High rates of child hypertension associated with obesity: a community survey in China, India and Mexico

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Background: Hypertension is a significant risk factor for cardiovascular disease, and epidemiological evidence suggests that it is increasing in parallel with obesity in children and adolescents in low- and middle-income countries.

Aim: To identify and determine the relationship between overweight, obesity and hypertension in a community sample of school children.

Methods: Anthropometric data were collected from 12,730 school children aged 12–18 years in China, India and Mexico as part of the Community Interventions for Health programme, an international study evaluating community interventions to reduce non-communicable disease by addressing the three main risk factors of tobacco use, unhealthy diets and physical inactivity. Logistic regression was used to examine the association of body mass index and gender and hypertension.

Results: Prevalence rates of hypertension were 5.2% in China, 10.1% in India and 14.1% in Mexico, and pre-hypertension rates in China, India and Mexico were 13.4%, 9.4% and 11.2%, respectively. Overweight and obesity prevalence rates varied by country and were 16.6% in China, 4.1% in India and 37.1% in Mexico. In all countries there was a significant association between overweight and obesity and rates of hypertension. Overweight children were 1.7–2.3 times more likely to be hypertensive and obese children 3.5–5.5 more likely to show hypertension than those of normal weight.

Conclusions: Rates of hypertension and overweight and obesity are high in school children in China, India and Mexico, and increased bodyweight is a significant risk factor for hypertension.

Keywords: Epidemiology, Children, Hypertension, Obesity

Abbreviations
ASH American Society of Hypertension;
BMI body mass index;
CI confidence interval;
CIH Community Interventions for Health;
CVD cardiovascular disease;
IOTF International Obesity Task Force;
IRB institutional review board;
LMIC low- and middle-income country;
NCD non-communicable disease;
OR odds ratio;
STEPS World Health Organization’s STEPwise approach to surveillance.

Introduction
Hypertension is a significant risk factor for cardiovascular disease (CVD), which in turn is the leading cause of death in low- and middle-income countries (LMICs). Globally, 17 million deaths are attributable to CVD and approximately 80% of these occur in LMICs,¹ with hypertension alone responsible for 7.1 million premature deaths.² During the past 30 years, high-income countries have seen a decline in mortality from cardiovascular disease;³ in contrast, LMICs have shown significant increases in blood pressure⁴ and associated CVD.⁵ It is apparent that an epidemic of premature cardiovascular mortality is developing in LMICs,⁶ and there is growing evidence that risk factors such as hypertension are appearing earlier, in some cases in childhood and adolescence.

The true incidence of hypertension among children and adolescents is largely unknown, partly because child hypertension was rare until recently, and partly because relatively few epidemiological studies have
been performed. However, there are recent data for some LMICs, including China, India and Egypt. Reports from the China Health and Nutrition Survey indicate a prevalence of 8.3% for pre-hypertension and 13.8% for hypertension among children aged 6–17 years in China. A cross-sectional study in Surat city in India reported a prevalence rate for hypertension of 6.5% in 1249 school children aged 6–18 years, and a study of 1500 adolescents aged 11–19 years in Alexandria, Egypt reported that prevalence rates of pre-hypertension and hypertension were 5.5% and 4%, respectively. Although the number of children with hypertension is much lower than that of adults, there is evidence that cardiovascular risk in children is associated with obesity, and that an accelerated rate of increasing obesity is demonstrable in LMICs. Recent data from cross-sectional studies in LMICs have shown that obesity increases the risk of hypertension in children, and the odds ratio for hypertension are 2.1 for overweight children, rising to 7.2 for the obese.

The diagnosis, evaluation and treatment of childhood hypertension is becoming increasingly important, and the American Society for Hypertension (ASH) has called for universal screening of all children aged ≥3 years. It is widely recognized that primary hypertension in young people is largely undiagnosed and untreated, and this is especially true in LMICs.

This study utilizes data from the Community Interventions for Health (CIH) programme to report the prevalence of hypertension in young people in China, India and Mexico and to characterize those at risk of short- and long-term health issues related to early-onset hypertension. CIH is the action arm of the Oxford Health Alliance, a UK-registered charity (No. 1117580) dedicated to reducing non-communicable diseases (NCD) by addressing the three modifiable risk factors of tobacco use, unhealthy diet and physical inactivity. The CIH project was designed to develop interventions at the population level to curb the epidemic of chronic disease by changing behaviour patterns, encouraging structural change and facilitating community mobilization.

Subjects and Methods

A total of 12,730 children aged 12–18 years were recruited through schools. In each intervention and control area in each of the three countries, 20 secondary schools were randomly sampled from all schools within the area. Two classes of children were sampled at each school and all pupils in the class were included in the study.

CIH was designed as a non-randomised, controlled, quasi-experimental study incorporating action-oriented research with the aim of promoting replication. The full methodology for CIH, describing sampling and data collection, has been reported previously.

Briefly, CIH is taking place in three different places: Hangzhou city in China, Kerala in India and Mexico City. Each site identified intervention and control areas with populations of between 150,000 and 250,000 with similar economic and socio-demographic profiles. Baseline data were collected from each area. The information collected included risk factor assessment by questionnaire together with biometric and biochemical evaluation in a sub-sample. All data were collected by trained study personnel. CIH is taking place in health centres, places of work, schools and in the community at large. The data reported here relate only to baseline information collected from schools in the CIH programme.

The study obtained institutional review board (IRB) approval in each country (China: IRB00001052-08003 certified by IRB at Peking University Health Science Centre; India: IEC/184; Mexico: Oficio JST/1003/08), and written, informed parental consent was obtained where required.

Data collection

Each pupil completed the CIH Youth Survey which was designed to collect data on risk factors for NCDs, and the CIH Biometric Study proforma that included anthropometric and biological measurements, including blood pressure measurements. The CIH Youth Survey is based on the World Health Organization’s STEPwise approach to Surveillance (STEPS) of risk factors for NCDs and the INTER-HEART global study of risk factors for acute myocardial infarction.

Blood pressure measurements

The STEPS protocol called for the subject to be in a seated position and resting for at least 5 minutes before measurements were taken. Three readings at 3-minute intervals were taken on the left arm of each subject. Appropriate cuff size was based on the participant’s arm circumference: 17–22 cm, small cuff; 22–32 cm, medium cuff; >32 cm, large cuff. Measurements were taken with a digital automatic blood pressure monitor. The Omron HEM 4021 was used in China, the Omron SEM1 in India, and the Omron HEM-781INT in Mexico. The means of the second two blood pressure measurements were averaged for analysis. When fewer than three measurements were recorded, the mean of the recorded measurements was used. In Mexico, it proved possible to collect only one blood pressure reading for each subject.

Body mass index

In China and Mexico, height was recorded in bare feet to the nearest 0.5 cm with subjects standing with their backs against a vertical wall fitted with a measuring tape. A set-square used for measurement
was placed on the head and against the tape measure on the wall. Subjects were asked to remove hats, but not head-scarves. In India, height in bare feet was measured by a portable stadiometer (SECA214). Weight was measured using portable electronic scales. Subjects were weighed after removing footwear and emptying pockets, and wearing light indoor clothing. Scales were tared before each measurement. Body mass index (BMI) was calculated by the formula wt (kg)/ht (m)\(^2\), and children were categorized as normal weight, overweight or obese using the international cut-off points by age and gender, as described by the International Obesity Task Force (IOTF).

**Definition of hypertension**

Hypertension was defined by the standards proposed by ASH\(^2\) which are widely regarded as an international standard. Hypertension was defined as a mean systolic or diastolic reading (or both) \(\geq \)95th per centile for the predicted value based on gender, age and height. Prehypertension was defined as a mean systolic or diastolic blood pressure reading between the 90th and 95th per centiles of the predicted values based on gender, age and height and/or if systolic blood pressure was at or above 120, or diastolic blood pressure was at or above 80, or both. Stage I hypertension was defined as hypertension between \(>95\)th and \(<99\)th per centile + 5 mmHg; stage II hypertension was defined as hypertension at the extreme range \(>99\)th per centile + 5 mmHg.

**Statistical analysis**

Descriptive statistics are presented by country, age and gender. Continuous variables are presented as means and standard deviations and categorical variables as percentages.

\(\chi^2\) tests were used to assess differences between countries. Logistic regression was used to examine the association between BMI, age, gender and hypertension. Weighted odds ratios (ORs) are reported for hypertension by BMI status and for each gender within countries. \(P<0.05\) was considered statistically significant, and 95% confidence intervals (CI) were calculated for ORs. Analyses were performed using IBM SPSS version 20.

**Results**

The physical characteristics of 12,730 children and adolescents (4444 from China, 4197 from India and 4089 from Mexico) are shown in Table 1. The proportions of boys and girls in each country were approximately equal. There were some differences between the three country sites: there were more girls in Mexico, China had significantly more adolescents in the older age range (\(>15\)) and in India there were significantly more children in the youngest age group (12) (\(P<0.001\)).

The general pattern of anthropomorphic characteristics varied between the three sites. Prevalence of

<table>
<thead>
<tr>
<th>Country</th>
<th>Age, y</th>
<th>BMI status (%)</th>
<th>SBP Mean (SD)</th>
<th>DBP Mean (SD)</th>
<th>BMI Mean (SD)</th>
<th>BMI status, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>12</td>
<td>62.1 (8.7)</td>
<td>19.9 (6.2)</td>
<td>78.2</td>
<td>1.3 (0.7)</td>
<td>106.0 (10.1)</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>68.1 (8.3)</td>
<td>19.9 (6.0)</td>
<td>82.8</td>
<td>1.6 (0.7)</td>
<td>108.5 (10.6)</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>72.1 (8.5)</td>
<td>19.5 (5.7)</td>
<td>86.3</td>
<td>1.8 (0.5)</td>
<td>109.8 (10.3)</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>77.1 (9.4)</td>
<td>19.9 (6.3)</td>
<td>90.3</td>
<td>1.7 (0.5)</td>
<td>110.4 (10.8)</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>82.1 (9.5)</td>
<td>19.9 (6.3)</td>
<td>94.7</td>
<td>2.4 (0.7)</td>
<td>111.2 (10.7)</td>
</tr>
<tr>
<td></td>
<td>All ages</td>
<td>87.1 (9.8)</td>
<td>19.9 (6.3)</td>
<td>97.1</td>
<td>2.9 (0.5)</td>
<td>109.9 (10.5)</td>
</tr>
</tbody>
</table>

| Mexico     | 12     | 63.7 (7.9)     | 19.9 (6.3)    | 78.2          | 1.4 (0.7)     | 106.0 (10.1)  |
|            | 13     | 63.8 (8.3)     | 19.9 (6.2)    | 82.8          | 1.6 (0.7)     | 108.5 (10.6)  |
|            | 14     | 64.1 (8.4)     | 19.5 (6.0)    | 86.3          | 1.8 (0.5)     | 109.8 (10.3)  |
|            | 15     | 64.8 (8.5)     | 19.9 (6.3)    | 90.3          | 1.7 (0.5)     | 110.4 (10.8)  |
|            | 16     | 72.1 (9.4)     | 19.9 (6.3)    | 94.7          | 2.4 (0.7)     | 111.2 (10.7)  |
|            | All ages | 70.2 (9.8)   | 19.9 (6.3)    | 97.1          | 2.9 (0.5)     | 109.9 (10.5)  |

| India      | 12     | 63.9 (8.8)     | 19.9 (6.2)    | 78.2          | 1.4 (0.7)     | 106.0 (10.1)  |
|            | 13     | 64.9 (8.5)     | 19.9 (6.2)    | 82.8          | 1.6 (0.7)     | 108.5 (10.6)  |
|            | 14     | 65.1 (8.5)     | 19.5 (6.0)    | 86.3          | 1.8 (0.5)     | 109.8 (10.3)  |
|            | 15     | 65.5 (8.6)     | 19.9 (6.3)    | 90.3          | 1.7 (0.5)     | 110.4 (10.8)  |
|            | 16     | 73.1 (9.4)     | 19.9 (6.3)    | 94.7          | 2.4 (0.7)     | 111.2 (10.7)  |
|            | All ages | 71.2 (9.8)   | 19.9 (6.3)    | 97.1          | 2.9 (0.5)     | 109.9 (10.5)  |
Obesity was 3.2% in China, 0.4% in India and 8.4% in Mexico, and the prevalence of overweight children was 13.4% in China, 3.7% in India and 28.7% in Mexico. Chinese children and adolescents had the highest mean systolic blood pressure (109.2 mmHg) and children in Mexico had the highest mean diastolic blood pressure (68.7 mmHg).

Prevalence of hypertension
This study shows that the prevalence of pre-hypertension and hypertension was high across all three countries (Table 2), with a hypertension prevalence in China of 5.2%, 10.1% in India and 14.1% in Mexico. Stage II hypertension was particularly prevalent in Mexican children (2.6%), especially among boys, with 3.0% categorized as stage II hypertensive (>99th percentile + 5 mmHg). In addition, 13.4%, 9.4% and 11.2% of the children and adolescents in China, India and Mexico, respectively, were pre-hypertensive.

Obesity and hypertension
In all three countries, obese and overweight children showed significantly higher rates of hypertension than those who were of normal weight or underweight (Table 3). Overweight children were 1.7–2.3-times more likely to be hypertensive than those who were not. Obesity posed an even greater risk: in all three countries, obese children had a 3.6–5.5-times greater risk of hypertension than those who were of normal weight or underweight. Increased BMI in India demonstrated the highest risk of hypertension, with overweight children 3.4-times as likely, and obese children 8.6-times as likely to be hypertensive than those of normal weight.

In both boys and girls in all three countries, the odds for hypertension increased incrementally with each BMI category (Fig. 1). For example, in Mexico, both overweight and obese boys were more likely to be hypertensive than boys of normal weight (OR 1.6, \(P=0.001\), overweight; OR 3.4, \(P<0.001\), obese). Within each BMI category, there was no significant association between hypertension and gender (\(P=0.46\)) or age (\(P=0.67\)).

Discussion
This study reports relatively high rates of child hypertension in communities in China, India and Mexico. Previous reports of the prevalence of hypertension in children and adolescents have shown ranges from 1% to 17%,26 and, although data for LMICs are sparse, recent reports from India and China have described prevalence rates of 6.5–13.8%.7,8 It is apparent that these countries show higher prevalence rates than high-income countries: studies in the US and Switzerland have reported rates of 1–3% and 2.2%, respectively,27,30 suggesting that rates of hypertension in LMICs are at least double those in higher-income countries. The published data may not reflect true prevalences as there are methodological issues with measurement of blood pressure and heterogeneity across studies in young people, but it appears that rates of hypertension are increasing in LMICs,26 and that this can be explained partly by increases in obesity, especially abdominal obesity.31

The world epidemic of overweight and obesity is well documented and shows no sign of diminishing.32 However, although rates are unacceptably high, there is recent evidence of a plateau effect in some high-income countries including the US,33 Sweden34 and England.35 Comparable data from LMICs are few, but a recent meta-analysis from China reports that the prevalence of overweight and obesity increased from 1.8% in 1981–1985 to 13.1% in 2006–2010,36 and studies from India show increases in obesity from 9.8% to 11.7% during 2006–2009,37 with no sign of the flattening seen in high-income countries. Also, evidence of the effect of obesity on blood pressure is contradictory and, despite strong evidence that BMI levels are positively associated with both systolic and diastolic blood pressure, there is some evidence from high-income countries that hypertension has not increased in parallel with obesity,38 although this has not been reported in LMICs.26,39 The association between childhood obesity and hypertension as an adult has been systematically observed and quantified40,41 and is likely to have a major impact on subsequent adult health, as primary hypertension in childhood has been shown to predict hypertension in later life,42,43 which in turn will have serious economic and health-care implications.

The CIH study shows the association in children in three countries between weight categories (normal, overweight and obese) and the prevalence of hypertension. The data show relatively high prevalences in

<table>
<thead>
<tr>
<th>Table 2 Percentage of children with normal blood pressure, pre-hypertension and hypertension by CIH site and gender</th>
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</thead>
<tbody>
<tr>
<td><strong>China</strong></td>
</tr>
<tr>
<td><strong>Boys</strong></td>
</tr>
<tr>
<td>Normal</td>
</tr>
<tr>
<td>Pre-hypertensive</td>
</tr>
<tr>
<td>Hypertensive:</td>
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<tr>
<td>Stage I</td>
</tr>
<tr>
<td>Stage II</td>
</tr>
</tbody>
</table>

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In Hangzhou in China, Kerala in India, and Mexico City, and in all countries there was a significant association between overweight and obesity and rates of hypertension. Overweight children were generally about twice as likely to be hypertensive, and obese children four times more likely to show hypertension than children of normal weight. There were some differences between the three countries, with Mexico showing the greatest prevalence of both obesity and hypertension. The children in Kerala showed the lowest prevalence of overweight and obesity but an elevated risk of hypertension, and obese children four times more likely to show hypertension than children of normal weight. There were some differences between the three countries, with Mexico showing the greatest prevalence of both obesity and hypertension. The children in Kerala showed the lowest prevalence of overweight and obesity but an elevated risk of hypertension. The children in Kerala showed the lowest prevalence of overweight and obesity but an elevated risk of hypertension. The children in Kerala showed the lowest prevalence of overweight and obesity but an elevated risk of hypertension.

The limitations of this study are that the data are derived from community samples in widely disparate settings. The higher risk of hypertension seen in the Indian children might be explained by factors such as fetal programming, in which maternal nutrition may lead to reduced body size at birth, increasing the risk of hypertension. The children in Nepal and India, and in all countries there was a significant association between overweight and obesity and rates of hypertension. Overweight children were generally about twice as likely to be hypertensive, and obese children four times more likely to show hypertension than children of normal weight. There were some differences between the three countries, with Mexico showing the greatest prevalence of both obesity and hypertension. The children in Kerala showed the lowest prevalence of overweight and obesity but an elevated risk of hypertension. The children in Kerala showed the lowest prevalence of overweight and obesity but an elevated risk of hypertension.
settings, from rural settings in Kerala, India to urban settings in Hangzhou, China and Mexico City, and cannot be taken as representative samples in each country site. Different cultures and racial characteristics, and widely disparate eating habits and lifestyles including diet, salt intake and levels of physical activity which would affect blood pressure were not taken into account. In addition, only one blood pressure measurement was taken in Mexico, and this may account for the high levels of hypertension recorded in that sample.

However, one of the limitations of the study is also a strength. The data are derived from three communities in different countries encompassing the globe, and although not representative of the populations of China, India and Mexico, they are nevertheless exemplars of their populations. With concordance of an association between overweight and obesity and hypertension in the three sampling sites, it can be concluded that there is a high likelihood that the data reflect the situation prevailing in LMICs, and the implications are profound. Hypertension is likely to increase the risk of disease in adulthood and overall reduce life expectancy. Beyond hypertension as a univariate risk, it is well established that overweight and obesity are strongly associated with the onset of type 2 diabetes, and that the combination of hypertension and diabetes is at least additive and may be synergistic in the aetiology of microvascular disease.

The study demonstrates relatively high rates of hypertension in children in communities in China, India and Mexico, and a strong association with overweight and obesity. Although there is little evidence of the management of obesity or hypertension in children, most treatments aim to modify lifestyle by reducing the bodyweight of children who are overweight or obese, increasing physical activity and adopting a healthy diet. Intervention studies aimed at preventing obesity and hypertension in children are needed, and the CIH programme will be reporting the effects of community interventions in China, India and Mexico in the near future.

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References


