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TRENDS IN CARDIOVASCULAR DISEASE RISK AND OUTCOMES AMONG ASIAN COMMUNITIES POST-COVID-19: A SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT

The COVID-19 pandemic has significantly impacted cardiovascular health, particularly in Asian populations. These communities already experience high rates of cardiovascular diseases (CVD), exacerbated by various socio-economic, lifestyle, and genetic factors. This systematic review and meta-analysis aimed to evaluate the impact of the COVID-19 pandemic on cardiovascular disease risks and outcomes in Asian populations.
Studies published between 2020 and 2025 were included, focusing on adults (≥18 years) from Asian countries. A random-effects model was employed to pool effect sizes, and heterogeneity was assessed using the I^2 statistic. Risk of bias was evaluated using the Newcastle-Ottawa Scale. Subgroup analyses were conducted based on geographic region, pre-existing comorbidities, and study design.
The pooled odds ratio (OR) for increased cardiovascular risk post-COVID-19 was 3.59 (95% CI: 3.58–3.61), indicating a significant rise in risk. Individuals with pre-existing comorbidities, especially DM and HTN, faced a higher risk of severe outcomes. DM alone increased mortality risk by 69%, and when combined with cardiovascular disease, the risk was even higher (OR = 6.98).
This systematic review and meta-analysis underscore the substantial increase in cardiovascular risk post-COVID-19, particularly for individuals with pre-existing comorbidities such as DM and HTN.

Keywords

COVID-19, cardiovascular disease, DM, hypertension, Asian populations, systematic review, meta-analysis, healthcare disparities, public health interventions..

INTRODUCTION

The advent of the COVID-19 pandemic has added another dimension to the already complicated situation in terms of cardiovascular disease risks and outcomes, especially in the diverse global communities of Asians [1]. This complexity is increased because of the direct physiological effects triggered by SARS-CoV-2 infection on the cardiovascular system and the indirect outcomes of the impact of the pandemic on the healthcare access and lifestyle factors [2]. To make the matters worse, the conventional cardiovascular risk assessment models fail to yield sufficient results when applied to the population of Asians, which may require the reconsideration of existing approaches with the consideration of health changes after the pandemic [3]. In particular, the high rates of such conditions as DM, abdominal obesity, and HTN among the subgroups of South Asians, which do not receive credit and are under-managed, point to an immediate necessity of culturally-friendly preventive measures [4,5].

Cardiovascular outcomes due to COVID-19 have been reported extensively in many studies; however, very little emphasis has been placed on bringing together all the available data about the specific impact of COVID-19 on people from Asia specifically that consider the combination of preexisting medical conditions (co-morbidities) and how they affect cardiovascular risk after the COVID-19 pandemic ends [1-5].

The latter intervention is essential due to the disproportionately larger number of aggressive and premature cardiovascular disease prevalence of the South Asian immigrants compared to the local populations, which can be explained by a combination of genetic factors, alterations in diets, and lifestyle [6,7]. These disparities have been further intensified by the post-COVID-19 period experiencing major increases in the burden of cardiovascular diseases in all countries across the world including those who have not been infected directly by SARS-CoV-2 [8]. This requires an in-depth examination of the role of the pandemic in altering the cardiovascular risk profiles and outcomes of different subgroups of Asians based on both biological and socio-economic factors [9].

Cardiovascular Disease Burden Pre-COVID-19 in Asian Communities

An example can be South Asian people who are either in their home countries or are in the diaspora, in all cases, they are always highly susceptible to premature atherosclerotic cardiovascular disease [10-13]. In South Asian populations, there is an increased risk of early onset associated with cardiovascular disease due to both a genetic component as well as high rates of the metabolic risk factors (diabetes, dyslipidemia, hypertension and obesity). These non-communicable diseases usually present at an earlier age in this population than in other ethnic groups. One of these diseases that poses significant issues for South Asians at the present time is HTN. Issues arise from the fact that many cases of HTN go undiagnosed as there is a low level of awareness regarding the need for routine hypertension screening and lead to devastating outcomes such as coronary artery disease, stroke, and heart failure. [14, 15, 16, 17]

Impact of COVID-19 on Cardiovascular Health

COVID-19 has significantly increased existing cardiovascular vulnerabilities, with infections by SARS-CoV-2 being directly linked to myocardial damage, arrhythmias, and thrombotic events as well as indirectly affecting cardiovascular health by affecting access to healthcare and promoting the adoption of inactive lifestyles [18]. Among the indirect effects, there are also the depreciation of the overall levels of physical activity among Asian populations in 2020-2022 at the negative affect on cardiovascular health, immune functions, and metabolic levels [19]. This decrease in physical activities, which is one of the greatest global population health issues, has a significant regional disparity, especially among older women, thus adding to the global burden of heart diseases [20]. All these lifestyle changes, accompanied by the physiological burden of the pandemic, have led to a rise in the burden of cardiovascular disease on a global scale, with ischemic heart disease and stroke continuing to be major factors especially in low and middle-income populations [21,22].

Rapid urbanization and industrialization in South Asia, plus poor diet and lack of exercise have all combined to create an increased rate of cardiovascular disease. The years that have been lost due to ischemic heart disease increased by 73% between 1990 and 2010, much higher than the overall world average increase of 30% during this same time period [23,24]. More so to this trend is the fact that HTN has become one of the major public health issues in South Asia with some studies showing that it is very high amongst adolescents and is rapidly advancing a risk factor by the time a person reaches adulthood in the urban Indian populations [25]. The current situation in low- and middle-income countries, especially in South Asia, and the increased HTN prevalence clearly shows the dire necessity to improve screening and management strategies as a significant portion of HTN-related mortality in the world is concentrated in these regions [4]. The entire weight of the cardiovascular diseases is high all over the world and a high body mass index, high fasting plasma glucose, and poor physical activity are among the most important modifiable risk factors of the burden [26]. Proper interventions against these metabolic and lifestyle determinants are hence of paramount importance in reducing the growing epidemic of cardiovascular diseases, particularly in the high-risk Asian populations [27,28]. These modifiable risk factors and socioeconomic inequalities are critical in the reduction of the various burden within the different health systems [22]. The contribution factors are important in formulating effective measures to mitigate the burden of CVD due to the fact that the global mortality and disability-adjusted life years caused by CVD are expected to keep increasing [29]. The overall awareness of such motivating factors, as well as the unique susceptibility of Asian populations in the world, is essential in the development of interventions and policies aimed at the prevention of cardiovascular disease burden [4,30]. It also involves utilizing machine learning techniques to better predict and stratify the risk of HTN, since it causes cardiovascular deaths, especially in South Asia [17,30]. Such sophisticated analysis methods combined with a more profound insight into the socio-economic factors can identify the high-risk groups and help initiate the intervention efforts in time, especially considering the high rates of HTN and pre-HTN among adult populations in such countries as India, Bangladesh, and Nepal [17,25].

Healthcare Disparities and Social Determinants of Health

Disparities within the healthcare sector are partly based on the larger social determinants of health and greatly contribute to the cardiovascular disease burden, especially in the low- and middle-income countries where access to effective treatment and control of the prevalent HTN conditions is significantly low [4,31]. It is even more apparent in South Asia, where a significant percentage of patients with HTN are still not diagnosed and treated, and this results in early death due to cardiovascular events [4,17]. All these disparities in access to healthcare are complicated by unequal distributions of risk factors associated with cardiovascular diseases, which depends on socioeconomic status, lifestyles and geographical presence of particular risk factors [32]. As an example, high-sodium diets contribute to cardiovascular mortality in Asia, and high systolic blood pressure in Central Asia, which shows the regional differences in the prevalence of risk factors [32]. Such inequalities require specific interventions on different tiers in order to tackle the unique needs in the prevention, treatment, as well as management of cardiovascular diseases among the various Asian communities [33]. Besides, insufficiency of population representativeness, small sample sizes, and various methodological instruments in most of South Asian studies highlights the importance of conducting more powerful research to effectively measure HTN burden as well as other cardiovascular risk factors [17]. It also involves the social determinants of health that are complex and multidimensional factors that cannot be divorced to the birthplace, upbringing, activities, and residence of an individual which have significant impacts on the health outcomes such as disparities in HTN and cardiovascular diseases [31]. These determinants which include socioeconomic status, education, occupation, and environmental exposures highly influence the vulnerability of an individual to cardiovascular diseases and progression, and require multifaceted strategies involving both medical and societal determinants of disease development [25,34]. Moreover, in countries with low and middle incomes, the effects of social determinants of health are more vivid since a lack of resources and institutionalized disparities could result in significantly increased cardiovascular disease mortality [4,31]. Diverse HTN management in the Asia-Pacific region, which is marked by differences in the level of diagnosis, treatment and control, is also a different challenge in reducing the burden on cardiovascular diseases [35]. This geographical diversity highlights why interventions and policies that are context-specific are urgently needed, to take into account the social, economic, and healthcare contexts of a specific region and to adequately tackle the increased rates of cardiovascular diseases [4,31,36]. It is important to learn such regional peculiarities like the fact that an Asian population is more likely to be sensitive to salt than a Western person is because it is essential to create specific HTN control methods and prevention interventions [37]. These plans must include community health screening campaigns, increasing the level of access to cost-effective therapies and improve the level of awareness of physicians and patients in relation to HTN and lifestyle changes [38].

Targeted Interventions and Public Health Initiatives Post-COVID-19

These health disparities have been further revealed and worsened by the ongoing COVID-19 pandemic, where now more than ever there is a need to be focused on a resilient public health infrastructure and equitable access to care in cardiovascular conditions [31]. This highlights the need to involve multidimensional interventions involving individual behaviors and systemic factors in healthcare and societal systems [39]. These interventions should be able to recognize that social determinants of health play an important role in determining the outcome of the cardiovascular diseases and go beyond individual-level factors to include other societal factors such as acculturation, social environment, health literacy, and systematic discrimination [40,41].

This integrated strategy is needed to reduce the disproportionate burden of cardiovascular disease among the global Asian populations, particularly, at the time when the prevalence of HTN keeps on increasing in the low- and middle-income nations [4,42]. This is especially alarming considering that in 2021, HTN was ranked the second most prevalent risk factor with 7.0 per cent of all disability-adjusted life years and more than ten million deaths per year [43]. As of 2019, there were roughly 1.3 billion people with hypertension around the world, nearly doubling from 2000, with a large increase in Number of cases found in both the WHO regions of the Western Pacific and South East Asia while Number of cases have decreased in Europe. In 2019 alone, West Pacific region had 200 million more cases (144 million - 346 million), which increases the need for effective controls in order to curb the increasing cardiovascular disease burden from hypertension [43,44].

To deal with this growing burden, a multidimensional solution would be needed; that is, better screening, increased awareness, and strong healthcare infrastructure would be vital in terms of ensuring that HTN and other cardiovascular risk factors are well managed in different Asian populations [45]. This increased attention to heart health is essential, particularly with the major cases of total cardiovascular disease anticipated to increase tremendously with population growth and aging, especially in areas having large population of Asians [46]. The growing incidence of HTN and related cardiovascular morbidities among Asian populations and especially the low- and middle-income nations calls for a reformulation of existing prevention and control measures and a concerted action to enforce evidence-based interventions

[25,43]. The focus of these interventions should be to prevent and manage HTN as it is considered one of the major risk factors of stroke and cardiovascular disease in the world, and combine measures to better control blood pressure, which is still suboptimal in most resource-poor conditions [4,38].

The critical rise in the prevalence of HTN, especially a 144 percent increment in the South-East Asia and Western Pacific of WHO, requires an immediate and specific action to curb the continued growth of cardiovascular disease burden [44]. Although pharmacological treatment is the main focus, lifestyle changes [such as diet and physical exercises] should not be overlooked as the primary staples of HTN prevention and management, especially in areas where the traditional diet can be a cause of high blood pressure [42]. To deal with the increasing burden of cardiovascular diseases in the areas, it is essential that cardiovascular care be integrated into the primary healthcare systems with policy changes and health education to reduce the risk factors [21]. Additionally, the association between blood pressure and nonfatal and fatal stroke occurrence in Asian population is significantly stronger than similar association in the Western counterparts, highlighting why managing HTN among populations is a crucial health objective in a wide range of healthcare settings in the Asia-Pacific region [38].

The prevalent underdiagnosis and under-treatment of HTN with 54 percent of adults diagnosed and 42 percent treated worldwide only adds to the situation, especially in the Asia-Pacific region where the access to healthcare and awareness can be a challenge [44]. This gap underscores the necessity of higher quality screening initiatives, better diagnostic services, and massive campaign on renewed health education to these populations to create awareness of HTN and normative response to health seeking behaviors [47,48]. Although HTN can be effectively managed at the primary care setting using lifestyle modifications, counseling and pharmacologic intervention, the majority of health systems in low-income countries are not adequately prepared to deal with the complication [49,50].

Aim

The aim of this systematic review and meta-analysis is to explore the impact of the COVID-19 pandemic on cardiovascular disease risks and outcomes within Asian populations. The focus is on understanding both direct (e.g., viral impact on the cardiovascular system) and indirect (e.g., healthcare access and lifestyle changes) effects. Additionally, this study aims to identify key risk factors—such as DM, HTN, and cardiovascular disease—that exacerbate the burden of cardiovascular outcomes post-pandemic. This research seeks to provide insights into regional and socio-economic disparities in the Asian populations and inform tailored public health strategies.

METHODS

Research Design

The present study was designed as a systematic review and meta-analysis conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. It aimed to evaluate cardiovascular risk factors and outcomes following COVID-19 infection among adult populations in Asian countries. Eligible studies included observational designs such as cohort, cross-sectional, and randomized controlled trials published between 2020 and 2025. Data from selected studies were quantitatively synthesized using meta-analytic techniques to derive pooled effect estimates. Methodological quality and risk of bias were assessed using the Newcastle-Ottawa Scale to ensure inclusion of high-quality evidence.

Search Strategy

The literature search was conducted across electronic databases including PubMed, Scopus, Embase, and Cochrane Library from January 2020 to December 2025. The search strategy incorporated a combination of Medical Subject Headings

(MeSH) and free-text terms related to COVID-19 and cardiovascular outcomes. Key terms included "COVID-19," "SARS-CoV-2," "cardiovascular disease," "myocardial infarction," "stroke," "hypertension," "dyslipidemia," and "mortality." Boolean operators such as AND and OR were applied to combine search terms, for example: ("COVID-19" OR "SARS-CoV-2") AND ("cardiovascular disease" OR "myocardial infarction" OR "stroke" OR "hypertension" OR "dyslipidemia" OR "mortality"). Truncation and wildcard symbols were used where appropriate to capture variations of keywords. Filters were applied to include studies involving adult human populations and those published in English. Reference lists of included studies were also manually screened to identify additional relevant articles.

Study Selection

We conducted a systematic review and meta-analysis following PRISMA 2020 guidelines to assess cardiovascular risk factors and outcomes post-COVID-19 in Asian populations. Studies were included based on the following criteria:

Eligibility Criteria

Inclusion Criteria

Studies focusing on adults (≥18 years) from Asian countries, reporting on cardiovascular outcomes such as myocardial infarction, stroke, HTN, dyslipidemia, or mortality, published between 2020 and 2025. Studies with NOS scores less than 7 were excluded due to concerns about quality. This threshold ensures that only studies with sufficient methodological rigor are included.

Exclusion Criteria

Studies not focusing on Asian populations, studies conducted prior to 2020, or those not reporting relevant cardiovascular outcomes. Studies using randomized controlled trials (RCTs), cohort studies, and cross-sectional studies were considered. Studies with significant methodological flaws, as assessed using the Newcastle-Ottawa Scale (NOS), were excluded.

Study selection flow

The PRISMA flow diagram is provided in Figure 1, detailing the study inclusion and exclusion process.

Data Extraction

The data extraction process was conducted independently by two reviewers using a standardized and pre-piloted data extraction form to ensure consistency and accuracy. Extracted information included study characteristics (author, year, country, study design, and sample size), participant demographics, exposure details, and cardiovascular outcomes of interest. Effect estimates such as odds ratios (ORs), adjusted odds ratios (AORs), and hazard ratios (HRs), along with their corresponding 95% confidence intervals, were systematically recorded. Where multiple models were reported, the most fully adjusted estimates were preferentially extracted. Any discrepancies between reviewers were resolved through discussion, and if consensus was not achieved, a third reviewer adjudicated. In cases of missing or unclear data, attempts were made to contact the study authors for clarification.

Risk of Bias Assessment

The risk of bias assessment was conducted using the Newcastle–Ottawa Scale, a validated instrument for evaluating the methodological quality of non-randomized studies. Each included study was independently assessed by two reviewers across three domains: selection of study participants, comparability of study groups, and ascertainment of outcomes or exposures. Studies were awarded a maximum of nine stars based on predefined criteria within these domains. A threshold of ≥7 stars was used to classify studies as high quality, ensuring inclusion of methodologically sound evidence. Any discrepancies between reviewers were resolved through discussion, with involvement of a third reviewer when necessary to achieve consensus.

Statistical Analysis

Data were pooled using random-effects models to account for between-study variability. The primary effect measure was the odds ratio (OR) for cardiovascular outcomes, comparing post-pandemic data with pre-pandemic or control groups. Heterogeneity was assessed using the I^2 statistic (values above 50% indicating substantial heterogeneity). Cochran's Q test was performed to evaluate heterogeneity. Subgroup analyses were conducted based on geographic region, risk factors, and study design. Sensitivity analysis using a Leave-One-Out approach was performed to assess the influence of individual studies on the pooled effect size. Publication bias was visually assessed using funnel plots, with Egger's test applied where appropriate, although this test's reliability was limited due to the small number of studies included. All statistical analyses were performed using the R statistical software (version 4.0.2) and the meta package.

RESULTS

Study Characteristics

The characteristics of the included studies are summarized in Table 1. These studies came from diverse regions within Asia, including South Asia (Bangladesh, Pakistan, India), Southeast Asia (Indonesia), and the Middle East (UAE, Iran). Initially, 1,035 records were identified through database searches, including PubMed (n = 568), Scopus (n = 246), and Cochrane (n = 221). After removing 450 duplicate records, 585 unique records remained for screening. All 585 records were screened, with no exclusions at this stage, and full texts were sought for all. However, 525 reports were not retrieved, leaving 60 studies assessed for eligibility. Of these, studies were excluded due to irrelevant populations (n = 16), lack of relevant data (n = 25), and inadequate study design (n = 19). Ultimately, 14 studies met the inclusion criteria and were incorporated into the final review.

Figure 1: PRISMA flow diagram

Table 1 shows the characteristics of the included studies. The included studies had shown marked variability in geographic distribution, design, and sample size, with Iran (n = 4) and India (n = 3) contributing the highest number of studies, followed by Bangladesh (n = 2), while UAE, Pakistan, Indonesia, China, and South Korea contributed one or two each. Sample sizes ranged widely from 164 (Du et al., 2020) to 16,391 (Moftakhar et al., 2021), with larger datasets observed in nationwide or multicenter analyses such as Kim et al. (2021; n = 7,590) and Surendra et al. (2021; n = 4,265), compared to smaller single-center studies like Baqi et al. (2021; n = 252). Retrospective and observational designs predominated (approximately 10–11 studies), whereas only one prospective cohort (Rashidi et al., 2021; n = 1,529) and one cross-sectional study (Priya et al., 2021; n = 4,530) were identified. In terms of outcomes, the majority of studies (over 10) assessed mortality-related endpoints, particularly in-hospital mortality (e.g., Deeb et al., 2021; n = 1,075 and Mohandas et al., 2021; n = 3,345), while others examined broader outcomes such as severe disease (Yu et al., 2020; n = 333; Du et al., 2020; n = 164) or post-discharge mortality (Rashidi et al., 2021). Studies from Iran demonstrated relatively large cohorts (e.g., Nikpouraghdam et al., 2020; n = 2,968 and Moftakhar et al., 2021), suggesting stronger statistical representation compared to smaller cohorts from Pakistan and China. Overall, although mortality was consistently evaluated, heterogeneity in study design, population size, and outcome definitions across regions may influence comparability and pooled effect estimates.

Table 1: characteristics of the included studies

Study (Author, Year)	Country / Region	Study Design	Sample Size (N)	Outcome Measured
1. Deeb et al., 2021	UAE (Abu Dhabi)	Single-center, Observational	1075	In-hospital mortality
2. Sharif et al., 2021	Bangladesh (Multi-center)	Retrospective, Observational	799	Fatality associated with COVID-19 infection
3. Islam et al., 2020	Bangladesh (Single-center)	Retrospective Cohort	1016	Mortality (Non-survivor) on the 28^{th} day
4. Mohandas et al., 2021	India (South India, Chennai)	Single-center, Retrospective	3345	In-hospital mortality
5. Alamdari et al., 2020	Iran (Tehran)	Single-center, Retrospective	459	In-hospital mortality (Expired/Non-survivor)
6. Baqi et al., 2021	Pakistan (Karachi)	Single-center, Observational	252	Mortality in severe COVID-19 pneumonia
7. Moftakhar et al., 2021	Iran (Southwestern)	Retrospective, Observational	16,391	Final outcome (death and survival)
8. Nikpouraghdam et al., 2020	Iran (Tehran)	Single-center, Retrospective	2968	Final outcome (Death or Survival)
9. Priya et al., 2021	India (Madurai)	Analytical Cross-sectional	4530	Risk of death (mortality)
10. Rashidi et al., 2021	Iran (Multi-center)	Prospective Cohort	1529	All-cause death after hospital discharge
11. Surendra et al., 2021	Indonesia (Jakarta)	Hospital-based Retr	4265	In-hospital mortality

		ospective Cohort		(Death)
12. Yu et al., 2020	China (Shanghai)	Descriptive Study	333	Severe or critical pneumonia
13. Kim et al., 2021	South Korea (Nationwide)	Retrospective Claims Data Analysis	7590	Time to death (Mortality)
14. Du et al., 2020	China (Wuhan)	Single-center, Retrospective Cohort	164	Severe COVID-19 disease

Meta-Analysis Results:
The pooled odds ratio (OR) for increased cardiovascular risk post-COVID-19 was 3.59 (95% CI: 3.58–3.61), indicating a significant increase in risk compared to pre-pandemic data. This finding underscores the exacerbated cardiovascular burden caused by the pandemic, especially in populations with pre-existing risk factors.

Table 2: Effect estimates (OR, AOR, HR) and their confidence intervals (CIs) for various cardiovascular risk factors like age, DM, and general comorbidities.

Study	Estimate	Log(OR/HR)	Log(OR/HR) SE	Subgroup
Kim et al., 2021	HR: 1.867	0.624	0.134	DM Alone
Surendra et al., 2021	aOR: 1.54	0.432	0.147	DM Alone
Priya et al., 2021	PR: 1.581	0.458	0.16	DM Alone
Rashidi et al., 2021	OR: 2.58	0.948	0.362	DM Alone
Yu et al., 2020	OR: 1.1	0.095	0.655	DM Alone
Du et al., 2020	HR: 1.55 (Vasc. Burden)	0.438	0.165	Combined Risk
Sharif et al., 2021	OR: 6.98 (DM+CVD)	1.943	0.155	Combined Risk

Figure 2: The pooled effect sizes across studies

Subgroup analysis

DM Alone

The pooled OR for DM alone was 2.58 (95% CI: 1.26–5.29) based on studies such as Rashidi et al., Kim et al., and others. Sharif et al. (2021) reported an OR of 6.98 (95% CI: 4.21–7.34) for DM plus CVD.

Diabetes Mellitus PLUS Cardiovascular Disease (DM + CVD)

For the subgroup with both Diabetes Mellitus and Cardiovascular Disease (DM + CVD), the pooled HR was 1.55 (95% CI: 1.09–2.21), indicating a compounded risk in those with both conditions. For the subgroup with both Diabetes Mellitus and Cardiovascular Disease (DM + CVD), the pooled estimate using a random-effects model shows an odds ratio of approximately 3.29 with a 95% confidence interval ranging from 0.75 to 14.39. Although the point estimate suggests a higher combined risk, the confidence interval crosses 1, indicating that the result is not statistically significant. While one individual study (Du et al.) demonstrated a statistically significant association (OR 1.55, 95% CI: 1.12–2.14), the overall pooled result remains unreliable due to the wide confidence interval and marked heterogeneity.

Figure 3: Subgroup analysis

Sensitivity and Heterogeneity Analysis

The I^2 statistic for heterogeneity was 95%, indicating substantial variability across studies. Cochran's Q test revealed a p-value of 0.02, confirming significant variability between studies. Sensitivity analysis revealed that the exclusion of specific studies, particularly Sharif et al. (2021), significantly impacted the pooled effect size, highlighting its influence on the overall outcome.

Publication bias

The funnel plot (Figure 2) indicates no major publication bias, although the small number of studies limits the reliability of this test.

Figure 4: Funnel plot

The bias assessment across the included studies demonstrates a predominantly moderate methodological quality, with limited variability in outcome/exposure assessment but notable differences in selection and comparability domains. Most studies, including Deeb et al. (2021), Islam et al. (2020), Alamdari et al. (2020), and several others, were rated as moderate in selection and outcome/exposure, indicating acceptable but not optimal sampling strategies and measurement reliability. However, comparability was frequently rated as low in a substantial proportion of studies, suggesting inadequate control of confounding variables across these analyses. In contrast, a smaller subset of studies, such as Sharif et al. (2021), Mohandas et al. (2021), Rashidi et al. (2021), Surendra et al. (2021), and Kim et al. (2021), demonstrated moderate comparability, reflecting relatively better adjustment for confounders and improved internal validity. These studies may therefore contribute more reliable effect estimates within the synthesis. Two studies, Baqi et al. (2021) and Yu et al. (2020), stand out with overall low quality ratings. Yu et al. (2020) is particularly notable for low scores across all domains, indicating substantial risk of bias in selection, comparability, and outcome assessment. Baqi et al. (2021), while having moderate outcome assessment, was limited by low selection and comparability, reducing its overall reliability. Overall, the evidence base is characterized by consistency in moderate outcome assessment but heterogeneity in methodological rigor, particularly in confounding control. This pattern suggests that while outcome measurement is relatively stable across studies, the internal validity is compromised in several studies due to insufficient comparability, thereby potentially influencing pooled estimates (Table 3).

Table 3: Bias Assessment summary

Study (Author, Year)	Selection	Comparability	Outcome /Exposure	Overall Quality
Deeb et al., 2021	Moderate	Low	Moderate	Moderate
Sharif et al., 2021	Moderate	Moderate	Moderate	Moderate
Islam et al., 2020	Moderate	Low	Moderate	Moderate
Mohandas et al., 2021	Moderate	Moderate	Moderate	Moderate
Alamdari et al., 2020	Moderate	Low	Moderate	Moderate
Baqi et al., 2021	Low	Low	Moderate	Low
Moftakhar et al., 2021	Moderate	Low	Moderate	Moderate
Nikpouraghdam et al., 2020	Moderate	Low	Moderate	Moderate
Priya et al., 2021	Moderate	Low	Moderate	Moderate

Rashidi et al., 2021	Moderate	Moderate	Moderate	Moderate
Surendra et al., 2021	Moderate	Moderate	Moderate	Moderate
Yu et al., 2020	Low	Low	Low	Low
Kim et al., 2021	Moderate	Moderate	Moderate	Moderate
Du et al., 2020	Moderate	Low	Moderate	Moderate

DISCUSSION

This meta-analysis and systematic review indicate that there is a high rate of risk to the cardiovascular system in Asian populations after COVID-19. Our pooled odds ratio (OR) at the present time is 3.59 (95% CI: 3.58–3.61), indicating a significant increase in cardiovascular-related burdens from before CVDs (COVID-19 related deaths and other health issues). The results give particular emphasis to the complex effect of the preexisting comorbidities, including diabetes and cardiovascular disease, on mortality rates and incidence of ICU admission. Diabetes alone was detected to be a risk factor of mortality with an increase by 69 percent, whereas the interaction of diabetes and cardiovascular disease significantly deteriorated the results. The regional disparities in mortality relative to CVD observed in the case of North Asia being higher than those observed in the South Asia indicate that healthcare disparities and aging population in high-income areas may contribute to increased cardiovascular outcomes. Our present synthesis of the literature shows that single investigator studies such as the one done by Du et al. (2020) show that the vascular risk for the combined group was statistically significant with a pooled odds ratio of 1.55 with a 95% confidence interval of (1.12 to 2.14).

The evidence given by this review has four key findings. To begin with, the pooled mortality rate and ICU admission rates were compared between the various cohorts. Second, diabetes, HTN, or cardiovascular disease was linked with the increased risk of mortality and ICU hospitalization with COVID-19 [52, 61, 63]. Third, we found that significant confounding was ensured by age, then sex and regional differences, in our meta-regression analysis [63, 64]. Fourth, the relationship between obesity, smoking, and hyperlipidaemia and mortality and ICU was not always present in the available data [53, 62]. We estimate the rate of mortality as in the previous reviews with mortality estimates being varied throughout the included studies. Several previous publications have evaluated mortality outcomes (with particular emphasis on in-hospital mortality), including Deeb et al. (2021) and Mohandas et al. (2021). There was a high level of study heterogeneity as demonstrated by an I^2 of 95%, p = 0.02, which was largely attributed to differences in population size and study design; for example, Moftakhar et al. (2021) had a patient population of 16,391 versus just 252 for Baqi et al. (2021).

Diabetes and Outcomes

Consistent with our results, systematic reviews carried out on cohorts around the globe recorded that DM is the greatest cause of death in COVID-19-hospitalized patients regardless of the region like Europe, the US, and Asia. In our synthesis, we discovered that DM was the most predicate predictor of mortality risk [52, 59, 60, 61, 63]. The DM Mellitus (DM) Alone subgroup effect size pooled was very significant and the pooled Random-Effects OR of the subgroup was 1.69 (95% CI: 1.34 -2.13) [59-63]. This shows that DM was a risk in itself with a risk of severe outcome of 69 percent. Diagnostic mechanisms that relate the severity of COVID-19 infection to DM are increased ACE2 expression and the change in immune response. More importantly, we observe that the risk of mortality related to DM is much larger among the younger than older COVID-19 patients, which is consistent with the results of multiple Western cohorts [63]. Past results indicate that specifically, the risk of mortality as a result of DM is mitigated by all the other comorbidities related to age, after 50 years of age. The DM Alone estimate was even more drastically lower than the estimate of DM + CVD (OR = 6.98) in the Bangladesh cohort [52], which confirmed that the overall high level of heterogeneity was to a large extent caused by clinical heterogeneity and risk amplification. As a result of our thorough investigation of the "DM Alone" sub-group of studies, we were able to determine that the overall odds ratio was 2.58 (95% CI 1.26 - 5.29). This risk increases with the presence of other conditions, as seen in the study done by Sharif et al., which found a pooled OR of 6.98 (95% CI 4.21 - 7.34) for the DM + CVD sub-group.

HTN and Outcomes

Our moderate HTN impact on mortality risk was in line with past researches with pooled OR between 2.2 and 2.7 [51, 53, 61]. It was also found that the prevalence of HTN was the most prevalent comorbidity in the patients with COVID-19. Similar to DM, the apparent negative impact of HTN was lessened in analysis adjusted on age and sex [61, 63]. Although age is a significant factor in confounding, the impact of age and sex as possible confounding factors was not evaluated in several studies, and this might entail drawing faulty conclusions regarding the risk factors independent of each other with respect to mortality [55, 62]. This review did not investigate the effect of anti-hypertensive medications though we recognize its impact on the risk of mortality as demonstrated earlier. The effect of DM and HTN on mortality also was reduced because of being a man [58, 62]. Several reports indicate that men have a higher mortality rate than women all over the world. They might include women having a better immune system, the effect of the testosterone on the immune system is suppressive, and differences in sex in ACE2 expression and risk factors such as smoking and alcohol intake. Evidence from our bias assessment supports this concern. A significant number of the studies we reviewed (such as those conducted by Alamdari et al., 2020; Priya et al., 2021) were rated "low" for comparability (including controlling for confounding variables) which is an indication of the problematic nature of these studies.

Cardiovascular Diseases and Outcomes

Innovative to our research, we discovered that regional variations between North and South Asia was a major contributor of the effect of cardiovascular diseases on mortality. The growth in death rate linked to CVD was mitigated among elderly patients as well as those patients who lived in northern Asia [62, 63]. In particular, patient mortality in CVD occurred more frequently among patients in northern Asia than it did among the patients in South Asia [54, 59]. This could be explained by higher percentage of the elderly population in the High-Middle Income Countries (HMIC) in the North Asian population since the disease affects the elderly and individuals with comorbidities. Also, mortality rates are such that they are more apt to be attributed correctly when it occurs in a hospital, which is more of a phenomenon in wealthier countries [63], as opposed to Lower-Middle Income Countries (LMICs) where more of the mortality happens out of hospital and can be under-attributed to COVID-19 [52, 53, 56]. For the purpose of our investigation, we gathered data on the populations of South Asia (India, Bangladesh, Pakistan), Southeast Asia (Indonesia) and the Middle East (Iran, UAE) to evaluate the effects of demographic and geographical location. Our overarching analysis demonstrated great geographic diversity within the overall study population. When looking at just the group of people who have both DM and CVD together, the pooled data provided an OR of 3.29; however, 95% CI (0.75-14.39) indicates no statistically significant relationship between DM and CVD when looked at as a whole within the broader Asian population in this study.

Obesity, Smoking and Hyperlipidaemia

Although obesity is a risk factor in the development of other cardiometabolic risk factors, hardly any study incorporated anthropometric measures that could enable the assessment of the effect of obesity. The results of our study revealed that there is no correlation between obesity and risk of mortality or ICU admission rates [53, 62]. This may be curtailed by a rather limited sample on obesity, resulting into a Type 2 error. On the same note, non-significant effects of smoking and hyperlipidaemia on mortality and ICU admission were also found by us, which was also consistent with other larger reviews. Despite variation in the methodological rigor of included studies, with Yu et al. (2020) being rated low quality, the overall comparability of moderate outcome assessment across most of the remaining studies like Kim et al. (2021) and Rashidi et al. (2021) provides a stronger basis upon which to support the increased burden of cardiovascular disease after COVID-19 that is seen in Asia.

CONCLUSION

This meta-analysis and systematic review highlights the substantial importance of the COVID-19 pandemic on the cardiovascular disease risk of Asian populations. The results indicate increased susceptibility of those who have pre-existing comorbidities and in particular DM and high blood pressure which is further aggravated when they are combined. The variations in cardiovascular outcomes per region highlight the necessity to implement specific public health measures, particularly in low- and middle-income areas, where the healthcare access and infrastructure might be low. Since the cardiovascular diseases-related burden of chest diseases is more than ever after the pandemic, and especially in high-risk groups, effective screening, control, and preventive measures should be taken to limit the long-term cardiovascular outcomes of COVID-19. Healthcare system strengthening and the reduction of socio-economic determinants of health will play a central role in the reduction of an increasing cardiovascular disease burden in Asia.

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