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Global Prevalence and Trends in Hypertension and Type 2 Diabetes Mellitus among Slum Residents: A Systematic Review and Meta-analysis

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4 1 **Global Prevalence and Trends in Hypertension and Type 2**
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7 2 **Diabetes Mellitus among Slum Residents: A Systematic**
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10 3 **Review and Meta-analysis**
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24 ABSTRACT

25 **Objective:** To obtain regional estimates of prevalence of hypertension and Type 2 diabetes in urban
26 slums, and secondly to compare these with those in urban and rural areas.

27
28 **Design:** Systematic review and meta-analysis

29
30 **Data sources:** Ovid MEDLINE, Cochrane CENTRAL and EMBASE from inception to December 2020

31
32 **Eligibility criteria:** Studies that reported hypertension prevalence using the definition of blood
33 pressure $\geq 140/90$ mm Hg and/or prevalence of type 2 diabetes.

34
35 **Data extraction and synthesis:** Two authors extracted relevant data and assessed risk of bias
36 independently. We used random-effects meta-analyses to pool prevalence estimates.

37
38 **Results:** A total 61 studies involving 105,559 participants met the inclusion criteria. Prevalence of
39 hypertension and type 2 diabetes in slum populations ranged from 4.2% to 52.5% and 0.9% to 25.0%,
40 respectively. The pooled prevalence of hypertension tended to be higher among studies from South
41 Asia (25.3%, 95% CI 21.3 to 29.6, 26 studies) and sub-Saharan Africa (24.4%, 95% CI 17.7 to 31.9, 10
42 studies) than those from Latin America and Caribbean (18.3%, 95% CI 13.4 to 23.9, 6 studies).
43 However, the pooled prevalence of type 2 tended to be higher among studies from South Asia (11.6%,
44 95% CI 9.1 to 21.9, 18 studies) than those from sub-Saharan Africa (4.5%, 95% CI 2.4 to 7.2, 8 studies).
45 In six studies presenting comparator data, all from the Indian sub-continent, slum residents were 35%
46 more likely to be hypertensive than those living in comparator rural areas and 30% less likely to be
47 hypertensive than those from comparator non-slum urban areas. Four studies from India (n=3) and
48 Bangladesh reported prevalence of type 2 diabetes by place of residence and the pooled prevalence
49 of type 2 diabetes was highest among those residing in non-slum urban areas, followed by urban slum
50 residents and was lowest among rural residents.

51
52 **Conclusion:** The burden of hypertension and type 2 diabetes varied widely between countries and
53 regions and, to some degree, also within countries. In addition, many hypertensive individuals are not
54 aware of their condition, not on treatment and control of hypertension is poor. The burden of
55 hypertension and type 2 diabetes was higher among non-slum urban residents than their counterparts
56 living in urban slums and rural areas.

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58 **PROSPERO registration number:** CRD42017077381

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Strengths and limitations of this study

- The prevalence of hypertension and type 2 diabetes differed greatly across countries and regions, and to some extent within countries.
- Many hypertensive people are unaware of their disease, are not on medication, and their hypertension control is weak.
- The prevalence of hypertension and type 2 diabetes was higher in non-slum urban residents than in urban slums and rural areas.
- This meta-analysis pooled prevalence estimates from various regions and reported over an 11-year period, and as predicted, high heterogeneity between studies was found in the meta-analyses.

60

61 INTRODUCTION

62 Noncommunicable diseases (NCDs) are currently the leading cause of death globally, even in
63 low- and middle-income countries (LMICs) the burden of disease is shifting from infectious
64 diseases to NCDs¹. NCDs now account for about 41 million deaths annually, corresponding to
65 nearly 7 in 10 of all deaths worldwide. Every year, 15 million people of ages of 30 to 69 years
66 die from these diseases, more than 85% of which are people living in LMICs. Most of the
67 deaths from NCDs are caused by cardiovascular diseases, followed by cancer and respiratory
68 diseases. NCDs affect people in all age groups, countries and geographic regions. The leading
69 causes of these diseases include increased consumption of unhealthy foods, increased
70 physical inactivity and population ageing²⁻⁴. These factors are mediated through metabolic
71 risk factors for NCDs the most common of which include hypertension and type 2 diabetes²⁻⁴

72
73 Urbanization is a global phenomenon that is occurring at a fast pace in most LMICs^{5 6}. For
74 more than 20 years, urban settlements have been increasing in population size because of
75 fast growth in urban births, significant movement of people from rural areas and sustained
76 integration of the global economy^{5 6}. The United Nations defines slums as urban areas with
77 overcrowding, poor sanitation infrastructure, limited access to safe water, and/or poor
78 structural quality of housing^{7 8}. Slums are now an important component of today's urban
79 settlements and likely continue to be for the foreseeable future^{7 8}.

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3 81 Despite increased global awareness about the presence and persistence of slums, and
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5 82 evidence that their populations are affected by different health problems and needs to other
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8 83 urban inhabitants, the health of their inhabitants is under researched⁷⁻¹⁰. The health of the
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10 84 urban poor, people with low socioeconomic status living in urban areas, is usually conflated
11
12 85 with that of slum residents. Although there is substantial overlap between these groups, there
13
14 86 are also richer residents within slum neighbourhoods, as well as urban poverty occurring in
15
16 87 non-slum urban areas. Health outcomes for these two groups may differ depending on
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18 88 whether deprivation is at the individual (urban poverty) or neighbourhood level (slum
19
20 89 resident) due to neighbourhood effects ^{7 8 11 12}. For example, with respect to NCD risk-factors,
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22 90 those resident in slums, whatever their personal socio-economic status, may be more
23
24 91 exposed to a common physical environmental risk factors (for example: air pollution
25
26 92 increasing risk of hypertension), social environmental risk factors (for example: crime rates
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28 93 which may increase stress and drive metabolic risk) or institutional risk-factors (for example:
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30 94 stigma on the basis of their address reducing access to appropriate medical care). Many
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32 95 existing studies of NCDs risk factors done in urban areas do not disaggregate the population's
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34 96 health data by slum and non-slums status to allow for the detection of intra-urban health
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36 97 disparities that are due to neighbourhood effects rather than individual socio-economic
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38 98 status¹³⁻²².

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49 100 Understanding how the global challenges of hypertension, type 2 diabetes and rapid
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51 101 unplanned urbanisation intersect, by investigating whether the up to 1 billion people residing
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53 102 in slums²³ are succumbing to these important metabolic risk factors for non-communicable
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55 103 disease, will inform priorities for health services and health policy in LMICs. To fill this research
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57 104 gap, we therefore systematically gathered all the publications that relate to the burden of
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105 hypertension among slum residents to (1) assess the contemporary prevalence estimates of
106 hypertension among slum residents (2) compare the prevalence of hypertension and Type 2
107 diabetes in slums with those in two other types of settlement i.e. non-slum urban and rural
108 areas; and (3) assess the proportion of those with hypertension who were aware of their
109 hypertensive status, those on treatment and those with blood pressure under control.

110

111

For peer review only

METHODS

Protocol and registration

The study background, rationale, and methods were specified in advance and documented in a protocol that was published in the PROSPERO register (CRD42017077381).

Search and information sources:

We searched Ovid MEDLINE, Cochrane CENTRAL and EMBASE from inception to December 2020 using the following keywords: slum, shanty town, ghetto, hypertension and type 2 diabetes. The search strategy for Medline is shown in **Annex 1**.

Eligibility criteria:

We evaluated each identified study against the following pre-defined selection criteria:

- *Types of studies:* We included all studies (cross-sectional studies, retrospective or prospective cohort studies) that reported prevalence of hypertension among slum residents as a primary or secondary outcome. No language, publication date or publication status restrictions were imposed.
- *Types of participants:* adult population (18 years and above) living in slum (as defined by the authors of the original studies included).
- *Types of Interventions:* Not applicable.
- *Types of outcomes:* Essential hypertension (also called primary or idiopathic hypertension), defined as persistent (seated) systolic blood pressure (SBP) of 140 mmHg or greater or had diastolic blood pressure 90mmHg or greater regardless of age and sex. We excluded studies that included subjects with pregnancy-induced, pre-

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3 135 eclampsia, malignant, portal, pulmonary, renal, intracranial or ocular hypertension.
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6 136 We also excluded studies used only self-reported measure, i.e. deducible from the
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8 137 use of antihypertensive drugs or self-reported physician-diagnosed cases. If data were
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10
11 138 available, we noted (1) the percentage of those aware of their hypertension status (2)
12
13 139 on any anti-hypertensive treatment, and (3) blood pressure controlled to a target
14
15 140 level. Awareness of hypertension was defined as self-reporting of any prior diagnosis
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18 141 of hypertension by a healthcare professional. Treatment of hypertension was defined
19
20 142 as receiving prescribed antihypertensive medication for management of high BP at
21
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23 143 some time in the 1 year preceding the survey. Control of hypertension was defined as
24
25 144 the proportion of patients reporting antihypertensive therapy with SBP of less than
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28 145 140 mmHg and DBP of less than 90 mmHg.

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30 146
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32 147 Type 2 diabetes was defined based on measured fasting plasma glucose, or oral
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35 148 glucose tolerance test. Type 2 diabetes was diagnosed if the fasting blood glucose was
36
37 149 ≥ 126 mg/dL (≥ 7.0 mmol/L) after an overnight fast for at least 8 hours, or random
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40 150 capillary blood glucose of ≥ 11.1 mmol/L or if the participant was taking treatment
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42 151 for type 2 diabetes.

43 44 45 152 46 47 153 **Study selection**

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49 154 In pairs, three reviewers (OAU, AAA, OO) independently evaluated the eligibility and
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52 155 methodological quality of the studies obtained from the literature searches. All articles
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54 156 yielded by the database search were initially screened by their titles and abstracts to obtain
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57 157 studies that met inclusion criteria. In cases of discrepancies, agreement was reached by
58
59 158 discussion with a third reviewer.
60

159 **Data collection process and data items**

160 OAU extracted data and AAA and OO checked the extracted data. For each study that met the
 161 selection criteria, details extracted included on year of publication, country of origin, study
 162 design, sample size, sampling strategy, study period, setting (rural/urban/slum), socio-
 163 demographic variables, prevalence estimates; etc.

165 **Risk of bias (quality) assessment**

166 We used the Risk of Bias Assessment tool for Non-randomized Studies (RoBANS)²⁴ to
 167 assessed the risk of bias of included studies (see Box 1). The risk of bias in a study was graded
 168 as low, high or unclear on the basis of study features including the selection of participants
 169 (selection bias), participation rate (selection bias), outcome measurement (detection bias),
 170 consideration of confounding variables (analytical methods to control for bias), and other form
 171 of bias.

172 For each included study, we estimated the precision (C) or margin of error, considering the
 173 sample size (SS) and the observed prevalence (p) of hypertension among slum dwellers from
 174 the formula:

$$SS = Z^2 * p * (1-p) / C^2 \quad (1)$$

176 where Z was the z-value fixed at 1.96 across studies (corresponding to 95% confidence
 177 interval). The desirable margin of error is 5% (0.05) or lower.

178

Box 1: Risk of bias assessment			
Bias type	Low-risk of bias	High-risk of bias	Unclear risk of bias
Selection (sample population)	participants selected randomly	Sample selection ambiguous and sample unlikely to be representative	Insufficient information
Selection (participation rate)	High participation rate (>70-85%)	Low participation rate (<70%)	Insufficient information

Performance bias (outcome assessment)	Objective measures of hypertension	Self-reported measure of hypertension	Insufficient information
Performance bias (analytical methods to control for bias)	Analysis appropriate for type of sample (unadjusted, univariable analyses etc.)	Analysis does not account for common adjustment (adjusted, multivariable analyses)	Insufficient information
Other form of bias	There is no evidence of bias from other sources.	There is potential bias present from other sources	Insufficient information

179

180 Synthesis of results

181 For the meta-analysis, we used DerSimonian-Laird random effects model²⁵ due to anticipated
 182 variations in study population, health care delivery systems and stage of epidemic transition to
 183 pool the hypertension and type 2 diabetes prevalence estimates. We performed leave-one-
 184 study-out sensitivity analysis to determine the stability of the results²⁶. This analysis evaluated
 185 the influence of individual studies by estimating the pooled prevalence estimates in the absence
 186 of each study²⁶. We assessed heterogeneity among studies by inspecting the forest plots and
 187 using the chi-squared test for heterogeneity with a 10% level of statistical significance and
 188 using the I^2 statistic where we interpret a value of 50% as representing moderate heterogeneity²⁷
 189 ²⁸. We assessed the possibility of publication bias by evaluating a funnel plot for asymmetry.
 190 Because graphical evaluation can be subjective, we also conducted a Egger's regression
 191 asymmetry test as formal statistical tests for publication bias²⁹.

192

193 Following the overall analyses, we performed the following sub-group analyses: place of
 194 residence (rural versus urban slum versus non-slum urban); participants risk factors, including
 195 socioeconomic position; study design (cross-sectional, cohort); study location (low- and
 196 middle income versus high-income countries); and study precision.

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3 198 We examined time trends in the hypertension prevalence estimates using meta-regression
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5 199 regression models with the prevalence estimates as the outcome variable and the calendar year
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8 200 of the publication as the predictor. In order to measure secular patterns in prevalence figures,
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10 201 we use the annual average percentages change (AAPC). We fitted a regression line to the
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12 202 natural logarithm of the prevalence estimates, i.e., $y = \alpha + \beta x + \epsilon$, where $y = \ln(\text{Prevalence})$,
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15 203 and $x = \text{calendar year}$. The AAPC was calculated as $100 \times (\exp(\beta) - 1)$. The 95% confidence
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17 204 interval (CI) of the AAPC was also computed from the regression model.³⁰ The prevalence
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19 205 calculations indicated an upward trend when both the AAPC estimate and the lower limit of
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21 206 its 95% CI were > 0 . However, they indicated a downward trend when both the AAPC and its
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23 207 upper limits were less than 0. The prevalence estimates were otherwise considered stable
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25 208 over time³⁰. This systematic review was reported according to the Preferred Reporting Items
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27 209 for Systematic Reviews and Meta-analyses (PRISMA) guideline (**Annex 2**)³¹.

211 Patient and public involvement

212 The design of this review meant it was not appropriate or possible to involve patients or the
213 public in the design, or conduct, or reporting, or dissemination plans of our research.

214 Results

215 Study selection and characteristics

216 The literature search yielded 1490 articles. **eFigure 1** shows the study selection flow diagram.
217 After review, 134 articles were selected for critical reading. Seventy-three studies did not
218 meet the inclusion criteria and were excluded (see **eTable 1** for list of excluded studies). The
219 other 61 studies involving 105,559 participants met the inclusion criteria and were included
220 in the meta-analysis^{13-22 32-80}. Forty-three studies reported only hypertension prevalence

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3 221 estimates, 29 studies reported only type 2 diabetes prevalence estimates and seven reported
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6 222 both. **Table 1 and eTable 2** presents the characteristics of the included studies. The studies
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8 223 were reported between 1989 and 2019. Studies were reported as full-text journal articles
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10 224 (n=50, **98%**); except for one which was reported as a conference abstract. The number of
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13 225 participants included in the studies ranged from 100 to 15,763. When reported, the mean age
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15 226 of participants ranged from 32 years to 47 years. Most of the studies were carried out in South
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18 227 Asia: India (n=30); Bangladesh (n=7) and Nepal (n=1) and Pakistan (n=1); followed by sub-
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20 228 Saharan Africa: Kenya (n=9) and Nigeria (n=4); Latin America and Caribbean: Brazil (n=5) and
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22
23 229 Peru (n=1) and East Asia and Pacific: Thailand (n=1). Most of the studies were conducted in
24
25 230 the following urban slums: Kibera (n=4), Delhi (n=3), Hyderabad (n=3), Ajegunle (n=2),
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28 231 Chandigarh (n=2), Chennai (n=2), Dhaka (n=2), Haryana (n=2), and Maceio (n=2).

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233 **Risk of bias of included studies**

234 Summary of risk of bias assessment for each study is shown in **eTable 3**. The risk of bias in the
235 selection of participants was low in most studies (n=57, 93%), high in three studies (5%) and
236 unclear in one study. The risk of selection bias due to participate rate was low in most studies
237 (n=55, 90%), unclear in four (7%) and high in two study (3%). The performance bias due to
238 outcome assessment was low in all the 61 studies as we included all studies that used
239 objective measure of hypertension and type 2 diabetes. The performance bias due to
240 analytical methods was low in 39 studies (64%) and high in 22 studies (36%). The risk of other
241 biases was low in most studies (n=44, 72%), unclear in 16 studies (26%) and high in one study
242 (2%).

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244 **Variations in prevalence of hypertension and type 2 diabetes by geographical regions**

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3 245 Prevalence of hypertension and type 2 diabetes from individuals are shown in **Figure 1 and**
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6 246 **Figure 2** respectively.

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10 248 East Asia and Pacific

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13 249 *Thailand:* One study from Klong-Toey slum found that 77 of the 976 respondents had type 2
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15 250 diabetes in 1989 (7.9%, 95% CI 6.3 to 9.8).

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23 253 *Brazil:* Four studies reported the prevalence of hypertension from three different slums:
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25 254 Maceio (n=2), Rio de Janeiro (n=1) and Salvador (n=1). Florencio et al. found that almost one
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27 255 third of the Maceio slum dweller were hypertensive in 2004 (29.8%, 95% CI 24.8 to 35.2),
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29 256 while Ferriera et al estimated prevalence of hypertension among Maceio slum residents to
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31 257 be 14.8% (95% CI 10.4 to 20.2) in 2005. The reported prevalence of hypertension in other slums
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33 258 was 11.3% (95% CI 10.2 to 12.4) in Rio de Janeiro in 2007 and 20.6% (95% CI 19.5 to 21.7) in
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35 259 Salvador in 2015. The pooled prevalence ('annualised year average') of hypertension for the
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37 260 four studies yielded an estimate of 18.4% (95% CI 12.0% to 26.2%). One study from Brazil
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39 261 found that one in ten had type 2 diabetes in 2017.

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45 263 *Peru:* One study from a Lima slum conducted in 2014 found that 21 of the 142 respondents
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47 264 were hypertensive (14.8%, 95% CI 9.4 to 21.7).

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52 266 South Asia

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55 267 *Bangladesh:* Three studies from Dhakan slum reported prevalence of hypertension. The
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57 268 reported prevalence of hypertension ranged from 11.6% (95% CI 9.7 to 13.8) in 2012 to 19.56%

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3 269 (95% CI 17.85 to 21.37) in 2018. Four studies from Dhakan slum reported prevalence of type
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6 270 2 diabetes. The pooled prevalence ('annualised year average') of hypertension for the three
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8 271 studies yielded an estimate of 14.9% (95% CI 9.9% to 20.6%). The reported prevalence of type
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10 272 2 diabetes in these slums ranged from 8.1% (95% CI 6.8 to 9.6) in 2004 to 18.12% (95% CI
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13 273 16.46 to 19.87) in 2019.

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18 275 *India:* Twenty-two studies from India reported prevalence of hypertension from more than
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20 276 15 difference slums. The reported prevalence varied across and within the slums. For
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23 277 example, Kar and colleagues estimated the prevalence of hypertension of 27.6% (95% 21.4 to
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25 278 34.4) among 196 Chandigarh and Haryana slum residents in 2008; however they estimated
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28 279 the prevalence of hypertension of 16.5% (95% CI 15.1 to 18.0) among 2,562 196 Chandigarh
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30 280 and Haryana slum residents in 2010. Prevalence of type diabetes also varied across slums in
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33 281 India. The pooled prevalence ('annualised year average') of hypertension for the 22 studies
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35 282 yielded an estimate of 26.8% (95% CI 22.5% to 31.3%). In Delhi, the reported prevalence of
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38 283 type 2 diabetes ranged from 12.7% (95% CI 11.3 to 14.2) in 2007 to 31.5% (95% CI 27.8 to
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40 284 35.4) in 2012. The pooled prevalence ('annualised year average') of type 2 for the 13 studies
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42 285 yielded an estimate of 12.2% (95% CI 9.2% to 15.6%).

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47 287 *Nepal:* One study from a Kathmandu slum conducted in 2013 found that 193 of the 689
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50 288 respondents were hypertensive (28.0%, 95% CI 24.7 to 31.5).

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54 290 *Pakistan:* One study from a Lahore slum found that 22 of the 695 respondents had type 2
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57 291 diabetes in 2008 (3.2%, 95% CI 2.0 to 4.8).

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3 293 Sub-Saharan Africa. *Kenya*: Six studies reported the prevalence of hypertension from three
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6 294 different slums: Kibera (n=4) and Viwandani and Korogocho (n=2). The reported prevalence
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8 295 among Kibera slum residents ranged from 13.0% (95% CI 9.9 to 16.7) in 2013 to 27.8% (95%
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11 296 CI 25.9 to 29.7) in 2015. van de Vijver found that 640 of the 5,190 respondents from
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13 297 Viwandani and Korogocho slum residents were hypertensive (12.3%, 95% CI 11.5 to 13.3). The
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15 298 pooled prevalence ('annualised year average') of hypertension for the six studies yielded an
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17 299 estimate of 19.2% (95% CI 13.2% to 26.0%). The reported prevalence of type 2 diabetes
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19 300 ranged from 0.9% (95% CI 0.7 to 1.2 in Nairobi slum in 2016 to 4.4% (95% CI 3.8 to 5.0) in
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21 301 Viwandani and Korogocho in 2013. The pooled prevalence ('annualised year average') of type
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23 302 2 diabetes for the six studies yielded an estimate of 4.5% (95% CI 2.0% to 7.9%).
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30 304 *Nigeria*: Four studies from five different slums reported prevalence of hypertension. The
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32 305 reported prevalence varied across and within the slums. Ezeala-Adikaibe found that half of
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34 306 the respondents from Enugu slum were hypertensive in 2016 (52.5%, 95% CI 48.9 to 56.0).
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36 307 While Daniel et al. and Sowemimo et al. found that almost one-third of the Ajegule (38.2%,
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38 308 95% CI 35.1 to 41.3, 2013) and Yemetu (33.1%, 95% CI 30.0 to 36.5, 2015) slum residents were
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40 309 hypertensive. However, Akinwale found that only 12.8% of the respondents from Ijora Oloye,
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42 310 Ajegunle and Makoko were hypertensive in 2013. The pooled prevalence ('annualised year
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44 311 average') of hypertension for the four studies yielded an estimate of 33.2% (95% CI 15.6% to
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46 312 53.5%). Akinwale found that only 3.3% of the respondents from Ijora Oloye, Ajegunle and
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48 313 Makoko had type 2 diabetes in 2013.
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57 315 **Secular trends in hypertension and Type 2 diabetes prevalence estimates**
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3 316 Secular trends in hypertension, in 5 countries for which there were data across multiple time
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6 317 points, and type 2 diabetes, in 3 countries in which we had data across multiple time points,
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8 318 among slum residents are shown in **Figures 3 and 4**. We observed a continuous increase in
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11 319 prevalence of hypertension among slum residents in four out of five countries. The increase
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13 320 is more pronounced in India, followed by Kenya and Bangladesh. The prevalence of
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15 321 hypertension increased by 204.6% from 11.7% in 2001 to 35.5% in 2019 in India. The
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17 322 prevalence of hypertension increased by 98.8% from 12.3% in 2013 to 24.5% in 2019 in Kenya.
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20 323 However, the results of the trend analysis showed statistically significant upward trends only
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23 324 in India, such that the prevalence of hypertension increased +6.9% (95% CI +2.0% to +12.0%)
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25 325 per year between 2001 and 2019. There was no statistically significant trend was observed in
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27 326 Brazil using trend analyses (trend =-0.0%, 95% CI -22.7% to +29.2%). We also observed a
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29 327 continuous increase in prevalence of type 2 diabetes among slum residents in India and
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31 328 Bangladesh. The prevalence of type 2 diabetes increased by 123.6% from 8.1% in 2004 to
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33 329 18.1% in 2019 in Bangladesh. The prevalence of type 2 diabetes increased by 95.8% from
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35 330 10.3% in 2001 to 20.2% in 2019 in India. However, the results of the trend analysis showed
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37 331 statistically significant upward trends only in Bangladesh such that the prevalence of type 2
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39 332 diabetes increased +5.9% (95% CI +1.1% to +10.8%) per year between 2004 and 2019. A non-
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41 333 statistically significant downward trends in type 2 diabetes prevalence was also observed in
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43 334 Kenya (trend =-11.1%, 95% CI -45.7% to +45.6%).
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337 **Prevalence of hypertension by different hypertension and type 2 diabetes subgroups**

338 *Study characteristics:* As shown in **Table 1**, the pooled prevalence of hypertension was
339 highest in studies conducted in lower-middle income countries (23.2%, 95% CI 21.5 to 29.0,

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3 340 36 studies) than those from upper-middle income countries (17.9%, 95% CI 12.1 to 24.6, 5
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6 341 studies). The pooled prevalence of hypertension tended to be higher among studies from
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8 342 South Asia (25.3%, 95% CI 21.3 to 29.6, 26 studies) and sub-Saharan Africa (24.4%, 95% CI
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10 343 17.7 to 31.9, 10 studies) than those from Latin America and Caribbean (18.3%, 95% CI 13.4
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13 344 to 23.9, 6 studies). The pooled prevalence tended to higher among imprecise studies (33.4%,
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15 345 95% CI 25.7 to 41.7, 8 studies) than those from precise studies (22.4%, 95% CI 18.9 to 26.1%,
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17 346 35 studies). The pattern was similar for type 2 diabetes prevalence estimates.

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23 348 *Socio-demographic characteristics:* As shown in **Table 1**, the pooled prevalence of
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25 349 hypertension was similar among males (22.5%, 95% CI 16.0 to 29.7, 24 studies) and females
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27 350 (23.5%, 95% CI 18.6 to 28.1, 24 studies). The pooled prevalence of hypertension tended to
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30 351 be higher among older adults (49.6%, 95% CI 36.7 to 62.6, 9 studies) than middle-age (35.0%,
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32 352 95% CI 45.6, 9 studies) and young adults (15.7%, 95% CI 10.1 to 22.1, 8 studies). Similarly,
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35 353 the pooled prevalence of hypertension tended to be higher obese (45.4%, 95% CI 34.5 to
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37 354 56.5, 6 studies) and overweight (32.9%, 95% CI 21.2 to 45.8, 6 studies) participants than
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40 355 participants with normal (21.9%, 95% CI 11.8 to 34.2, 6 studies) and under-weight (21.8%,
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42 356 95% CI 11.4 to 34.4, 5 studies). The pooled prevalence of hypertension tended to be higher
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45 357 among those never studied (39.1%, 95% CI 27.5 to 51.3) than those with less than primary
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47 358 (18.3%, 95% CI 13.9 to 23.1, 4 studies), primary (24.8%, 95% CI 12.0 to 40.4, 6 studies) or
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50 359 secondary/higher education attainment (22.4%, 95% CI 11.2 to 36.2, 7 studies). The pooled
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52 360 prevalence of hypertension tended to be higher among least poor (29.2%, 95% CI 13.1 to
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54 361 48.5, 5 studies) than those with middle- (25.3%, 10.6 to 43.8, 5 studies) and poorest-income
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57 362 (20.9%, 95% CI 10.4 to 33.8, 5 studies). The pattern was similar for type 2 diabetes
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59 363 prevalence estimates.
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365 *Lifestyle factors:* The pooled prevalence of hypertension tended to be higher among
366 smokers (38.0%, 95% CI 19.1 to 59.0, 5 studies) than those not smoking (30.5%, 95% CI 17.6
367 to 45.2, 5 studies). We found that the pooled prevalence of hypertension tended to be
368 higher those not physically active (30.8%, 95% CI 7.7 to 60.9, 3 studies) than those physical
369 active (28.8%, 95% CI 11.1 to 50.8); tended to be higher among with no history of alcohol
370 consumption (29.1%, 95% CI 9.3 to 54.3, 3 studies) than those reported alcohol consumption
371 (26.5%, 95% CI 18.0 to 35.9, 3 studies).

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373 *Comparative prevalence by place of residence*

374 Six studies from India included non-slum populations alongside data from the slum
375 population, and reported prevalence of hypertension by place of residence^{36 38 46 48 49 51}. As
376 shown in **Figure 5**, the pooled prevalence of hypertension was highest among those residing
377 in non-slum urban areas (33.5%, 95% CI 26.0 to 42.0, 6 studies), followed by urban slum
378 residents (28.8%, 95% CI 23.7 to 34.4%, 6 studies) and was lowest among rural residents
379 (24.4%, 95% 18.4 to 31.5, 5 studies). Slum residents were 35% more likely to be hypertensive
380 than those living in rural areas (OR = 1.35, 95% 1.29 to 1.42) and 30% less likely to be
381 hypertensive than those living in other urban areas (OR = 0.70, 95% CI 0.51 to 0.96).

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383 Four studies from India (n=3) and Bangladesh reported prevalence of Type 2 diabetes by place
384 of residence^{46 51 59 71}. As shown in **Figure 6**, the pooled prevalence of type 2 diabetes was
385 highest among those residing in non-slum urban areas (13.06%, 95% CI 6.53 to 24.43, 4
386 studies; 2813 participants), followed by urban slum residents (7.88%, 95% CI 3.32 to 17.55; 4
387 studies; 1811 participants) and was lowest among rural residents (1.64%; 95% CI 0.06 to

32.21; 3 studies; 405 participants). Such that prevalence of type 2 diabetes tended to be higher among urban slum residents than those living in rural areas (OR = 3.78, 95% 0.75 to 18.93). Urban slum residents were 46% less likely to be diabetic than those from other urban areas (OR = 0.54, 95% CI 0.44 to 0.66).

392

393 *Treatment cascade*

394 Among those diagnosed with hypertension, only one-third were aware of their hypertensive
395 status (33.6%, 95% CI 19.1 to 50.0%, 12 studies) (**Table 1**). Among those aware of their high
396 blood pressure, half of them were on antihypertensive medications (51.9%, 95% CI 35.2 to
397 68.3, 9 studies). Among those on treatment, only one-quarter had good blood pressure
398 control (25.2, 95% CI 18.4 to 34.3, 8 studies). Among those diagnosed with type 2 diabetes,
399 57.4% were aware of their type 2 diabetes status (95% CI 18.2 to 91.8%, 2 studies).

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402 **Discussion**

403 **Main Findings**

404 This systematic review and meta-analysis summarises available evidence on the global
405 prevalence of hypertension and type 2 diabetes among slum residents. There were several
406 key findings: firstly, the burden of hypertension and type 2 diabetes among slum dweller is
407 high and may be rising globally, with wide variation between countries and regions and, to
408 some degree, also within countries. Using data from within study comparator populations
409 when presented, the pooled prevalence of hypertension and Type 2 diabetes was highest
410 among those residing in non-slum urban areas, followed by slum residents and was lowest

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3 411 among rural residents. This finding corroborates those of previous reviews that observed
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5 412 higher prevalence of hypertension among urban residents than those living in rural areas⁸¹
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8 413 ⁸². This high prevalence may be due to rapid urbanization, lifestyle changes, dietary changes
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10 414 and increased life expectancy^{83 84} or a combination of these factors^{85 86}. In addition, the
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13 415 observed difference could be due to other factors including but not limited to lack of access
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15 416 to testing and care of NCDs risk factors in rural areas and urban areas.
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20 418 The observed gradient in burden of hypertension and Type 2 diabetes among rural, slum and
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23 419 urban residents is consistent with the effects of urbanization and wealth, as residents
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25 420 experience an economic transition when moving from one area to the next⁸⁷⁻⁹². LMICs are
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28 421 now undergoing epidemiological transition, the change from a burden of infectious diseases
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30 422 to chronic diseases⁹³. In addition, it could be due to increase in awareness in (non-slum) urban
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33 423 areas and recent availability of testing in some places. Recent systematic reviews of dietary
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35 424 risk-behaviour in Sub-Saharan Africa have found that urban populations tended to consume
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37 425 more salt than rural populations⁹⁴ and consume fewer portions of vegetables¹². The rapid
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40 426 pace of urbanisation and economic growth is accelerating the rate of this epidemiologic
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43 427 transition; as such LMICs are at great risk for an explosive growth in the burden of NCDs,
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45 428 including hypertension and type 2 diabetes^{87 88}.

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48 429 We found evidence of significant unmet need for hypertension care among urban slum
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51 430 residents. Significant proportion of the urban slum residents were unscreened, undiagnosed,
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53 431 untreated or uncontrolled. This huge unmet need has been documented in previous studies
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56 432 from low- and middle-income settings⁹⁵⁻¹⁰¹. We also found that control of hypertension
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58 433 among slum residents was poor, such that only one in four slum residents on treatment, had
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3 434 their blood pressure controlled. The poor control of BP noted in our study, despite the fact
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6 435 the one half of those that were unaware of high blood pressure being on antihypertensive
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8 436 medications, needs further exploration. One possible explanation is availability and
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10 437 affordability of the medications and there could be minimal additional contact with a health
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12 438 professional¹⁵. It has been documented that the control of BP was related to the frequency
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14 439 of follow-up visits⁹⁶. Another possible explanation could be low adherence to prescribed
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16 440 medications, as they may not be able to afford the medications.
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21 441 As expected, we found that the burden of hypertension increased with the participants' age,
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23 442 which may be attributed to age-related structural changes in blood vessels which potentially
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25 443 cause narrowing of the vascular lumen, and consequently increasing blood pressure, as have
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27 444 been reported in previous studies^{102 103}. The association between combined
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29 445 overweight/obesity and hypertension shown in our results exemplify the role of excess body
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31 446 weight in hypertension prevalence, which has been long recognized and consistent across
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33 447 numerous observational and trial data¹⁰⁴⁻¹⁰⁶. We found evidence of significantly high
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35 448 prevalence of hypertension among smokers compared to the non-smokers. Direct relation of
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37 449 chronic tobacco consumption with hypertension however is not yet well established^{107 108}
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39 450 although tobacco consumption has been shown to cause an acute elevation of BP¹⁰⁹.
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48 452 **Study Limitations and Strengths**

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52 453 To the best of our knowledge, this paper is the first systematic reviews that summarises data
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54 454 about prevalence of hypertension and type 2 diabetes among slum residents. Strengths of
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56 455 this study include the use of a predefined and published protocol, a comprehensive search
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58 456 strategy, and involvement of two independent reviewers in the review process. Nevertheless,
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3 457 the findings of this study should be interpreted with caution. Prevalence estimates from
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6 458 different regions and published over the course of 11 years were pooled in this meta-analysis,
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8 459 and as expected, high heterogeneity between studies was found in the meta-analyses.
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11 460 Nonetheless, as affirmed by previous evidence, meta-analyses are the preferred options to
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13 461 narrative syntheses for interpreting the results in a review, even in spite of the presence of a
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15 462 considerable amount of heterogeneity¹¹⁰. Heterogeneity appeared to be the norm rather
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18 463 than exception in published meta-analyses of observational studies¹¹¹.

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21 464 In conclusion, the burden of hypertension and type 2 diabetes varied widely between
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24 465 countries and regions and, to some degree, also within countries. In addition, many
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26 466 hypertensive individuals are not aware of their condition, not on treatment and control of
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29 467 hypertension is poor. The burden of hypertension and type 2 diabetes was higher among
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31 468 urban residents than their counterparts living in urban slums and rural areas. There is a need
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34 469 for public health strategies to improve the awareness, control and overall management of
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36 470 hypertension and type 2 diabetes in urban areas.

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23 480 Not applicable.
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27 482 **Consent for publication**
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30 483 Not applicable.
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35 485 **Data sharing statement:**
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37 486 No additional data available
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45 489 **Competing interests**
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47 490 The authors declare that they have no competing interests.
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52 492 **Authors' contribution**
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54 493 OAU, AAA, OO and RL conceived the study. OAU, AAA and OO collected and analysed initial
55
56 494 data. OAU, AAA, OO, JO, PG and RL participated contributed in refining the data analysis.
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58
59 495 OAU wrote the first manuscript. OAU, AAA, OO, JS, PG and RL contributed to further
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3 496 analysis, interpreting and shaping of the argument of the manuscript and participated in
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5
6 497 writing the final draft of the manuscript. All the authors read and approved the final
7
8 498 manuscript.
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860 **TABLES**861 **Table 1: Pooled prevalence by difference subgroup**

Subgroup		Hypertension			Type 2 Diabetes		
		n	%	I ²	n	%	I ²
Sample size	Smaller studies (<1000)	27	25.9 (21.6 to 30.6)	97.1	15	11.0 (8.2 to 14.2)	93.9
Sample size	Larger studies (1000+)	16	21.6 (16.6 to 27.0)	99.6	14	7.2 (4.6 to 10.3)	99.3
Study precision	Imprecise studies	8	33.4 (25.7 to 41.7)	91.2	1	25.2 (17.3 to 34.2)	
Study precision	Precise studies	35	22.4 (18.9 to 26.1)	99.3	28	8.6 (6.6 to 11.0)	98.8
Publication year	2001 to 2005	5	15.6 (9.0 to 23.8)	94.7	4	8.2 (6.7 to 9.8)	53.6
Publication year	2006 to 2010	6	28.6 (18.9 to 39.4)	98.7	4	6.3 (3.3 to 10.3)	90.6
Publication year	2011 to 2020	32	24.9 (21.2 to 28.8)	99.2	21	9.9 (7.2 to 12.9)	99.1
Region	South Asia	26	25.3 (21.3 to 29.6)	98.9	18	11.6 (9.1 to 14.3)	97.3
Region	Sub-Saharan Africa	10	24.4 (17.7 to 31.9)	99.2	8	4.5 (2.4 to 7.2)	98.8
Region	Latin America and Caribbean	6	18.3 (13.4 to 23.9)	97.1	1	10.2 (8.1 to 12.3)	
Region	Middle East and North Africa	1	31.2 (28.4 to 34.1)		1	8.8 (7.1 to 10.6)	
					1	7.9 (6.3 to 9.7)	
Income category	Lower Middle Income	36	25.2 (21.5 to 29.0)	99.1	27	9.0 (6.8 to 11.5)	98.8
Income category	Upper Middle Income	5	17.9 (12.1 to 24.6)	97.6	2	9.0 (6.9 to 11.3)	62
Income category	Low Income	2	24.0 (16.9 to 32.0)	92.2			
Sex	Male	24	22.5 (16.0 to 29.7)	99.2	11	8.1 (5.1 to 11.6)	97.6
Sex	Female	24	23.2 (18.6 to 28.1)	98.7	11	7.3 (4.6 to 10.6)	97.5
Age	Young adult	8	15.7 (10.1 to 22.1)	97.8	2	2.1 (0.3 to 5.4)	96.7
Age	Middle-age adult	9	35.0 (25.0 to 45.6)	99.2	2	5.6 (4.5 to 6.8)	0
Age	Older adult	9	49.6 (36.7 to 62.6)	98.3	2	9.1 (7.0 to 11.4)	0
Body mass index	Under weight	5	21.8 (11.4 to 34.4)	87.3			
Body mass index	Normal weight	6	21.9 (11.8 to 34.2)	98.6	2	2.3 (1.8 to 2.8)	0
Body mass index	Overweight	6	32.9 (21.2 to 45.8)	97.4	2	4.2 (1.2 to 8.8)	50
Body mass index	Obese	6	45.4 (34.5 to 56.6)	93.3	2	6.4 (4.0 to 9.3)	0
Education Status	Never studied	7	39.1 (27.5 to 51.3)	98	1	5.1 (3.0 to 7.8)	
Education Status	Less than primary	4	18.3 (13.9 to 23.1)	87.1	1	4.6 (3.4 to 6.1)	
Education Status	Primary	6	24.8 (12.0 to 40.4)	99.4	1	4.4 (3.6 to 5.2)	
Education Status	Secondary or higher	7	22.4 (11.1 to 36.2)	99.3	1	4.1 (3.2 to 5.2)	
Income	Poorest	5	20.9 (10.4 to 33.8)	98.9			
Income	Middle	5	25.3 (10.6 to 43.8)	99.5			
Income	Least poor	5	29.2 (13.1 to 48.5)	98.3			
Smoking status	Yes	5	38.0 (19.1 to 59.0)	99.1			
Smoking status	No	5	30.5 (17.6 to 45.2)	99.6			
Alcohol consumption	Yes	3	26.5 (18.0 to 35.9)	83.4			
Alcohol consumption	No	3	29.1 (9.3 to 54.3)	99.7			
Physically active	Yes	3	28.8 (11.1 to 50.8)	99.6			
Physically active	No	3	30.8 (7.7 to 60.9)	98.4			
Treatment cascade	Aware of HBP	12	33.6 (19.1 to 50.0)	99.7			
Treatment cascade	On treatment	9	51.9 (35.2 to 68.3)	98.6			
Treatment cascade	BP controlled	8	25.9 (18.4 to 34.3)	87.8			

862 * World Bank Country Income Groups, 2018

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3 863 Participants were divided into age groups that, broadly defined, covered young adulthood (18 to 35 years),
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5 864 middle age (36 to 55 years), and older adulthood (56 years and older).
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7 865 Underweight - BMI under 18.5 kg/m²
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9 866 Normal weight - BMI greater than or equal to 18.5 to 24.9 kg/m²
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11 867 Overweight – BMI greater than or equal to 25 to 29.9 kg/m²
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13 868 Obesity – BMI greater than or equal to 30 kg/m²
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17 870 Physical activity as defined by the authors
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19 871 Alcohol consumption as defined by authors
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21 872 Smoking status as defined by authors
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23 873 Income status as reported by authors
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31 32 877 **FIGURE LEGENDS** 33

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35 878 **Figure 1: Hypertension prevalence estimates among slum residents and 95% confidence**
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37 **intervals from individual studies and pooled data**
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42 881 **Figure 2: Type 2 diabetes mellitus prevalence estimates among slum residents and 95%**
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44 **confidence intervals from individual studies and pooled data**
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49 884 **Figure 3: Secular trends in hypertension prevalence estimates among slum residents across**
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51 **different regions**
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57 887 **Figure 4: Secular trends in Type 2 diabetes mellitus prevalence estimates among slum**
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59 **residents across different regions**
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890 **Figure 5: Hypertension prevalence estimates by place of residence: urban versus rural**
891 **versus slum**

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893 **Figure 6: Type 2 diabetes mellitus prevalence estimates by place of residence: urban versus**
894 **rural versus slum**

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4 897 **ONLINE ONLY SUPPLEMENTS**

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6 898 **eFigure 1: Study selection and inclusion flow chart**

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11 900 **eTable 1: List of Excluded Studies**

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16 902 **eTable 2: Characteristics of included studies**

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26 906 **Annex 1: MEDLINE Search Strategy**

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31 908 **Annex 2: PRISMA Checklist**

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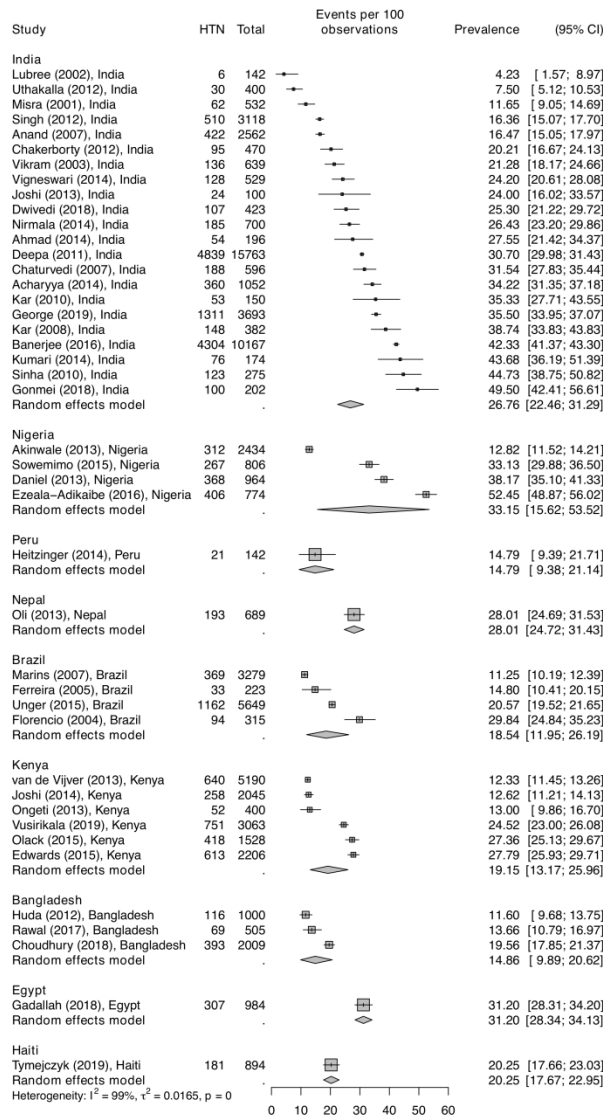


Figure 1

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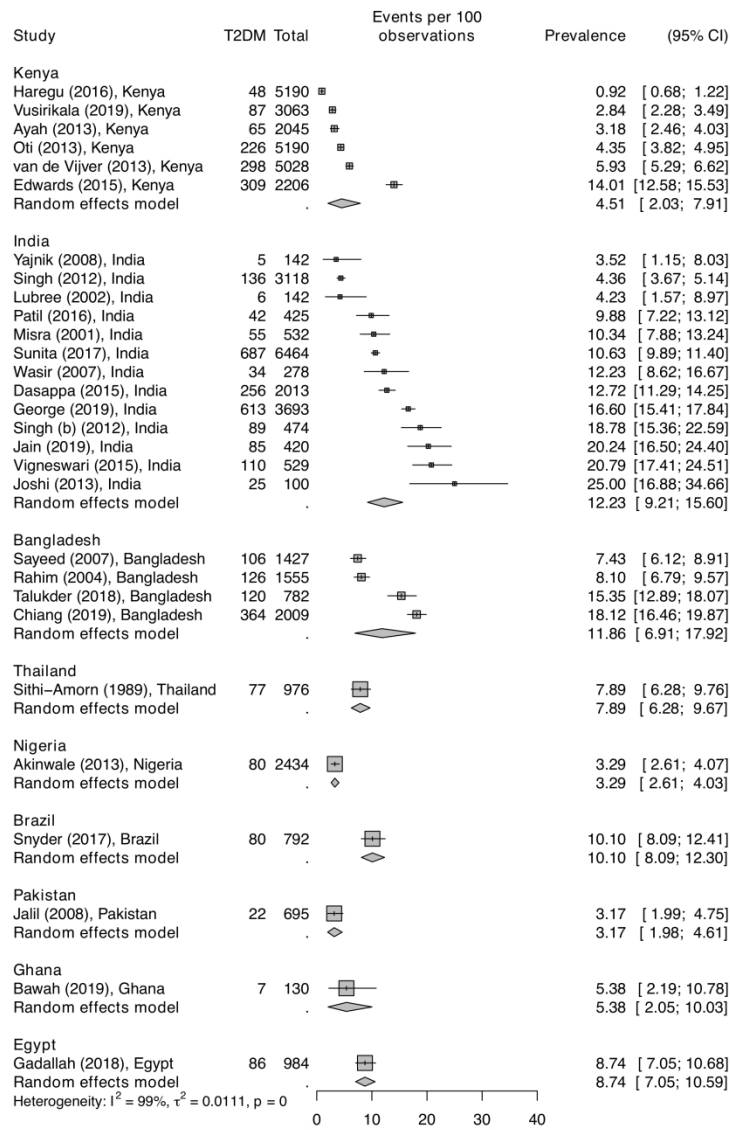


Figure 2

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Figure 3

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Figure 4

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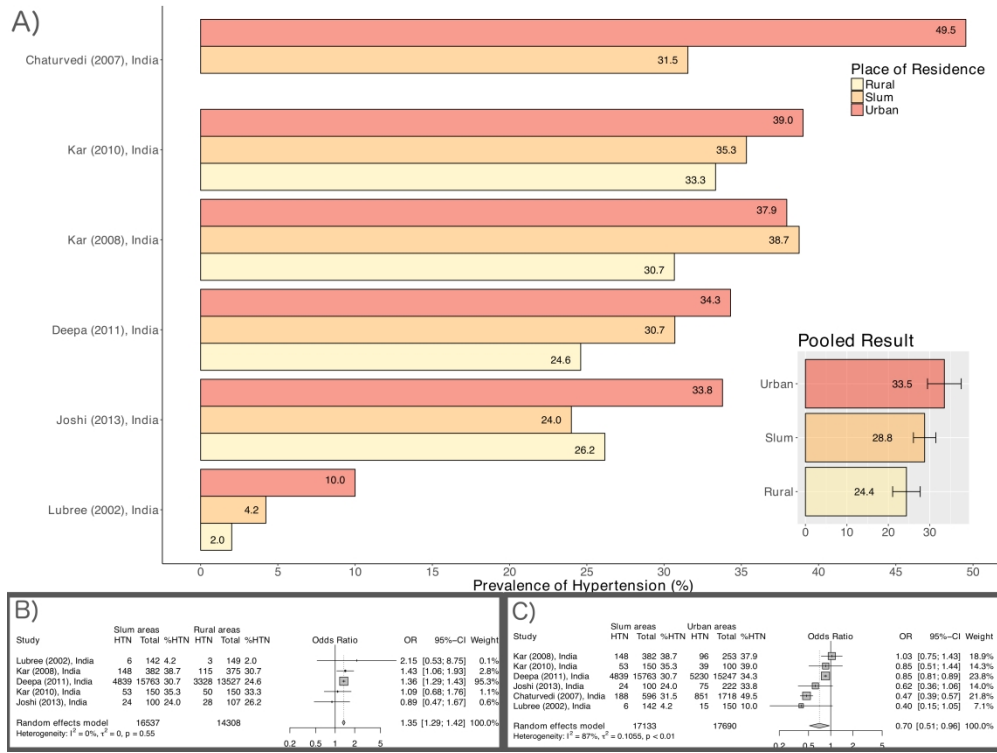


Figure 5

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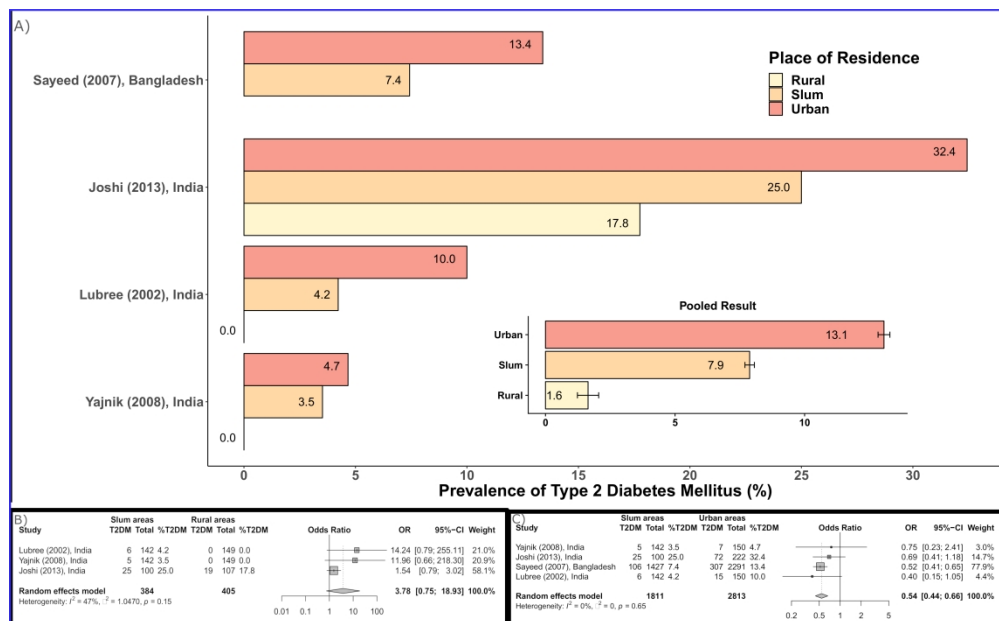


Figure 6

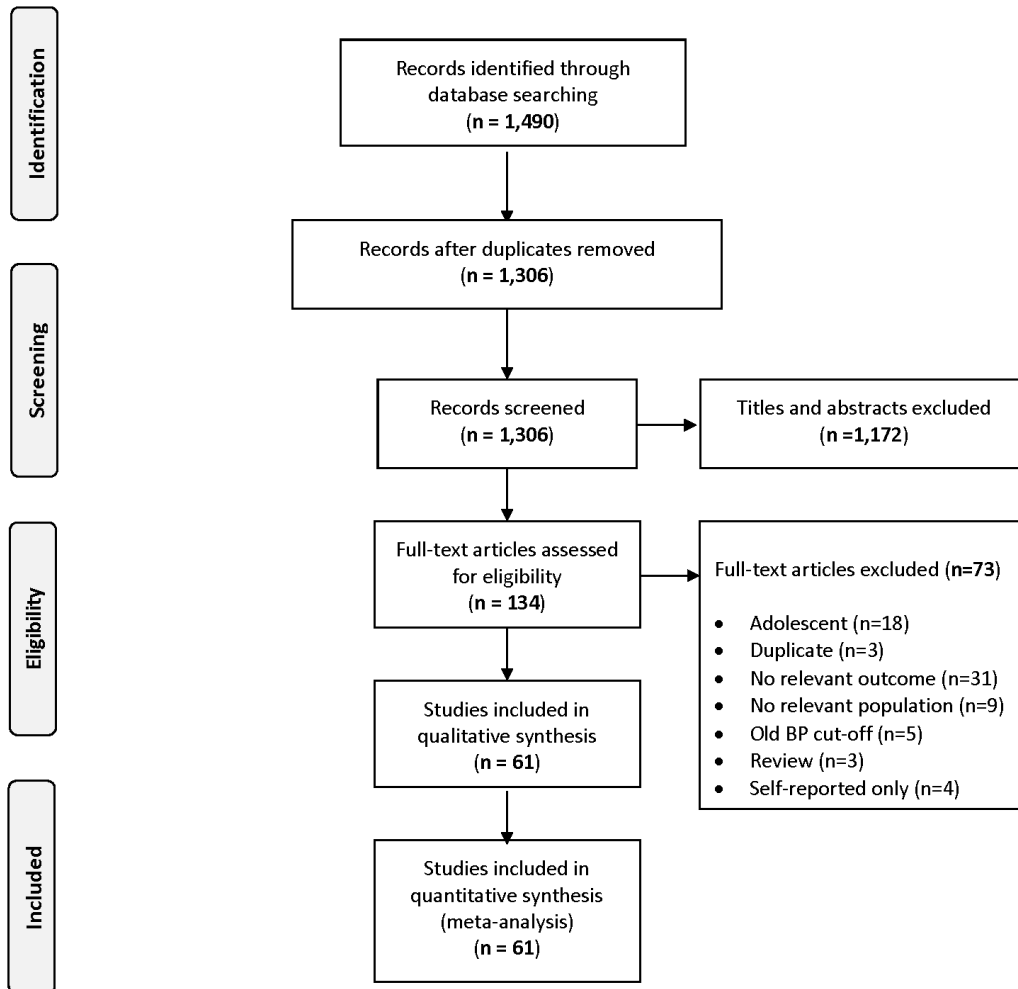
425x261mm (300 x 300 DPI)

Supplementary Digital Content

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eFigure 1: Study selection and inclusion flow chart



eTable 1: List of Excluded Studies

s/n	Study	Reason
1	Maiti 2016 ¹	Adolescent
2	Khopkar 2015 ²	Adolescent
3	Paul 2013 ³	Adolescent
4	Kamath 2012 ⁴	Adolescent
5	Simsek 2012 ⁵	Adolescent
6	Saha 2011 ⁶	Adolescent
7	Oria 2010 ⁷	Adolescent
8	Saha 2008 ⁸	Adolescent
9	Saha 2008 ⁹	Adolescent
10	Sesso 2004 ¹⁰	Adolescent
11	Fernandes 2003 ¹¹	Adolescent
12	Zeelie 2010 ¹²	Adolescent
13	Soudrassanane 2008 ¹³	Adolescent
14	Werner 2015 ¹⁴	Duplicate
15	van de Vijver 2016 ¹⁵	Duplicate
16	Haregu 2016 ¹⁶	Duplicate
17	Ezenwaka 1997 ¹⁷	Old BP cut-off
18	Suriyawongpaisal 1993 ¹⁸	Old BP cut-off
19	Suriyawongpaisal 1991 ¹⁹	Old BP cut-off
20	Sitthi-Amornn 1989 ²⁰	Old BP cut-off
21	Bunnag 1990 ²¹	Old BP cut-off
22	E. Sharmin Trisha 2016 ²²	No relevant outcome
23	Bhandari 2015 ²³	No relevant outcome
24	Oti 2014 ²⁴	No relevant outcome
25	Hiremath 2014 ²⁵	No relevant outcome
26	Joshi 2013 ²⁶	No relevant outcome
27	van de Vijver 2013 ²⁷	No relevant outcome
28	Itrat 2011 ²⁸	No relevant outcome
29	Ahmed 2011 ²⁹	No relevant outcome
30	Haregu 2015 ³⁰	No relevant outcome
31	van de Vijver 2015 ³¹	No relevant outcome
32	Kohli 2016 ³²	No relevant outcome
33	Mudgapalli 2016 ³³	No relevant population
34	Natarajan 2014 ³⁴	No relevant population
35	Kumaramanickavel 2014 ³⁵	No relevant population
36	Kumaramanickavel 2015 ³⁶	No relevant population
37	Hulzebosch 2015 ³⁷	No relevant population
38	Madhu 2016 ³⁸	No relevant population
39	Mugure 2014 ³⁹	No relevant population
40	Mukhopadhyay 2012 ⁴⁰	No relevant population
41	Khan 2010 ⁴¹	No relevant population
42	Etyang 2013 ⁴²	Review
43	Dhar 2014 ⁴³	Review
44	Bhargava 1991 ⁴⁴	Review
45	Khalequzzaman 2017 ⁴⁵	Self-reported only
46	Kien 2015 ⁴⁶	Self-reported only
47	Sur 2007 ⁴⁷	Self-reported only
48	Thakur 2013 ⁴⁸	Self-reported only
49	Ahmedani 2019 ⁴⁹	No relevant outcome
50	Ashe 2019 ⁵⁰	No relevant outcome
51	Asiki 2018 ⁵¹	No relevant outcome
52	Bagdey 2019 ⁵²	No relevant outcome
53	Cope 2020 ⁵³	No relevant outcome
54	De Silva 2018 ⁵⁴	No relevant outcome
55	Kapwata 2018 ⁵⁵	No relevant outcome

56	Kawazoe 2018 ⁵⁶	No relevant outcome
57	Khanam 2019 ⁵⁷	No relevant outcome
58	Kolak 2018 ⁵⁸	No relevant outcome
59	Korn 2018 ⁵⁹	No relevant outcome
60	Kotian 2019 ⁶⁰	No relevant outcome
61	Kumar 2018 ⁶¹	No relevant outcome
62	Ma 2018 ⁶²	No relevant outcome
63	Maharana 2019 ⁶³	No relevant outcome
64	Nagarkar 2018 ⁶⁴	No relevant outcome
65	Narendran 2018 ⁶⁵	No relevant outcome
66	Rajapakshe 2018 ⁶⁶	No relevant outcome
67	Sarkar 2019 ⁶⁷	No relevant outcome
68	Sczufca 2019 ⁶⁸	No relevant outcome
69	Wang 2018 ⁶⁹	No relevant outcome
70	Wekasah 2020 ⁷⁰	No relevant outcome
71	Wilson 2020 ⁷¹	No relevant outcome
72	Yadav 2018 ⁷²	No relevant outcome
73	Zhang 2019 ⁷³	No relevant outcome

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eTable 2: Characteristics of included studies

Study	Country	Slum	Sample size	Age group	% female
Acharyya (2014)	India	North-Parganas	1052	25-64	49.8
Ahmad (2014)	India	Meerut	196	>60	50
Akinwale (2013)	Nigeria	Ijora Oloye, Ajegunle & Makoko	2434		
Anand (2007)	India	Faridabad	2562	15+	50.9
Ayah (2013)	Kenya		2061	18-90	49.1
Banerjee (2016)	India	Kolkata	10167	>20 years	60
Chakerborty (2012)	India	Kolkata	470	18-60	0
Chaturvedi (2007)	India	Delhi	596	>20	
Daniel (2013)	Nigeria	Ajegunle	964	20-81	65.8
Dasappa (2015)	India	Bangalore	2013	35+	50.8
Deepa (2011)	India	Ballabgarh, Delhi, Chennai, Trivandrum, Dibrugarh and Nagpur	15763	15-64	
Edwards (2015)	Kenya	Kibera			
Ezeala-Adikaibe (2016)	Nigeria	Enugu	774	≥ 20	64.7
Ferreira (2005)	Brazil	Maceio	223	18-65	100
Florencio (2004)	Brazil	Maceio	416	18-60	57
Haregu (2016)	Kenya	Nairobi	5190	18+	46.2
Heitzinger (2014)	Peru	Lima	142	18-81	69.7
Huda (2012)	Bangladesh	Mirpur, Dhaka	1000	15-65	33.4
Jalil (2008)	Pakistan	Lahore	695		43.6
Joshi (2013)	India	Rourkela & Bhubaneswar	100	>18	69
Joshi (2014)	Kenya	Kibera	2045	18-90	49.1
Kar (2008)	India	Chandigarh & Haryana	1010	>30	58.9
Kar (2010)	India	Chandigarh & Haryana	150	>30	62
Kumari (2014)	India	Hyderabad	250		78
Lubree (2002)	India	Pune	150	30-50	100
Marins (2007)	Brazil	Rio-de-Janeiro	3279	>20	56.9
Misra (2001)	India	Gautam-Nagar, Delhi	532		68
Nirmala (2014)	India	Hyderabad, Telangana	700	>20	50.8
Olack (2015)	Kenya	Kibera	1528	35-64	58.1
Oli (2013)	Nepal	Kathmandu	689	15-64	58.9
Ongeti (2013)	Kenya	Kibera	400	14-75	70.3
Oti (2013)	Kenya	Viwandani & Korogocho		18+	46
Patil (2016)	India	Pune, Maharashtra	425	20+	
Rahim (2004)	Bangladesh	Dhakar	1555	20+	52.99
Rawal (2017)	Bangladesh	Dhaka	507		50
Sayeed (2007)	Bangladesh	Dhakar			59.2
Singh (b) (2012)	India	Delhi	474	60+	48
Singh (2012)	India	Patna	3118	>30	56.5
Sinha (2010)	India	Gokulpuri	275	18-40	100
Sithi-Amorn (1989)	Thailand	Klong-Toey	976		54.7
Snyder (2017)	Brazil		792		64.5

Sowemimo (2015)	Nigeria	Yemetu, Ibadan	806	18-90	
Sunita (2017)	India	Mumbai	6464	>40	
Unger (2015)	Brazil	Salvador	5649	>18	58.3
Uthakalla (2012)	India	Hyderabad		20-60	56
Vigneswari (2014)	India	Chennai	529	18+	77.3
Vigneswari (2015)	India		529	18+	77.3
Vikram (2003)	India	New-Delhi	639		73.4
Wasir (2007)	India	Delhi	278		
Yajnik (2008)	India		142	30-50	0
van de Vijver (2013)	Kenya	Viwandani & Korogocho	5190	>18	46.2
Bawah (2019)	Ghana	Accra	2009		
Chiang (2019)	Bangladesh	Dhaka	423		
Choudhury (2018)	Bangladesh	Dhaka	984	43.4	73
Dwivedi (2018)	India	Bangalore			
Gadallah (2018)	Egypt	West Delhi			
George (2019)	India	Bangalore		57.6	
Gonmei (2018)	India	Delhi			
Jain (2019)	India	Delhi	984	43.4	73
Tymejczyk (2019)	Haiti	Gurugram	420		
Vusirikala (2019)	Kenya	Nairobi		57.6	

eTable 3: Risk of bias of included studies

Study	Selection (sample population)	Selection (participation rate)	Performance bias (analytical methods to control for bias)	Other form of bias
Acharyya (2014)	Low risk	Low risk	Low risk	Low risk
Ahmad (2014)	Low risk	Unclear risk	High risk	Unclear risk
Akinwale (2013)	Low risk	Low risk	High risk	Unclear risk
Anand (2007)	Low risk	Low risk	Low risk	Low risk
Ayah (2013)	Low risk	Low risk	Low risk	Low risk
Banerjee (2016)	Low risk	Unclear risk	Low risk	Low risk
Chakerborty (2012)	High risk	Low risk	High risk	Low risk
Chaturvedi (2007)	Low risk	Low risk	Low risk	Low risk
Daniel (2013)	Low risk	Low risk	Low risk	Low risk
Dasappa (2015)	Low risk	Low risk	High risk	Low risk
Deepa (2011)	Low risk	Low risk	High risk	Low risk
Edwards (2015)	Low risk	Low risk	High risk	Unclear risk
Ezeala-Adikaibe (2016)	High risk	High risk	Low risk	Low risk
Ferreira (2005)	Low risk	Low risk	Low risk	Low risk
Florencio (2004)	Low risk	Low risk	Low risk	Low risk
Haregu (2016)	Unclear risk	Unclear risk	Low risk	Low risk
Heitzinger (2014)	Low risk	Low risk	Low risk	Low risk
Huda (2012)	Low risk	Low risk	High risk	Unclear risk
Jalil (2008)	Low risk	Low risk	Low risk	Unclear risk
Joshi (2013)	High risk	Low risk	Low risk	High risk
Joshi (2014)	Low risk	Low risk	Low risk	Low risk
Kar (2008)	Low risk	Low risk	Low risk	Low risk
Kar (2010)	Low risk	Low risk	Low risk	Low risk
Kumari (2014)	Low risk	Low risk	High risk	Low risk
Lubree (2002)	Low risk	Low risk	High risk	Low risk
Marins (2007)	Low risk	Low risk	High risk	Unclear risk
Misra (2001)	Low risk	Low risk	High risk	Low risk
Nirmala (2014)	Low risk	Low risk	High risk	Low risk
Olack (2015)	Low risk	Low risk	Low risk	Low risk
Oli (2013)	Low risk	Low risk	Low risk	Low risk
Ongeti (2013)	Low risk	Low risk	Low risk	Low risk
Oti (2013)	Low risk	Low risk	Low risk	Low risk
Patil (2016)	Low risk	Low risk	High risk	Unclear risk
Rahim (2004)	Low risk	Low risk	High risk	Unclear risk
Rawal (2017)	Low risk	Low risk	Low risk	Low risk
Sayeed (2007)	Low risk	Low risk	High risk	Unclear risk
Singh (b) (2012)	Low risk	Low risk	Low risk	Unclear risk
Singh (2012)	Low risk	Low risk	Low risk	Low risk
Sinha (2010)	Low risk	Low risk	Low risk	Low risk
Sithi-Amorn (1989)	Low risk	Low risk	High risk	Unclear risk
Snyder (2017)	Low risk	Low risk	Low risk	Low risk
Sowemimo (2015)	Low risk	Unclear risk	Low risk	Unclear risk

Sunita (2017)	Low risk	Low risk	High risk	Unclear risk
Unger (2015)	Low risk	Low risk	Low risk	Low risk
Uthakalla (2012)	Low risk	Low risk	High risk	Unclear risk
Vigneswari (2014)	Low risk	Low risk	High risk	Low risk
Vigneswari (2015)	Low risk	Low risk	High risk	Low risk
Vikram (2003)	Low risk	Low risk	Low risk	Low risk
Wasir (2007)	Low risk	High risk	High risk	Unclear risk
Yajnik (2008)	Low risk	Low risk	High risk	Unclear risk
van de Vijver (2013)	Low risk	Low risk	Low risk	Low risk
Bawah (2019)	Unclear risk	Unclear risk	Low risk	Unclear risk
Chiang (2019)	Low risk	Low risk	Low risk	Low risk
Choudhury (2018)	Low risk	Low risk	Low risk	Low risk
Dwivedi (2018)	Low risk	Low risk	Low risk	Low risk
Gadallah (2018)	Low risk	Low risk	Low risk	Low risk
George (2019)	Low risk	Low risk	Low risk	Low risk
Gonmei (2018)	Unclear risk	Unclear risk	Unclear risk	Unclear risk
Jain (2019)	Low risk	Low risk	Low risk	Low risk
Tymejczyk (2019)	Low risk	Low risk	Low risk	Low risk
Vusirikala (2019)	Low risk	Low risk	Low risk	Low risk

Annex 1: MEDLINE Search Strategy

1	exp hypertension/
2	hypertens\$.mp.
3	exp blood pressure/
4	(blood pressure or bloodpressure).mp.
5	(essential adj3 hypertension).ti,ab.
6	(isolat* adj3 hypertension).ti,ab.
7	(elevat* adj3 blood adj pressur*).ti,ab.
8	(high adj3 blood adj pressur*).ti,ab.
9	(increase* adj3 blood pressur*).ti,ab.
10	((systolic or diastolic or arterial) adj3 pressur*).ti,ab.
11	essential hypertension.mp.
12	isolated hypertension.mp.
13	elevated blood pressure.mp.
14	high blood pressure.mp.
15	increase blood pressure.mp.
16	diastolic pressure.mp.
17	pre-hypertension.mp.
18	pre-hypertensive.mp.
19	prehypertension.mp.
20	prehypertensive.mp.
21	arterial pressure.mp.
22	cardiovascular diseases/
23	exp coronary disease/
24	cardiovascular risk factor\$.tw.
25	(cardiovascular adj3 disease\$).tw.
26	(Coronary adj3 disease\$).tw.
27	heart disease\$.tw.
28	coronary risk factor\$.tw.
29	or/1-28
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31	
32	1 exp Diabetes Mellitus, Type 2/
33	2 exp DIABETES MELLITUS/
34	3 T2DM.ti,ab.
35	4 (Type* adj3 ("2" or "II" or two*) adj3 (diabete* or diabetic*)).tw.
36	5 ((Maturit* or adult* or slow*) adj3 onset* adj3 (diabete* or diabetic*)).tw.
37	6 ((Ketosis-resistant* or stable*) adj3 (diabete* or diabetic*)).tw.
38	7 ((Non-insulin* or Non insulin* or Noninsulin*) adj3 depend* adj3 (diabete* or diabetic*)).tw.
39	8 IDDM.ti,ab.
40	9 diabet\$.ti.
41	10 PREDIABETIC STATE/
42	11 prediabet\$.ti,ab.
43	12 impaired glucose tolerance.ti,ab.
44	13 IGT.ti,ab.
45	14 Impaired fasting glucose.ti,ab.
46	15 IFG.ti,ab.
47	16 Impaired glucose regulation.ti,ab. 1
48	17 IGR.ti,ab.
49	18 GLUCOSE INTOLERANCE/
50	19 (diabet* or glucose or hyperglycaemia or hyperglycaemia or postprandial or post-prandial or insulin or hypoglycemia or hypoglycaemia or IGT or OGTT or CGMS).tw.
51	20 (subclinical diabetes" or "subclinical diabetic" or "sub-clinical diabetes" or "sub-clinical diabetic").tw.
52	21 or/1-20
53	22 (baladi or bandas de miseria or barraca or barrio marginal or barrio or bidonville or brarek or bustee or chalis or chereka bete or dagatan or estero or favela or galoos or gecekonddu or hrushebi).mp.
54	23 (ishash or karyan or katras or looban or loteamento or medina achouaia or morro or mudun safi or musseque or solares or tanake or taudis or township or tugurio or udukku or umjondolo or watta or zopadpattis).mp.
55	24 (slum or slums or ghetto or ghettos or informal settlement\$ or shantytown\$ or shanty town\$).mp.
56	25 slum/
57	26 ghetto/
58	27 or/22-26
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Annex 2: PRISMA Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	6
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	6-7
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	6
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	7
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	7
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	7
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	8
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	9
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	9
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	8

Section/topic	#	Checklist item	Reported on page #
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	9
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	10
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	10
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	11
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	11-12
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	12-15
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	11
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	12-15
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	15-17
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	18-19
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	18-19
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	20

BMJ Open

Global Prevalence and Trends in Hypertension and Type 2 Diabetes Mellitus among Slum Residents: A Systematic Review and Meta-analysis

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-052393.R1
Article Type:	Original research
Date Submitted by the Author:	17-Nov-2021
Complete List of Authors:	Uthman, Olalekan; University of Warwick, Warwick Centre for Global Health, Warwick Medical School Ayorinde, Abimbola; University of Warwick, Warwick Centre for Global Health, Warwick Medical School Oyebode, Oyinlola; University of Warwick Warwick Medical School, Warwick Centre for Global Health, Warwick Medical School Sartori, Jo; University of Birmingham, Institute of Applied Health Research Gill, Paramjit ; University of Warwick, Warwick Centre for Global Health, Warwick Medical School, Lilford, RJ; University of Birmingham, Institute of Applied Health Research
Primary Subject Heading:	Global health
Secondary Subject Heading:	Global health
Keywords:	Hypertension < CARDIOLOGY, DIABETES & ENDOCRINOLOGY, Public health < INFECTIOUS DISEASES

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4 1 **Global Prevalence and Trends in Hypertension and Type 2**
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7 2 **Diabetes Mellitus among Slum Residents: A Systematic**
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10 3 **Review and Meta-analysis**
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24 ABSTRACT

25 **Objective:** To obtain regional estimates of prevalence of hypertension and Type 2 diabetes in urban
26 slums, and secondly to compare these with those in urban and rural areas.

27
28 **Design:** Systematic review and meta-analysis

29
30 **Eligibility criteria:** Studies that reported hypertension prevalence using the definition of blood
31 pressure $\geq 140/90$ mm Hg and/or prevalence of type 2 diabetes.

32
33 **Information sources:** Ovid MEDLINE, Cochrane CENTRAL and EMBASE from inception to December
34 2020

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37 **Risk of bias:** Two authors extracted relevant data and assessed risk of bias independently using the
38 Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline.

39
40 **Synthesis of results:** We used random-effects meta-analyses to pool prevalence estimates. We
41 examined time trends in the prevalence estimates using meta-regression regression models with the
42 prevalence estimates as the outcome variable and the calendar year of the publication as the
43 predictor.

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46 **Results:** A total 62 studies involving 108,110 participants met the inclusion criteria. Prevalence of
47 hypertension and type 2 diabetes in slum populations ranged from 4.2% to 52.5% and 0.9% to 25.0%,
48 respectively. In six studies presenting comparator data, all from the Indian sub-continent, slum
49 residents were 35% more likely to be hypertensive than those living in comparator rural areas and
50 30% less likely to be hypertensive than those from comparator non-slum urban areas.

51
52 **Limitations of evidence:** Of the included studies, only few studies from India compared the slum
53 prevalence estimates with those living on non-slum urban and rural areas, this limits the
54 generalisability of the finding.

55
56 **Interpretation:** The burden of hypertension and type 2 diabetes varied widely between countries and
57 regions and, to some degree, also within countries.

58
59 **Funding:** This research was funded by the National Institute for Health Research (NIHR) (16/136/87)
60 using UK aid from the UK Government to support global health research.

61
62 **PROSPERO registration number:** CRD42017077381

Strengths and limitations of this study

- To reduce the chance of missing relevant studies, no language constraints were applied during the literature search.
- The data was extracted by two independent reviewers, reducing the possibility of bias.
- We analysed trends over time, and between geographical regions.
- The substantial between studies heterogeneity is an important limitation.
- Of the included studies, only few studies from India compared the slum prevalence estimates with those living on non-slum urban and rural areas, this limits the generalisability of the finding.

65

66 INTRODUCTION

67 Noncommunicable diseases (NCDs) are currently the leading cause of death globally, even in
68 low- and middle-income countries (LMICs) the burden of disease is shifting from infectious
69 diseases to NCDs¹. NCDs now account for about 41 million deaths annually, corresponding to
70 nearly 7 in 10 of all deaths worldwide. Every year, 15 million people of ages of 30 to 69 years
71 die from these diseases, more than 85% of which are people living in LMICs. Most of the
72 deaths from NCDs are caused by cardiovascular diseases, followed by cancer and respiratory
73 diseases. NCDs affect people in all age groups, countries and geographic regions. The leading
74 causes of these diseases include increased consumption of unhealthy foods, increased
75 physical inactivity and population ageing²⁻⁴. These factors are mediated through metabolic
76 risk factors for NCDs the most common of which include hypertension and type 2 diabetes²⁻⁴

77
78 Urbanization is a global phenomenon that is occurring at a fast pace in most LMICs^{5 6}. For
79 more than 20 years, urban settlements have been increasing in population size because of
80 fast growth in urban births, significant movement of people from rural areas and sustained
81 integration of the global economy^{5 6}. The United Nations defines slums as urban areas with
82 overcrowding, poor sanitation infrastructure, limited access to safe water, and/or poor
83 structural quality of housing^{7 8}. Slums are now an important component of today's urban
84 settlements and likely continue to be for the foreseeable future^{7 8}.

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3 86 Despite increased global awareness about the presence and persistence of slums, and
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6 87 evidence that their populations are affected by different health problems and needs to other
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8 88 urban inhabitants, the health of their inhabitants is under researched⁷⁻¹⁰. The health of the
9
10 89 urban poor, people with low socioeconomic status living in urban areas, is usually conflated
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12
13 90 with that of slum residents. Although there is substantial overlap between these groups, there
14
15 91 are also richer residents within slum neighbourhoods, as well as urban poverty occurring in
16
17
18 92 non-slum urban areas. Health outcomes for these two groups may differ depending on
19
20 93 whether deprivation is at the individual (urban poverty) or neighbourhood level (slum
21
22
23 94 resident) due to neighbourhood effects^{7 8 11 12}. For example, with respect to NCD risk-factors,
24
25 95 those resident in slums, whatever their personal socio-economic status, may be more
26
27
28 96 exposed to a common physical environmental risk factors (for example: air pollution
29
30 97 increasing risk of hypertension), social environmental risk factors (for example: crime rates
31
32
33 98 which may increase stress and drive metabolic risk) or institutional risk-factors (for example:
34
35 99 stigma on the basis of their address reducing access to appropriate medical care). Many
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37
38 100 existing studies of NCDs risk factors done in urban areas do not disaggregate the population's
39
40 101 health data by slum and non-slums status to allow for the detection of intra-urban health
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42 102 disparities that are due to neighbourhood effects rather than individual socio-economic
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45 103 status¹³⁻²².

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49 105 Understanding how the global challenges of hypertension, type 2 diabetes and rapid
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51
52 106 unplanned urbanisation intersect, by investigating whether the up to 1 billion people residing
53
54 107 in slums²³ are succumbing to these important metabolic risk factors for non-communicable
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57 108 disease, will inform priorities for health services and health policy in LMICs. To fill this research
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59 109 gap, we therefore systematically gathered all the publications that relate to the burden of

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110 hypertension among slum residents to (1) assess the contemporary prevalence estimates of
111 hypertension among slum residents (2) compare the prevalence of hypertension and Type 2
112 diabetes in slums with those in two other types of settlement i.e. non-slum urban and rural
113 areas; and (3) assess the proportion of those with hypertension who were aware of their
114 hypertensive status, those on treatment and those with blood pressure under control.

115

116

For peer review only

117 **METHODS**

118 **Protocol and registration**

119 The study background, rationale, and methods were specified in advance and documented in
120 a protocol that was published in the PROSPERO register (CRD42017077381).

122 **Search and information sources:**

123 We searched Ovid MEDLINE, Cochrane CENTRAL and EMBASE from inception to December
124 2020 using the following keywords: slum, shanty town, ghetto, hypertension and type 2
125 diabetes. The search strategy for Medline is shown in **Annex 1**.

127 **Eligibility criteria:**

128 We evaluated each identified study against the following pre-defined selection criteria:

- 129 • *Types of studies:* We included all studies (cross-sectional studies, retrospective or
130 prospective cohort studies) that reported prevalence of hypertension and type 2
131 diabetes mellitus among slum residents as a primary or secondary outcome. No
132 language, publication date or publication status restrictions were imposed.
- 133 • *Types of participants:* adult population (18 years and above) living in slum (as defined
134 by the authors of the original studies included).
- 135 • *Types of Interventions:* Not applicable.
- 136 • *Types of outcomes:* Essential hypertension (also called primary or idiopathic
137 hypertension), defined as persistent (seated) systolic blood pressure (SBP) of 140
138 mmHg or greater or had diastolic blood pressure 90mmHg or greater regardless of age
139 and sex. We excluded studies that included subjects with pregnancy-induced, pre-

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3 140 eclampsia, malignant, portal, pulmonary, renal, intracranial or ocular hypertension.
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6 141 We also excluded studies used only self-reported measure, i.e. deducible from the
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8 142 use of antihypertensive drugs or self-reported physician-diagnosed cases. If data were
9
10
11 143 available, we noted (1) the percentage of those aware of their hypertension status (2)
12
13 144 on any anti-hypertensive treatment, and (3) blood pressure controlled to a target
14
15 145 level. Awareness of hypertension was defined as self-reporting of any prior diagnosis
16
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18 146 of hypertension by a healthcare professional. Treatment of hypertension was defined
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20 147 as receiving prescribed antihypertensive medication for management of high BP at
21
22
23 148 some time in the 1 year preceding the survey. Control of hypertension was defined as
24
25 149 the proportion of patients reporting antihypertensive therapy with SBP of less than
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28 150 140 mmHg and DBP of less than 90 mmHg.

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30 151
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32 152 Type 2 diabetes was defined based on measured fasting plasma glucose, or oral
33
34
35 153 glucose tolerance test. Type 2 diabetes was diagnosed if the fasting blood glucose was
36
37 154 ≥ 126 mg/dL (≥ 7.0 mmol/L) after an overnight fast for at least 8 hours, or random
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40 155 capillary blood glucose of ≥ 11.1 mmol/L or if the participant was taking treatment
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42 156 for type 2 diabetes.

43 44 45 46 47 158 **Study selection**

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50 159 In pairs, three reviewers (OAU, AAA, OO) independently evaluated the eligibility and
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52 160 methodological quality of the studies obtained from the literature searches. All articles
53
54 161 yielded by the database search were initially screened by their titles and abstracts to obtain
55
56
57 162 studies that met inclusion criteria. In cases of discrepancies, agreement was reached by
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59 163 discussion with a third reviewer. In pairs, three reviewers (OAU, AAA, OO) independently

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3 164 then independently evaluated the full-text articles of all identified citations to establish
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6 165 relevance of the article according to the pre-specified criteria. In cases of discrepancies,
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8 166 agreement was reached by discussion with a third reviewer.
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12 13 168 **Data collection process and data items**

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15 169 OAU extracted data and AAA and OO checked the extracted data. For each study that met the
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17
18 170 selection criteria, details extracted included on year of publication, country of origin, study
19
20
21 171 design, sample size, sampling strategy, study period, setting (rural/urban/slum), socio-
22
23 172 demographic variables, prevalence estimates; etc.
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26 27 28 174 **Risk of bias (quality) assessment**

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30 175 The risk of bias of included studies will be assessed by using the Strengthening the Reporting
31
32 176 of Observational Studies in Epidemiology (STROBE)^{24 25}(see Box 1). The risk of bias in a
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34
35 177 study was graded as low, high or unclear on the basis of study features including the selection
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37 178 of participants (selection bias), participation rate (selection bias), outcome measurement
38
39 179 (detection bias), consideration of confounding variables (analytical methods to control for
40
41 180 bias), and other form of bias.

42
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44 181 For each included study, we estimated the precision (C) or margin of error, considering the
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46 182 sample size (SS) and the observed prevalence (p) of hypertension among slum dwellers from
47
48 183 the formula:

$$49
50
51 184 \quad \quad \quad SS = Z^2 * p * (1-p) / C^2 \quad \quad \quad (1)$$

52
53 185 where Z was the z-value fixed at 1.96 across studies (corresponding to 95% confidence
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55 186 interval). The desirable margin of error is 5% (0.05) or lower.
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Box 1: Risk of bias assessment			
Bias type	Low-risk of bias	High-risk of bias	Unclear risk of bias
Selection (sample population)	participants selected randomly	Sample selection ambiguous and sample unlikely to be representative	Insufficient information
Selection (participation rate)	High participation rate (>70-85%)	Low participation rate (<70%)	Insufficient information
Performance bias (outcome assessment)	Objective measures of hypertension	Self-reported measure of hypertension	Insufficient information
Performance bias (analytical methods to control for bias)	Analysis appropriate for type of sample (unadjusted, univariable analyses etc.)	Analysis does not account for common adjustment (adjusted, multivariable analyses)	Insufficient information
Other form of bias	There is no evidence of bias from other sources.	There is potential bias present from other sources	Insufficient information

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190 Synthesis of results

191 For the meta-analysis, we used DerSimonian-Laird random effects model²⁶ due to anticipated
 192 variations in study population, health care delivery systems and stage of epidemic transition to
 193 pool the hypertension and type 2 diabetes prevalence estimates. We performed leave-one-
 194 study-out sensitivity analysis to determine the stability of the results²⁷. This analysis evaluated
 195 the influence of individual studies by estimating the pooled prevalence estimates in the absence
 196 of each study²⁷. We assessed heterogeneity among studies by inspecting the forest plots and
 197 using the chi-squared test for heterogeneity with a 10% level of statistical significance and
 198 using the I^2 statistic where we interpret a value of 50% as representing moderate heterogeneity²⁸
 199 ²⁹. We assessed the possibility of publication bias by evaluating a funnel plot for asymmetry.
 200 Because graphical evaluation can be subjective, we also conducted a Egger's regression
 201 asymmetry test as formal statistical tests for publication bias³⁰.

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3 203 Following the overall analyses, we performed the following sub-group analyses: place of
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5 204 residence (rural versus urban slum versus non-slum urban); participants risk factors, including
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7 205 socioeconomic position; study design (cross-sectional, cohort); study location (low- and
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9 206 middle income versus high-income countries); and study precision.
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15 208 We examined time trends in the prevalence estimates using meta-regression regression models
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17 209 with the prevalence estimates as the outcome variable and the calendar year of the publication
18
19 210 as the predictor. In order to measure secular patterns in prevalence figures, we use the annual
20
21 211 average percentages change (AAPC). We fitted a regression line to the natural logarithm of
22
23 212 the prevalence estimates, i.e., $y = \alpha + \beta x + \epsilon$, where $y = \ln(\text{Prevalence})$, and $x = \text{calendar year}$.
24
25 213 The AAPC was calculated as $100 \times (\exp(\beta) - 1)$. The 95% confidence interval (CI) of the AAPC
26
27 214 was also computed from the regression model.³¹ The prevalence calculations indicated an
28
29 215 upward trend when both the AAPC estimate and the lower limit of its 95% CI were > 0 .
30
31 216 However, they indicated a downward trend when both the AAPC and its upper limits were
32
33 217 less than 0. The prevalence estimates were otherwise considered stable over time³¹. This
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35 218 systematic review was reported according to the Preferred Reporting Items for Systematic
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37 219 Reviews and Meta-analyses (PRISMA) guideline (**Annex 2**)³².
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46 221 **Patient and public involvement**

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48 222 No patient was involved.
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Results

Study selection and characteristics

The literature search yielded 1490 articles. **eFigure 1** shows the study selection flow diagram. After review, 135 articles were selected for critical reading. Seventy-two studies did not meet the inclusion criteria and were excluded (see **eTable 1** for list of excluded studies). The other 62 studies involving 108,110 participants met the inclusion criteria and were included in the meta-analysis^{13-22 33-81}. Forty-three studies reported only hypertension prevalence estimates, 29 studies reported only type 2 diabetes prevalence estimates and eight reported both. **Table 1 and eTable 2** presents the characteristics of the included studies. The studies were reported between 1989 and 2019. Studies were reported as full-text journal articles (n=61, **98%**); except for one which was reported as a conference abstract. The number of participants included in the studies ranged from 100 to 15,763. When reported, the mean age of participants ranged from 32 years to 47 years. Most of the studies were carried out in South Asia: India (n=30); Bangladesh (n=8) and Nepal (n=1) and Pakistan (n=1); followed by sub-Saharan Africa: Kenya (n=9) and Nigeria (n=4); Latin America and Caribbean: Brazil (n=5) and Peru (n=1) and East Asia and Pacific: Thailand (n=1). Most of the studies were conducted in the following urban slums: Kibera (n=4), Delhi (n=3), Hyderabad (n=3), Ajegunle (n=2), Chandigarh (n=2), Chennai (n=2), Dhaka (n=2), Haryana (n=2), and Maceio (n=2).

Risk of bias of included studies

Summary of risk of bias assessment for each study is shown in **eTable 3**. The risk of bias in the selection of participants was low in most studies (n=58, 94%), high in three studies (5%) and unclear in one study. The risk of selection bias due to participate rate was low in most studies

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3 248 (n=56, 90%), unclear in four (7%) and high in two study (3%). The performance bias due to
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6 249 outcome assessment was low in all the 62 studies as we included all studies that used
7
8 250 objective measure of hypertension and type 2 diabetes. The performance bias due to
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10 251 analytical methods was low in 40 studies (64%) and high in 22 studies (35%). The risk of other
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13 252 biases was low in most studies (n=45, 73%), unclear in 16 studies (26%) and high in one study
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15 253 (2%).
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255 Variations in prevalence of hypertension and type 2 diabetes by geographical regions

256 Prevalence of hypertension and type 2 diabetes from individuals are shown in **Figure 1 and**
257 **Figure 2** respectively.
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259 East Asia and Pacific

260 *Thailand:* One study from Klong-Toey slum found that 77 of the 976 respondents had type 2
261 diabetes in 1989 (7.9%, 95% CI 6.3 to 9.8).
262

263 Latin America and Caribbean

264 *Brazil:* Four studies reported the prevalence of hypertension from three different slums:
265 Maceio (n=2), Rio de Janeiro (n=1) and Salvador (n=1). Florencio et al. found that almost one
266 third of the Maceio slum dweller were hypertensive in 2004 (29.8%, 95% CI 24.8 to 35.2),
267 while Ferriera et al estimated prevalence of hypertension among Maceio slum residents to
268 be 14.8% (95% CI 10.4 to 20.2) in 2005. The reported prevalence of hypertension in other slums
269 was 11.3% (95% CI 10.2 to 12.4) in Rio de Janeiro in 2007 and 20.6% (95% CI 19.5 to 21.7) in
270 Salvador in 2015. The pooled prevalence ('annualised year average') of hypertension for the

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3 271 four studies yielded an estimate of 18.4% (95% CI 12.0% to 26.2%). One study from Brazil
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6 272 found that one in ten had type 2 diabetes in 2017.
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10 274 *Peru:* One study from a Lima slum conducted in 2014 found that 21 of the 142 respondents
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13 275 were hypertensive (14.8%, 95% CI 9.4 to 21.7).
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18 277 South Asia

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20 278 *Bangladesh:* Four studies from Dhakan slum reported prevalence of hypertension. The
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22
23 279 reported prevalence of hypertension ranged from 11.6% (95% CI 9.7 to 13.8) in 2012 to
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25 280 19.56% (95% CI 17.85 to 21.37) in 2018. Fivestudies from Dhakan slum reported prevalence
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28 281 of type 2 diabetes. The pooled prevalence ('annualised year average') of hypertension for the
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30 282 three studies yielded an estimate of 16.1% (95% CI 12.2% to 20.3%). The reported prevalence
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32 283 of type 2 diabetes in these slums ranged from 8.1% (95% CI 6.8 to 9.6) in 2004 to 18.12% (95%
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34
35 284 CI 16.46 to 19.87) in 2019.
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40 286 *India:* Twenty-two studies from India reported prevalence of hypertension from more than
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42 287 15 difference slums. The reported prevalence varied across and within the slums. For
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45 288 example, Kar and colleagues estimated the prevalence of hypertension of 27.6% (95% 21.4 to
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47 289 34.4) among 196 Chandigarh and Haryana slum residents in 2008; however they estimated
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50 290 the prevalence of hypertension of 16.5% (95% CI 15.1 to 18.0) among 2,562 196 Chandigarh
51
52 291 and Haryana slum residents in 2010. Prevalence of type diabetes also varied across slums in
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54 292 India. The pooled prevalence ('annualised year average') of hypertension for the 22 studies
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57 293 yielded an estimate of 26.8% (95% CI 22.5% to 31.3%). In Delhi, the reported prevalence of
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59 294 type 2 diabetes ranged from 12.7% (95% CI 11.3 to 14.2) in 2007 to 31.5% (95% CI 27.8 to
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3 295 35.4) in 2012. The pooled prevalence ('annualised year average') of type 2 for the 13 studies
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6 296 yielded an estimate of 12.2% (95% CI 9.2% to 15.6%).
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10 298 *Nepal:* One study from a Kathmandu slum conducted in 2013 found that 193 of the 689
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13 299 respondents were hypertensive (28.0%, 95% CI 24.7 to 31.5).
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18 301 *Pakistan:* One study from a Lahore slum found that 22 of the 695 respondents had type 2
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20 302 diabetes in 2008 (3.2%, 95% CI 2.0 to 4.8).
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24
25 304 Sub-Saharan Africa. *Kenya:* Six studies reported the prevalence of hypertension from three
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27 305 different slums: Kibera (n=4) and Viwandani and Korogocho (n=2). The reported prevalence
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29 306 among Kibera slum residents ranged from 13.0% (95% CI 9.9 to 16.7) in 2013 to 27.8% (95%
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32 307 CI 25.9 to 29.7) in 2015. van de Vijver found that 640 of the 5,190 respondents from
33
34 308 Viwandani and Korogocho slum residents were hypertensive (12.3%, 95% CI 11.5 to 13.3). The
35
36 309 pooled prevalence ('annualised year average') of hypertension for the six studies yielded an
37
38 310 estimate of 19.2% (95% CI 13.2% to 26.0%). The reported prevalence of type 2 diabetes
39
40 311 ranged from 0.9% (95% CI 0.7 to 1.2 in Nairobi slum in 2016 to 4.4% (95% CI 3.8 to 5.0) in
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42 312 Viwandani and Korogocho in 2013. The pooled prevalence ('annualised year average') of type
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44 313 2 diabetes for the six studies yielded an estimate of 4.5% (95% CI 2.0% to 7.9%).
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52 315 *Nigeria:* Four studies from five different slums reported prevalence of hypertension. The
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54 316 reported prevalence varied across and within the slums. Ezeala-Adikaibe found that half of
55
56 317 the respondents from Enugu slum were hypertensive in 2016 (52.5%, 95% CI 48.9 to 56.0).
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58 318 While Daniel et al. and Sowemimo et al. found that almost one-third of the Ajegule (38.2%,
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3 319 95% CI 35.1 to 41.3, 2013) and Yemetu (33.1%, 95% CI 30.0 to 36.5, 2015) slum residents were
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6 320 hypertensive. However, Akinwale found that only 12.8% of the respondents from Ijora Oloye,
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8 321 Ajegunle and Makoko were hypertensive in 2013. The pooled prevalence ('annualised year
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10 322 average') of hypertension for the four studies yielded an estimate of 33.2% (95% CI 15.6% to
11
12 323 53.5%). Akinwale found that only 3.3% of the respondents from Ijora Oloye, Ajegunle and
13
14
15 324 Makoko had type 2 diabetes in 2013.
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326 **Secular trends in hypertension and Type 2 diabetes prevalence estimates**

327 Secular trends in hypertension, in 5 countries for which there were data across multiple time
328 points, and type 2 diabetes, in 3 countries in which we had data across multiple time points,
329 among slum residents are shown in **Figures 3 and 4**. We observed a continuous increase in
330 prevalence of hypertension among slum residents in four out of five countries. The increase
331 is more pronounced in India, followed by Kenya and Bangladesh. The prevalence of
332 hypertension increased by 204.6% from 11.7% in 2001 to 35.5% in 2019 in India. The
333 prevalence of hypertension increased by 98.8% from 12.3% in 2013 to 24.5% in 2019 in Kenya.
334 However, the results of the trend analysis showed statistically significant upward trends only
335 in India, such that the prevalence of hypertension increased +6.9% (95% CI +2.0% to +12.0%)
336 per year between 2001 and 2019. There was no statistically significant trend was observed in
337 Brazil using trend analyses (trend =-0.0%, 95% CI -22.7% to +29.2%). We also observed a
338 continuous increase in prevalence of type 2 diabetes among slum residents in India and
339 Bangladesh. The prevalence of type 2 diabetes increased by 123.6% from 8.1% in 2004 to
340 18.1% in 2019 in Bangladesh. The prevalence of type 2 diabetes increased by 95.8% from
341 10.3% in 2001 to 20.2% in 2019 in India. However, the results of the trend analysis showed
342 statistically significant upward trends only in Bangladesh such that the prevalence of type 2

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3 343 diabetes increased +5.9% (95% CI +1.1% to +10.8%) per year between 2004 and 2019. A non-
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6 344 statistically significant downward trends in type 2 diabetes prevalence was also observed in
7
8 345 Kenya (trend =-11.1%, 95% CI -45.7% to +45.6%).
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12 13 14 15 348 **Prevalence of hypertension by different hypertension and type 2 diabetes subgroups**

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18 349 *Study characteristics:* As shown in **Table 1**, the pooled prevalence of hypertension was
19
20 350 highest in studies conducted in lower-middle income countries (23.2%, 95% CI 21.5 to 29.0,
21
22 351 36 studies) than those from upper-middle income countries (17.9%, 95% CI 12.1 to 24.6, 5
23
24 352 studies). The pooled prevalence of hypertension tended to be higher among studies from
25
26 353 South Asia (25.3%, 95% CI 21.3 to 29.6, 26 studies) and sub-Saharan Africa (24.4%, 95% CI
27
28 354 17.7 to 31.9, 10 studies) than those from Latin America and Caribbean (18.3%, 95% CI 13.4
29
30 355 to 23.9, 6 studies). The pooled prevalence tended to be higher among imprecise studies (33.4%,
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32 356 95% CI 25.7 to 41.7, 8 studies) than those from precise studies (22.4%, 95% CI 18.9 to 26.1%,
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34 357 35 studies). The pattern was similar for type 2 diabetes prevalence estimates.
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42 359 *Socio-demographic characteristics:* As shown in **Table 1**, the pooled prevalence of
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44 360 hypertension was similar among males (22.5%, 95% CI 16.0 to 29.7, 24 studies) and females
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46 361 (23.5%, 95% CI 18.6 to 28.1, 24 studies). The pooled prevalence of hypertension tended to
47
48 362 be higher among older adults (49.6%, 95% CI 36.7 to 62.6, 9 studies) than middle-age (35.0%,
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50 363 95% CI 45.6, 9 studies) and young adults (15.7%, 95% CI 10.1 to 22.1, 8 studies). Similarly,
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52 364 the pooled prevalence of hypertension tended to be higher obese (45.4%, 95% CI 34.5 to
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54 365 56.5, 6 studies) and overweight (32.9%, 95% CI 21.2 to 45.8, 6 studies) participants than
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56 366 participants with normal (21.9%, 95% CI 11.8 to 34.2, 6 studies) and under-weight (21.8%,
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3 367 95% CI 11.4 to 34.4, 5 studies). The pooled prevalence of hypertension tended to be higher
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6 368 among those never studied (39.1%, 95% CI 27.5 to 51.3) than those with less than primary
7
8 369 (18.3%, 95% CI 13.9 to 23.1, 4 studies), primary (24.8%, 95% CI 12.0 to 40.4, 6 studies) or
9
10 370 secondary/higher education attainment (22.4%, 95% CI 11.2 to 36.2, 7 studies). The pooled
11
12 371 prevalence of hypertension tended to be higher among least poor (29.2%, 95% CI 13.1 to
13
14 372 48.5, 5 studies) than those with middle- (25.3%, 10.6 to 43.8, 5 studies) and poorest-income
15
16 373 (20.9%, 95% CI 10.4 to 33.8, 5 studies). The pattern was similar for type 2 diabetes
17
18 374 prevalence estimates.

375

376 *Lifestyle factors:* The pooled prevalence of hypertension tended to be higher among
377 smokers (38.0%, 95% CI 19.1 to 59.0, 5 studies) than those not smoking (30.5%, 95% CI 17.6
378 to 45.2, 5 studies). We found that the pooled prevalence of hypertension tended to be
379 higher those not physically active (30.8%, 95% CI 7.7 to 60.9, 3 studies) than those physical
380 active (28.8%, 95% CI 11.1 to 50.8); tended to be higher among with no history of alcohol
381 consumption (29.1%, 95% CI 9.3 to 54.3, 3 studies) than those reported alcohol consumption
382 (26.5%, 95% CI 18.0 to 35.9, 3 studies).

383

384 *Comparative prevalence by place of residence*

385 Six studies from India included non-slum populations alongside data from the slum
386 population, and reported prevalence of hypertension by place of residence^{37 39 47 49 50 52}. As
387 shown in **Figure 5**, the pooled prevalence of hypertension was highest among those residing
388 in non-slum urban areas (33.5%, 95% CI 26.0 to 42.0, 6 studies), followed by urban slum
389 residents (28.8%, 95% CI 23.7 to 34.4%, 6 studies) and was lowest among rural residents
390 (24.4%, 95% CI 18.4 to 31.5, 5 studies). Slum residents were 35% more likely to be hypertensive

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3 391 than those living in rural areas (OR = 1.35, 95% 1.29 to 1.42) and 30% less likely to be
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6 392 hypertensive than those living in other urban areas (OR = 0.70, 95% CI 0.51 to 0.96).
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10 394 Four studies from India (n=3) and Bangladesh reported prevalence of Type 2 diabetes by place
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12
13 395 of residence^{47 52 60 72}. As shown in **Figure 6**, the pooled prevalence of type 2 diabetes was
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15 396 highest among those residing in non-slum urban areas (13.06%, 95% CI 6.53 to 24.43, 4
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17 397 studies; 2813 participants), followed by urban slum residents (7.88%, 95% CI 3.32 to 17.55; 4
18
19 398 studies; 1811 participants) and was lowest among rural residents (1.64%; 95% CI 0.06 to
20
21 399 32.21; 3 studies; 405 participants). Such that prevalence of type 2 diabetes tended to be
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23 400 higher among urban slum residents than those living in rural areas (OR = 3.78, 95% 0.75 to
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25 401 18.93). Urban slum residents were 46% less likely to be diabetic than those from other urban
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27 402 areas (OR = 0.54, 95% CI 0.44 to 0.66).
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35 404 *Treatment cascade*

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37 405 Among those diagnosed with hypertension, only one-third were aware of their hypertensive
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39 406 status (33.6%, 95% CI 19.1 to 50.0%, 12 studies) (**Table 1**). Among those aware of their high
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41 407 blood pressure, half of them were on antihypertensive medications (51.9%, 95% CI 35.2 to
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43 408 68.3, 9 studies). Among those on treatment, only one-quarter had good blood pressure
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45 409 control (25.2, 95% CI 18.4 to 34.3, 8 studies). Among those diagnosed with type 2 diabetes,
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47 410 57.4% were aware of their type 2 diabetes status (95% CI 18.2 to 91.8%, 2 studies).
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414 Discussion

415 Main Findings

416 This systematic review and meta-analysis summarises available evidence on the global
417 prevalence of hypertension and type 2 diabetes among slum residents. There were several
418 key findings: firstly, the burden of hypertension and type 2 diabetes among slum dweller is
419 high and may be rising globally, with wide variation between countries and regions and, to
420 some degree, also within countries. Using data from within study comparator populations
421 when presented, the pooled prevalence of hypertension and Type 2 diabetes was highest
422 among those residing in non-slum urban areas, followed by slum residents and was lowest
423 among rural residents. This finding corroborates those of previous reviews that observed
424 higher prevalence of hypertension among urban residents than those living in rural areas⁸²
425 ⁸³. This high prevalence may be due to rapid urbanization, lifestyle changes, dietary changes
426 and increased life expectancy^{84 85} or a combination of these factors^{86 87}. In addition, the
427 observed difference could be due to other factors including but not limited to lack of access
428 to testing and care of NCDs risk factors in rural areas and urban areas.

429
430 The observed gradient in burden of hypertension and Type 2 diabetes among rural, slum and
431 urban residents is consistent with the effects of urbanization and wealth, as residents
432 experience an economic transition when moving from one area to the next⁸⁸⁻⁹³. LMICs are
433 now undergoing epidemiological transition, the change from a burden of infectious diseases
434 to chronic diseases⁹⁴. In addition, it could be due to increase in awareness in (non-slum) urban
435 areas and recent availability of testing in some places. Recent systematic reviews of dietary
436 risk-behaviour in Sub-Saharan Africa have found that urban populations tended to consume

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3 437 more salt than rural populations⁹⁵ and consume fewer portions of vegetables¹². The rapid
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6 438 pace of urbanisation and economic growth is accelerating the rate of this epidemiologic
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8 439 transition; as such LMICs are at great risk for an explosive growth in the burden of NCDs,
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11 440 including hypertension and type 2 diabetes^{88 89}.

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14 441 We found evidence of significant unmet need for hypertension care among urban slum
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16 442 residents. Significant proportion of the urban slum residents were unscreened, undiagnosed,
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19 443 untreated or uncontrolled. This huge unmet need has been documented in previous studies
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21 444 from low- and middle-income settings⁹⁶⁻¹⁰². We also found that control of hypertension
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24 445 among slum residents was poor, such that only one in four slum residents on treatment, had
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26 446 their blood pressure controlled. The poor control of BP noted in our study, despite the fact
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29 447 the one half of those that were unaware of high blood pressure being on antihypertensive
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31 448 medications, needs further exploration. One possible explanation is availability and
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34 449 affordability of the medications and there could be minimal additional contact with a health
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36 450 professional¹⁵. It has been documented that the control of BP was related to the frequency
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39 451 of follow-up visits⁹⁷. Another possible explanation could be low adherence to prescribed
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41 452 medications, as they may not be able to afford the medications.

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45 453 As expected, we found that the burden of hypertension increased with the participants' age,
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47 454 which may be attributed to age-related structural changes in blood vessels which potentially
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50 455 cause narrowing of the vascular lumen, and consequently increasing blood pressure, as have
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52 456 been reported in previous studies^{103 104}. The association between combined
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54 457 overweight/obesity and hypertension shown in our results exemplify the role of excess body
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57 458 weight in hypertension prevalence, which has been long recognized and consistent across
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59 459 numerous observational and trial data¹⁰⁵⁻¹⁰⁷. We found evidence of significantly high

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3 460 prevalence of hypertension among smokers compared to the non-smokers. Direct relation of
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6 461 chronic tobacco consumption with hypertension however is not yet well established^{108 109}
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8 462 although tobacco consumption has been shown to cause an acute elevation of BP¹¹⁰.
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13 464 **Study Limitations and Strengths**

16 465 To the best of our knowledge, this paper is the first systematic reviews that summarises data
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18 466 about prevalence of hypertension and type 2 diabetes among slum residents. Strengths of
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21 467 this study include the use of a predefined and published protocol, a comprehensive search
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24 468 strategy, and involvement of two independent reviewers in the review process. Nevertheless,
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26 469 the findings of this study should be interpreted with caution. Prevalence estimates from
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29 470 different regions and published over the course of 11 years were pooled in this meta-analysis,
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31 471 and as expected, high heterogeneity between studies was found in the meta-analyses.
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34 472 Nonetheless, as affirmed by previous evidence, meta-analyses are the preferred options to
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36 473 narrative syntheses for interpreting the results in a review, even in spite of the presence of a
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39 474 considerable amount of heterogeneity¹¹¹. Heterogeneity appeared to be the norm rather
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41 475 than exception in published meta-analyses of observational studies¹¹².

44 476 In conclusion, the burden of hypertension and type 2 diabetes varied widely between
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47 477 countries and regions and, to some degree, also within countries. In addition, many
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50 478 hypertensive individuals are not aware of their condition, not on treatment and control of
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52 479 hypertension is poor. The burden of hypertension and type 2 diabetes was higher among
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55 480 urban residents than their counterparts living in urban slums and rural areas. There is a need
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57 481 for public health strategies to improve the awareness, control and overall management of
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59 482 hypertension and type 2 diabetes in urban areas.
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13 487 publication are those of the author(s) and not necessarily those of the NIHR or the UK
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20 490 **Ethics approval and consent to participate**
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23 491 Not applicable.
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27 493 **Consent for publication:** Not applicable.
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32 495 **Data sharing statement:** No additional data available
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37 497 **Competing interests**
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40 498 The authors declare that they have no competing interests.
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44 500 **Authors' contribution**
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47 501 OAU, AAA, OO and RL conceived the study. OAU, AAA and OO collected and analysed initial
48
49 502 data. OAU, AAA, OO, JO, PG and RL participated contributed in refining the data analysis.
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51
52 503 OAU wrote the first manuscript. OAU, AAA, OO, JS, PG and RL contributed to further
53
54 504 analysis, interpreting and shaping of the argument of the manuscript and participated in
55
56
57 505 writing the final draft of the manuscript. All the authors read and approved the final
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59 506 manuscript.
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872 **TABLES**873 **Table 1: Pooled prevalence by difference subgroup**

Subgroup		Hypertension			Type 2 Diabetes		
		n	%	I ²	n	%	I ²
Sample size	Smaller studies (<1000)	27	25.9 (21.6 to 30.6)	97.1	15	11.0 (8.2 to 14.2)	93.9
Sample size	Larger studies (1000+)	17	21.4 (17.2 to 26.1)	99.6	15	7.8 (5.1 to 11.1)	99.4
Study precision	Imprecise studies	8	33.4 (25.7 to 41.7)	91.2	1	25.2 (17.3 to 34.2)	-
Study precision	Precise studies	36	22.3 (18.9 to 25.9)	99.2	29	8.9 (6.9 to 11.2)	98.9
Publication year	2001 to 2005	5	15.6 (9.0 to 23.8)	94.7	4	8.2 (6.7 to 9.8)	53.6
Publication year	2006 to 2010	6	28.6 (18.9 to 39.4)	98.7	4	6.3 (3.3 to 10.3)	90.6
Publication year	2011 to 2020	33	24.7 (21.0 to 28.6)	99.2	22	10.2 (7.4 to 13.4)	99.2
Region	South Asia	27	25.1 (20.7 to 29.8)	98.9	19	11.9 (9.1 to 15.1)	97.6
Region	Sub-Saharan Africa	10	24.4 (17.7 to 31.9)	99.2	8	4.5 (2.4 to 7.2)	98.8
Region	Latin America and Caribbean	6	18.3 (13.4 to 23.9)	97.1	1	10.2 (8.1 to 12.3)	-
Region	Middle East and North Africa	1	31.2 (28.4 to 34.1)	-	1	8.8 (7.1 to 10.6)	-
Region	East Asia and Pacific	-	-	-	1	7.9 (6.3 to 9.7)	-
Income category	Lower Middle Income	36	25.2 (21.2 to 29.4)	99.1	28	9.3 (7.0 to 11.92)	98.9
Income category	Upper Middle Income	5	17.9 (12.1 to 24.6)	97.6	2	9.0 (6.9 to 11.3)	62
Income category	Low Income	2	24.0 (16.9 to 32.0)	92.2			
Sex	Male	24	22.5 (16.0 to 29.7)	99.2	11	8.1 (5.1 to 11.6)	97.6
Sex	Female	24	23.2 (18.6 to 28.1)	98.7	11	7.3 (4.6 to 10.6)	97.5
Age	Young adult	8	15.7 (10.1 to 22.1)	97.8	2	2.1 (0.3 to 5.4)	96.7
Age	Middle-age adult	9	35.0 (25.0 to 45.6)	99.2	2	5.6 (4.5 to 6.8)	0
Age	Older adult	9	49.6 (36.7 to 62.6)	98.3	2	9.1 (7.0 to 11.4)	0
Body mass index	Under weight	5	21.8 (11.4 to 34.4)	87.3			
Body mass index	Normal weight	6	21.9 (11.8 to 34.2)	98.6	2	2.3 (1.8 to 2.8)	0
Body mass index	Overweight	6	32.9 (21.2 to 45.8)	97.4	2	4.2 (1.2 to 8.8)	50
Body mass index	Obese	6	45.4 (34.5 to 56.6)	93.3	2	6.4 (4.0 to 9.3)	0
Education Status	Never studied	7	39.1 (27.5 to 51.3)	98	1	5.1 (3.0 to 7.8)	-
Education Status	Less than primary	4	18.3 (13.9 to 23.1)	87.1	1	4.6 (3.4 to 6.1)	-
Education Status	Primary	6	24.8 (12.0 to 40.4)	99.4	1	4.4 (3.6 to 5.2)	-
Education Status	Secondary or higher	7	22.4 (11.1 to 36.2)	99.3	1	4.1 (3.2 to 5.2)	-
Income	Poorest	5	20.9 (10.4 to 33.8)	98.9			
Income	Middle	5	25.3 (10.6 to 43.8)	99.5			
Income	Least poor	5	29.2 (13.1 to 48.5)	98.3			
Smoking status	Yes	5	38.0 (19.1 to 59.0)	99.1			
Smoking status	No	5	30.5 (17.6 to 45.2)	99.6			
Alcohol consumption	Yes	3	26.5 (18.0 to 35.9)	83.4			
Alcohol consumption	No	3	29.1 (9.3 to 54.3)	99.7			
Physically active	Yes	3	28.8 (11.1 to 50.8)	99.6			
Physically active	No	3	30.8 (7.7 to 60.9)	98.4			
Treatment cascade	Aware of HBP	12	33.6 (19.1 to 50.0)	99.7			
Treatment cascade	On treatment	9	51.9 (35.2 to 68.3)	98.6			
Treatment cascade	BP controlled	8	25.9 (18.4 to 34.3)	87.8			

874 * World Bank Country Income Groups, 2018

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3 875 Participants were divided into age groups that, broadly defined, covered young adulthood (18 to 35 years),
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5 876 middle age (36 to 55 years), and older adulthood (56 years and older).
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7 877 Underweight - BMI under 18.5 kg/m²
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9 878 Normal weight - BMI greater than or equal to 18.5 to 24.9 kg/m²
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11 879 Overweight – BMI greater than or equal to 25 to 29.9 kg/m²
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13 880 Obesity – BMI greater than or equal to 30 kg/m²
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17 882 Physical activity as defined by the authors
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FIGURE LEGENDS

Figure 1: Hypertension prevalence estimates among slum residents and 95% confidence intervals from individual studies and pooled data

Figure 2: Type 2 diabetes mellitus prevalence estimates among slum residents and 95% confidence intervals from individual studies and pooled data

Figure 3: Secular trends in hypertension prevalence estimates among slum residents across different regions

Figure 4: Secular trends in Type 2 diabetes mellitus prevalence estimates among slum residents across different regions

Figure 5: Hypertension prevalence estimates by place of residence: urban versus rural versus slum

Figure 6: Type 2 diabetes mellitus prevalence estimates by place of residence: urban versus rural versus slum

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4 910 **ONLINE ONLY SUPPLEMENTS**

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6 911 **eFigure 1: Study selection and inclusion flow chart**

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11 913 **eTable 1: List of Excluded Studies**

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16 915 **eTable 2: Characteristics of included studies**

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21 917 **eTable 3: Risk of bias of included studies**

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26 919 **Annex 1: MEDLINE Search Strategy**

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31 921 **Annex 2: PRISMA Checklist**

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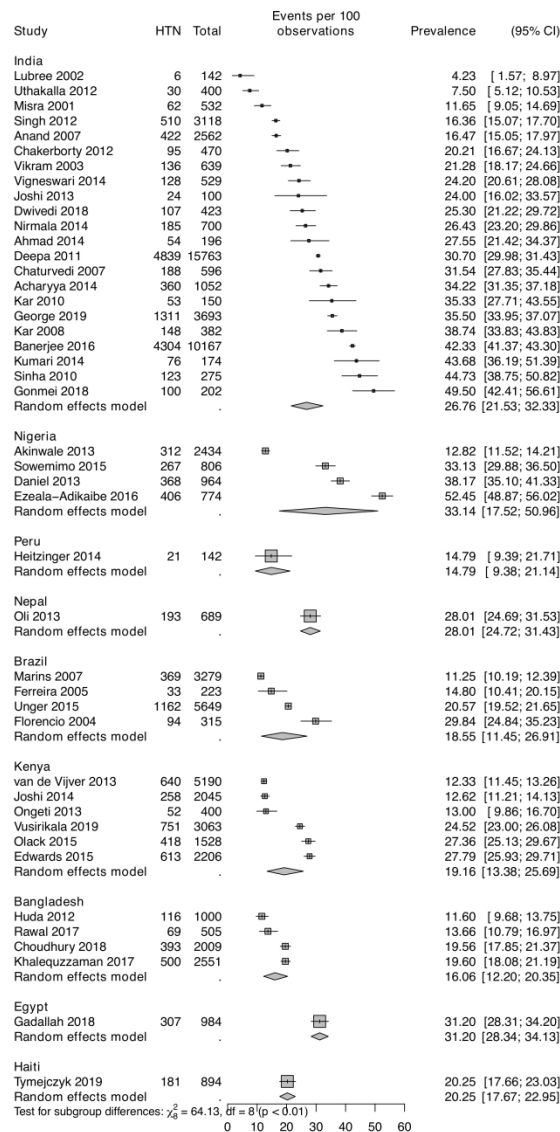


Figure 1

228x406mm (300 x 300 DPI)

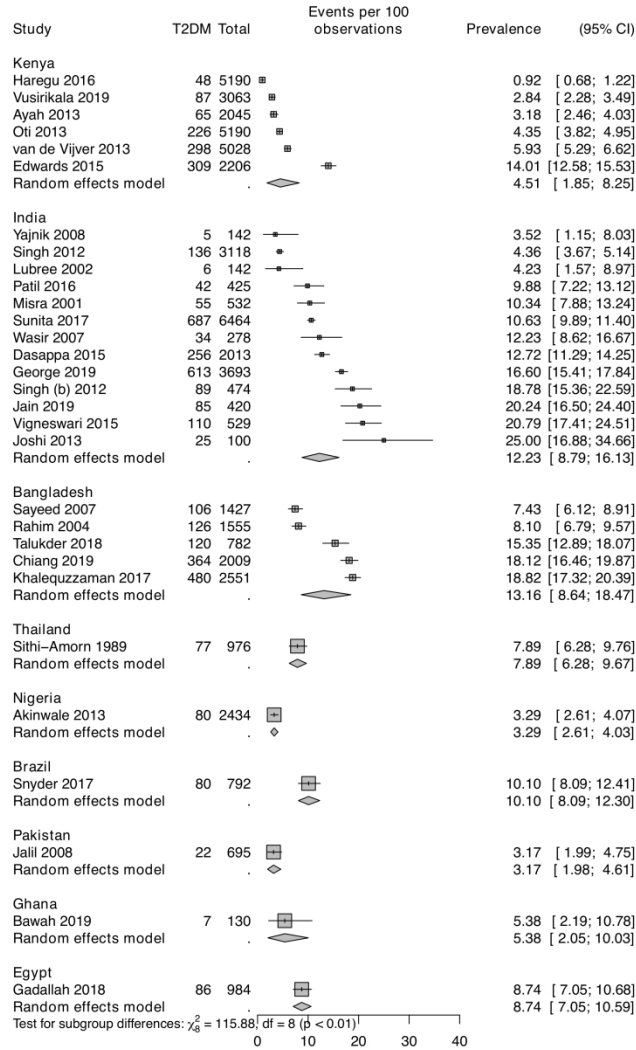


Figure 2

228x355mm (300 x 300 DPI)

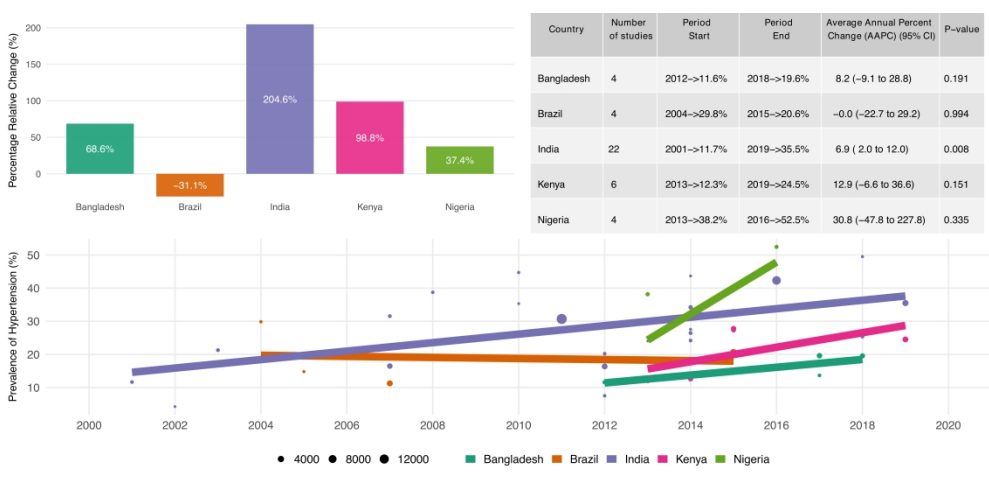


Figure 3

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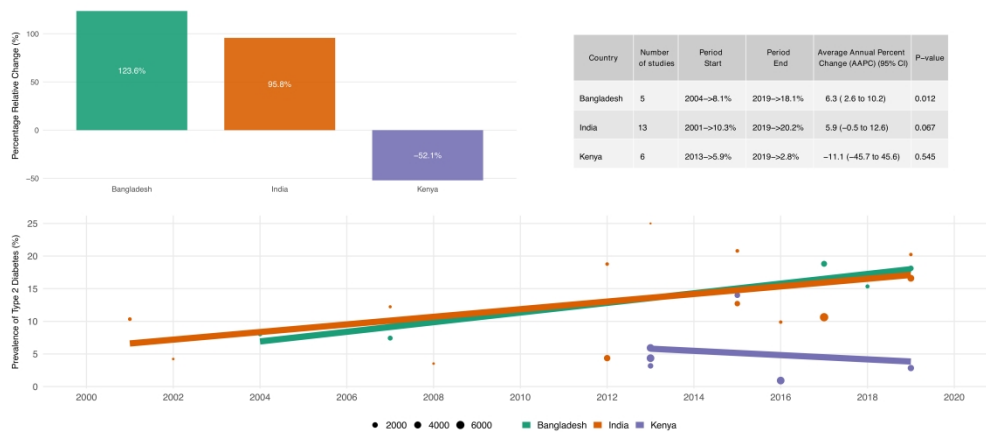


Figure 4

602x263mm (300 x 300 DPI)

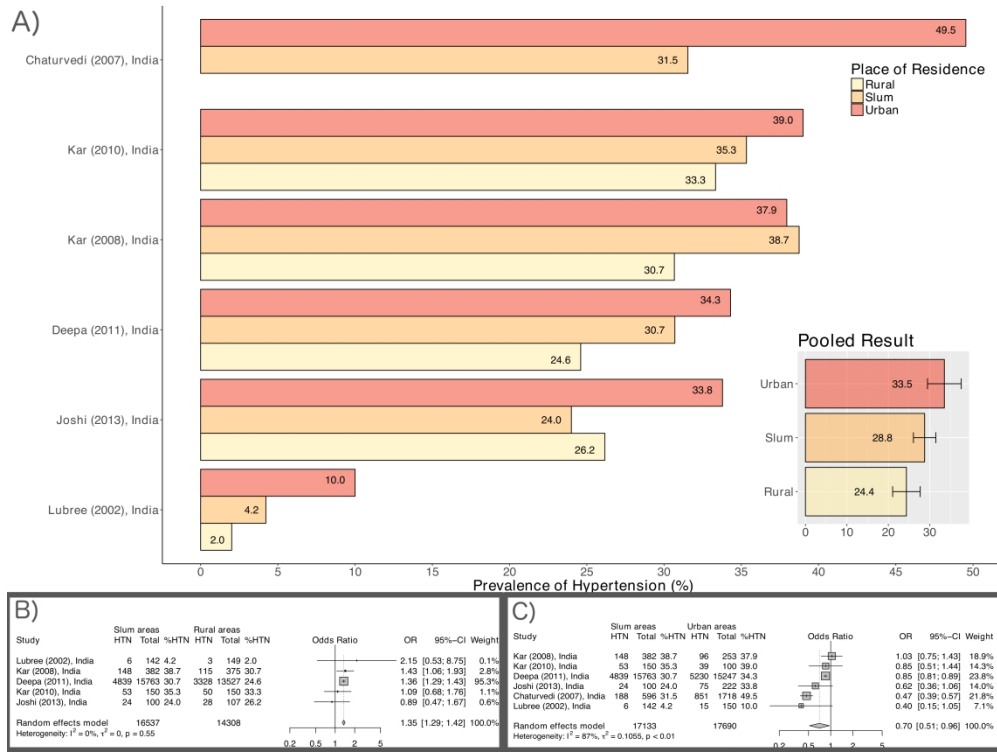


Figure 5

478x357mm (300 x 300 DPI)

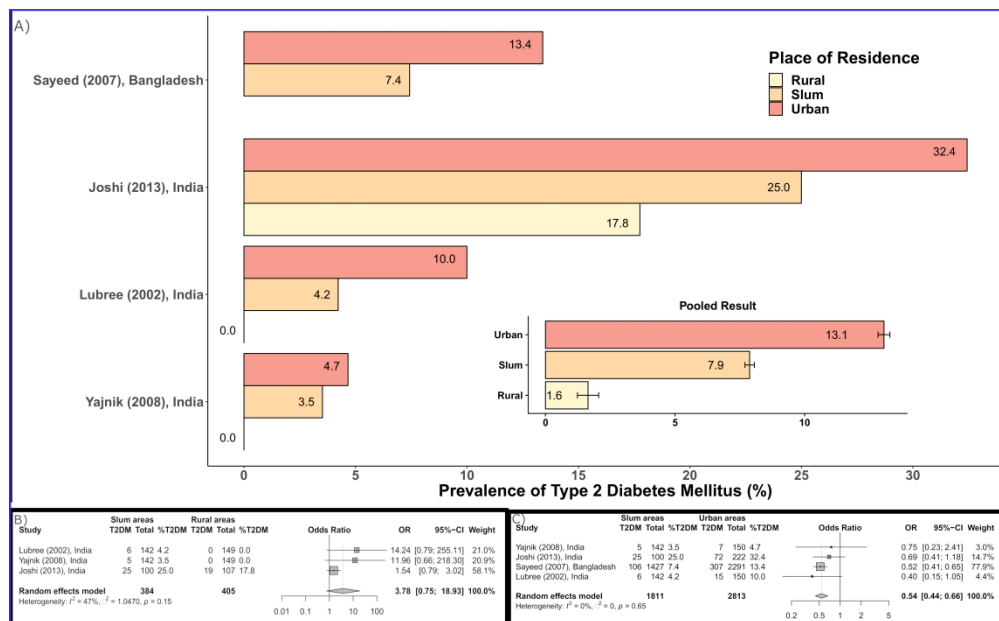


Figure 6

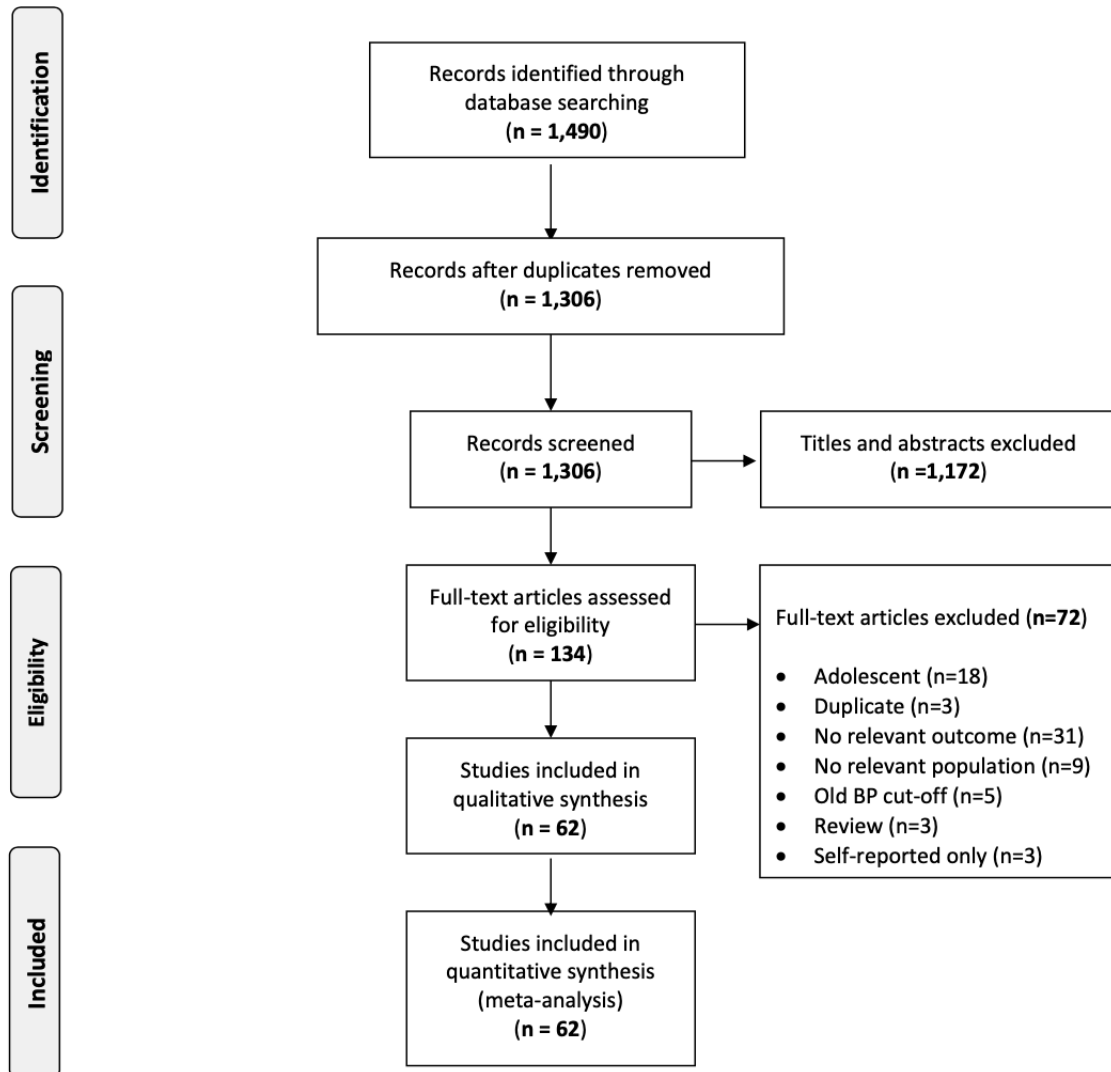
425x261mm (300 x 300 DPI)

Supplementary Digital Content

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eFigure 1: Study selection and inclusion flow chart



eTable 1: List of Excluded Studies

s/n	Study	Reason
1	Maiti 2016 ¹	Adolescent
2	Khopkar 2015 ²	Adolescent
3	Paul 2013 ³	Adolescent
4	Kamath 2012 ⁴	Adolescent
5	Simsek 2012 ⁵	Adolescent
6	Saha 2011 ⁶	Adolescent
7	Oria 2010 ⁷	Adolescent
8	Saha 2008 ⁸	Adolescent
9	Saha 2008 ⁹	Adolescent
10	Sesso 2004 ¹⁰	Adolescent
11	Fernandes 2003 ¹¹	Adolescent
12	Zeelie 2010 ¹²	Adolescent
13	Soudrassanane 2008 ¹³	Adolescent
14	Werner 2015 ¹⁴	Duplicate
15	van de Vijver 2016 ¹⁵	Duplicate
16	Haregu 2016 ¹⁶	Duplicate
17	Ezenwaka 1997 ¹⁷	Old BP cut-off
18	Suriyawongpaisal 1993 ¹⁸	Old BP cut-off
19	Suriyawongpaisal 1991 ¹⁹	Old BP cut-off
20	Sitthi-Amornn 1989 ²⁰	Old BP cut-off
21	Bunnag 1990 ²¹	Old BP cut-off
22	E. Sharmin Trisha 2016 ²²	No relevant outcome
23	Bhandari 2015 ²³	No relevant outcome
24	Oti 2014 ²⁴	No relevant outcome
25	Hiremth 2014 ²⁵	No relevant outcome
26	Joshi 2013 ²⁶	No relevant outcome
27	van de Vijver 2013 ²⁷	No relevant outcome
28	Itrat 2011 ²⁸	No relevant outcome
29	Ahmed 2011 ²⁹	No relevant outcome
30	Haregu 2015 ³⁰	No relevant outcome
31	van de Vijver 2015 ³¹	No relevant outcome
32	Kohli 2016 ³²	No relevant outcome
33	Mudgapalli 2016 ³³	No relevant population
34	Natarajan 2014 ³⁴	No relevant population
35	Kumaramanickavel 2014 ³⁵	No relevant population
36	Kumaramanickavel 2015 ³⁶	No relevant population
37	Hulzebosch 2015 ³⁷	No relevant population
38	Madhu 2016 ³⁸	No relevant population
39	Mugure 2014 ³⁹	No relevant population
40	Mukhopadhyay 2012 ⁴⁰	No relevant population
41	Khan 2010 ⁴¹	No relevant population
42	Etyang 2013 ⁴²	Review
43	Dhar 2014 ⁴³	Review
44	Bhargava 1991 ⁴⁴	Review
46	Kien 2015 ⁴⁵	Self-reported only
47	Sur 2007 ⁴⁶	Self-reported only
48	Thakur 2013 ⁴⁷	Self-reported only
49	Ahmedani 2019 ⁴⁸	No relevant outcome
50	Ashe 2019 ⁴⁹	No relevant outcome
51	Asiki 2018 ⁵⁰	No relevant outcome
52	Bagdey 2019 ⁵¹	No relevant outcome
53	Cope 2020 ⁵²	No relevant outcome
54	De Silva 2018 ⁵³	No relevant outcome
55	Kapwata 2018 ⁵⁴	No relevant outcome
56	Kawazoe 2018 ⁵⁵	No relevant outcome

57	Khanam 2019 ⁵⁶	No relevant outcome
58	Kolak 2018 ⁵⁷	No relevant outcome
59	Korn 2018 ⁵⁸	No relevant outcome
60	Kotian 2019 ⁵⁹	No relevant outcome
61	Kumar 2018 ⁶⁰	No relevant outcome
62	Ma 2018 ⁶¹	No relevant outcome
63	Maharana 2019 ⁶²	No relevant outcome
64	Nagarkar 2018 ⁶³	No relevant outcome
65	Narendran 2018 ⁶⁴	No relevant outcome
66	Rajapakshe 2018 ⁶⁵	No relevant outcome
67	Sarkar 2019 ⁶⁶	No relevant outcome
68	Scazufca 2019 ⁶⁷	No relevant outcome
69	Wang 2018 ⁶⁸	No relevant outcome
70	Wekasah 2020 ⁶⁹	No relevant outcome
71	Wilson 2020 ⁷⁰	No relevant outcome
72	Yadav 2018 ⁷¹	No relevant outcome
73	Zhang 2019 ⁷²	No relevant outcome

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For peer review only

eTable 2: Characteristics of included studies

Study	Country	Slum	Sample size	Age group	% female
Acharyya (2014)	India	North-Parganas	1052	25-64	49.8
Ahmad (2014)	India	Meerut	196	>60	50
Akinwale (2013)	Nigeria	Ijora Oloye, Ajegunle & Makoko	2434		
Anand (2007)	India	Faridabad	2562	15+	50.9
Ayah (2013)	Kenya		2061	18-90	49.1
Banerjee (2016)	India	Kolkata	10167	>20 years	60
Chakerborty (2012)	India	Kolkata	470	18-60	0
Chaturvedi (2007)	India	Delhi	596	>20	
Daniel (2013)	Nigeria	Ajegunle	964	20-81	65.8
Dasappa (2015)	India	Bangalore	2013	35+	50.8
Deepa (2011)	India	Ballabgarh, Delhi, Chennai, Trivandrum, Dibrugarh and Nagpur	15763	15-64	
Edwards (2015)	Kenya	Kibera			
Ezeala-Adikaibe (2016)	Nigeria	Enugu	774	≥ 20	64.7
Ferreira (2005)	Brazil	Maccio	223	18-65	100
Florencio (2004)	Brazil	Maccio	416	18-60	57
Haregu (2016)	Kenya	Nairobi	5190	18+	46.2
Heitzinger (2014)	Peru	Lima	142	18-81	69.7
Huda (2012)	Bangladesh	Mirpur, Dhaka	1000	15-65	33.4
Jalil (2008)	Pakistan	Lahore	695		43.6
Joshi (2013)	India	Rourkela & Bhubaneswar	100	>18	69
Joshi (2014)	Kenya	Kibera	2045	18-90	49.1
Kar (2008)	India	Chandigarh & Haryana	1010	>30	58.9
Kar (2010)	India	Chandigarh & Haryana	150	>30	62
Khalequzzaman (2017)	Bangladesh	Dhakar	2551	18+	46.7
Kumari (2014)	India	Hyderabad	250		78
Lubree (2002)	India	Pune	150	30-50	100
Marins (2007)	Brazil	Rio-de-Janeiro	3279	>20	56.9
Misra (2001)	India	Gautam-Nagar, Delhi	532		68
Nirmala (2014)	India	Hyderabad, Telangana	700	>20	50.8
Olack (2015)	Kenya	Kibera	1528	35-64	58.1
Oli (2013)	Nepal	Kathmandu	689	15-64	58.9
Ongeti (2013)	Kenya	Kibera	400	14-75	70.3
Oti (2013)	Kenya	Viwandani & Korogocho		18+	46
Patil (2016)	India	Pune, Maharashtra	425	20+	
Rahim (2004)	Bangladesh	Dhakar	1555	20+	52.99
Rawal (2017)	Bangladesh	Dhaka	507		50
Sayeed (2007)	Bangladesh	Dhakar			59.2
Singh (b) (2012)	India	Delhi	474	60+	48
Singh (2012)	India	Patna	3118	>30	56.5
Sinha (2010)	India	Gokulpuri	275	18-40	100
Sithi-Amorn (1989)	Thailand	Klong-Toey	976		54.7

Snyder (2017)	Brazil		792		64.5
Sowemimo (2015)	Nigeria	Yemetu, Ibadan	806	18-90	
Sunita (2017)	India	Mumbai	6464	>40	
Unger (2015)	Brazil	Salvador	5649	>18	58.3
Uthakalla (2012)	India	Hyderabad		20-60	56
Vigneswari (2014)	India	Chennai	529	18+	77.3
Vigneswari (2015)	India		529	18+	77.3
Vikram (2003)	India	New-Delhi	639		73.4
Wasir (2007)	India	Delhi	278		
Yajnik (2008)	India		142	30-50	0
van de Vijver (2013)	Kenya	Viwandani & Korogocho	5190	>18	46.2
Bawah (2019)	Ghana	Accra	2009		
Chiang (2019)	Bangladesh	Dhaka	423		
Choudhury (2018)	Bangladesh	Dhaka	984	43.4	73
Dwivedi (2018)	India	Bangalore			
Gadallah (2018)	Egypt	West Delhi			
George (2019)	India	Bangalore		57.6	
Gonmei (2018)	India	Delhi			
Jain (2019)	India	Delhi	984	43.4	73
Tymejczyk (2019)	Haiti	Gurugram	420		
Vusirikala (2019)	Kenya	Nairobi		57.6	

eTable 3: Risk of bias of included studies

Study	Selection (sample population)	Selection (participation rate)	Performance bias (analytical methods to control for bias)	Other form of bias
Acharyya (2014)	Low risk	Low risk	Low risk	Low risk
Ahmad (2014)	Low risk	Unclear risk	High risk	Unclear risk
Akinwale (2013)	Low risk	Low risk	High risk	Unclear risk
Anand (2007)	Low risk	Low risk	Low risk	Low risk
Ayah (2013)	Low risk	Low risk	Low risk	Low risk
Banerjee (2016)	Low risk	Unclear risk	Low risk	Low risk
Chakerborty (2012)	High risk	Low risk	High risk	Low risk
Chaturvedi (2007)	Low risk	Low risk	Low risk	Low risk
Daniel (2013)	Low risk	Low risk	Low risk	Low risk
Dasappa (2015)	Low risk	Low risk	High risk	Low risk
Deepa (2011)	Low risk	Low risk	High risk	Low risk
Edwards (2015)	Low risk	Low risk	High risk	Unclear risk
Ezeala-Adikaibe (2016)	High risk	High risk	Low risk	Low risk
Ferreira (2005)	Low risk	Low risk	Low risk	Low risk
Florencio (2004)	Low risk	Low risk	Low risk	Low risk
Haregu (2016)	Unclear risk	Unclear risk	Low risk	Low risk
Heitzinger (2014)	Low risk	Low risk	Low risk	Low risk
Huda (2012)	Low risk	Low risk	High risk	Unclear risk
Jalil (2008)	Low risk	Low risk	Low risk	Unclear risk
Joshi (2013)	High risk	Low risk	Low risk	High risk
Joshi (2014)	Low risk	Low risk	Low risk	Low risk
Kar (2008)	Low risk	Low risk	Low risk	Low risk
Kar (2010)	Low risk	Low risk	Low risk	Low risk
Khalequzzaman (2017)	Low risk	Low risk	Low risk	Low risk
Kumari (2014)	Low risk	Low risk	High risk	Low risk
Lubree (2002)	Low risk	Low risk	High risk	Low risk
Marins (2007)	Low risk	Low risk	High risk	Unclear risk
Misra (2001)	Low risk	Low risk	High risk	Low risk
Nirmala (2014)	Low risk	Low risk	High risk	Low risk
Olack (2015)	Low risk	Low risk	Low risk	Low risk
Oli (2013)	Low risk	Low risk	Low risk	Low risk
Ongeti (2013)	Low risk	Low risk	Low risk	Low risk
Oti (2013)	Low risk	Low risk	Low risk	Low risk
Patil (2016)	Low risk	Low risk	High risk	Unclear risk
Rahim (2004)	Low risk	Low risk	High risk	Unclear risk
Rawal (2017)	Low risk	Low risk	Low risk	Low risk
Sayeed (2007)	Low risk	Low risk	High risk	Unclear risk
Singh (b) (2012)	Low risk	Low risk	Low risk	Unclear risk
Singh (2012)	Low risk	Low risk	Low risk	Low risk
Sinha (2010)	Low risk	Low risk	Low risk	Low risk
Sithi-Amorn (1989)	Low risk	Low risk	High risk	Unclear risk
Snyder (2017)	Low risk	Low risk	Low risk	Low risk

Sowemimo (2015)	Low risk	Unclear risk	Low risk	Unclear risk
Sunita (2017)	Low risk	Low risk	High risk	Unclear risk
Unger (2015)	Low risk	Low risk	Low risk	Low risk
Uthakalla (2012)	Low risk	Low risk	High risk	Unclear risk
Vigneswari (2014)	Low risk	Low risk	High risk	Low risk
Vigneswari (2015)	Low risk	Low risk	High risk	Low risk
Vikram (2003)	Low risk	Low risk	Low risk	Low risk
Wasir (2007)	Low risk	High risk	High risk	Unclear risk
Yajnik (2008)	Low risk	Low risk	High risk	Unclear risk
van de Vijver (2013)	Low risk	Low risk	Low risk	Low risk
Bawah (2019)	Unclear risk	Unclear risk	Low risk	Unclear risk
Chiang (2019)	Low risk	Low risk	Low risk	Low risk
Choudhury (2018)	Low risk	Low risk	Low risk	Low risk
Dwivedi (2018)	Low risk	Low risk	Low risk	Low risk
Gadallah (2018)	Low risk	Low risk	Low risk	Low risk
George (2019)	Low risk	Low risk	Low risk	Low risk
Gonmei (2018)	Unclear risk	Unclear risk	Unclear risk	Unclear risk
Jain (2019)	Low risk	Low risk	Low risk	Low risk
Tymeczyk (2019)	Low risk	Low risk	Low risk	Low risk
Vusirikala (2019)	Low risk	Low risk	Low risk	Low risk

Annex 1: MEDLINE Search Strategy

1	exp hypertension/
2	hypertens\$.mp.
3	exp blood pressure/
4	(blood pressure or bloodpressure).mp.
5	(essential adj3 hypertension).ti,ab.
6	(isolat* adj3 hypertension).ti,ab.
7	(elevat* adj3 blood adj pressur*).ti,ab.
8	(high adj3 blood adj pressur*).ti,ab.
9	(increase* adj3 blood pressur*).ti,ab.
10	((systolic or diastolic or arterial) adj3 pressur*).ti,ab.
11	essential hypertension.mp.
12	isolated hypertension.mp.
13	elevated blood pressure.mp.
14	high blood pressure.mp.
15	increase blood pressure.mp.
16	diastolic pressure.mp.
17	pre-hypertension.mp.
18	pre-hypertensive.mp.
19	prehypertension.mp.
20	prehypertensive.mp.
21	arterial pressure.mp.
22	cardiovascular diseases/
23	exp coronary disease/
24	cardiovascular risk factor\$.tw.
25	(cardiovascular adj3 disease\$).tw.
26	(Coronary adj3 disease\$).tw.
27	heart disease\$.tw.
28	coronary risk factor\$.tw.
29	or/1-28
1	exp Diabetes Mellitus, Type 2/
2	exp DIABETES MELLITUS/
3	T2DM.ti,ab.
4	(Type* adj3 ("2" or "II" or two*) adj3 (diabete* or diabetic*)).tw.
5	((Maturit* or adult* or slow*) adj3 onset* adj3 (diabete* or diabetic*)).tw.
6	((Ketosis-resistant* or stable*) adj3 (diabete* or diabetic*)).tw.
7	((Non-insulin* or Non insulin* or Noninsulin*) adj3 depend* adj3 (diabete* or diabetic*)).tw.
8	IDDM.ti,ab.
9	diabet\$.ti.
10	PREDIABETIC STATE/
11	prediabet\$.ti,ab.
12	impaired glucose tolerance.ti,ab.
13	IGT.ti,ab.
14	Impaired fasting glucose.ti,ab.
15	IFG.ti,ab.
16	Impaired glucose regulation.ti,ab. 1
17	IGR.ti,ab.
18	GLUCOSE INTOLERANCE/
19	(diabet* or glucose or hyperglycaemia or hyperglycaemia or postprandial or post-prandial or insulin or hypoglycemia or hypoglycaemia or IGT or OGTT or CGMS).tw.
20	(subclinical diabetes" or "subclinical diabetic" or "sub-clinical diabetes" or "sub-clinical diabetic").tw.
21	or/1-20
22	(baladi or bandas de miseria or barraca or barrio marginal or barrio or bidonville or brarek or bustee or chalis or chereka bete or dagatan or estero or favela or galoos or gecekondou or hrushebi).mp.
23	(ishash or karyan or katras or looban or loteamento or medina achouaia or morro or mudun safi or musseque or solares or tanake or taudis or township or tugurio or udukku or umjondolo or watta or zopadpattis).mp.
24	(slum or slums or ghetto or ghettos or informal settlement\$ or shantytown\$ or shanty town\$).mp.
25	slum/
26	ghetto/
27	or/22-26

Annex 2: PRISMA Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2 -3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	6
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	6-7
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	8
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	8-9
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	8
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	8
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	9
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	9
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	9
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	10-11
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	11-12
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	11-12

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	10-11
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	12
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	13
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	13
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	13-14
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	14-18
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	14-20
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	13-14
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	19-20
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	21-23
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	23
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	23
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	24

BMJ Open

Global Prevalence and Trends in Hypertension and Type 2 Diabetes Mellitus among Slum Residents: A Systematic Review and Meta-analysis

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Manuscript ID	bmjopen-2021-052393.R2
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Primary Subject Heading:	Global health
Secondary Subject Heading:	Global health
Keywords:	Hypertension < CARDIOLOGY, DIABETES & ENDOCRINOLOGY, Public health < INFECTIOUS DISEASES

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4 1 **Global Prevalence and Trends in Hypertension and Type 2**
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7 2 **Diabetes Mellitus among Slum Residents: A Systematic**
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10 3 **Review and Meta-analysis**
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24 ABSTRACT

25 **Objective:** To obtain regional estimates of prevalence of hypertension and Type 2 diabetes in urban
26 slums, and secondly to compare these with those in urban and rural areas.

27
28 **Design:** Systematic review and meta-analysis

29
30 **Eligibility criteria:** Studies that reported hypertension prevalence using the definition of blood
31 pressure $\geq 140/90$ mm Hg and/or prevalence of type 2 diabetes.

32
33 **Information sources:** Ovid MEDLINE, Cochrane CENTRAL and EMBASE from inception to December
34 2020

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36
37 **Risk of bias:** Two authors extracted relevant data and assessed risk of bias independently using the
38 Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline.

39
40 **Synthesis of results:** We used random-effects meta-analyses to pool prevalence estimates. We
41 examined time trends in the prevalence estimates using meta-regression regression models with the
42 prevalence estimates as the outcome variable and the calendar year of the publication as the
43 predictor.

44
45
46 **Results:** A total 62 studies involving 108,110 participants met the inclusion criteria. Prevalence of
47 hypertension and type 2 diabetes in slum populations ranged from 4.2% to 52.5% and 0.9% to 25.0%,
48 respectively. In six studies presenting comparator data, all from the Indian sub-continent, slum
49 residents were 35% more likely to be hypertensive than those living in comparator rural areas and
50 30% less likely to be hypertensive than those from comparator non-slum urban areas.

51
52 **Limitations of evidence:** Of the included studies, only few studies from India compared the slum
53 prevalence estimates with those living on non-slum urban and rural areas, this limits the
54 generalisability of the finding.

55
56 **Interpretation:** The burden of hypertension and type 2 diabetes varied widely between countries and
57 regions and, to some degree, also within countries.

58
59 **Funding:** This research was funded by the National Institute for Health Research (NIHR) (16/136/87)
60 using UK aid from the UK Government to support global health research.

61
62 **PROSPERO registration number:** CRD42017077381

Strengths and limitations of this study

- To reduce the chance of missing relevant studies, no language constraints were applied during the literature search.
- The data was extracted by two independent reviewers, reducing the possibility of bias.
- We analysed trends over time, and between geographical regions.
- The substantial between studies heterogeneity is an important limitation.
- Of the included studies, only few studies from India compared the slum prevalence estimates with those living on non-slum urban and rural areas, this limits the generalisability of the finding.

65

66 INTRODUCTION

67 Noncommunicable diseases (NCDs) are currently the leading cause of death globally, even in
68 low- and middle-income countries (LMICs) the burden of disease is shifting from infectious
69 diseases to NCDs¹. NCDs now account for about 41 million deaths annually, corresponding to
70 nearly 7 in 10 of all deaths worldwide. Every year, 15 million people of ages of 30 to 69 years
71 die from these diseases, more than 85% of which are people living in LMICs. Most of the
72 deaths from NCDs are caused by cardiovascular diseases, followed by cancer and respiratory
73 diseases. NCDs affect people in all age groups, countries and geographic regions. The leading
74 causes of these diseases include increased consumption of unhealthy foods, increased
75 physical inactivity and population ageing²⁻⁴. These factors are mediated through metabolic
76 risk factors for NCDs the most common of which include hypertension and type 2 diabetes²⁻⁴

77
78 Urbanization is a global phenomenon that is occurring at a fast pace in most LMICs^{5 6}. For
79 more than 20 years, urban settlements have been increasing in population size because of
80 fast growth in urban births, significant movement of people from rural areas and sustained
81 integration of the global economy^{5 6}. The United Nations defines slums as urban areas with
82 overcrowding, poor sanitation infrastructure, limited access to safe water, and/or poor
83 structural quality of housing^{7 8}. Slums are now an important component of today's urban
84 settlements and likely continue to be for the foreseeable future^{7 8}.

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3 86 Despite increased global awareness about the presence and persistence of slums, and
4
5
6 87 evidence that their populations are affected by different health problems and needs to other
7
8 88 urban inhabitants, the health of their inhabitants is under researched⁷⁻¹⁰. The health of the
9
10 89 urban poor, people with low socioeconomic status living in urban areas, is usually conflated
11
12
13 90 with that of slum residents. Although there is substantial overlap between these groups, there
14
15 91 are also richer residents within slum neighbourhoods, as well as urban poverty occurring in
16
17
18 92 non-slum urban areas. Health outcomes for these two groups may differ depending on
19
20 93 whether deprivation is at the individual (urban poverty) or neighbourhood level (slum
21
22
23 94 resident) due to neighbourhood effects^{7 8 11 12}. For example, with respect to NCD risk-factors,
24
25 95 those resident in slums, whatever their personal socio-economic status, may be more
26
27
28 96 exposed to a common physical environmental risk factors (for example: air pollution
29
30 97 increasing risk of hypertension), social environmental risk factors (for example: crime rates
31
32
33 98 which may increase stress and drive metabolic risk) or institutional risk-factors (for example:
34
35 99 stigma on the basis of their address reducing access to appropriate medical care). Many
36
37
38 100 existing studies of NCDs risk factors done in urban areas do not disaggregate the population's
39
40 101 health data by slum and non-slums status to allow for the detection of intra-urban health
41
42 102 disparities that are due to neighbourhood effects rather than individual socio-economic
43
44
45 103 status¹³⁻²².

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47 104

48
49 105 Understanding how the global challenges of hypertension, type 2 diabetes and rapid
50
51
52 106 unplanned urbanisation intersect, by investigating whether the up to 1 billion people residing
53
54 107 in slums²³ are succumbing to these important metabolic risk factors for non-communicable
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57 108 disease, will inform priorities for health services and health policy in LMICs. To fill this research
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59 109 gap, we therefore systematically gathered all the publications that relate to the burden of

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110 hypertension among slum residents to (1) assess the contemporary prevalence estimates of
111 hypertension among slum residents (2) compare the prevalence of hypertension and Type 2
112 diabetes in slums with those in two other types of settlement i.e. non-slum urban and rural
113 areas; and (3) assess the proportion of those with hypertension who were aware of their
114 hypertensive status, those on treatment and those with blood pressure under control.

115

116

For peer review only

117 **METHODS**

118 **Protocol and registration**

119 The study background, rationale, and methods were specified in advance and documented in
120 a protocol that was published in the PROSPERO register (CRD42017077381).

122 **Search and information sources:**

123 We searched Ovid MEDLINE, Cochrane CENTRAL and EMBASE from inception to December
124 2020 using the following keywords: slum, shanty town, ghetto, hypertension and type 2
125 diabetes. The search strategy for Medline is shown in **Annex 1**.

127 **Eligibility criteria:**

128 We evaluated each identified study against the following pre-defined selection criteria:

- 129 • *Types of studies:* We included all studies (cross-sectional studies, retrospective or
130 prospective cohort studies) that reported prevalence of hypertension and type 2
131 diabetes mellitus among slum residents as a primary or secondary outcome. No
132 language, publication date or publication status restrictions were imposed.
- 133 • *Types of participants:* adult population (18 years and above) living in slum (as defined
134 by the authors of the original studies included).
- 135 • *Types of Interventions:* Not applicable.
- 136 • *Types of outcomes:* Essential hypertension (also called primary or idiopathic
137 hypertension), defined as persistent (seated) systolic blood pressure (SBP) of 140
138 mmHg or greater or had diastolic blood pressure 90mmHg or greater regardless of age
139 and sex. We excluded studies that included subjects with pregnancy-induced, pre-

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3 140 eclampsia, malignant, portal, pulmonary, renal, intracranial or ocular hypertension.
4
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6 141 We also excluded studies used only self-reported measure, i.e. deducible from the
7
8 142 use of antihypertensive drugs or self-reported physician-diagnosed cases. If data were
9
10
11 143 available, we noted (1) the percentage of those aware of their hypertension status (2)
12
13 144 on any anti-hypertensive treatment, and (3) blood pressure controlled to a target
14
15 145 level. Awareness of hypertension was defined as self-reporting of any prior diagnosis
16
17
18 146 of hypertension by a healthcare professional. Treatment of hypertension was defined
19
20 147 as receiving prescribed antihypertensive medication for management of high BP at
21
22
23 148 some time in the 1 year preceding the survey. Control of hypertension was defined as
24
25 149 the proportion of patients reporting antihypertensive therapy with SBP of less than
26
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28 150 140 mmHg and DBP of less than 90 mmHg.

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30 151
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32 152 Type 2 diabetes was defined based on measured fasting plasma glucose, or oral
33
34
35 153 glucose tolerance test. Type 2 diabetes was diagnosed if the fasting blood glucose was
36
37 154 ≥ 126 mg/dL (≥ 7.0 mmol/L) after an overnight fast for at least 8 hours, or random
38
39
40 155 capillary blood glucose of ≥ 11.1 mmol/L or if the participant was taking treatment
41
42 156 for type 2 diabetes.

43 44 45 157 46 47 158 **Study selection**

48
49 159 Two reviewers (OAU, AAA) independently evaluated the eligibility and methodological quality
50
51
52 160 of the studies obtained from the literature searches. All articles yielded by the database
53
54 161 search were initially screened by their titles and abstracts to obtain studies that met inclusion
55
56
57 162 criteria. In cases of discrepancies, agreement was reached by discussion with a third reviewer.
58
59 163 Two reviewers (OAU, AAA) independently then independently evaluated the full-text articles
60

1
2
3 164 of all identified citations to establish relevance of the article according to the pre-specified
4
5 165 criteria. In cases of discrepancies, agreement was reached by discussion with a third reviewer.
6
7
8 166

10 167 **Data collection process and data items**

12
13 168 OAU extracted data and AAA and OO checked the extracted data. For each study that met the
14
15 169 selection criteria, details extracted included on year of publication, country of origin, study
16
17 170 design, sample size, sampling strategy, study period, setting (rural/urban/slum), socio-
18
19 171 demographic variables, prevalence estimates; etc.
20
21
22
23 172

25 173 **Risk of bias (quality) assessment**

27 174 We used the Risk of Bias Assessment tool for Non-randomized Studies (RoBANS)²⁴ to
28
29 175 assessed the risk of bias of included studies (see Box 1). The risk of bias in a study was graded
30
31 176 as low, high or unclear on the basis of study features including the selection (selection of
32
33 177 participants and confounding variables), performance (measurement of exposure), detection
34
35 178 (blinding of outcome assessments), attrition (incomplete outcome data) and reporting (selective
36
37 179 outcome reporting).
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41 180
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45
46 182 For each included study, we estimated the precision (C) or margin of error, considering the
47
48 183 sample size (SS) and the observed prevalence (p) of hypertension among slum dwellers from
49
50 184 the formula:

$$53 185 \quad SS = Z^2 * p * (1-p) / C^2 \quad (1)$$

54
55 186 where Z was the z-value fixed at 1.96 across studies (corresponding to 95% confidence
56
57 187 interval). The desirable margin of error is 5% (0.05) or lower.
58
59
60 188

189 Synthesis of results

190 For the meta-analysis, we used DerSimonian-Laird random effects model²⁵ due to anticipated
191 variations in study population, health care delivery systems and stage of epidemic transition to
192 pool the hypertension and type 2 diabetes prevalence estimates. We performed leave-one-
193 study-out sensitivity analysis to determine the stability of the results²⁶. This analysis evaluated
194 the influence of individual studies by estimating the pooled prevalence estimates in the absence
195 of each study²⁶. We assessed heterogeneity among studies by inspecting the forest plots and
196 using the chi-squared test for heterogeneity with a 10% level of statistical significance and
197 using the I^2 statistic where we interpret a value of 50% as representing moderate heterogeneity²⁷
198 ²⁸. We assessed the possibility of publication bias by evaluating a funnel plot for asymmetry.
199 Because graphical evaluation can be subjective, we also conducted a Egger's regression
200 asymmetry test as formal statistical tests for publication bias²⁹.

201
202 Following the overall analyses, we performed the following sub-group analyses: place of
203 residence (rural versus urban slum versus non-slum urban); participants risk factors, including
204 socioeconomic position; study design (cross-sectional, cohort); study location (low- and
205 middle income versus high-income countries); and study precision.

206
207 We examined time trends in the prevalence estimates using meta-regression regression models
208 with the prevalence estimates as the outcome variable and the calendar year of the publication
209 as the predictor. In order to measure secular patterns in prevalence figures, we use the annual
210 average percentages change (AAPC). We fitted a regression line to the natural logarithm of
211 the prevalence estimates, i.e., $y = \alpha + \beta x + \epsilon$, where $y = \ln(\text{Prevalence})$, and $x = \text{calendar year}$.
212 The AAPC was calculated as $100 \times (\exp(\beta)-1)$. The 95% confidence interval (CI) of the AAPC
213 was also computed from the regression model. ³⁰ The prevalence calculations indicated an

1
2
3 214 upward trend when both the AAPC estimate and the lower limit of its 95% CI were > 0.
4
5
6 215 However, they indicated a downward trend when both the AAPC and its upper limits were
7
8 216 less than 0. The prevalence estimates were otherwise considered stable over time³⁰. This
9
10 217 systematic review was reported according to the Preferred Reporting Items for Systematic
11
12
13 218 Reviews and Meta-analyses (PRISMA) guideline (**Annex 2**)³¹.

219 **Patient and public involvement**

220 No patient was involved.

221 **Results**

222 **Study selection and characteristics**

223 The literature search yielded 1490 articles. **eFigure 1** shows the study selection flow diagram.
224 After review, 135 articles were selected for critical reading. Seventy-two studies did not meet
225 the inclusion criteria and were excluded (see **eTable 1** for list of excluded studies). The other
226 62 studies involving 108,110 participants met the inclusion criteria and were included in the
227 meta-analysis^{13-22 32-80}. Forty-three studies reported only hypertension prevalence estimates,
228 29 studies reported only type 2 diabetes prevalence estimates and eight reported both. **Table**
229 **1 and eTable 2** presents the characteristics of the included studies. The studies were reported
230 between 1989 and 2019. Studies were reported as full-text journal articles (n=61, **98%**);
231 except for one which was reported as a conference abstract. The number of participants
232 included in the studies ranged from 100 to 15,763. When reported, the mean age of
233 participants ranged from 32 years to 47 years. Most of the studies were carried out in South
234 Asia: India (n=30); Bangladesh (n=8) and Nepal (n=1) and Pakistan (n=1); followed by sub-
235 Saharan Africa: Kenya (n=9) and Nigeria (n=4); Latin America and Caribbean: Brazil (n=5) and
236 Peru (n=1) and East Asia and Pacific: Thailand (n=1). Most of the studies were conducted in

1
2
3 237 the following urban slums: Kibera (n=4), Delhi (n=3), Hyderabad (n=3), Ajegunle (n=2),
4
5
6 238 Chandigarh (n=2), Chennai (n=2), Dhaka (n=2), Haryana (n=2), and Maceio (n=2).

7
8 239

10 240 **Risk of bias of included studies**

11
12
13 241 Summary of risk of bias assessment for each study is shown in **eTable 3**. The risk of bias in
14
15 242 the selection of participants was low in most studies (n=56, 90%), high in three studies (5%)
16
17
18 243 and unclear in three studies (5%). Risk of bias due to confounding variables was low in most
19
20 244 studies (n=39, 63%), high in 22 studies (36%) and unclear in one study. Risk of bias due to
21
22
23 245 measurement of exposure, blinding of outcome assessments and selective outcome
24
25 246 reporting was low in all the 62 studies as we included all studies that used objective measure
26
27
28 247 of hypertension and type 2 diabetes. Risk of bias due to incomplete outcome data was low
29
30 248 in most studies (n=54, 87%), high in 2 studies (3%) and unclear in six studies (10%).

31
32 249

35 250 **Variations in prevalence of hypertension and type 2 diabetes by geographical regions**

36
37 251 Prevalence of hypertension and type 2 diabetes from individuals are shown in **Figure 1 and**
38
39
40 252 **Figure 2** respectively.

41
42 253

43
44
45 254 East Asia and Pacific

46
47 255 *Thailand:* One study from Klong-Toey slum found that 77 of the 976 respondents had type 2
48
49 256 diabetes in 1989 (7.9%, 95% CI 6.3 to 9.8).

50
51
52 257

53
54 258 Latin America and Caribbean

55
56
57 259 *Brazil:* Four studies reported the prevalence of hypertension from three different slums:
58
59 260 Maceio (n=2), Rio de Janeiro (n=1) and Salvador (n=1). Florencio et al. found that almost one

1
2
3 261 third of the Maceio slum dweller were hypertensive in 2004 (29.8%, 95% CI 24.8 to 35.2),
4
5
6 262 while Ferriera et al estimated prevalence of hypertenssion among Maceio slum residents to
7
8 263 be 14.8% (95% 10.4 to 20.2) in 2005. The reported prevalence of hypertension in other slums
9
10
11 264 was 11.3% (95% CI10.2 to 12.4) in Rio de Janerio in 2007 and 20.6% (95% CI 19.5 to 21.7) in
12
13 265 Salvador in 2015. The pooled prevalence ('annualised year average') of hypertension for the
14
15 266 four studies yielded an estimate of 18.4% (95% CI 12.0% to 26.2%). One study from Brazil
16
17 267 found that one in ten had type 2 diabetes in 2017.

18
19
20 268
21
22
23 269 *Peru:* One study from a Lima slum conducted in 2014 found that 21 of the 142 respondents
24
25 270 were hypertensive (14.8%, 95% CI 9.4 to 21.7).

26
27
28 271
29
30 272 South Asia

31
32 273 *Bangladesh:* Four studies from Dhakan slum reported prevalence of hypertension. The
33
34 274 reported prevalence of hypertension ranged from 11.6% (95% CI 9.7 to 13.8) in 2012 to
35
36 275 19.56% (95% CI 17.85 to 21.37) in 2018. Fivestudies from Dhakan slum reported prevalence
37
38 276 of type 2 diabetes. The pooled prevalence ('annualised year average') of hypertension for the
39
40 277 three studies yielded an estimate of 16.1% (95% CI 12.2% to 20.3%). The reported prevalence
41
42 278 of type 2 diabetes in these slums ranged from 8.1% (95% CI 6.8 to 9.6) in 2004 to 18.12% (95%
43
44 279 CI 16.46 to 19.87) in 2019.

45
46
47 280
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49
50
51 281 *India:* Twenty-two studies from India reported prevalence of hypertension from more than
52
53 282 15 difference slums. The reported prevalence varied across and within the slums. For
54
55 283 example, Kar and colleagues estimated the prevalence of hypertension of 27.6% (95% 21.4 to
56
57 284 34.4) among 196 Chandigarh and Haryana slum residents in 2008; however they estimated

1
2
3 285 the prevalence of hypertension of 16.5% (95% CI 15.1 to 18.0) among 2,562 196 Chandigarh
4
5
6 286 and Haryana slum residents in 2010. Prevalence of type diabetes also varied across slums in
7
8 287 India. The pooled prevalence ('annualised year average') of hypertension for the 22 studies
9
10 288 yielded an estimate of 26.8% (95% CI 22.5% to 31.3%). In Delhi, the reported prevalence of
11
12
13 289 type 2 diabetes ranged from 12.7% (95% CI 11.3 to 14.2) in 2007 to 31.5% (95% CI 27.8 to
14
15
16 290 35.4) in 2012. The pooled prevalence ('annualised year average') of type 2 for the 13 studies
17
18 291 yielded an estimate of 12.2% (95% CI 9.2% to 15.6%).
19
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21 292

22
23 293 *Nepal:* One study from a Kathmandu slum conducted in 2013 found that 193 of the 689
24
25 294 respondents were hypertensive (28.0%, 95% CI 24.7 to 31.5).
26
27
28 295

29
30 296 *Pakistan:* One study from a Lahore slum found that 22 of the 695 respondents had type 2
31
32 297 diabetes in 2008 (3.2%, 95% CI 2.0 to 4.8).
33
34
35 298

36
37 299 Sub-Saharan Africa. *Kenya:* Six studies reported the prevalence of hypertension from three
38
39
40 300 different slums: Kibera (n=4) and Viwandani and Korogocho (n=2). The reported prevalence
41
42 301 among Kibera slum residents ranged from 13.0% (95% CI 9.9 to 16.7) in 2013 to 27.8% (95%
43
44 302 CI 25.9 to 29.7) in 2015. van de Vijver found that 640 of the 5,190 respondents from
45
46
47 303 Viwandani and Korogocho slum residents were hypertensive (12.3%, 95% CI 11.5 to 13.3). The
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49
50 304 pooled prevalence ('annualised year average') of hypertension for the six studies yielded an
51
52 305 estimate of 19.2% (95% CI 13.2% to 26.0%). The reported prevalence of type 2 diabetes
53
54 306 ranged from 0.9% (95% CI 0.7 to 1.2) in Nairobi slum in 2016 to 4.4% (95% CI 3.8 to 5.0) in
55
56
57 307 Viwandani and Korogocho in 2013. The pooled prevalence ('annualised year average') of type
58
59 308 2 diabetes for the six studies yielded an estimate of 4.5% (95% CI 2.0% to 7.9%).
60

309

310 *Nigeria*: Four studies from five different slums reported prevalence of hypertension. The
311 reported prevalence varied across and within the slums. Ezeala-Adikaibe found that half of
312 the respondents from Enugu slum were hypertensive in 2016 (52.5%, 95% CI 48.9 to 56.0).
313 While Daniel et al. and Sowemimo et al. found that almost one-third of the Ajegule (38.2%,
314 95% CI 35.1 to 41.3, 2013) and Yemetu (33.1%, 95% CI 30.0 to 36.5, 2015) slum residents were
315 hypertensive. However, Akinwale found that only 12.8% of the respondents from Ijora Oloye,
316 Ajegunle and Makoko were hypertensive in 2013. The pooled prevalence ('annualised year
317 average') of hypertension for the four studies yielded an estimate of 33.2% (95% CI 15.6% to
318 53.5%). Akinwale found that only 3.3% of the respondents from Ijora Oloye, Ajegunle and
319 Makoko had type 2 diabetes in 2013.

320

321 **Secular trends in hypertension and Type 2 diabetes prevalence estimates**

322 Secular trends in hypertension, in 5 countries for which there were data across multiple time
323 points, and type 2 diabetes, in 3 countries in which we had data across multiple time points,
324 among slum residents are shown in **Figures 3 and 4**. We observed a continuous increase in
325 prevalence of hypertension among slum residents in four out of five countries. The increase
326 is more pronounced in India, followed by Kenya and Bangladesh. The prevalence of
327 hypertension increased by 204.6% from 11.7% in 2001 to 35.5% in 2019 in India. The
328 prevalence of hypertension increased by 98.8% from 12.3% in 2013 to 24.5% in 2019 in Kenya.
329 However, the results of the trend analysis showed statistically significant upward trends only
330 in India, such that the prevalence of hypertension increased +6.9% (95% CI +2.0% to +12.0%)
331 per year between 2001 and 2019. There was no statistically significant trend was observed in
332 Brazil using trend analyses (trend =-0.0%, 95% CI -22.7% to +29.2%). We also observed a

1
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3 333 continuous increase in prevalence of type 2 diabetes among slum residents in India and
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5
6 334 Bangladesh. The prevalence of type 2 diabetes increased by 123.6% from 8.1% in 2004 to
7
8 335 18.1% in 2019 in Bangladesh. The prevalence of type 2 diabetes increased by 95.8% from
9
10 336 10.3% in 2001 to 20.2% in 2019 in India. However, the results of the trend analysis showed
11
12
13 337 statistically significant upward trends only in Bangladesh such that the prevalence of type 2
14
15 338 diabetes increased +5.9% (95% CI +1.1% to +10.8%) per year between 2004 and 2019. A non-
16
17
18 339 statistically significant downward trends in type 2 diabetes prevalence was also observed in
19
20 340 Kenya (trend =-11.1%, 95% CI -45.7% to +45.6%).
21
22

341

342

343 **Prevalence of hypertension by different hypertension and type 2 diabetes subgroups**

344 *Study characteristics:* As shown in **Table 1**, the pooled prevalence of hypertension was
345 highest in studies conducted in lower-middle income countries (23.2%, 95% CI 21.5 to 29.0,
346 36 studies) than those from upper-middle income countries (17.9%, 95% CI 12.1 to 24.6, 5
347 studies). The pooled prevalence of hypertension tended to be higher among studies from
348 South Asia (25.3%, 95% CI 21.3 to 29.6, 26 studies) and sub-Saharan Africa (24.4%, 95% CI
349 17.7 to 31.9, 10 studies) than those from Latin America and Caribbean (18.3%, 95% CI 13.4
350 to 23.9, 6 studies). The pooled prevalence tended to higher among imprecise studies (33.4%,
351 95% CI 25.7 to 41.7, 8 studies) than those from precise studies (22.4%, 95% CI 18.9 to 26.1%,
352 35 studies). The pattern was similar for type 2 diabetes prevalence estimates.

353

354 *Socio-demographic characteristics:* As shown in **Table 1**, the pooled prevalence of
355 hypertension was similar among males (22.5%, 95% CI 16.0 to 29.7, 24 studies) and females
356 (23.5%, 95% CI 18.6 to 28.1, 24 studies). The pooled prevalence of hypertension tended to

1
2
3 357 be higher among older adults (49.6%, 95% CI 36.7 to 62.6, 9 studies) than middle-age (35.0%,
4
5
6 358 95% CI 45.6, 9 studies) and young adults (15.7%, 95% CI 10.1 to 22.1, 8 studies). Similarly,
7
8 359 the pooled prevalence of hypertension tended to be higher obese (45.4%, 95% CI 34.5 to
9
10
11 360 56.5, 6 studies) and overweight (32.9%, 95% CI 21.2 to 45.8, 6 studies) participants than
12
13 361 participants with normal (21.9%, 95% CI 11.8 to 34.2, 6 studies) and under-weight (21.8%,
14
15 362 95% CI 11.4 to 34.4, 5 studies). The pooled prevalence of hypertension tended to be higher
16
17
18 363 among those never studied (39.1%, 95% CI 27.5 to 51.3) than those with less than primary
19
20 364 (18.3%, 95% CI 13.9 to 23.1, 4 studies), primary (24.8%, 95% CI 12.0 to 40.4, 6 studies) or
21
22
23 365 secondary/higher education attainment (22.4%, 95% CI 11.2 to 36.2, 7 studies). The pooled
24
25 366 prevalence of hypertension tended to be higher among least poor (29.2%, 95% CI 13.1 to
26
27
28 367 48.5, 5 studies) than those with middle- (25.3%, 10.6 to 43.8, 5 studies) and poorest-income
29
30 368 (20.9%, 95% CI 10.4 to 33.8, 5 studies). The pattern was similar for type 2 diabetes
31
32
33 369 prevalence estimates.

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35 370

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37 371 *Lifestyle factors:* The pooled prevalence of hypertension tended to be higher among
38
39
40 372 smokers (38.0%, 95% CI 19.1 to 59.0, 5 studies) than those not smoking (30.5%, 95% CI 17.6
41
42 373 to 45.2, 5 studies). We found that the pooled prevalence of hypertension tended to be
43
44
45 374 higher those not physically active (30.8%, 95% CI 7.7 to 60.9, 3 studies) than those physical
46
47 375 active (28.8%, 95% CI 11.1 to 50.8); tended to be higher among with no history of alcohol
48
49
50 376 consumption (29.1%, 95% CI 9.3 to 54.3, 3 studies) than those reported alcohol consumption
51
52 377 (26.5%, 95% CI 18.0 to 35.9, 3 studies).

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57 379 *Comparative prevalence by place of residence*

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3 380 Six studies from India included non-slum populations alongside data from the slum
4
5
6 381 population, and reported prevalence of hypertension by place of residence^{36 38 46 48 49 51}. As
7
8 382 shown in **Figure 5**, the pooled prevalence of hypertension was highest among those residing
9
10
11 383 in non-slum urban areas (33.5%, 95% CI 26.0 to 42.0, 6 studies), followed by urban slum
12
13 384 residents (28.8%, 95% CI 23.7 to 34.4%, 6 studies) and was lowest among rural residents
14
15 385 (24.4%, 95% 18.4 to 31.5, 5 studies). Slum residents were 35% more likely to be hypertensive
16
17
18 386 than those living in rural areas (OR = 1.35, 95% 1.29 to 1.42) and 30% less likely to be
19
20 387 hypertensive than those living in other urban areas (OR = 0.70, 95% CI 0.51 to 0.96).
21
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23 388

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25 389 Four studies from India (n=3) and Bangladesh reported prevalence of Type 2 diabetes by place
26
27 390 of residence^{46 51 59 71}. As shown in **Figure 6**, the pooled prevalence of type 2 diabetes was
28
29
30 391 highest among those residing in non-slum urban areas (13.06%, 95% CI 6.53 to 24.43, 4
31
32 392 studies; 2813 participants), followed by urban slum residents (7.88%, 95% CI 3.32 to 17.55; 4
33
34 393 studies; 1811 participants) and was lowest among rural residents (1.64%; 95% CI 0.06 to
35
36
37 394 32.21; 3 studies; 405 participants). Such that prevalence of type 2 diabetes tended to be
38
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40 395 higher among urban slum residents than those living in rural areas (OR = 3.78, 95% 0.75 to
41
42 396 18.93). Urban slum residents were 46% less likely to be diabetic than those from other urban
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44 397 areas (OR = 0.54, 95% CI 0.44 to 0.66).
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46
47 398

49 399 *Treatment cascade*

50
51
52 400 Among those diagnosed with hypertension, only one-third were aware of their hypertensive
53
54 401 status (33.6%, 95% CI 19.1 to 50.0%, 12 studies) (**Table 1**). Among those aware of their high
55
56
57 402 blood pressure, half of them were on antihypertensive medications (51.9%, 95% CI 35.2 to
58
59 403 68.3, 9 studies). Among those on treatment, only one-quarter had good blood pressure
60

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3 404 control (25.2, 95% CI 18.4 to 34.3, 8 studies). Among those diagnosed with type 2 diabetes,
4
5 405 57.4% were aware of their type 2 diabetes status (95% CI 18.2 to 91.8%, 2 studies).
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17 409 **Discussion**

20 410 **Main Findings**

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23 411 This systematic review and meta-analysis summarises available evidence on the global
24
25 412 prevalence of hypertension and type 2 diabetes among slum residents. There were several
26
27 413 key findings: firstly, the burden of hypertension and type 2 diabetes among slum dweller is
28
29 414 high and may be rising globally, with wide variation between countries and regions and, to
30
31 415 some degree, also within countries. Using data from within study comparator populations
32
33 416 when presented, the pooled prevalence of hypertension and Type 2 diabetes was highest
34
35 417 among those residing in non-slum urban areas, followed by slum residents and was lowest
36
37 418 among rural residents. This finding corroborates those of previous reviews that observed
38
39 419 higher prevalence of hypertension among urban residents than those living in rural areas⁸¹
40
41 420 ⁸². This high prevalence may be due to rapid urbanization, lifestyle changes, dietary changes
42
43 421 and increased life expectancy^{83 84} or a combination of these factors^{85 86}. In addition, the
44
45 422 observed difference could be due to other factors including but not limited to lack of access
46
47 423 to testing and care of NCDs risk factors in rural areas and urban areas.
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57 425 The observed gradient in burden of hypertension and Type 2 diabetes among rural, slum and
58
59 426 urban residents is consistent with the effects of urbanization and wealth, as residents
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2
3 427 experience an economic transition when moving from one area to the next⁸⁷⁻⁹². LMICs are
4
5
6 428 now undergoing epidemiological transition, the change from a burden of infectious diseases
7
8 429 to chronic diseases⁹³. In addition, it could be due to increase in awareness in (non-slum) urban
9
10
11 430 areas and recent availability of testing in some places. Recent systematic reviews of dietary
12
13 431 risk-behaviour in Sub-Saharan Africa have found that urban populations tended to consume
14
15 432 more salt than rural populations⁹⁴ and consume fewer portions of vegetables¹². The rapid
16
17
18 433 pace of urbanisation and economic growth is accelerating the rate of this epidemiologic
19
20 434 transition; as such LMICs are at great risk for an explosive growth in the burden of NCDs,
21
22
23 435 including hypertension and type 2 diabetes^{87 88}.

24
25
26 436 We found evidence of significant unmet need for hypertension care among urban slum
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28
29 437 residents. Significant proportion of the urban slum residents were unscreened, undiagnosed,
30
31 438 untreated or uncontrolled. This huge unmet need has been documented in previous studies
32
33
34 439 from low- and middle-income settings⁹⁵⁻¹⁰¹. We also found that control of hypertension
35
36 440 among slum residents was poor, such that only one in four slum residents on treatment, had
37
38
39 441 their blood pressure controlled. The poor control of BP noted in our study, despite the fact
40
41 442 the one half of those that were unaware of high blood pressure being on antihypertensive
42
43
44 443 medications, needs further exploration. One possible explanation is availability and
45
46 444 affordability of the medications and there could be minimal additional contact with a health
47
48
49 445 professional¹⁵. It has been documented that the control of BP was related to the frequency
50
51 446 of follow-up visits⁹⁶. Another possible explanation could be low adherence to prescribed
52
53
54 447 medications, as they may not be able to afford the medications.

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57 448 As expected, we found that the burden of hypertension increased with the participants' age,
58
59 449 which may be attributed to age-related structural changes in blood vessels which potentially
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3 450 cause narrowing of the vascular lumen, and consequently increasing blood pressure, as have
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5
6 451 been reported in previous studies^{102 103}. The association between combined
7
8 452 overweight/obesity and hypertension shown in our results exemplify the role of excess body
9
10 453 weight in hypertension prevalence, which has been long recognized and consistent across
11
12
13 454 numerous observational and trial data¹⁰⁴⁻¹⁰⁶. We found evidence of significantly high
14
15 455 prevalence of hypertension among smokers compared to the non-smokers. Direct relation of
16
17 456 chronic tobacco consumption with hypertension however is not yet well established^{107 108}
18
19
20 457 although tobacco consumption has been shown to cause an acute elevation of BP¹⁰⁹.
21
22
23 458

25 459 **Study Limitations and Strengths**

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27
28
29 460 To the best of our knowledge, this paper is the first systematic reviews that summarises data
30
31 461 about prevalence of hypertension and type 2 diabetes among slum residents. Strengths of
32
33 462 this study include the use of a predefined and published protocol, a comprehensive search
34
35 463 strategy, and involvement of two independent reviewers in the review process. Nevertheless,
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37 464 the findings of this study should be interpreted with caution. Prevalence estimates from
38
39 465 different regions and published over the course of 11 years were pooled in this meta-analysis,
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41 466 and as expected, high heterogeneity between studies was found in the meta-analyses.
42
43
44 467 Nonetheless, as affirmed by previous evidence, meta-analyses are the preferred options to
45
46 468 narrative syntheses for interpreting the results in a review, even in spite of the presence of a
47
48 469 considerable amount of heterogeneity¹¹⁰. Heterogeneity appeared to be the norm rather
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50
51 470 than exception in published meta-analyses of observational studies¹¹¹.
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57 471 In conclusion, the burden of hypertension and type 2 diabetes varied widely between
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59 472 countries and regions and, to some degree, also within countries. In addition, many
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3 473 hypertensive individuals are not aware of their condition, not on treatment and control of
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5
6 474 hypertension is poor. The burden of hypertension and type 2 diabetes was higher among
7
8 475 urban residents than their counterparts living in urban slums and rural areas. There is a need
9
10
11 476 for public health strategies to improve the awareness, control and overall management of
12
13 477 hypertension and type 2 diabetes in urban areas.

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24
25
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27
28 483 Department of Health and Social Care.

33 485 **Ethics approval and consent to participate**

34
35 486 Not applicable.

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40 488 **Consent for publication:** Not applicable.

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45 490 **Data sharing statement:** All data relevant to the study are included in the article or
46
47
48 491 uploaded as supplementary information

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51 492

52 493 **Competing interests**

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54 494 The authors declare that they have no competing interests.

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58 496 **Authors' contribution**

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3 497 OAU, AAA, OO and RL conceived the study. OAU, AAA and OO collected and analysed initial
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6 498 data. OAU, AAA, OO, JS, PG and RL participated contributed in refining the data analysis.
7
8 499 OAU wrote the first manuscript. OAU, AAA, OO, JS, PG and RL contributed to further
9
10 500 analysis, interpreting and shaping of the argument of the manuscript and participated in
11
12
13 501 writing the final draft of the manuscript. All the authors read and approved the final
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15 502 manuscript.
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865 **TABLES**866 **Table 1: Pooled prevalence by difference subgroup**

Subgroup		Hypertension			Type 2 Diabetes		
		n	%	I ²	n	%	I ²
Sample size	Smaller studies (<1000)	27	25.9 (21.6 to 30.6)	97.1	15	11.0 (8.2 to 14.2)	93.9
Sample size	Larger studies (1000+)	17	21.4 (17.2 to 26.1)	99.6	15	7.8 (5.1 to 11.1)	99.4
Study precision	Imprecise studies	8	33.4 (25.7 to 41.7)	91.2	1	25.2 (17.3 to 34.2)	-
Study precision	Precise studies	36	22.3 (18.9 to 25.9)	99.2	29	8.9 (6.9 to 11.2)	98.9
Publication year	2001 to 2005	5	15.6 (9.0 to 23.8)	94.7	4	8.2 (6.7 to 9.8)	53.6
Publication year	2006 to 2010	6	28.6 (18.9 to 39.4)	98.7	4	6.3 (3.3 to 10.3)	90.6
Publication year	2011 to 2020	33	24.7 (21.0 to 28.6)	99.2	22	10.2 (7.4 to 13.4)	99.2
Region	South Asia	27	25.1 (20.7 to 29.8)	98.9	19	11.9 (9.1 to 15.1)	97.6
Region	Sub-Saharan Africa	10	24.4 (17.7 to 31.9)	99.2	8	4.5 (2.4 to 7.2)	98.8
Region	Latin America and Caribbean	6	18.3 (13.4 to 23.9)	97.1	1	10.2 (8.1 to 12.3)	-
Region	Middle East and North Africa	1	31.2 (28.4 to 34.1)	-	1	8.8 (7.1 to 10.6)	-
Region	East Asia and Pacific	-	-	-	1	7.9 (6.3 to 9.7)	-
Income category	Lower Middle Income	36	25.2 (21.2 to 29.4)	99.1	28	9.3 (7.0 to 11.92)	98.9
Income category	Upper Middle Income	5	17.9 (12.1 to 24.6)	97.6	2	9.0 (6.9 to 11.3)	62
Income category	Low Income	2	24.0 (16.9 to 32.0)	92.2			
Sex	Male	24	22.5 (16.0 to 29.7)	99.2	11	8.1 (5.1 to 11.6)	97.6
Sex	Female	24	23.2 (18.6 to 28.1)	98.7	11	7.3 (4.6 to 10.6)	97.5
Age	Young adult	8	15.7 (10.1 to 22.1)	97.8	2	2.1 (0.3 to 5.4)	96.7
Age	Middle-age adult	9	35.0 (25.0 to 45.6)	99.2	2	5.6 (4.5 to 6.8)	0
Age	Older adult	9	49.6 (36.7 to 62.6)	98.3	2	9.1 (7.0 to 11.4)	0
Body mass index	Under weight	5	21.8 (11.4 to 34.4)	87.3			
Body mass index	Normal weight	6	21.9 (11.8 to 34.2)	98.6	2	2.3 (1.8 to 2.8)	0
Body mass index	Overweight	6	32.9 (21.2 to 45.8)	97.4	2	4.2 (1.2 to 8.8)	50
Body mass index	Obese	6	45.4 (34.5 to 56.6)	93.3	2	6.4 (4.0 to 9.3)	0
Education Status	Never studied	7	39.1 (27.5 to 51.3)	98	1	5.1 (3.0 to 7.8)	-
Education Status	Less than primary	4	18.3 (13.9 to 23.1)	87.1	1	4.6 (3.4 to 6.1)	-
Education Status	Primary	6	24.8 (12.0 to 40.4)	99.4	1	4.4 (3.6 to 5.2)	-
Education Status	Secondary or higher	7	22.4 (11.1 to 36.2)	99.3	1	4.1 (3.2 to 5.2)	-
Income	Poorest	5	20.9 (10.4 to 33.8)	98.9			
Income	Middle	5	25.3 (10.6 to 43.8)	99.5			
Income	Least poor	5	29.2 (13.1 to 48.5)	98.3			
Smoking status	Yes	5	38.0 (19.1 to 59.0)	99.1			
Smoking status	No	5	30.5 (17.6 to 45.2)	99.6			
Alcohol consumption	Yes	3	26.5 (18.0 to 35.9)	83.4			
Alcohol consumption	No	3	29.1 (9.3 to 54.3)	99.7			
Physically active	Yes	3	28.8 (11.1 to 50.8)	99.6			
Physically active	No	3	30.8 (7.7 to 60.9)	98.4			
Treatment cascade	Aware of HBP	12	33.6 (19.1 to 50.0)	99.7			
Treatment cascade	On treatment	9	51.9 (35.2 to 68.3)	98.6			
Treatment cascade	BP controlled	8	25.9 (18.4 to 34.3)	87.8			

867 * World Bank Country Income Groups, 2018

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3 868 Participants were divided into age groups that, broadly defined, covered young adulthood (18 to 35 years),
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5 869 middle age (36 to 55 years), and older adulthood (56 years and older).
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7 870 Underweight - BMI under 18.5 kg/m²
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9 871 Normal weight - BMI greater than or equal to 18.5 to 24.9 kg/m²
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11 872 Overweight – BMI greater than or equal to 25 to 29.9 kg/m²
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13 873 Obesity – BMI greater than or equal to 30 kg/m²
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17 875 Physical activity as defined by the authors
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19 876 Alcohol consumption as defined by authors
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21 877 Smoking status as defined by authors
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883 **FIGURE LEGENDS**

884 **Figure 1: Hypertension prevalence estimates among slum residents and 95% confidence**
885 **intervals from individual studies and pooled data**

886
887 **Figure 2: Type 2 diabetes mellitus prevalence estimates among slum residents and 95%**
888 **confidence intervals from individual studies and pooled data**

889
890 **Figure 3: Secular trends in hypertension prevalence estimates among slum residents across**
891 **different regions**

892
893 **Figure 4: Secular trends in Type 2 diabetes mellitus prevalence estimates among slum**
894 **residents across different regions**

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896 **Figure 5: Hypertension prevalence estimates by place of residence: urban versus rural**
897 **versus slum**

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899 **Figure 6: Type 2 diabetes mellitus prevalence estimates by place of residence: urban versus**
900 **rural versus slum**

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4 903 **ONLINE ONLY SUPPLEMENTS**

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6 904 **eFigure 1: Study selection and inclusion flow chart**

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11 906 **Box 1: Study selection and inclusion flow chart**

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26 912 **eTable 3: Risk of bias of included studies**

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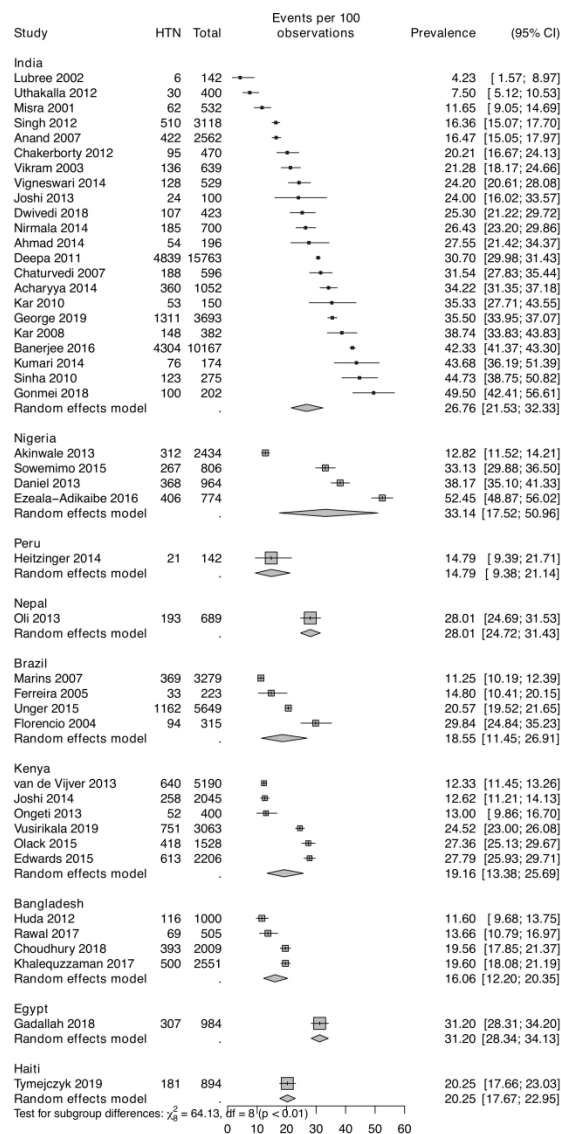


Figure 1

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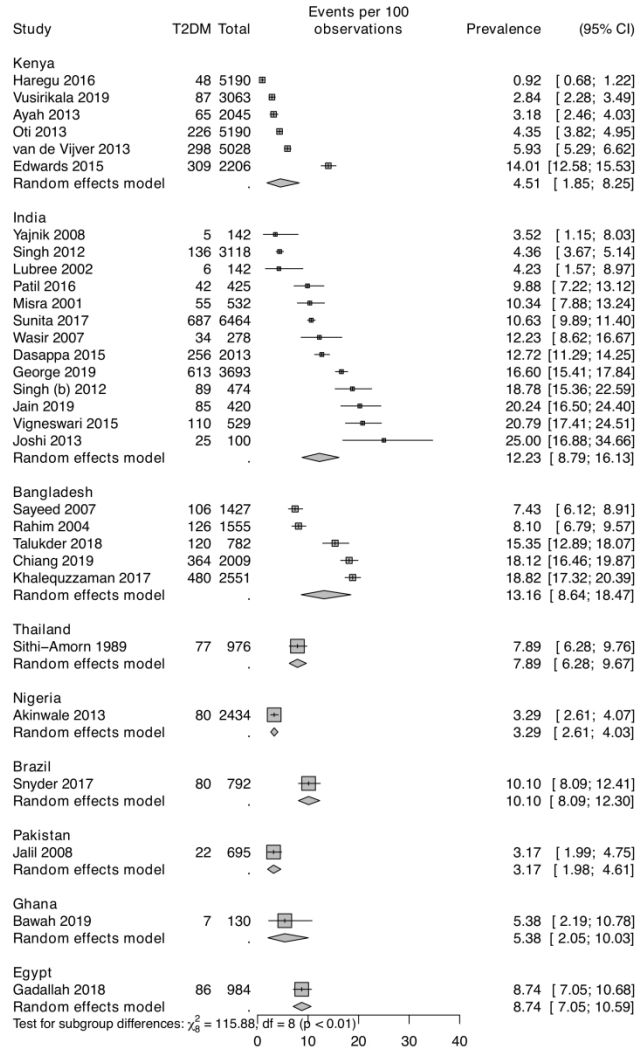


Figure 2

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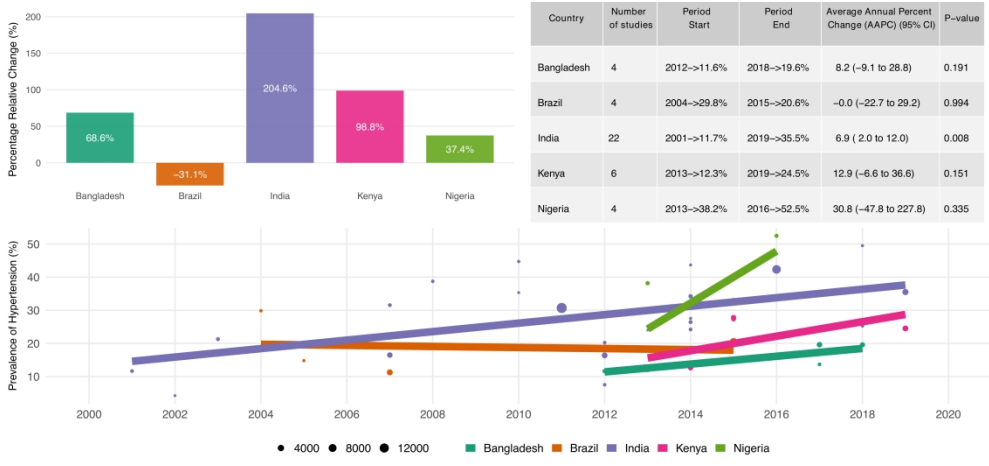


Figure 3

496x229mm (300 x 300 DPI)



Figure 4

602x263mm (300 x 300 DPI)

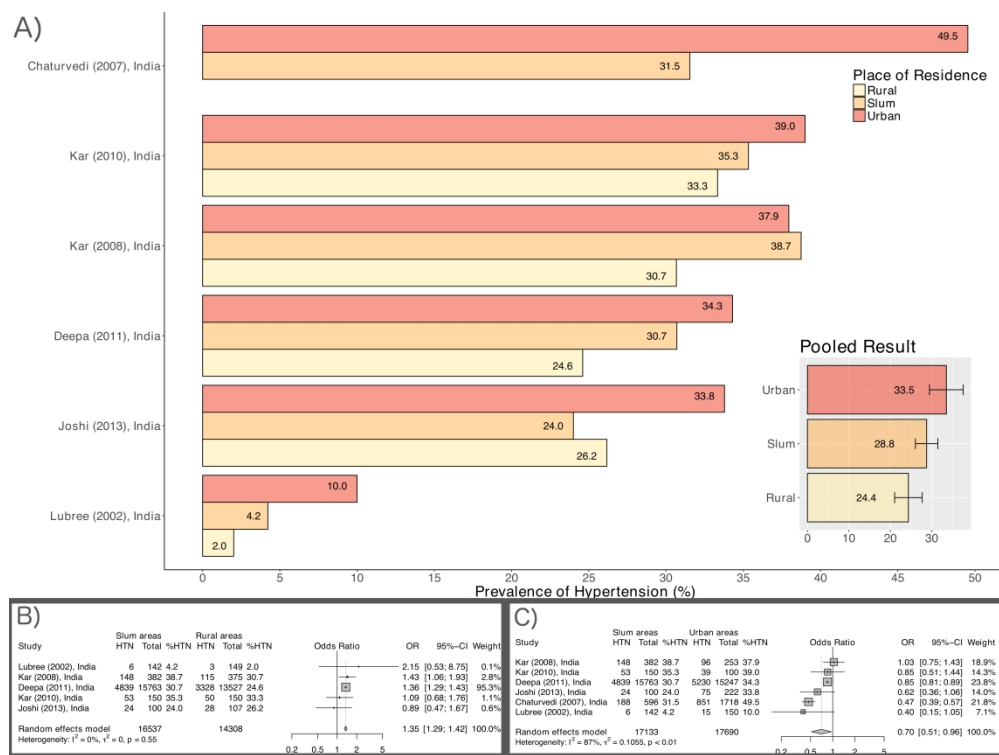


Figure 5

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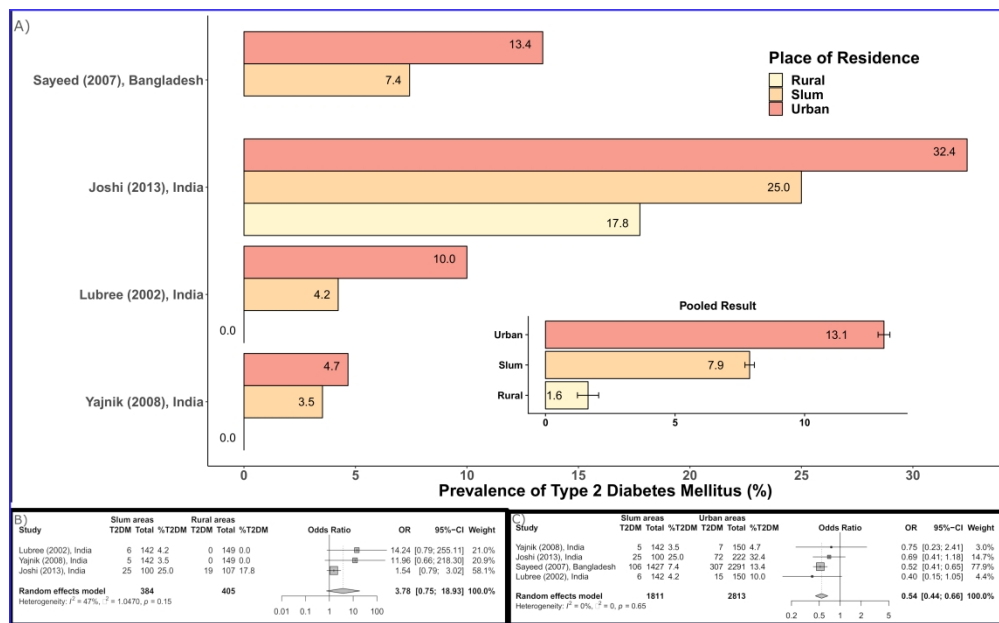


Figure 6

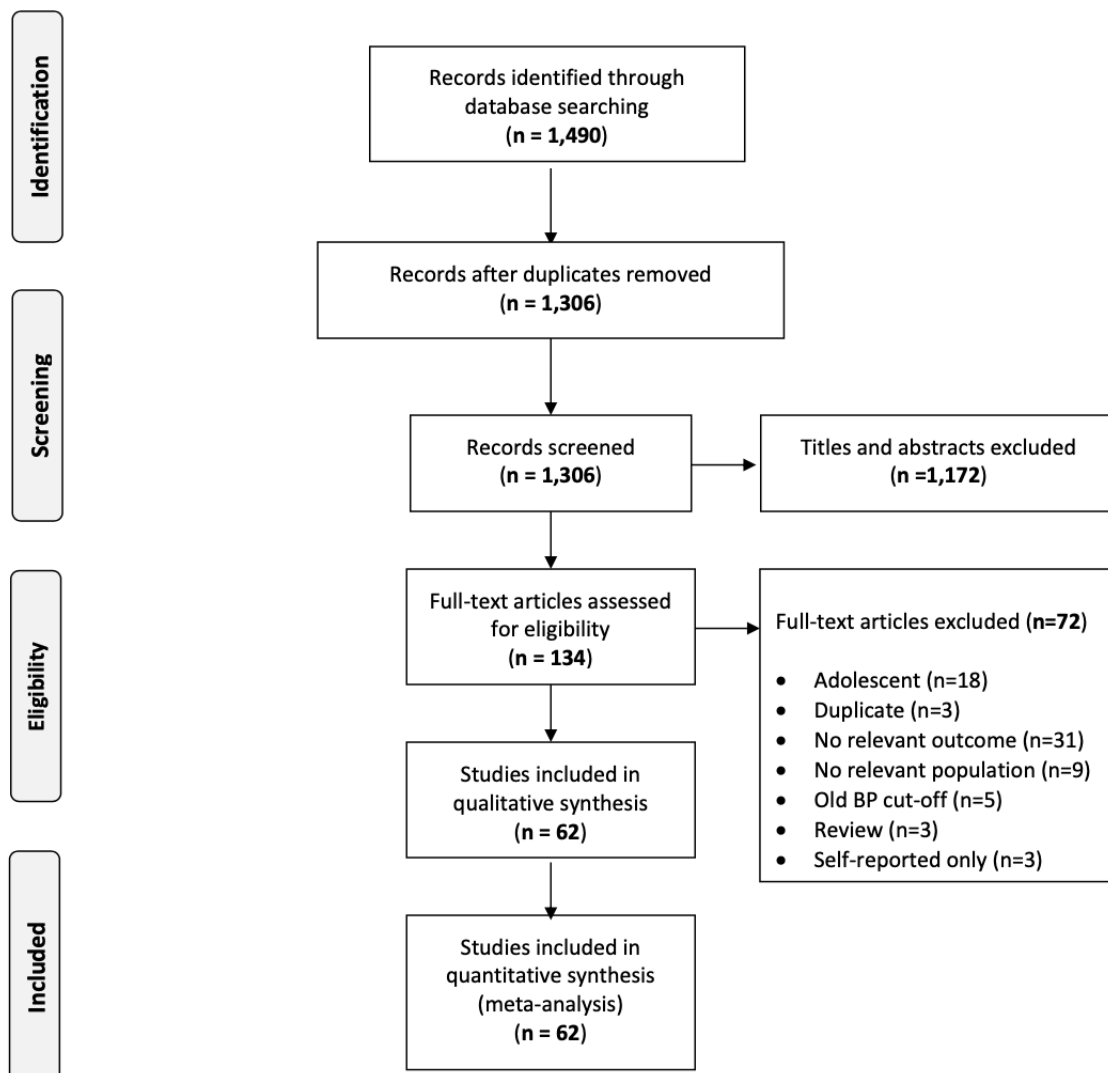
425x261mm (300 x 300 DPI)

Supplementary Digital Content

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eFigure 1: Study selection and inclusion flow chart



Box 1: Study selection and inclusion flow chart

Domain	Details	Risk of bias
Selection of participants	Selection bias caused by the inadequate selection of participants	- Low - High - Unclear
Confounding variables	Selection bias caused by the inadequate confirmation and consideration of confounding variable	- Low - High - Unclear
Measurement of exposure	Performance bias caused by the inadequate measurement of exposure	- Low - High - Unclear
Blinding of outcome assessments	Detection bias caused by the inadequate blinding of outcome assessments	- Low - High - Unclear
Incomplete outcome data	Attrition bias caused by the inadequate handling of incomplete outcome data	- Low - High - Unclear
Selective outcome reporting	Reporting bias caused by the selective reporting of outcomes	- Low - High - Unclear

eTable 1: List of Excluded Studies

s/n	Study	Reason
1	Maiti 2016 ¹	Adolescent
2	Khopkar 2015 ²	Adolescent
3	Paul 2013 ³	Adolescent
4	Kamath 2012 ⁴	Adolescent
5	Simsek 2012 ⁵	Adolescent
6	Saha 2011 ⁶	Adolescent
7	Oria 2010 ⁷	Adolescent
8	Saha 2008 ⁸	Adolescent
9	Saha 2008 ⁹	Adolescent
10	Sesso 2004 ¹⁰	Adolescent
11	Fernandes 2003 ¹¹	Adolescent
12	Zeelie 2010 ¹²	Adolescent
13	Soudrassanane 2008 ¹³	Adolescent
14	Werner 2015 ¹⁴	Duplicate
15	van de Vijver 2016 ¹⁵	Duplicate
16	Haregu 2016 ¹⁶	Duplicate
17	Ezenwaka 1997 ¹⁷	Old BP cut-off
18	Suriyawongpaisal 1993 ¹⁸	Old BP cut-off
19	Suriyawongpaisal 1991 ¹⁹	Old BP cut-off
20	Sitthi-Amornn 1989 ²⁰	Old BP cut-off
21	Bunnag 1990 ²¹	Old BP cut-off
22	E. Sharmin Trisha 2016 ²²	No relevant outcome
23	Bhandari 2015 ²³	No relevant outcome
24	Oti 2014 ²⁴	No relevant outcome
25	Hiremth 2014 ²⁵	No relevant outcome
26	Joshi 2013 ²⁶	No relevant outcome
27	van de Vijver 2013 ²⁷	No relevant outcome
28	Itrat 2011 ²⁸	No relevant outcome
29	Ahmed 2011 ²⁹	No relevant outcome
30	Haregu 2015 ³⁰	No relevant outcome
31	van de Vijver 2015 ³¹	No relevant outcome
32	Kohli 2016 ³²	No relevant outcome
33	Mudgapalli 2016 ³³	No relevant population
34	Natarajan 2014 ³⁴	No relevant population
35	Kumaramanickavel 2014 ³⁵	No relevant population
36	Kumaramanickavel 2015 ³⁶	No relevant population
37	Hulzebosch 2015 ³⁷	No relevant population
38	Madhu 2016 ³⁸	No relevant population
39	Mugure 2014 ³⁹	No relevant population
40	Mukhopadhyay 2012 ⁴⁰	No relevant population
41	Khan 2010 ⁴¹	No relevant population
42	Etyang 2013 ⁴²	Review
43	Dhar 2014 ⁴³	Review
44	Bhargava 1991 ⁴⁴	Review
46	Kien 2015 ⁴⁵	Self-reported only
47	Sur 2007 ⁴⁶	Self-reported only
48	Thakur 2013 ⁴⁷	Self-reported only
49	Ahmedani 2019 ⁴⁸	No relevant outcome
50	Ashe 2019 ⁴⁹	No relevant outcome
51	Asiki 2018 ⁵⁰	No relevant outcome
52	Bagdey 2019 ⁵¹	No relevant outcome
53	Cope 2020 ⁵²	No relevant outcome
54	De Silva 2018 ⁵³	No relevant outcome
55	Kapwata 2018 ⁵⁴	No relevant outcome
56	Kawazoe 2018 ⁵⁵	No relevant outcome

57	Khanam 2019 ⁵⁶	No relevant outcome
58	Kolak 2018 ⁵⁷	No relevant outcome
59	Korn 2018 ⁵⁸	No relevant outcome
60	Kotian 2019 ⁵⁹	No relevant outcome
61	Kumar 2018 ⁶⁰	No relevant outcome
62	Ma 2018 ⁶¹	No relevant outcome
63	Maharana 2019 ⁶²	No relevant outcome
64	Nagarkar 2018 ⁶³	No relevant outcome
65	Narendran 2018 ⁶⁴	No relevant outcome
66	Rajapakshe 2018 ⁶⁵	No relevant outcome
67	Sarkar 2019 ⁶⁶	No relevant outcome
68	Scazufca 2019 ⁶⁷	No relevant outcome
69	Wang 2018 ⁶⁸	No relevant outcome
70	Wekasah 2020 ⁶⁹	No relevant outcome
71	Wilson 2020 ⁷⁰	No relevant outcome
72	Yadav 2018 ⁷¹	No relevant outcome
73	Zhang 2019 ⁷²	No relevant outcome

List of excluded studies

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eTable 2: Characteristics of included studies

Study	Country	Slum	Sample size	Age group	% female
Acharyya (2014)	India	North-Parganas	1052	25-64	49.8
Ahmad (2014)	India	Meerut	196	>60	50
Akinwale (2013)	Nigeria	Ijora Oloye, Ajegunle & Makoko	2434		
Anand (2007)	India	Faridabad	2562	15+	50.9
Ayah (2013)	Kenya		2061	18-90	49.1
Banerjee (2016)	India	Kolkata	10167	>20 years	60
Chakerborty (2012)	India	Kolkata	470	18-60	0
Chaturvedi (2007)	India	Delhi	596	>20	
Daniel (2013)	Nigeria	Ajegunle	964	20-81	65.8
Dasappa (2015)	India	Bangalore	2013	35+	50.8
Deepa (2011)	India	Ballabgarh, Delhi, Chennai, Trivandrum, Dibrugarh and Nagpur	15763	15-64	
Edwards (2015)	Kenya	Kibera			
Ezeala-Adikaibe (2016)	Nigeria	Enugu	774	≥ 20	64.7
Ferreira (2005)	Brazil	Maccio	223	18-65	100
Florencio (2004)	Brazil	Maccio	416	18-60	57
Haregu (2016)	Kenya	Nairobi	5190	18+	46.2
Heitzinger (2014)	Peru	Lima	142	18-81	69.7
Huda (2012)	Bangladesh	Mirpur, Dhaka	1000	15-65	33.4
Jalil (2008)	Pakistan	Lahore	695		43.6
Joshi (2013)	India	Rourkela & Bhubaneswar	100	>18	69
Joshi (2014)	Kenya	Kibera	2045	18-90	49.1
Kar (2008)	India	Chandigarh & Haryana	1010	>30	58.9
Kar (2010)	India	Chandigarh & Haryana	150	>30	62
Khalequzzaman (2017)	Bangladesh	Dhakar	2551	18+	46.7
Kumari (2014)	India	Hyderabad	250		78
Lubree (2002)	India	Pune	150	30-50	100
Marins (2007)	Brazil	Rio-de-Janeiro	3279	>20	56.9
Misra (2001)	India	Gautam-Nagar, Delhi	532		68
Nirmala (2014)	India	Hyderabad, Telangana	700	>20	50.8
Olack (2015)	Kenya	Kibera	1528	35-64	58.1
Oli (2013)	Nepal	Kathmandu	689	15-64	58.9
Ongeti (2013)	Kenya	Kibera	400	14-75	70.3
Oti (2013)	Kenya	Viwandani & Korogocho		18+	46
Patil (2016)	India	Pune, Maharashtra	425	20+	
Rahim (2004)	Bangladesh	Dhakar	1555	20+	52.99
Rawal (2017)	Bangladesh	Dhaka	507		50
Sayeed (2007)	Bangladesh	Dhakar			59.2
Singh (b) (2012)	India	Delhi	474	60+	48
Singh (2012)	India	Patna	3118	>30	56.5
Sinha (2010)	India	Gokulpuri	275	18-40	100
Sithi-Amorn (1989)	Thailand	Klong-Toey	976		54.7

Snyder (2017)	Brazil		792		64.5
Sowemimo (2015)	Nigeria	Yemetu, Ibadan	806	18-90	
Sunita (2017)	India	Mumbai	6464	>40	
Unger (2015)	Brazil	Salvador	5649	>18	58.3
Uthakalla (2012)	India	Hyderabad		20-60	56
Vigneswari (2014)	India	Chennai	529	18+	77.3
Vigneswari (2015)	India		529	18+	77.3
Vikram (2003)	India	New-Delhi	639		73.4
Wasir (2007)	India	Delhi	278		
Yajnik (2008)	India		142	30-50	0
van de Vijver (2013)	Kenya	Viwandani & Korogocho	5190	>18	46.2
Bawah (2019)	Ghana	Accra	2009		
Chiang (2019)	Bangladesh	Dhaka	423		
Choudhury (2018)	Bangladesh	Dhaka	984	43.4	73
Dwivedi (2018)	India	Bangalore			
Gadallah (2018)	Egypt	West Delhi			
George (2019)	India	Bangalore		57.6	
Gonmei (2018)	India	Delhi			
Jain (2019)	India	Delhi	984	43.4	73
Tymejczyk (2019)	Haiti	Gurugram	420		
Vusirikala (2019)	Kenya	Nairobi		57.6	

eTable 3: Risk of bias of included studies

Study	Selection of participants	Confounding variables	Measurement of exposure	Blinding of outcome assessments	Incomplete outcome data	Selective outcome reporting
Acharyya (2014)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Ahmad (2014)	Low risk	High risk	Low risk	Low risk	Unclear risk	Low risk
Akinwale (2013)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Anand (2007)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Ayah (2013)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Banerjee (2016)	Low risk	Low risk	Low risk	Low risk	Unclear risk	Low risk
Chakerborty (2012)	High risk	High risk	Low risk	Low risk	Low risk	Low risk
Chaturvedi (2007)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Daniel (2013)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Dasappa (2015)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Deepa (2011)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Edwards (2015)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Ezeala-Adikaibe (2016)	High risk	Low risk	Low risk	Low risk	High risk	Low risk
Ferreira (2005)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Florencio (2004)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Haregu (2016)	Unclear risk	Low risk	Low risk	Low risk	Unclear risk	Low risk
Heitzinger (2014)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Huda (2012)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Jalil (2008)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Joshi (2013)	High risk	Low risk	Low risk	Low risk	Low risk	Low risk
Joshi (2014)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Kar (2008)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Kar (2010)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Khalequzzaman (2017)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Kumari (2014)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Lubree (2002)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Marins (2007)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Misra (2001)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Nirmala (2014)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Olack (2015)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Oli (2013)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Ongeti (2013)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Oti (2013)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Patil (2016)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Rahim (2004)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Rawal (2017)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Sayeed (2007)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Singh (b) (2012)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Singh (2012)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk

Study	Selection of participants	Confounding variables	Measurement of exposure	Blinding of outcome assessments	Incomplete outcome data	Selective outcome reporting
Sinha (2010)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Sithi-Amorn (1989)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Snyder (2017)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Sowemimo (2015)	Low risk	Low risk	Low risk	Low risk	Unclear risk	Low risk
Sunita (2017)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Unger (2015)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Uthakalla (2012)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Vigneswari (2014)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Vigneswari (2015)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Vikram (2003)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Wasir (2007)	Low risk	High risk	Low risk	Low risk	High risk	Low risk
Yajnik (2008)	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
van de Vijver (2013)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Bawah (2019)	Unclear risk	Low risk	Low risk	Low risk	Unclear risk	Low risk
Chiang (2019)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Choudhury (2018)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Dwivedi (2018)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Gadallah (2018)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
George (2019)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Gonmei (2018)	Unclear risk	Unclear risk	Low risk	Low risk	Unclear risk	Low risk
Jain (2019)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Tymiecznyk (2019)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Vusirikala (2019)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk

Annex 1: MEDLINE Search Strategy

1	exp hypertension/
2	hypertens\$.mp.
3	exp blood pressure/
4	(blood pressure or bloodpressure).mp.
5	(essential adj3 hypertension).ti,ab.
6	(isolat* adj3 hypertension).ti,ab.
7	(elevat* adj3 blood adj pressur*).ti,ab.
8	(high adj3 blood adj pressur*).ti,ab.
9	(increase* adj3 blood pressur*).ti,ab.
10	((systolic or diastolic or arterial) adj3 pressur*).ti,ab.
11	essential hypertension.mp.
12	isolated hypertension.mp.
13	elevated blood pressure.mp.
14	high blood pressure.mp.
15	increase blood pressure.mp.
16	diastolic pressure.mp.
17	pre-hypertension.mp.
18	pre-hypertensive.mp.
19	prehypertension.mp.
20	prehypertensive.mp.
21	arterial pressure.mp.
22	cardiovascular diseases/
23	exp coronary disease/
24	cardiovascular risk factor\$.tw.
25	(cardiovascular adj3 disease\$).tw.
26	(Coronary adj3 disease\$).tw.
27	heart disease\$.tw.
28	coronary risk factor\$.tw.
29	or/1-28
1	exp Diabetes Mellitus, Type 2/
2	exp DIABETES MELLITUS/
3	T2DM.ti,ab.
4	(Type* adj3 ("2" or "II" or two*) adj3 (diabete* or diabetic*)).tw.
5	((Maturit* or adult* or slow*) adj3 onset* adj3 (diabete* or diabetic*)).tw.
6	((Ketosis-resistant* or stable*) adj3 (diabete* or diabetic*)).tw.
7	((Non-insulin* or Non insulin* or Noninsulin*) adj3 depend* adj3 (diabete* or diabetic*)).tw.
8	IDDM.ti,ab.
9	diabet\$.ti.
10	PREDIABETIC STATE/
11	prediabet\$.ti,ab.
12	impaired glucose tolerance.ti,ab.
13	IGT.ti,ab.
14	Impaired fasting glucose.ti,ab.
15	IFG.ti,ab.
16	Impaired glucose regulation.ti,ab. 1
17	IGR.ti,ab.
18	GLUCOSE INTOLERANCE/
19	(diabet* or glucose or hyperglycaemia or hyperglycaemia or postprandial or post-prandial or insulin or hypoglycemia or hypoglycaemia or IGT or OGTT or CGMS).tw.
20	(subclinical diabetes" or "subclinical diabetic" or "sub-clinical diabetes" or "sub-clinical diabetic").tw.
21	or/1-20
22	(baladi or bandas de miseria or barraca or barrio marginal or barrio or bidonville or brarek or bustee or chalis or chereka bete or dagatan or estero or favela or galoos or gecekondou or hrushabi).mp.
23	(ishash or karyan or katras or looban or loteamento or medina achouaia or morro or mudun safi or musseque or solares or tanake or taudis or township or tugurio or udukku or umjondolo or watta or zopadpattis).mp.
24	(slum or slums or ghetto or ghettos or informal settlement\$ or shantytown\$ or shanty town\$).mp.
25	slum/
26	ghetto/
27	or/22-26

Annex 2: PRISMA Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2 -3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	6
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	6-7
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	8
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	8-9
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	8
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	8
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	9
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	9
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	9
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	10-11
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	11-12
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	11-12

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	10-11
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	12
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	13
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	13
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	13-14
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	14-18
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	14-20
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	13-14
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	19-20
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	21-23
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	23
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	23
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	24