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Global prevalence and trends in hypertension and type 2 diabetes mellitus among slum residents: a systematic review and meta-analysis

Olalekan Abdulrahman Uthman ,[1] Abimbola Ayorinde ,[2] Oyinlola Oyebode,[1] Jo Sartori,[3] Paramjit Gill,[2] R J Lilford[3]

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[1]Warwick Centre for Global Health, Warwick Medical School, University of Warwick, Coventry, UK
[2]Division of Health Sciences, Warwick Medical School, University of Warwick, Coventry, UK
[3]Institute of Applied Health Research, University of Birmingham, Birmingham, UK

Correspondence to
Professor Olalekan Abdulrahman Uthman;
olalekan.uthman@warwick.ac.uk

ABSTRACT

Objective First, to obtain regional estimates of prevalence of hypertension and type 2 diabetes in urban slums; and second, to compare these with those in urban and rural areas.

Design Systematic review and meta-analysis.

Eligibility criteria Studies that reported hypertension prevalence using the definition of blood pressure ≥140/90 mm Hg and/or prevalence of type 2 diabetes.

Information sources Ovid MEDLINE, Cochrane CENTRAL and EMBASE from inception to December 2020.

Risk of bias Two authors extracted relevant data and assessed risk of bias independently using the Strengthening the Reporting of Observational Studies in Epidemiology guideline.

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

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

Limitations of evidence Of the included studies, only few studies from India compared the slum prevalence estimates with those living in non-slum urban and rural areas; this limits the generalisability of the finding.

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

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 were 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 in non-slum urban and rural areas; this limits the generalisability of the finding.

INTRODUCTION

Non-communicable diseases (NCDs) are currently the leading cause of death globally; even in low/middle-income countries (LMICs), the burden of disease is shifting from infectious diseases to NCDs.[1] NCDs now account for about 41 million deaths annually, corresponding to nearly 7 in 10 of all deaths worldwide. Every year, 15 million people of ages 30–69 years die from these diseases, more than 85% of which are people living in LMICs. Most of the deaths from NCDs are caused by cardiovascular diseases, followed by cancer and respiratory diseases. NCDs affect people in all age groups, countries and geographical regions. The leading causes of these diseases include increased consumption of unhealthy foods, increased physical inactivity and population ageing.[2–4] These factors are mediated through metabolic risk factors for NCDs, the most common of which include hypertension and type 2 diabetes.[2–4]

Urbanisation is a global phenomenon that is occurring at a fast pace in most LMICs.[5 6] For more than 20 years, urban settlements have been increasing in population size because of fast growth in urban births, significant movement of people from rural areas and sustained integration of the global economy.[5 6] The United Nations defines slums as urban areas with overcrowding,

poor sanitation infrastructure, limited access to safe water, and/or poor structural quality of housing.[7 8] Slums are now an important component of today's urban settlements and likely continue to be for the foreseeable future.[7 8]

Despite increased global awareness about the presence and persistence of slums, and evidence that their populations are affected by different health problems and needs to other urban inhabitants, the health of their inhabitants is under-researched.[7–10] The health of the urban poor, people with low socioeconomic status living in urban areas, is usually conflated with that of slum residents. Although there is substantial overlap between these groups, there are also richer residents within slum neighbourhoods, as well as urban poverty occurring in non-slum urban areas. Health outcomes for these two groups may differ depending on whether deprivation is at the individual (urban poverty) or neighbourhood level (slum resident) due to neighbourhood effects.[7 8 11 12] For example, with respect to NCD risk factors, those residents in slums, whatever their personal socioeconomic status, may be more exposed to common physical environmental risk factors (for example: air pollution increasing risk of hypertension), social environmental risk factors (for example: crime rates which may increase stress and drive metabolic risk) or institutional risk factors (for example: stigma on the basis of their address reducing access to appropriate medical care). Many existing studies of NCD risk factors done in urban areas do not disaggregate the population's health data by slum and non-slum status to allow for the detection of intraurban health disparities that are due to neighbourhood effects rather than individual socioeconomic status.[13–22]

Understanding how the global challenges of hypertension, type 2 diabetes and rapid unplanned urbanisation intersect, by investigating whether the up to 1 billion people residing in slums[23] are succumbing to these important metabolic risk factors for NCD, will inform priorities for health services and health policy in LMICs. To fill this research gap, we therefore systematically gathered all the publications that relate to the burden of hypertension among slum residents to (1) assess the contemporary prevalence estimates of hypertension among slum residents; (2) compare the prevalence of hypertension and type 2 diabetes in slums with those in two other types of settlement, that is, non-slum urban and rural areas; and (3) assess the proportion of those with hypertension who were aware of their hypertensive status, those on treatment and those with blood pressure (BP) under control.

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 online supplemental annex 1.

Eligibility criteria

We evaluated each identified study against the following predefined selection criteria:

- *Types of studies:* we included all studies (cross-sectional studies, retrospective or prospective cohort studies) that reported prevalence of hypertension and type 2 diabetes mellitus 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 slums (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 BP (SBP) of 140 mm Hg or greater or had diastolic BP (DBP) 90 mm Hg or greater regardless of age and sex. We excluded studies that included subjects with pregnancy-induced, pre-eclampsia, malignant, portal, pulmonary, renal, intracranial or ocular hypertension. We also excluded studies that used only self-reported measure, that is, deducible from the use of antihypertensive drugs or self-reported physician-diagnosed cases. If data were available, we noted (1) the percentage of those aware of their hypertension status, (2) on any antihypertensive treatment and (3) BP controlled to a target level. Awareness of hypertension was defined as self-reporting of any prior diagnosis of hypertension by a healthcare professional. Treatment of hypertension was defined as receiving prescribed antihypertensive medication for management of high BP at some time in the 1 year preceding the survey. Control of hypertension was defined as the proportion of patients reporting antihypertensive therapy with SBP of less than 140 mm Hg and DBP of less than 90 mm Hg.
  Type 2 diabetes was defined based on measured fasting plasma glucose, or oral glucose tolerance test. Type 2 diabetes was diagnosed if the fasting blood glucose was ≥126 mg/dL (≥7.0 mmol/L) after an overnight fast for at least 8 hours, or random capillary blood glucose of ≥11.1 mmol/L or if the participant was taking treatment for type 2 diabetes.

Study selection

Two reviewers (OAU, AA) independently evaluated the eligibility and methodological quality of the studies obtained from the literature searches. All articles yielded by the database search were initially screened by their titles and abstracts to obtain studies that met inclusion criteria. In cases of discrepancies, agreement was reached

by discussion with a third reviewer. Two reviewers (OAU, AA) independently evaluated the full-text articles of all identified citations to establish relevance of the article according to the prespecified criteria. In cases of discrepancies, agreement was reached by discussion with a third reviewer.

Data collection process and data items

OAU extracted data, and AA and OO checked the extracted data. For each study that met the selection criteria, details extracted included year of publication, country of origin, study design, sample size, sampling strategy, study period, setting (rural/urban/slum), sociodemographic variables, prevalence estimates, etc.

Risk of bias (quality) assessment

We used the Risk of Bias Assessment tool for Nonrandomized Studies[24] to assess the risk of bias of included studies (see online supplemental box 1). The risk of bias in a study was graded as low, high or unclear on the basis of study features including the selection (selection of participants and confounding variables), performance (measurement of exposure), detection (blinding of outcome assessments), attrition (incomplete outcome data) and reporting (selective outcome reporting).

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

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

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

Synthesis of results

For the meta-analysis, we used DerSimonian-Laird random-effects model[25] due to anticipated variations in study population, healthcare delivery systems and stage of epidemic transition to pool the hypertension and type 2 diabetes prevalence estimates. We performed leave-one-study-out sensitivity analysis to determine the stability of the results.[26] This analysis evaluated the influence of individual studies by estimating the pooled prevalence estimates in the absence of each study.[26] We assessed heterogeneity among studies by inspecting the forest plots and using the X^2 test for heterogeneity with a 10% level of statistical significance and using the I^2 statistic where we interpret a value of 50% as representing moderate heterogeneity.[27 28] We assessed the possibility of publication bias by evaluating a funnel plot for asymmetry. Because graphical evaluation can be subjective, we also conducted an Egger's regression asymmetry test as formal statistical tests for publication bias.[29]

Following the overall analyses, we performed the following subgroup analyses: place of residence (rural vs urban slum vs non-slum urban); participants' risk factors, including socioeconomic position; study design (cross-sectional, cohort); study location (low/middle-income vs high-income countries) and study precision.

We examined time trends in the prevalence estimates using meta-regression regression models with the prevalence estimates as the outcome variable and the calendar year of the publication as the predictor. In order to measure secular patterns in prevalence figures, we use the annual average percentage change (AAPC). We fitted a regression line to the natural logarithm of the prevalence estimates, that is, $y=\alpha+\beta x+\varepsilon$, where y=ln(Prevalence), and x=calendar year. The AAPC was calculated as $100\times(\exp(\beta)-1)$. The 95% CI of the AAPC was also computed from the regression model.[30] The prevalence calculations indicated an upward trend when both the AAPC estimate and the lower limit of its 95% CI were >0. However, they indicated a downward trend when both the AAPC and its upper limits were less than 0. The prevalence estimates were otherwise considered stable over time.[30] This systematic review was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses guideline (online supplemental annex 2).[31]

Patient and public involvement

No patient was involved.

RESULTS

Study selection and characteristics

The literature search yielded 1490 articles. Online supplemental figure 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 online supplemental table 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 32–80] Forty-three studies reported only hypertension prevalence estimates, 29 studies reported only type 2 diabetes prevalence estimates and 8 reported both. Table 1 and online supplemental table 2 present 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), 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).

Table 1 Pooled prevalence by different subgroups

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	2001–2005	5	15.6 (9.0 to 23.8)	94.7	4	8.2 (6.7 to 9.8)	53.6
Publication year	2006 –2010	6	28.6 (18.9 to 39.4)	98.7	4	6.3 (3.3 to 10.3)	90.6
Publication year	2011–2020	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-aged 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	Underweight	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			

World Bank Country Income Groups, 2018.
Participants were divided into age groups that, broadly defined, covered young adulthood (18–35 years), middle age (36–55 years) and older adulthood (56 years and older).
Underweight—body mass index under 18.5 kg/m^2.
Normal weight—body mass index greater than or equal to 18.5–24.9 kg/m^2.
Overweight—body mass index greater than or equal to 25–29.9 kg/m^2.
Obesity—body mass index greater than or equal to 30 kg/m^2.
Physical activity as defined by authors.
Alcohol consumption as defined by authors.
Smoking status as defined by authors.
Income status as reported by authors.
BP, blood pressure; HBP, high BP.

Risk of bias of included studies

Summary of risk of bias assessment for each study is shown in online supplemental table 3. The risk of bias in the selection of participants was low in most studies (n=56, 90%), high in three studies (5%) and unclear in three studies (5%). Risk of bias due to confounding variables was low in most studies (n=39, 63%), high in 22 studies (36%) and unclear in 1 study. Risk of bias due to measurement of exposure, blinding of outcome assessments and selective outcome reporting was low in all the 62 studies as we included all studies that used objective measure of hypertension and type 2 diabetes. Risk of bias due to incomplete outcome data was low in most studies (n=54, 87%), high in two studies (3%) and unclear in six studies (10%).

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

Prevalence of hypertension and type 2 diabetes from individuals is shown in figures 1 and 2, respectively.

East Asia and Pacific

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

Latin America and Caribbean

Brazil: four studies reported the prevalence of hypertension from three different slums: Maceio (n=2), Rio de Janeiro (n=1) and Salvador (n=1). Florencio *et al*[42] found that almost one-third of the Maceio slum dwellers were hypertensive in 2004 (29.8%, 95% CI 24.8% to 35.2%), while Ferriera *et al*[41] estimated prevalence of hypertension among Maceio slum residents to be 14.8% (95% CI 10.4% to 20.2%) in 2005. The reported prevalence of hypertension in other slums 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 Salvador in 2015. The pooled prevalence ('annualised year average') of hypertension for the four studies yielded an estimate of 18.4% (95% CI 12.0% to 26.2%). One study from Brazil found that 1 in 10 had type 2 diabetes in 2017.

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

South Asia

Bangladesh: four studies from Dhakan slums reported prevalence of hypertension. The reported prevalence of hypertension ranged from 11.6% (95% CI 9.7% to 13.8%) in 2012 to 19.56% (95% CI 17.85% to 21.37%) in 2018. Five studies from Dhakan slums reported prevalence of type 2 diabetes. The pooled prevalence ('annualised year average') of hypertension for the three studies yielded an estimate of 16.1% (95% CI 12.2% to 20.3%). The reported prevalence of type 2 diabetes in these slums ranged from 8.1% (95% CI 6.8% to 9.6%) in 2004 to 18.12% (95% CI 16.46% to 19.87%) in 2019.

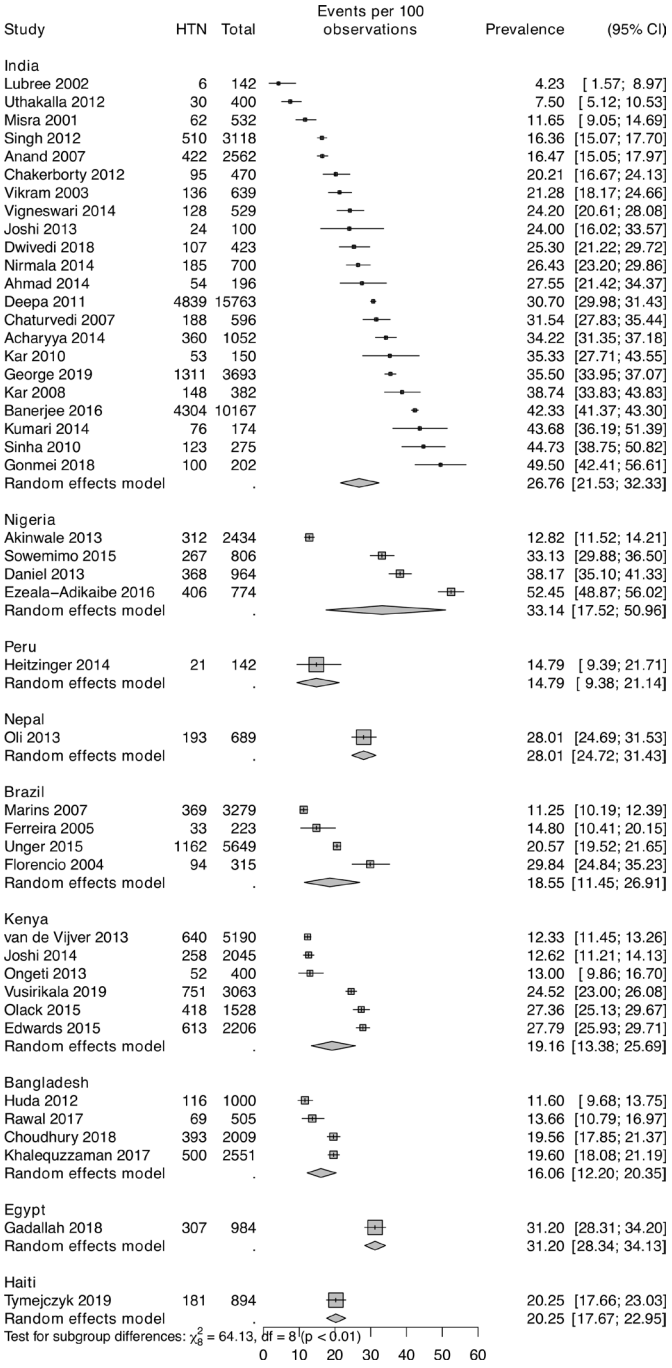


Figure 1 Hypertension (HTN) prevalence estimates among slum residents and 95% CIs from individual studies and pooled data.

India: 22 studies from India reported prevalence of hypertension from more than 15 different slums. The reported prevalence varied across and within the slums. For example, Kar *et al*[48] estimated the prevalence of hypertension to be 27.6% (95% CI 21.4% to 34.4%) among 196 Chandigarh and Haryana slum residents in 2008; however, they estimated the prevalence of hypertension to be 16.5% (95% CI 15.1% to 18.0%) among 2 562 196 Chandigarh and Haryana slum residents in 2010. Prevalence of type 2 diabetes also varied across slums in India. The pooled prevalence ('annualised year average')

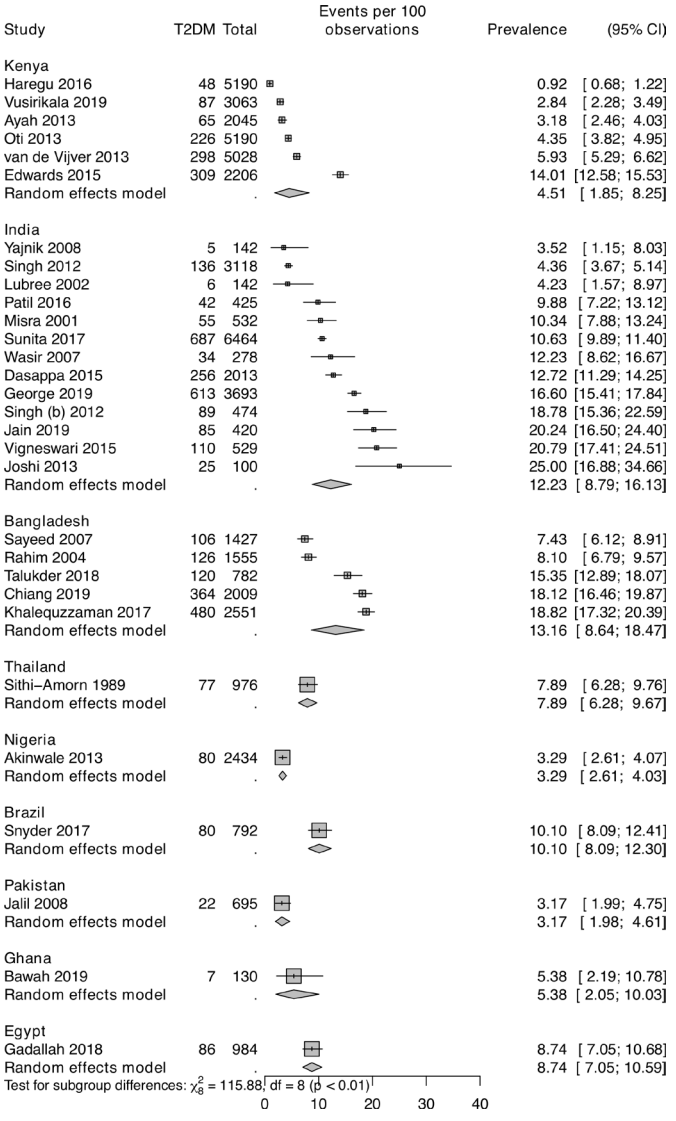


Figure 2 Type 2 diabetes mellitus (T2DM) prevalence estimates among slum residents and 95% CIs from individual studies and pooled data.

of hypertension for the 22 studies yielded an estimate of 26.8% (95% CI 22.5% to 31.3%). In Delhi, the reported prevalence of type 2 diabetes ranged from 12.7% (95% CI 11.3% to 14.2%) in 2007 to 31.5% (95% CI 27.8% to 35.4%) in 2012. The pooled prevalence ('annualised year average') of type 2 diabetes for the 13 studies yielded an estimate of 12.2% (95% CI 9.2% to 15.6%).

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

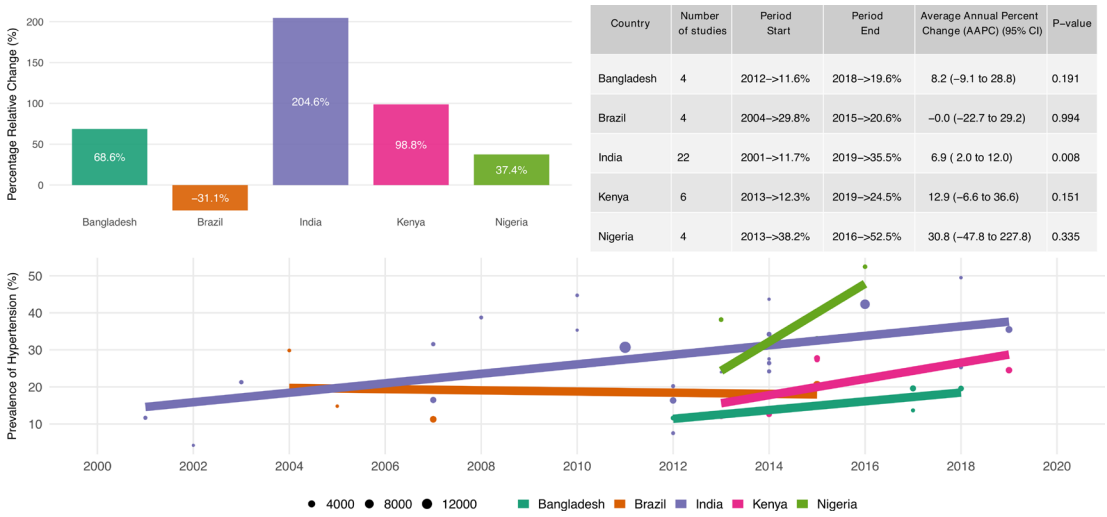
Pakistan: one study from a Lahore slum found that 22 of the 695 respondents had type 2 diabetes in 2008 (3.2%, 95% CI 2.0% to 4.8%).

Sub-Saharan Africa, *Kenya:* six studies reported the prevalence of hypertension from three different slums: Kibera (n=4) and Viwandani and Korogocho (n=2). The reported prevalence among Kibera slum residents ranged from 13.0% (95% CI 9.9% to 16.7%) in 2013 to 27.8% (95% CI 25.9% to 29.7%) in 2015. van de Vijver *et al*[68] found that 640 of the 5190 respondents from Viwandani and Korogocho slums were hypertensive (12.3%, 95% CI 11.5% to 13.3%). The pooled prevalence ('annualised year average') of hypertension for the six studies yielded an estimate of 19.2% (95% CI 13.2% to 26.0%). The reported prevalence of type 2 diabetes 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 Viwandani and Korogocho in 2013. The pooled prevalence ('annualised year average') of type 2 diabetes for the six studies yielded an estimate of 4.5% (95% CI 2.0% to 7.9%).

Nigeria: four studies from five different slums reported prevalence of hypertension. The reported prevalence varied across and within the slums. Ezeala-Adikaibe *et al*[40] found that half of the respondents from Enugu slums were hypertensive in 2016 (52.5%, 95% CI 48.9% to 56.0%). While Daniel *et al* and Sowemimo *et al*[16 64] found that almost one-third of the Ajegule (38.2%, 95% CI 35.1% to 41.3%, 2013) and Yemetu (33.1%, 95% CI 30.0% to 36.5%, 2015) slum residents were hypertensive. However, Akinwale *et al*[33] found that only 12.8% of the respondents from Ijora Oloye, Ajegunle and Makoko were hypertensive in 2013. The pooled prevalence ('annualised year average') of hypertension for the four studies yielded an estimate of 33.2% (95% CI 15.6% to 53.5%). Akinwale *et al* found that only 3.3% of the respondents from Ijora Oloye, Ajegunle and Makoko had type 2 diabetes in 2013.

Secular trends in hypertension and type 2 diabetes prevalence estimates

Secular trends in hypertension, in five countries for which there were data across multiple time points, and type 2 diabetes, in three countries in which we had data across multiple time points, among slum residents are shown in figures 3 and 4. We observed a continuous increase in prevalence of hypertension among slum residents in four out of five countries. The increase is more pronounced in India, followed by Kenya and Bangladesh. The prevalence of hypertension increased by 204.6% from 11.7% in 2001 to 35.5% in 2019 in India. The prevalence of hypertension increased by 98.8% from 12.3% in 2013 to 24.5% in 2019 in Kenya. However, the results of the trend analysis showed statistically significant upward trends only in India, such that the prevalence of hypertension increased +6.9% (95% CI +2.0% to +12.0%) per year between 2001 and 2019. There was no statistically significant trend observed in Brazil using trend analyses (trend=−0.0%, 95% CI −22.7% to +29.2%). We also observed a continuous increase in prevalence of type 2 diabetes among slum residents in India and Bangladesh. The prevalence of type 2 diabetes increased by 123.6% from 8.1% in 2004 to 18.1% in 2019 in Bangladesh. The prevalence of type 2 diabetes increased by 95.8% from 10.3% in 2001 to 20.2% in 2019 in India. However, the results of the trend analysis showed statistically significant upward trends only in Bangladesh such that the prevalence of type 2 diabetes increased +5.9% (95% CI +1.1% to +10.8%) per year between 2004 and 2019. A non-statistically significant downward trend



Country	Number of studies	Period Start	Period End	Average Annual Percent Change (AAPC) (95% CI)	P-value
Bangladesh	4	2012–>11.6%	2018–>19.6%	8.2 (−9.1 to 28.8)	0.191
Brazil	4	2004–>29.8%	2015–>20.6%	−0.0 (−22.7 to 29.2)	0.994
India	22	2001–>11.7%	2019–>35.5%	6.9 (2.0 to 12.0)	0.008
Kenya	6	2013–>12.3%	2019–>24.5%	12.9 (−6.6 to 36.6)	0.151
Nigeria	4	2013–>38.2%	2016–>52.5%	30.8 (−47.8 to 227.8)	0.335

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

in type 2 diabetes prevalence was also observed in Kenya (trend=−11.1%, 95% CI −45.7% to +45.6%).

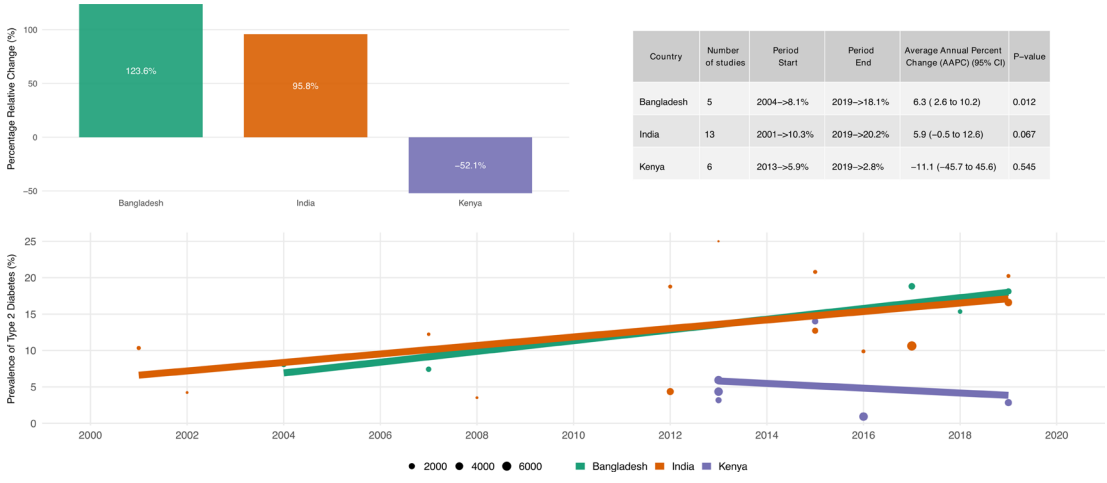
Prevalence of hypertension by different hypertension and type 2 diabetes subgroups

Study characteristics

As shown in table 1, the pooled prevalence of hypertension was higher in studies conducted in lower middle-income countries (23.2%, 95% CI 21.5% to 29.0%, 36 studies) than those from upper middle-income countries (17.9%, 95% CI 12.1% to 24.6%, 5 studies). The pooled prevalence of hypertension tended to be higher among studies from South 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 studies) than those from Latin America and Caribbean (18.3%, 95% CI 13.4% to 23.9%, 6 studies). The pooled prevalence tended to be higher among imprecise studies (33.4%, 95% CI 25.7% to 41.7%, 8 studies) than those from precise studies (22.4%, 95% CI 18.9% to 26.1%, 35 studies). The pattern was similar for type 2 diabetes prevalence estimates.

Sociodemographic characteristics

As shown in table 1, the pooled prevalence of hypertension was similar among men (22.5%, 95% CI 16.0% to 29.7%, 24 studies) and women (23.5%, 95% CI 18.6% to 28.1%, 24 studies). The pooled prevalence of hypertension tended to be higher among older adults (49.6%, 95% CI 36.7% to 62.6%, 9 studies) than middle-aged (35.0%, 95% CI 25.0% to 45.6%, 9 studies) and young adults (15.7%, 95% CI 10.1% to 22.1%, 8 studies). Similarly, the pooled prevalence of hypertension tended to be higher in obese (45.4%, 95% CI 34.5% to 56.5%, 6 studies) and overweight (32.9%, 95% CI 21.2% to 45.8%, 6 studies) participants than participants with normal (21.9%, 95% CI 11.8% to 34.2%, 6 studies) and underweight (21.8%, 95% CI 11.4% to 34.4%, 5 studies). The pooled prevalence of hypertension tended to be higher among those who never studied (39.1%, 95% CI 27.5% to 51.3%) than those with less than primary (18.3%, 95% CI 13.9% to 23.1%, 4 studies), primary (24.8%, 95% CI 12.0% to 40.4%, 6 studies) or secondary/higher



Country	Number of studies	Period Start	Period End	Average Annual Percent Change (AAPC) (95% CI)	P-value
Bangladesh	5	2004–>8.1%	2019–>18.1%	6.3 (2.6 to 10.2)	0.012
India	13	2001–>10.3%	2019–>20.2%	5.9 (−0.5 to 12.6)	0.067
Kenya	6	2013–>5.9%	2019–>2.8%	−11.1 (−45.7 to 45.6)	0.545

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

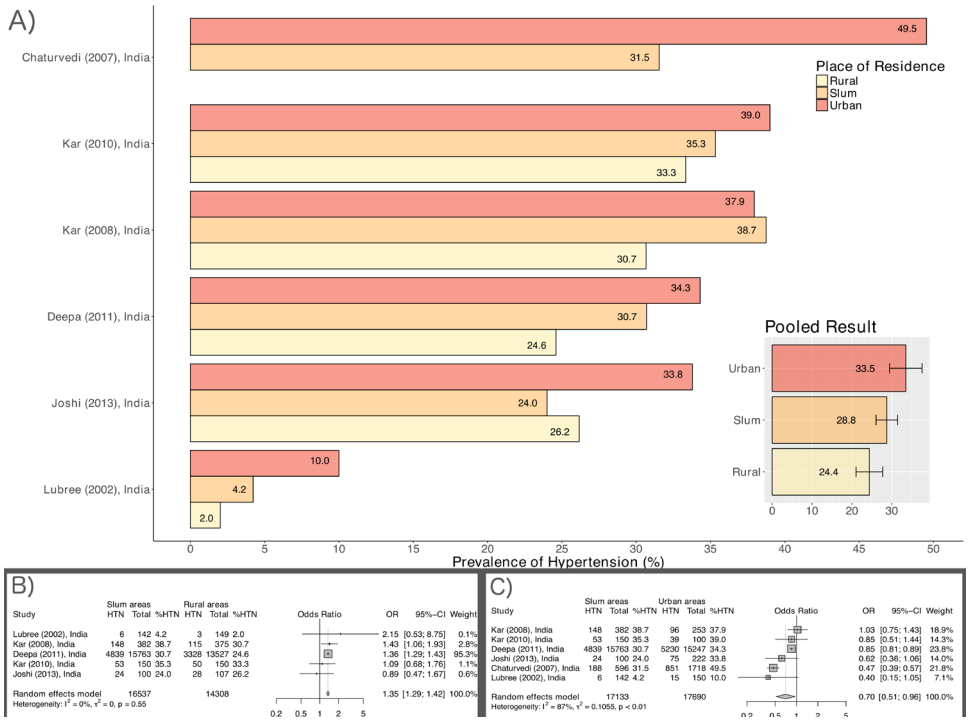


Figure 5 Hypertension (HTN) prevalence estimates by place of residence: urban versus rural versus slum. (A) Data from each studies, (B) Pooled estimates by place of residence, (C) Comparative pooled estimates.

educational attainment (22.4%, 95% CI 11.2% to 36.2%, 7 studies). The pooled prevalence of hypertension tended to be higher among the least poor (29.2%, 95% CI 13.1% to 48.5%, 5 studies) than those with middle (25.3%, 95% CI 10.6% to 43.8%, 5 studies) and poorest income (20.9%, 95% CI 10.4% to 33.8%, 5 studies). The pattern was similar for type 2 diabetes prevalence estimates.

Lifestyle factors

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

Comparative prevalence by place of residence

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

Four studies from India (n=3) and Bangladesh reported prevalence of type 2 diabetes by place of residence.[46 51 59 71] As shown in figure 6, the pooled prevalence of type 2 diabetes was highest among those residing in non-slum urban areas (13.06%, 95% CI 6.53% to 24.43%, 4 studies; 2813 participants), followed by urban slum residents (7.88%, 95% CI 3.32% to 17.55%; 4 studies; 1811 participants) and was lowest among rural residents (1.64%; 95% CI 0.06% to 32.21%; 3 studies; 405 participants). Prevalence of type 2 diabetes tended to be higher among urban slum residents than those living in rural areas (OR=3.78, 95% CI 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).

Treatment cascade

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

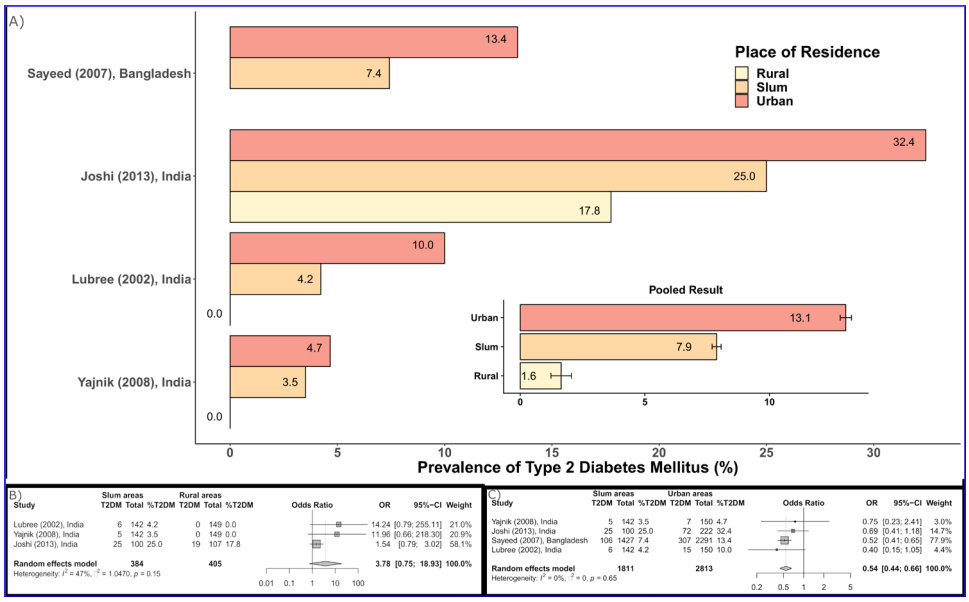


Figure 6 Type 2 diabetes mellitus (T2DM) prevalence estimates by place of residence: urban versus rural versus slum. (A) Data from each studies, (B) Pooled estimates by place of residence, (C) Comparative pooled estimates.

DISCUSSION

Main findings

This systematic review and meta-analysis summarises available evidence on the global prevalence of hypertension and type 2 diabetes among slum residents. There were several key findings: first, the burden of hypertension and type 2 diabetes among slum dwellers is high and may be rising globally, with wide variation between countries and regions and, to some degree, also within countries. Using data from within-study comparator populations when presented, the pooled prevalence of hypertension and type 2 diabetes was highest among those residing in non-slum urban areas, followed by slum residents, and was lowest among rural residents. This finding corroborates those of previous reviews that observed higher prevalence of hypertension among urban residents than those living in rural areas.[81 82] This high prevalence may be due to rapid urbanisation, lifestyle changes, dietary changes and increased life expectancy,[83 84] or a combination of these factors.[85 86] In addition, the observed difference could be due to other factors including but not limited to lack of access to testing and care of NCD risk factors in rural areas and urban areas.

The observed gradient in burden of hypertension and type 2 diabetes among rural, slum and urban residents is consistent with the effects of urbanisation and wealth, as residents experience an economic transition when moving from one area to the next.[87–92] LMICs are now undergoing epidemiological transition, the change from a burden of infectious diseases to chronic diseases.[93] In addition, it could be due to increase in awareness in (non-slum) urban areas and recent availability of testing in some places. Recent systematic reviews of dietary risk behaviour in sub-Saharan Africa have found that urban populations tended to consume more salt than rural populations[94] and consume fewer portions of vegetables.[12] The rapid pace of urbanisation and economic growth is accelerating the rate of this epidemiological transition; as such LMICs are at great risk of an explosive growth in the burden of NCDs, including hypertension and type 2 diabetes.[87 88]

We found evidence of significant unmet need for hypertension care among urban slum residents. A significant proportion of the urban slum residents were unscreened, undiagnosed, untreated or uncontrolled. This huge unmet need has been documented in previous studies from low/middle-income settings.[95–101] We also found that control of hypertension among slum residents was poor, such that only one in four slum residents on treatment had their BP controlled. The poor control of BP noted in our study, despite the fact the one-half of those who were unaware of high BP being on antihypertensive medications, needs further exploration. One possible explanation is availability and affordability of the medications and there could be minimal additional contact with a health professional.[15] It has been documented that the control of BP was related to the frequency of follow-up visits.[96] Another possible explanation could be low adherence to prescribed medications, as they may not be able to afford the medications.

As expected, we found that the burden of hypertension increased with the particpants' age, which may be attributed to age-related structural changes in blood vessels which potentially cause narrowing of the vascular lumen, and consequently increasing BP, as have been reported in previous studies.[102 103] The association between combined overweight/obesity and hypertension shown in our results exemplifies the role of excess body weight in hypertension prevalence, which has been long recognised and consistent across numerous observational and trial data.[104–106] We found evidence of significantly high prevalence of hypertension among smokers compared with non-smokers. Direct relation of chronic

tobacco consumption to hypertension however is not yet well established,[107 108] although tobacco consumption has been shown to cause an acute elevation of BP.[109]

Study limitations and strengths

To the best of our knowledge, this paper is the first systematic review that summarises data about prevalence of hypertension and type 2 diabetes among slum residents. Strengths of this study include the use of a predefined and published protocol, a comprehensive search strategy and involvement of two independent reviewers in the review process. Nevertheless, the findings of this study should be interpreted with caution. Prevalence estimates from different regions and published over the course of 11 years were pooled in this meta-analysis, and as expected, high heterogeneity between studies was found in the meta-analyses. Nonetheless, as affirmed by previous evidence, meta-analyses are the preferred options to narrative syntheses for interpreting the results in a review, even in spite of the presence of a considerable amount of heterogeneity.[110] Heterogeneity appeared to be the norm rather than exception in published meta-analyses of observational studies.[111]

In conclusion, the burden of hypertension and type 2 diabetes varied widely between countries and regions and, to some degree, also within countries. In addition, many individuals with hypertension are not aware of their condition, not on treatment and control of hypertension is poor. The burden of hypertension and type 2 diabetes was higher among urban residents than their counterparts living in urban slums and rural areas. There is a need for public health strategies to improve the awareness, control and overall management of hypertension and type 2 diabetes in urban areas.

Contributors OAU, AA, OO and RJL conceived the study. OAU, AA and OO collected and analysed initial data. OAU, AA, OO, JS, PG and RJL participated in and contributed to refining the data analysis. OAU wrote the first manuscript. OAU, AA, OO, JS, PG and RJL contributed to further analysis, interpreting and shaping of the argument of the manuscript and participated in writing the final draft. OAU is the guarantor of this study.

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Patient consent for publication Not required.

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ORCID iDs

Olalekan Abdulrahman Uthman http://orcid.org/0000-0002-8567-3081
Abimbola Ayorinde http://orcid.org/0000-0002-4915-5092

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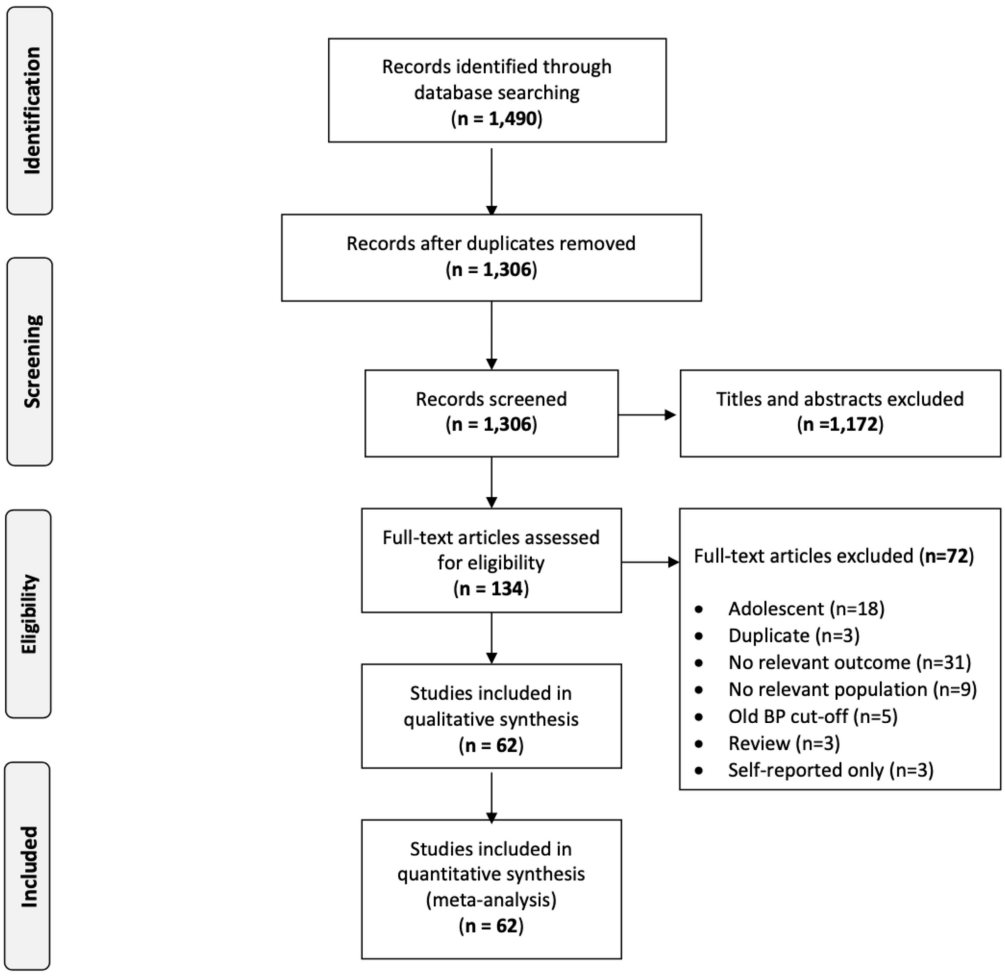
Supplementary Digital Content

Table of Contents

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

Uthman OA, *et al. BMJ Open* 2022; 12:e052393. doi: 10.1136/bmjopen-2021-052393

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
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	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
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
Tymejczyk (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 gecekondu 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