data at IJE online).

The association between hypertension and educational status was contradictory in the studies in which education was reported as a continuous variable. High educational status was associated with a greater risk of hypertension in a study from China, whereas it was associated with a lower risk in the study from India. A meta-analysis of the two studies showed no association between hypertension and educational status [ES 0.97 (95% CI 0.88, 1.06)] (Figure 2; and Supplementary Figure 6, available as Supplementary data at IJE online).

**Association between income level, household assets or social class and hypertension**

There were eight reports on the association between income and hypertension, three on household assets, three on social class and three reported composite SES scores. Income, household assets or social class was reported as a continuous variable in three articles and as a categorical variable in the remaining 12 articles. Lower income, household assets or social class was a reference group in eight articles whereas in four articles, higher income, household assets or social class was a reference group.

Overall, having higher income, household assets or social class was associated with a greater risk of hypertension in these rural populations of LMICs [ES 1.10 (95% CI 1.05, 1.14)] (Figure 2; and Supplementary Figure 7,
available as Supplementary data at IJE online). The findings were similar for each of the measures of SES (income and household assets) when they were assessed separately (Supplementary Figure 7, available as Supplementary data at IJE online) and when the data were stratified by geographical region (Figure 4).

Additionally, higher income, household assets or social class was associated with hypertension in men [ES 1.13 (95% CI 1.05, 1.21)] but not in women [ES 1.06 (95% CI 0.99, 1.14)] (Figure 2; and Supplementary Figure 8, available as Supplementary data at IJE online).

Neither of the two articles in which income was reported as a continuous variable provided evidence of association between income and hypertension in rural adults. In a study from Iran, which incorporated a composite wealth score (calculated using variables such as house ownership, house size, number of people living in the house and ownership of assets such as a car, TV and refrigerator), greater wealth was associated with a lower risk [OR 0.86 (95% CI 0.76, 0.97)] of hypertension. In another study from India in which SES was assessed as a composite of education, occupation, income and household assets, higher SES was associated with a greater risk for hypertension in both men [OR 1.09 (95% CI 1.05, 1.14)] and women [OR 1.08 (95% CI 1.05, 1.13)]. Furthermore, lower SES (assessed as a composite of education and household assets) was associated with hypertension [PR 1.49 (95% CI 1.17, 1.90)] in a rural Brazilian population.

**Association between occupation and hypertension**

Being a farmer or manual labourer was a reference category in six articles whereas being a housewife or housekeeper was a reference category in three articles.

Overall, the meta-analysis results revealed that having an occupation other than a farmer or manual labourer was associated with hypertension [ES 1.51 (95% CI 1.28, 1.79)] (Figure 5). Conversely, having an occupation other than housewife or housekeeper was associated with a lower risk of hypertension in two studies from India and one study from Nepal [ES 0.76 (95% CI 0.64, 0.89)].
South Asian populations.10,59 According to the current advanced along the epidemiological transition than are Asian populations, particularly those in China, are further believe this observation reflects the fact that in general East rural populations, a positive association was observed. We with the risk of hypertension. In contrast, in South Asian populations, educational status was inversely associated in East Asia compared with South Asia. In East Asian rural populations in South Asia whereas the latter, positive effects, dominate in East Asia. Our findings thus provide useful information to help target interventions specific for each population in the two geographical regions of Asia. In East Asia, interventions for control and prevention of hypertension in rural populations should be targeted at populations with low SES. In contrast, in South Asia, high SES populations should be targeted initially, but in the long run and with further epidemiological transition, low SES populations will also need to be targeted.

The positive association between income, household assets or social class and hypertension in South Asia is consistent with the observed association between educational status and hypertension. However, we were unable to detect a significant association between income, household assets or social class and hypertension in East Asia. The apparent disparity in these observations coupled with the fact that overall higher income was positively associated with hypertension in rural populations of LMICs, may reflect the role of income as a driver of unhealthy lifestyle choices but education as a factor that can mitigate this effect. Therefore, educational efforts aimed at increasing the knowledge and awareness of hypertension and its risk factors in high-risk populations may help individuals reduce their exposure to risk factors for hypertension and thus reduce the burden of this disease in these populations.

Assessment of publication bias and sensitivity analyses

According to Begg’s tests, there was no evidence of publication bias for the studies in which educational status \(P = 0.997\), income, household assets or social class \(P = 0.988\), and occupation \(P = 0.673\) were reported. Furthermore, in influence analyses no individual study significantly altered the pooled effect sizes for educational status, income, household assets or social class, and occupation. Other sensitivity analyses performed to examine the influence of differences in study design and the definition of hypertension on the estimate sizes provided results consistent with those of the main analysis (data not shown). Furthermore, due to controversy regarding the validity of the data used in one of the studies from India,42 a sensitivity analysis was performed. Exclusion of this study did not alter the interpretation of the findings (Supplementary Figure 10, available as Supplementary data at IJE online).

Discussion

The most important finding of this meta-analysis of the impact of SES on the risk of hypertension in rural populations of LMICs was the contrasting effects of educational status in East Asia compared with South Asia. In East Asian rural populations, educational status was inversely associated with the risk of hypertension. In contrast, in South Asian rural populations, a positive association was observed. We believe this observation reflects the fact that in general East Asian populations, particularly those in China, are further advanced along the epidemiological transition than are South Asian populations.10,59 According to the current statistics from the World Bank, in 2012 about 25.7% of the rural population in India were below the national poverty line whereas only 10.2% of the rural population in China were below the national poverty line.60 This implies that rural populations in China are more prosperous than those in India. Thus, Chinese rural populations may be more advanced along the epidemiological transition than are Indian rural populations. It has previously been proposed that the epidemiological transition might influence the association of SES with the risk of hypertension in urban populations.7,12 Our current findings provide strong evidence that this occurs in rural populations. Intervention strategies, aimed at prevention and treatment of hypertension, should take the context of the transition into account so as to optimize their effectiveness.

Theoretically, SES should have opposing effects on the risk of hypertension and other chronic diseases associated with a Western lifestyle. On the one hand, increased education and income should negatively affect hypertension by increasing the availability of high-energy and processed foods, while at the same time promoting a sedentary lifestyle. On the other hand, the positive effects of education and income on hypertension will be an increased awareness of the risks associated with these lifestyle choices, allowing the individual an opportunity to modulate their behaviour.7,61 Our findings support the notion that the former, negative effects of SES, dominate in rural populations in South Asia whereas the latter, positive effects, dominate in East Asia. Our findings thus provide useful information to help target interventions specific for each population in the two geographical regions of Asia. In East Asia, interventions for control and prevention of hypertension in rural populations should be targeted at populations with low SES. In contrast, in South Asia, high SES populations should be targeted initially, but in the long run and with further epidemiological transition, low SES populations will also need to be targeted.

The positive association between income, household assets or social class and hypertension in South Asia is consistent with the observed association between educational status and hypertension. However, we were unable to detect a significant association between income, household assets or social class and hypertension in East Asia. The apparent disparity in these observations coupled with the fact that overall higher income was positively associated with hypertension in rural populations of LMICs, may reflect the role of income as a driver of unhealthy lifestyle choices but education as a factor that can mitigate this effect. Therefore, educational efforts aimed at increasing the knowledge and awareness of hypertension and its risk factors in high-risk populations may help individuals reduce their exposure to risk factors for hypertension and thus reduce the burden of this disease in these populations.
The lower risk of hypertension in farmers and manual labourers compared with other occupations may reflect the high level of physical activity in these groups. Regular physical activity has established protective effects on the risk of hypertension.

There are some limitations of our meta-analysis that need to be considered in the interpretation of our findings. First, a major impediment for meta-analysis of observational studies is heterogeneity, which was evident in some of the meta-analyses performed. This was expected because of differences in the characteristics of the various populations that were studied and the methods that were applied (such as the design of the study, methods of data collection and analytical models). From the analyses conducted, we observed that factors such as geographical region, gender and methodology (for example, methods of data collection and analytical models) were responsible for most of the heterogeneity. Although most of the heterogeneity observed in this meta-analysis was moderate ($I^2 < 75\%$), we suggest caution when interpreting the pooled estimates.

The second limitation of meta-analysis of observational studies is that the outcome of a meta-analysis depends on the studies included. Large differences in sample sizes among studies can affect the results of the analysis. Depending on the meta-analysis model used, when the studies vary significantly in size, the large or small studies may have an unduly large influence on the results. Additionally, the precision with which the effect is estimated in meta-analyses is usually much greater than in the individual studies and this could affect interpretation of findings. Third, the reliance on studies with observational designs limits the ways in which one can account for potential confounding factors. Differences in the methods used to control for these confounding factors in the individual studies have the potential to affect the results of a meta-analysis.

The fourth limitation is the major contribution of crosssectional studies to our meta-analysis, which precludes us from drawing firm conclusions about temporal and causal relationships. Fifth, as most of the studies included in our analysis were not nationwide, there could be potential for geographical selection bias for countries like India and China, given the enormous national diversity of these two countries. In addition, although our meta-analysis included peer-reviewed publications written in English, Spanish, Portuguese and French, there were few studies from some regions such as Latin America and Africa that fulfilled our inclusion criteria. This may have limited our ability to determine comprehensively the impact of SES on hypertension in all rural populations of LMICs in the world. However, the findings from East and South Asia highlight the fact that the SES-hypertension gradient is not constant across the world’s various rural populations.

One might consider our exclusion of studies that included only young (≤24 years of age) or older (≥64 years of age) individuals as a limitation. However, exclusion of these studies was important to minimize the differential effects of age on the SES-hypertension gradient. There is some, albeit equivocal, evidence that the association between SES and health varies by age group. Furthermore, pooling studies that only included specific groups with those from the general population would increase heterogeneity. There might also be concerns that our data were limited to rural populations. However, given that our aim was to include only areas at relatively early stages of the epidemiological transition, it was logical to include only rural areas of LMICs. This was necessary for testing our hypothesis that SES is positively associated to hypertension in rural populations of LMICs. Importantly, we have provided evidence that the SES-hypertension gradient differs even between rural regions.

Our review of the literature also serves to highlight the gap in research undertaken in rural populations of some LMICs. In LMICs, most epidemiological studies of chronic diseases are conducted in urban or semi-urban populations. Lack of access to infrastructure and expertise as well as prioritization of communicable diseases over chronic diseases are some of the barriers to conducting high quality research in rural areas. Furthermore, this review highlights the critical deficiency of longitudinal studies designed to investigate the association between SES and hypertension in rural populations of LMICs. Longitudinal studies minimize bias in ascertaining of exposure as well as enable elucidation of the temporal relationship between exposure and disease. Therefore, large longitudinal studies have the potential to improve our understanding of the evolution of this association across the epidemiological transition in rural settings.

Our overall aim was to investigate the patterns in the SES-hypertension gradients in rural populations of LMICs. We undertook several analyses to identify the associations between SES and hypertension in these settings. Some of these findings are unexpected and novel and lead us to speculate that the SES-hypertension gradients in rural populations of LMICs in Asia vary by geographical region. Interpretation of these findings, particularly of the overall pooled estimates, is hampered to some degree by heterogeneity and other sources of potential bias. However, the absence of publication bias, the consistency of our results identified through sensitivity analyses, and the use of a more conservative random effects model for analysis enhance the confidence we have in our conclusions. To our knowledge, no previous meta-analysis has been conducted to evaluate the impact of SES on hypertension in rural populations of LMICs.

In summary, our findings provide evidence that the nature of the association between SES and risk of...
hypertension in rural populations differs strikingly between East and South Asia. Although this hypothesis was not a priori, our finding is important for the generation of new hypotheses. The finding also has important implications for the targeting of intervention strategies aimed at high-risk populations in these geographical regions which comprise a large proportion of the global population. Therefore, strategies to prevent and control hypertension in rural populations of LMICs should be more effectively aimed at relatively high SES groups in South Asia but relatively low SES groups in East Asia.

**Supplementary Data**

Supplementary data are available at IJE online.

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**References**


**Commentary:**

**Socioeconomic status and hypertension in low- and middle-income countries: can we learn anything from existing studies?**

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The prevailing narrative in the global health literature is an emergence of an inverse gradient between measures of socioeconomic status (SES) and chronic disease such as hypertension in low- and middle-income countries (LMICs).¹ However, evidence to support this assertion is often lacking and does not withstand careful review of available data.² For example, an in-depth review of studies from India observed that with the exception of smoking, hypertension and other risk factors for cardiovascular disease (CVD) continue to have a positive relationship with SES.³ In this issue of the *International Journal of Epidemiology*, Busingye and colleagues report a systematic review and meta-analysis with the laudable goal of examining the association between SES and hypertension in rural regions of LMICs.³ Their primary finding is: ‘In East Asian rural populations, educational status was inversely associated with the risk of hypertension. In contrast, in South Asian rural populations, a positive association was observed’.³ These findings of contrasting