




## META-ANALYSIS OPEN ACCESS

# Prevalence of Undiagnosed Hypertension in Bangladesh: A Systematic Review and Meta-Analysis

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## ABSTRACT

Undiagnosed hypertension (UHTN) remains a significant public health concern in Bangladesh, leading to severe complications due to delayed diagnosis and management. This systematic review and meta-analysis examined the prevalence of UHTN among adults aged 18 years and older, using data from studies conducted in Bangladesh and published between 2010 and 2024. A comprehensive search of major databases yielded 1028 records, from which nine relevant studies, encompassing a total of 28949 participants, were selected and evaluated for quality using the Newcastle–Ottawa Scale, providing valuable insights into the prevalence of UHTN within the Bangladeshi population. The pooled prevalence of UHTN was 11% (95% CI: 6%–19%) based on a random-effects model, with substantial heterogeneity ( $I^2 = 99.5\%$ ,  $p < 0.0001$ ). Subgroup analyses revealed higher prevalence in rural areas (13%; 95% CI: 4%–35%) compared to urban areas (12%; 95% CI: 1%–54%) and elevated occupational risk among bankers (17%; 95% CI: 0%–94%). While funnel plot asymmetry was noted, Egger's test ( $p = 0.3113$ ) indicated no significant publication bias. Sensitivity analyses, including Leave-One-Out Analysis, affirmed the robustness of the pooled estimate. The findings underscore notable geographic, occupational, and sociodemographic disparities in UHTN prevalence, highlighting the need for nationwide screening programs and targeted community awareness campaigns, particularly in underserved rural areas. Further research is imperative to explore causal factors and inform effective prevention and management strategies.

## 1 | Introduction

Hypertension (HTN), often referred to as the “silent killer,” is a prevalent and serious health condition defined by consistently elevated blood pressure, specifically a systolic blood pressure of  $\geq 130$  mm Hg or a diastolic blood pressure of  $\geq 80$  mm Hg, measured on at least two separate occasions [1, 2]. Despite advancements in healthcare, HTN continues to pose a substantial threat worldwide due to its asymptomatic nature, which

frequently delays diagnosis and treatment. Untreated HTN significantly elevates the risk of stroke, cardiovascular disease, chronic kidney disease, and premature mortality [3]. Globally, HTN is the leading modifiable risk factor for cardiovascular morbidity and mortality, with the World Health Organization estimating that over 1.3 billion people are affected, nearly half of whom remain undiagnosed [4, 5]. This gap underscores the urgent need for improved public health strategies focusing on early detection and intervention.

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In Bangladesh, the prevalence of HTN has risen alarmingly over the years [6], reflecting the nation's rapid urbanization, shifting dietary habits, and increasingly sedentary lifestyle. Recent studies estimate that approximately 25% of Bangladeshi adults are hypertensive, with a significant proportion of these cases remaining undiagnosed [7]. Undiagnosed hypertension (UHTN) contributes silently to the burden of non-communicable diseases, leading to severe complications due to missed opportunities for timely intervention, such as lifestyle modifications and antihypertensive therapy [8, 9]. The consequences of UHTN are particularly dire in Bangladesh, where limited healthcare infrastructure, especially in rural regions, compounds the challenges of screening and early diagnosis.

The lack of comprehensive national-level data on UHTN further exacerbates this issue, with existing studies primarily confined to specific regions or populations. Rural areas, in particular, remain underrepresented in epidemiological assessments despite evidence suggesting that sociodemographic factors such as age, gender, occupation, and lifestyle play a critical role in the development and progression of HTN [10, 11]. The disparity between rural and urban settings in healthcare access, awareness, and preventive measures further highlights the need for a systematic evaluation of UHTN prevalence. UHTN not only affects individuals but also places a substantial strain on the country's healthcare system [12]. Delayed diagnosis leads to advanced cardiovascular complications, increased healthcare costs, and reduced productivity [13]. Recognizing this public health crisis, it is essential to establish a clear understanding of UHTN's prevalence across diverse population groups and settings.

This systematic review and meta-analysis aim to fill this critical knowledge gap by providing a comprehensive assessment of the prevalence of UHTN among adults aged 18 years and above in Bangladesh. By synthesizing evidence from various studies, this analysis highlights geographic, occupational, and sociodemographic disparities in UHTN prevalence. The findings aim to inform public health policies and targeted interventions, emphasizing the need for robust screening programs and community awareness campaigns to mitigate the growing burden of UHTN, particularly in underserved rural areas.

## 2 | Materials and Methods

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines for the purpose of this review [14].

### 2.1 | Search Strategy and Study Identification

A systematic search of PubMed, Embase, Web of Science, and Google Scholar, along with gray literature sources such as government reports and conference proceedings, was conducted to identify studies on the prevalence of UHTN. Search terms included: (((“undiagnosed hypertension”) OR (“prevalence of hypertension”)) OR (“associated factors of hypertension”) OR (“hidden hypertension”) OR (“unaware of hypertension”) OR (“newly identified hypertension”))) AND “Bangladesh.” The search targeted studies published in English, reflecting the

growing emphasis on non-communicable diseases. After removing duplicates, two independent reviewers screened titles and abstracts, resolving discrepancies through discussion or a third reviewer's input. Full texts of eligible studies were retrieved and assessed for inclusion.

### 2.2 | Inclusion and Exclusion Criteria

Using the PICOS framework, studies were included if they focused on adults aged 18 or older residing in Bangladesh and reported the prevalence of UHTN across demographic and geographic settings. Eligible designs were cross-sectional studies published in English between 2010 and 2024. Studies conducted outside Bangladesh, lacking differentiation between diagnosed and undiagnosed hypertension, or presented as reviews, abstracts, letters, or conference papers were excluded. This approach ensured the selection of high-quality studies with well-defined data, offering a comprehensive assessment of UHTN prevalence in Bangladesh.

### 2.3 | Quality Assessment

The methodological quality of the included studies was evaluated using the Newcastle–Ottawa Scale (NOS) [15], which assesses selection, comparability, and outcome domains, with scores ranging from 0 to 9. Only studies scoring 7 or higher were included, ensuring methodological rigor. A total of nine studies met these criteria (see Table S1). Discrepancies during assessment were resolved through discussion or consultation with a third reviewer, enhancing the reliability and validity of the findings.

### 2.4 | Data Extraction

Data were systematically extracted using a standardized Microsoft Excel format to ensure consistency and minimize bias. Two independent authors, N.S. and M.K.K., collected details for each study, including author name, publication year, study design, data collection period, UHTN threshold, sample size, age groups, population type (urban, rural, or mixed), and geographic location (see Table S2). This process followed PRISMA guidelines to ensure transparency and replicability (see Table S3). Discrepancies were resolved through collaborative discussions with a third researcher, MPH, ensuring accuracy and consensus.

### 2.5 | Outcomes

The primary outcome of this study was the prevalence of undiagnosed hypertension (UHTN), while the secondary outcome focused on associated factors. UHTN was defined as systolic blood pressure (SBP)  $\geq 130$  or 140 mm Hg and/or diastolic blood pressure (DBP)  $\geq 80$  or 90 mm Hg in individuals unaware of their hypertensive status [16]. Prevalence was calculated as the proportion of participants with UHTN relative to the total sample size. Blood pressure measurements were taken in seated adults after at least 5 min of rest, ensuring participants avoided caffeine

and smoking for 30 min prior. This standardized approach ensured reliable and comparable data across studies.

## 2.6 | Statistical Analysis

Data analysis was performed using R version 4.4.0 with the Meta package. The pooled prevalence of undiagnosed hypertension (UHTN) was estimated using the metaprop function, and results were visualized through forest and funnel plots [17]. A random-effects model accounted for inter-study variability, with heterogeneity assessed via the  $I^2$  statistic ( $\geq 75\%$  indicating substantial heterogeneity) [18, 19]. Forest plots displayed pooled prevalence with 95% confidence intervals (CIs), alongside individual study details such as weight, cases, total participants, and proportion of UHTN. Values to the left of the vertical line indicate studies with lower proportions, while values to the right represent studies with higher proportions compared to the pooled estimate. Publication bias was evaluated through funnel plot asymmetry and Egger's test ( $p < 0.05$ ) [20]. Sensitivity analyses, excluding studies with extreme values, confirmed the robustness of the pooled prevalence estimates.

## 3 | Results

### 3.1 | Study Selection

A total of 1028 studies were identified through electronic searches across four databases. After removing 32 duplicates and irrelevant studies, 996 studies were screened. Of these, 985 were excluded based on titles and abstracts, leaving 11 eligible for full-text review. Nine studies were successfully obtained, but two could not be retrieved. Of the nine, two were excluded for combining diagnosed and undiagnosed hypertension. Additionally, 11 studies were identified from other sources, including three MSc theses and two studies via citation review. Two were excluded for duplication or irrelevance. In total, nine studies (seven from databases and two from other sources) were included in the final analysis (see Figure 1).

### 3.2 | Study Characteristics

The nine studies in this meta-analysis were conducted in diverse regions of Bangladesh, including Dhaka, Sylhet, Sirajganj, and nationwide, with data collected between 2010 and 2024. All studies used a cross-sectional design and defined undiagnosed hypertension (UHTN) using the standard threshold of 140/90 mm Hg [16, 21–28]. The total sample size was 28,949 participants, with individual study sizes ranging from 180 to 11981 [22, 27]. Participants represented a broad demographic, including urban, rural, and mixed populations, and age groups from over 18 to 60+ years. Most studies focused on the general population [21, 24, 25, 27, 28], while others targeted specific subgroups such as bankers, medical students, and older adults [16, 22, 23, 26]. These studies provide comprehensive insights into UHTN prevalence across different population types in Bangladesh (see Table S2).

## 3.3 | Synthesis of Results

### 3.3.1 | The Pooled Prevalence of Undiagnosed Hypertension

Figure 2 displays the pooled prevalence of undiagnosed hypertension (UHTN) across the included studies. Each square represents the UHTN proportion for an individual study, with its size reflecting the study's weight in the overall pooled estimate. The prevalence varied widely, from 5% (0.05) to 32% (0.32), with the highest proportion reported by F.M.A. Islam et al. (2015) and the lowest by Razibi et al. (2023). Most studies had wide confidence intervals, indicating some uncertainty in the estimates. The pooled prevalence of UHTN is 11% (95% CI: 6%–19%). The high heterogeneity ( $I^2 = 99.5\%$ ,  $p < 0.001$ ) suggests significant variability in estimates, likely due to differences in study populations, settings, or methodologies.

### 3.4 | Sub-Analysis of Undiagnosed Hypertension

Figure S1 presents the pooled prevalence of undiagnosed hypertension (UHTN) in rural and urban Bangladesh. According to the Bangladesh Bureau of Statistics, rural areas are characterized by lower population density, limited infrastructure, and primary reliance on agriculture, while urban areas are defined by higher population density, advanced infrastructure, and a focus on non-agricultural economic activities [29]. In rural areas, the prevalence was 13% (95% CI: 4%–35%), with variability across studies, ranging from 7% (A. Farhana et al., 2018) to 32% (F.M.A. Islam et al., 2015). The high heterogeneity ( $I^2 = 99.5\%$ ,  $p < 0.0001$ ) indicates that factors such as study design and healthcare access contribute to this variation. In urban areas, the prevalence was 12% (95% CI: 1%–54%), with significant uncertainty due to a wide confidence interval and substantial heterogeneity ( $I^2 = 94.5\%$ ,  $\tau^2 = 0.6928$ ). This variability is influenced by population characteristics and urban healthcare access. For the general population, the pooled prevalence was 10% (95% CI: 3%–29%), with high heterogeneity ( $I^2 = 99.7\%$ ,  $\tau^2 = 0.9473$ ,  $p < 0.0001$ ), reflecting the impact of study demographics and regional differences (see Figure S2). Among bankers, the prevalence was 17% (95% CI: 0%–94%), with a wide confidence interval due to limited studies and data variability (see Figure S3). High heterogeneity ( $I^2 = 85.9\%$ ,  $\tau^2 = 0.1998$ ,  $p < 0.01$ ) suggests that more focused research is needed. These findings underscore the importance of tailored interventions and further research to address the public health burden of UHTN in Bangladesh.

### 3.5 | Publication Bias

The funnel plot showed a generally symmetrical shape, with minor asymmetry on the left side, suggesting possible publication bias. However, study heterogeneity could also influence this shape (see Figure S4). To assess publication bias further, Egger's test was performed, yielding a  $p$  value of 0.3113, indicating no significant evidence of bias or small-study effects. Based on statistical analysis and visual inspection, we conclude that publication bias is unlikely to significantly affect the findings of this meta-analysis.

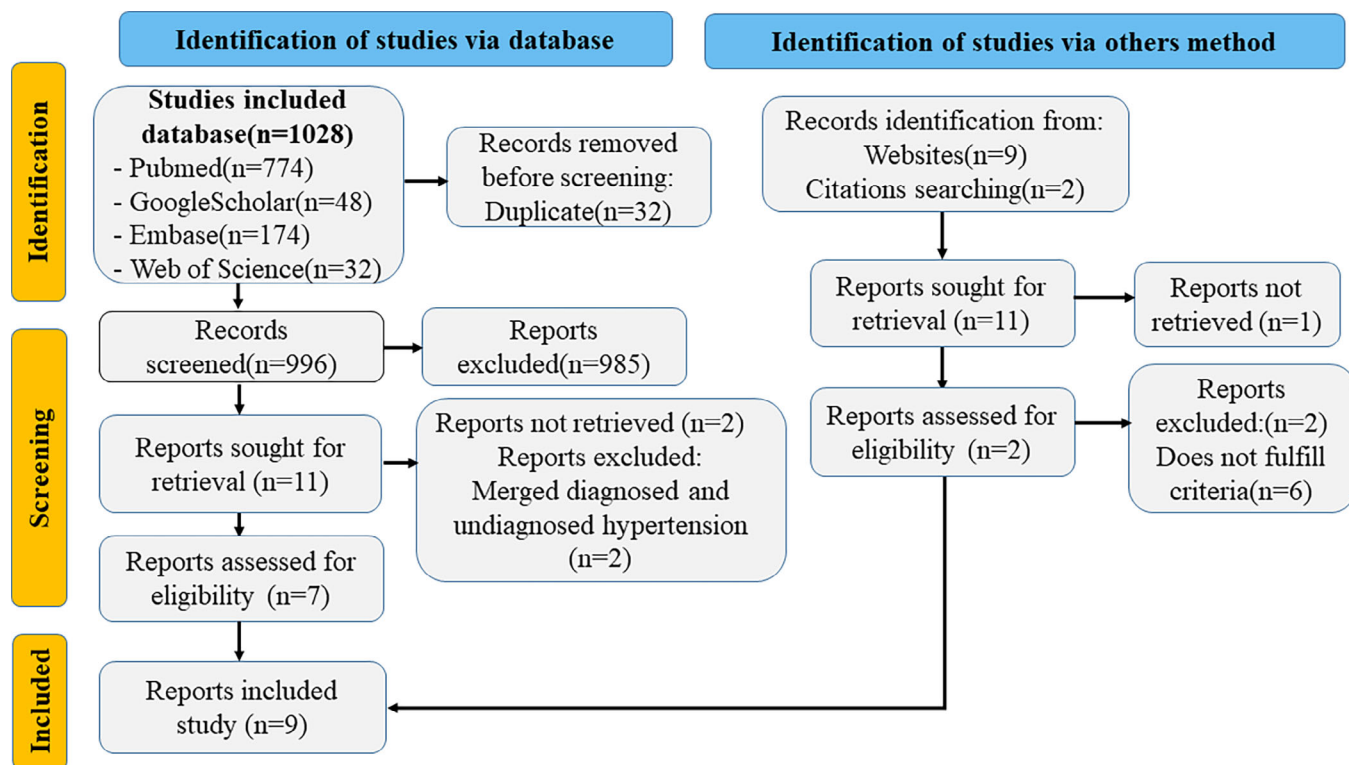


FIGURE 1 | Flow diagrams of included studies in the systematic review and meta-analysis.

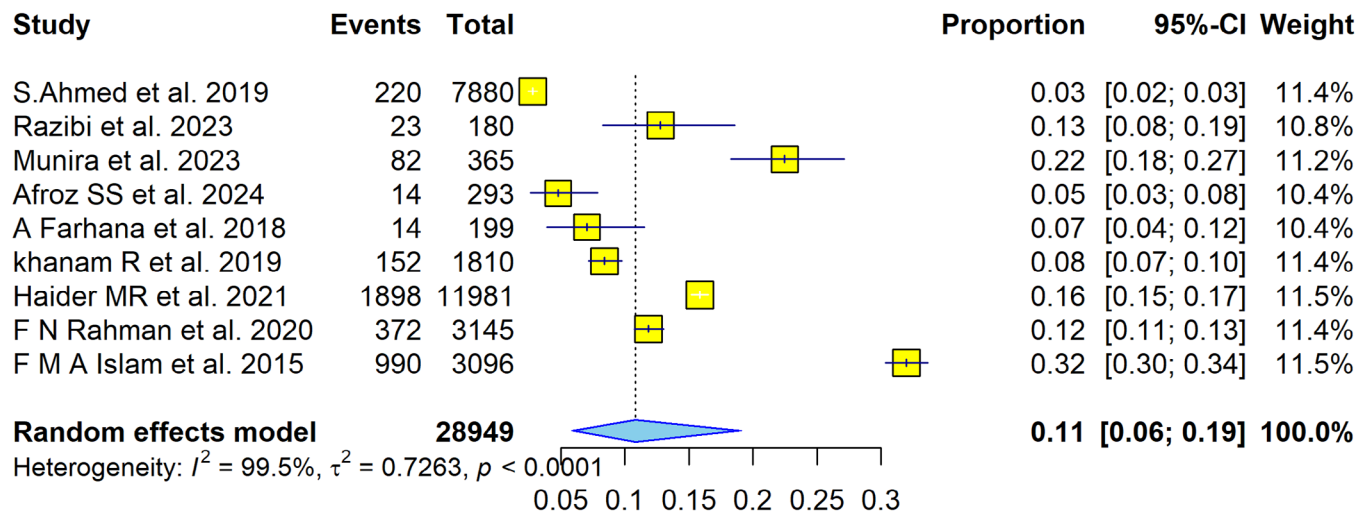


FIGURE 2 | Forest plot indicating the pooled prevalence of undiagnosed hypertension in Bangladesh. The horizontal lines represent the 95% confidence intervals (CIs) for each study's estimate, and the overall pooled estimate is shown as a diamond at the bottom.

### 3.6 | Sensitivity Analysis

The Leave-One-Out Sensitivity Analysis confirmed the robustness of the pooled effect size, with log odds ranging from -1.92 to -2.28 across study exclusions (see Figure S5). No single study significantly altered the overall estimate, as confidence intervals consistently overlapped. The largest effect size occurred with F.M.A. Islam et al. (2015), while the smallest was observed with S. Ahmed et al. (2019), but excluding these studies had minimal impact on the results. This stability suggests that heterogeneity

is due to broader study-level differences, not individual studies, reinforcing the reliability of the meta-analytic findings.

## 4 | Discussion

This systematic review and meta-analysis provide a comprehensive assessment of the prevalence of UHTN in Bangladesh, highlighting critical public health challenges. The pooled prevalence of UHTN was estimated at 11%, lower than similar studies

from Saudi Arabia [30], Sub-Saharan Africa (30%) [31], Nigeria (28.9%) [32], India (29.8%) [33], Pakistan (26.34%) [34], and Nepal (27.3%) [35]. This discrepancy may reflect differences in lifestyle, healthcare access, and awareness levels between Bangladesh and developed nations. Additionally, variations in geographical contexts, study periods, participant demographics, health-seeking behaviors, and socioeconomic factors could also contribute to these differences. Notably, limited studies were conducted in geographically remote or underserved regions of Bangladesh, which may underrepresent the true burden of UHTN in these areas.

The prevalence of UHTN across studies ranged from 15% to 70%, reflecting disparities in healthcare access, especially between urban and rural areas [36]. For instance, rural areas showed slightly higher pooled prevalence (13%) compared to urban settings (12%) which aligns with global trends observed in India [37], Sudan [38], and Nigeria [8]. Rural populations often face greater barriers, including limited healthcare infrastructure, reduced health literacy, and financial constraints, which impede early HTN detection and management [31]. Addressing these inequalities through improved healthcare, education, and community-based screening is essential.

Home blood pressure measurement (HBPM) has been widely recommended for blood pressure control and early detection of hypertension [39, 40]. HBPM provides the advantage of monitoring blood pressure in a non-clinical setting, reducing the risk of white-coat hypertension, and improving long-term management outcomes. However, the adoption of HBPM in Bangladesh is limited, with significant challenges related to cost, awareness, and accessibility. Many individuals cannot afford HBPM devices, and there is limited awareness about their benefits. Addressing these challenges through subsidized device costs, public education, and integration into primary healthcare systems could enhance hypertension management in resource-limited settings.

Age and gender also play a critical role in the burden of UHTN. Older adults are more affected, highlighting the need for routine blood pressure checks for those over 40 [41–43]. While the studies did not provide detailed gender comparisons, similar studies indicate higher UHTN rates in males due to delayed health-seeking behaviors. Future research should explore gender differences in UHTN prevalence.

Occupational differences were another significant finding, with bankers exhibiting a notably higher pooled prevalence of UHTN at 17% [16]. This could be attributed to occupational factors such as sedentary behavior, job stress, and limited physical activity [44, 45]. However, other occupations, including healthcare workers, laborers, and educators were underrepresented in the reviewed studies. A large-scale study investigating HTN prevalence across diverse occupational groups is warranted to understand the broader burden of non-communicable diseases (NCDs) in Bangladesh.

The financial aspect is a critical barrier to hypertension screening and management [46]. Many individuals are unwilling or unable to pay for routine screening due to the cost implications and lack of insurance coverage. Policies aimed at subsidizing healthcare services and introducing affordable blood pressure monitoring

in primary care facilities could mitigate these challenges. Additionally, dietary factors, such as excessive salt intake, remain understudied in Bangladesh. A carefully designed study exploring the impact of dietary salt on HTN prevalence is recommended.

Several recommendations and limitations from the included studies further guide this discussion. For instance, one study found that more than three-quarters of bankers in Bangladesh had either UHTN or prehypertension and HTN, underscoring the need for workplace health initiatives [16]. Another study highlighted a high prevalence of prehypertension and HTN among medical students in Dhaka city, suggesting the value of periodic medical check-ups for early detection [23]. However, this finding highlights the need for targeted measures to further reduce UHTN rates in Bangladesh. Strategies such as regular blood pressure screenings, workplace health initiatives, and community-based awareness campaigns could play a crucial role in early detection and prevention, particularly among high-risk occupational groups like bankers. Implementing these measures can contribute to better hypertension management and improved public health outcomes in the country.

From a policy perspective, this study aligns with several Sustainable Development Goals (SDGs), including SDG 3 (Good Health and Well-being), SDG 10 (Reduced Inequalities), SDG 1 (No Poverty), SDG 8 (Decent Work and Economic Growth), and SDG 17 (Partnerships for the Goals) [47]. Strengthening partnerships between the public and private sectors, expanding health insurance coverage, and enhancing workplace wellness programs could significantly reduce the burden of UHTN. Special focus should be given to rural and underserved populations to address healthcare disparities, aligning with SDG 10.

## 5 | Strengths and Limitations

This study's strengths include a comprehensive search strategy with clear inclusion and exclusion criteria, ensuring a robust identification of relevant studies. The population-based studies with high response rates also enhance the representativeness of the findings. However, significant heterogeneity across studies limits the precision and generalizability of the pooled estimates, despite using a random-effects model. Additionally, the cross-sectional study designs prevent establishing temporal or causal relationships. These limitations highlight the need for standardized methodologies and longitudinal studies to better understand UHTN dynamics in Bangladesh.

## 6 | Conclusions

This systematic review and meta-analysis highlight the prevalence of undiagnosed hypertension (UHTN) in Bangladesh, revealing significant geographic and subpopulation disparities. Rural areas show higher prevalence, indicating limited healthcare access and awareness, while specific occupational groups, such as bankers, face additional risks. These findings stress the need for nationwide screening, particularly in underserved areas, and the implementation of targeted interventions. Public health strategies should focus on addressing risk factors like physical inactivity, poor diet, and low health-seeking behaviors, alongside

community-based hypertension management programs. Future research should investigate causal relationships to enhance prevention and control efforts.

### Author Contributions

All authors contributed significantly to the study. **Nourin Sultana:** conceptualized and designed the study, conducted the literature search, performed data extraction and analysis, and drafted the manuscript. **Zeba Afia and Shamsuz Zoha:** assisted with the literature search, contributed to data analysis and synthesis, and provided critical revisions to the manuscript. **Md. Parvez Mosharaf:** conducted the statistical analysis, interpreted the results, and contributed to writing the results and discussion sections. **Md. Golam Hossain:** offered expertise in the methodology, refined the search strategy, and helped with writing and revising the manuscript. **Md. Kaderi Kibria:** conceptualized and designed the study, supervised the study, provided guidance on interpreting the findings, and contributed to the manuscript's final revision. All authors reviewed and approved the final version of the manuscript.

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### Ethics Statement

The authors have nothing to report.

### Conflicts of Interest

The authors declare no conflict of interest.

### Data Availability Statement

The authors have nothing to report.

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## Supporting Information

Additional supporting information can be found online in the Supporting Information section.