

# **The Global Burden and Risk Factors of Cardiovascular Diseases in Adolescent and Young Adults: A Systematic Review**

## **Abstract**

**Background and objectives:** Globally, cardiovascular diseases (CVDs), mainly stroke and ischemic heart disease (IHD) remain the leading and major causes of mortality in addition to being the key contributors to disabilities. The objective of this systematic review entails the evaluation of the global burden and the risk factors associated with CVDs in adolescents and young adults. To attain this objective, the study will examine the various underlying causes of CVD mortality and the associated risk factors.

**Methodology:** The study entailed an in-depth search of various online databases for original studies focusing on the global burden of CVDs and risk factors in adolescents and young adults. The search was conducted on databases that included Embase, PubMed, Google Scholar, SCOPUS, and Web of Science. The identified studies were subjected to evaluation and screening, and the selection of the apt studies was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A total of 15 studies were selected and included in this systematic review

**Results:** CVD prevalence and incidence rates in adolescents and young adults are highest in low and low-middle socio-demographic index (SDI) nations, despite the CVD burden progressively increasing in high and high-middle SDI countries. Male adolescents and young adults have the highest prevalence, incidence, and disability-adjusted life year (DALY), and mortality rates for endocarditis, even as females aged 30 to 39 years have the highest atrial fibrillation and atrial flutter-related DALY and mortality rates.

**Conclusion:** The global CVD burden in adolescents and young adults remains a major global health challenge. Therefore, it is important that factors that include disparities observed in the SDI levels amongst the nations, age and gender attributes of the populaces, the primary CVD

types, and the various attributable risk factors are taken into consideration during the formulation and execution of prevention strategies and interventions.

## **Introduction**

Cardiovascular diseases (CVDs), mainly stroke and ischemic heart disease, are not only major threats to human life and health, but are also the leading causes of mortality and morbidity, and key contributors to disability [1]. Often, individuals get exposed to different risk factors for CVD development as they age and across their lifespans, and this has been attributed to atherosclerosis pathological basis, beginning in early childhood and continuing throughout life [2-5]. Often, individuals get exposed to different risk factors for CVD development as they age and across their lifespans, and this has been attributed to CVD's atherosclerosis pathological basis, beginning in early childhood and continuing throughout life [2-5]. Globally, the total number of deaths attributable to CVDs has increased in the last two decades by over 12.5%, even as CVDs presently account for close to a third of the deaths occurring globally. While CVDs often infrequently occur in children, extant literature has explicitly indicated that the various risk factors for development of CVDs begins during childhood, owing to the atherosclerotic pathological basis of CVDs, and continue throughout an individual's life [3-4, 6]. However, in adolescents and young adults (individuals aged between 15 and 39 years), CVDs such as rheumatic heart disease (RHD), which is the key cause of heart failure, often requires cardiac surgery, particularly in the low and middle-income nations [7, 8]. Age's role as an independent risk factor with regard to CVD development is more pronounced after adulthood [6], even as CVD is considered the major disease type plundering life and affecting life quality up to old age.

Additionally, being the linkage between the present and past lives, adolescence and young adulthood bear the major challenges and burdens related to human psychological and physical changes [8]. Nevertheless, a limited number of studies and less focus has been placed on CVDs prevalence and risk factors in adolescents and young adults, as well as their needs with regard to CVD treatment, care, and management. Effective action demands dependable data and research on CVDs, its risk factors, as well as data regarding barriers to treatment and prevention, as this will assist in the development and execution of evidence-based health policy on CVDs in adolescents and young adults.

Furthermore, despite the observed increase in CVD mortality rates, the global absolute incidence rate of CVDs in adolescents and young adults increased by approximately 45.5% between 1990 and 2019, even as CVD-related mortality and DALYs were noted to have increased by 21.6% and 18%, correspondingly [9]. Globally, as at the end of 2019, a total of 5.7 million incidents of CVDs were reported, alongside 45.4 million CVD-linked DALYs, as well as nearly 761,000 CVD-linked deaths in adolescents and young adults [9]. However, the CVD-related mortality and DALYs in higher-SDI nations was noted to have declined by approximately 24.8% and 28.5%, correspondingly, between 1990 and 2019 [9]. On the contrary, the CVD incidence, CVD-related mortality, and CVD-linked DALYs rates were noted to have significantly increased in the low-SDI nations, by approximately 132.7%, 80.2%, and 85.1%, correspondingly [10]. The endocarditis and non-rheumatic calcific aortic valve disease incidence rates have continuously increased across the SDI regions. Similarly, males and females' incidence patterns with regard to CVDs have comparatively increased in a similar pattern, particularly with regard to endocarditis and non-rheumatic calcific aortic valve disease; however, significant decrements have been reported in peripheral artery disease and non-rheumatic degenerative mitral valve disease trends. Based on the observations above, this systematic review offers the best opportunity to evaluate the global burden of CVD and the associated risk factors in adolescents and young adults. Thus, the objective of this systematic review is to evaluate and report the global CVD burden and risk factors in adolescents and young adults, as well as compare the distribution of the burden based on gender and nations/regions with divergent degrees of economic development, as well as evaluate the risk factors for CVDs in the study population.

### **CVD Burden Risk Factors**

Among the notable risk factors of CVD burden in global adolescents and young adult populations, higher systolic blood pressure (SBP) has been considered a key risk factor for both CVD events and mortality rates [11]. Comparable outcomes have been found in the present systematic review. For instance, high SBP has been acknowledged as the main cause of CVD burden within the global adolescents and young adult population with an over 40% paroxysmal atrial fibrillation (PAF). Significant effects have also been noted with high BMI and high LDL cholesterol on CVD burden, both with over 30% PAF. For instance, a study conducted by Khan et al. disclosed that a larger proportion of CVD-related deaths occurred within the higher BMI

categories in adolescents and young adults, who are obese and overweight [12]. The rising prevalence of obesity and hypertension among adolescents, children, and young adults has turned out to be a major public health concern [13, 14]. For instance, globally, as at 2016, approximately 50 million girls and 74 million boys were obese, even as another 213 million individuals (children and adolescents) were categorized as overweight [15]. Such statistics emphasize the need for effective control and management of body weight, blood pressure, and LDL cholesterol, which should also be conducted during the development of CVD prevention interventions and strategies for adolescents and young adults. Moreover, there is a need to put emphasis on aspects of gender differences in CVD burden and risk factors in adolescents and young adults.

## **Materials and methods**

For this study, pertinent research alongside peer-reviewed studies published in English were identified through an in-depth search of different virtual medical databases that included Embase, PubMed, Google Scholar, SCOPUS, and Web of Science, covering 2010 to 2024. The articles selected include health assessment studies, epidemiological studies, multi-center studies and published peer-reviewed studies. All the studies had de-identified data. Furthermore, duplicate data sources were identified through a comparison of various studies and articles with similar population years. To identify the apt literature, MeSH keywords that included cardiovascular diseases, CVD mortality, adolescents, young adults, and ischemic heart disease were employed. The in-depth search conducted yielded a total of 898 articles.

## ***Inclusion and exclusion criteria***

Following the duplicates removal, the relevant articles were chosen using a three-stage process. The initial stage entailed screening of the article's titles and abstracts. The second stage entailed the exclusion of irrelevant articles, while the third stage entailed an in-depth full-text assessment of chosen articles to confirm relevance. To do this, three independent reviewers were tasked with the article's screening process, and any potential discrepancy was resolved using consensus and consultation.

Required in the inclusion criteria were mainly original studies, including crossover design studies, prospective cohort studies, and randomized controlled trials that satisfied the following set criteria: scientific publication of original study findings, articles published in high-impact factor peer-reviewed journals between 2010 and 2024, and also studies published in English Language. To be included, the studies must have investigated the global cardiovascular disease burden and included adolescents and young adults as the main participants.

For this study, the researchers excluded editorials, narrative reviews, and sponsored clinical trials. Additionally, studies that did not utilize standard tools in assessing the global burden of CVDs in adolescents and young adults, and devoid of any relevance to the study population. Studies found to be inaccessible or with illogical materials and methods were similarly excluded. Following the set exclusion criteria, a total of 965 articles were excluded.

For this systematic review, pertinent data was extracted from the qualified studies. The general study attributes, including the authors' names, publication and study year, and the sampling methods used were collected. Moreover, the researchers collected the various study population attributes, including sample size, gender and age, race, and follow-up information. Also documented were the intervention types utilized, and the duration of the intervention, among others. Ultimately, the main findings of every study were noted.

The study selection process was aptly performed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The first database search led to the retrieval of 988 article records. Following the screening, a total of 578 duplicates were eliminated, while another 207 articles were found ineligible through automation. An additional 130 articles were excluded for different reasons, such as misalignment with the objectives of this study, protocol issues (19 articles), and failure to report on study limitations (10 articles). Studies published in non-peer-reviewed journals and dissertations were also excluded. The researchers excluded studies that were first published in languages other than English, articles by non-academics, opinion pieces, scoping reviews, non-primary research types, and secondary studies.

Eventually, a total of 73 qualified articles were subjected to further screening, leading to the exclusion of 14 articles. The remaining 59 studies were then sought for retrieval, out of which a total of 20 articles were irretrievable. As a result, 39 studies underwent eligibility assessment,

resulting in the 34 articles following full-text screening, for reasons that included irretrievable full text (2 articles), failure to report limitations (1 article), and protocol issues (2 articles). The process of article selection has been presented in the PRISMA flow diagram in Figure 1.

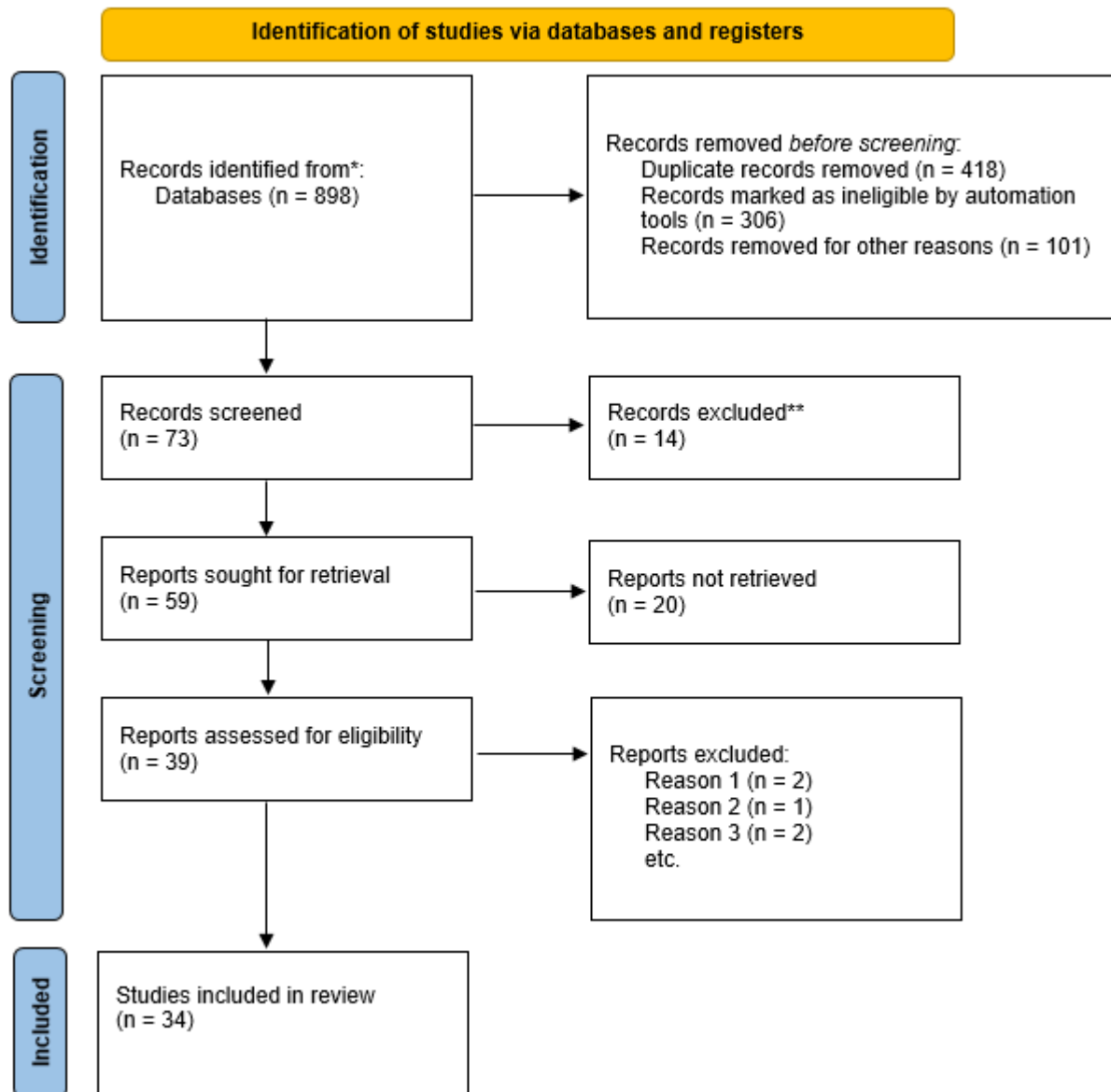


Figure 1: PRISMA flow diagram indicating the study selection process for this systematic review.

### Quality assessment

The evaluation of the included studies' quality was mainly conducted through the use of the Appraisal Tool for Cross-Sectional Studies, a 20-item critical evaluation tool for cross-sectional studies. Three authors were tasked with the independent evaluation of each study, while two

authors were required to confirm the assessments. Any possible disagreement and discrepancy was mainly resolved through consensus and discussion.

### ***Data extraction***

The authors developed a data extraction form to extract pertinent data from the selected studies. This was subsequently followed by a collection of data on the studies' attributes, including the sample sizes, names of the authors, publication year, study location, findings, research design, stigma prevalence, correlates, and impacts on the health outcomes. The data was extracted independently by the authors, and potential discrepancies were solved through consensus and discussions.

### **Discussion**

Reports show that significant reductions have been realized in relation to the mortality rates and age-standardized DALY of overall CVDs, the last 30 years has witnessed significant increments in both the incidence and prevalence rates in adolescents and young adults aged 15-39 years. This has been corroborated by findings of the study conducted by Roth et al., which indicated that, during the last 30 years, the global CVDs prevalence increased by 93% while CVD mortality rates increased by approximately 54%, representing a third of all annual deaths globally [16]. Furthermore, considerable increments in prevalence rates and age-standardized incidence rates have been reported in various kinds of CVDs, including rheumatic heart disease, stroke, IHD, and endocarditis between 1990 and 2019 [17-20, 22]. In agreement, Masaebi et al. have observed that, regardless of the remarkable improvements in prevention, as well as timely and early diagnosis and treatment, CVDs have continued to impose a significant socioeconomic burden on the global communities and health systems [17].

Nevertheless, it is noteworthy that the highest mortality rates due to CVDs have been reported in nations categorized as low and low-middle socio-demographic index (SDI), despite the observed steeper increment in CVD mortality rates in high and high-middle SDI nations [16]. Individuals aged 25-39 years have also been reported to have the highest DALY prevalence and incidence rates, alongside highest endocarditis mortality rates while females aged 30-39 years had the highest mortality rates alongside DALY attributable to flutter and atrial fibrillation [16].

Although non-communicable diseases (NCDs) have been acknowledged to account for 60% of

DALYs globally, approximately a quarter of the burden can be attributed to CVDs [23]. Consequently, several studies have further reported higher systolic blood pressure (SBP), higher body mass index (BMI), as well as high low-density lipoprotein (LDL) cholesterol as the major factors of DALY for CVDs [16-19].

Moreover, according to Adekoya et al., in low and low-middle-income countries (LMICS), higher rates of DALY for CVDs have been attributed to the household air pollution (HAP) due to the use of solid fuel, which is lacking in the middle, high-middle and high SDI nations [24]. Consequently, the studies have disclosed that males are affected more, almost in all risk factors, including smoking, in comparison to females [25]. These findings proffer important perspectives with regard to the global prevalence and incidence rates of CVD burden and the risk factors in adolescents and young adults, and makes an urgent call for action that not only inform priority setting but also informs resource mobilization and allocation for the healthcare, public health, and research on younger persons' health from the global point of view.

Many original and earlier studies, including studies conducted by Shi et al., Roth et al., Song et al., and Feigin et al. have reported greater global burden of CVDs within the general population, particularly in individuals aged 15 to 90 years [16, 20-22, 26]. Contrary to the diminishing trends of CVDs in middle-aged and elderly adults globally, Shi et al., and Andersson and Vasan, have, in their studies, disclosed that adolescents and young adults had a steady increment in the CVD incidence and prevalence rates [26, 27]. Similarly, the prevalence rates of numerous type-definite CVDs, including rheumatic heart disease, stroke, and IHD, have significantly increased in adolescents and young adults [16]. Despite these observations and findings, a limited number of studies have studied NCDs in adolescents and young adults [28]. Still, the findings of different studies focusing on ischemic stroke in adolescents and young adults have been inconsistent [29]. For instance, a study conducted in the European Union member states disclosed that the general and type-definite CVDs DALY and mortality rates in adolescents and young adults significantly decreased between 1990 and 2020, except for the endocarditis incidence rates [28]. Nonetheless, European Union member states are mostly high SDI nations, without the low and middle SDI nations being aptly represented. Further, Giovanni et al.'s study carried out globally in 204 nations disclosed that the CVD-related DALY and mortality rates in adolescents and young adults aged between 15 and 39 years significantly declined across the globe between

1990 and 2019 [19]. However, globally, the prevalence of CVDs consistently increased in adolescents and young adults, emphasizing the need to develop effective targeted prevention and management interventions. Extant public health interventions, including healthcare services coordination and expansion through inter-professional collaborations and care continuity, health-promotion school programs, affordable and accessible rehabilitation facilities, and digital decision-making tools use, are vital to the growing global burden of CVDs in this population demographic, as they conceptualize the care providers and involved organizations to ascertain provision of appropriate care at the most appropriate time [30, 31].

The CVDs-related DALY in adolescents and young adult populations are attributable to various metabolic risk factors, including the increase in SBP, high BMI, and increase in LDL cholesterol. In this regard, Wang et al. observed that, despite the stability of the global age-standardized DALY rates of elevated LDL cholesterol and SBP between 1990 and 2019, the DALY rates, attributable to higher BMI, have significantly increased in the adolescents and young adults populations [17]. For instance, in individuals aged 15 to 39 years, the age-standardized DALY rate attributable to higher BMI witnessed considerable increment, even as high SBP and LDL cholesterol rates moderately declined despite being consistently stable [16]. These findings emphasize the urgent need to tackle the risk factors for CVDs, including behavioral risks such as poor diets and smoking, in addition to ambient particulate matter pollution. Owing to the possibility of preventing CVDs through lifestyle adjustments, timely at-risk person identification, as well as promotion of healthy dietary patterns, stopping smoking, and regular physical activities, the burden of CVD may be mitigated [32]. Nonetheless, these interventions have not been effective in preventing the increase in CVDs prevalence and incidence rates in adolescents and young adults. Extant evidence further indicates that CVDs may be effectively controlled through execution of effective healthy interventions [33, 34]. For instance, timely interventions targeting at-high-risk groups, along with effective CVD burden management should include early intervention efforts that seek to mitigate the risk factors using strategies that promote adolescents and young adults' cessation of smoking, consumption of healthy diets, and engagement in regular physical activities [35].

In comparison to the previous studies that focused on ischemic stroke's prevalence to adolescents and young adults, Zhang et al. disclosed that persons aged 15 to 39 years in high SDI

nations had lesser overall CVDs burden than those in low and middle SDI nations [9]. Zhang et al. has also reported a negative correlation between SDI and the age-standardized prevalence rate, incidence rate, DALY, and mortality rate of CVDs [9]. Ostensibly, in high SDI nations, the lower burden for CVDs is attributable to different factors, including advanced care services and interventions sensitive to CVDs and effective in the screening of CVD risk factors, thereby enabling early detection and improved management of the CVD risk factors [36]. Consequently, in LMICs, the higher CVDs burden has been attributed to increased exposure to risk factors that include smoking, dietary factors, obesity and hypertension, changes in socioeconomic conditions, and inequalities in use, availability, and access to care [37]. Inadequate investment in healthcare alongside insufficient health-related knowledge by adolescents and young adults has also been linked to the increasing CVD burden in adolescents and young adults in LMICs [38]. Further, household air pollution (HAP) originating from the use of solid fuel is considered a key risk factor for CVD in individuals aged 15-39 years in LMICs, compared to those in middle, high-middle and high SDI nations, as the former has been acknowledged to contribute to a higher CVD burden. Therefore, targeted interventions that enhance the conditions of households in low- and middle-income nations. Certain public interventions pertaining to the reduction of HAP have adequate evidence, including the replacement of traditional cooking stoves devoid of chimneys executed in low and middle income nations has proven effective [39].

Still, a number of studies have equally indicated effectiveness and feasibility of interventions that target several risk factors for prevention of CVDs in low and middle income nations [40]. Further, additional studies have disclosed that nations in Africa, Eastern Europe, and Central Asia experienced faster increments in the incidence and prevalence rate of CVDs than countries from other regions of the world [41]. Owing to factors that include frequent military conflict and transitional recessions, individuals, including adolescents and young adults, residing in nations in Africa, Eastern Europe, and Central Asia regions have reduced access to healthcare services [41-43]. Nations in the Sub-Saharan Africa regions have a low capability to respond to the fast increasing prevalence and incidence rates of CVDs as a result of underfunding, insufficient resources, and weaker healthcare systems [44]. As such, there is a need for more targeted healthcare resources allocation to low and middle SDI nations and regions, in addition to the need to develop country-specific policies aimed at reducing the poverty levels, as well as socioeconomic and health disparities, as this will ascertain early prevention and management of

CVDs in adolescents and young adults in such nations and regions. Remarkably, this systematic review has found that, for various type-definite CVDs, the high SDI nations and regions had a higher burden of atrial fibrillation and flutter than the low and middle SDI nations [45].

Adolescents and young adults in high-income nations have additionally been found to report increased frequencies of high stress, abdominal obesity, smoking, and alcohol use [46]. Thus, targeted interventions aimed at such type-specific CVDs, particularly in high SDI nations should be implemented to reduce the prevalence and incidence rates.

Consequently, with regard to global burden of CVDs based on gender, various recent studies have indicated that overall CVD prevalence, incidence, and mortality rates, as well as age-standardized DALY was higher in male adolescents and young adults, compared to their female counterparts within the same age group, and that the dissimilarities on the basis of sex became broader with increase in age [47]. Still, regarding the type definite CVDs, in concurrence with the findings of earlier studies that focused on ischemic stroke in adolescents and young adults [48], this systematic review has disclosed that, as at the end of 2019, males had a higher rate of stroke-related mortality and age-standardized DALY compared to females. Further, this systematic review has disclosed that male adolescents and young adults had a prevalence, incidence, mortality, and DALY rates of cardiomyopathy, IHD, and myocarditis in comparison to their female counterparts of similar age groups [48]. Further, the study has disclosed that young male adults aged between 25 and 39 years experienced an increased burden of CVD resulting from endocarditis [9]. Additional experimental studies that have utilized gerbils have indicated that men tend to have increased levels of histological damages along with severe neurological sequelae in comparison to the women following unilateral carotid artery occlusion [49]. According to Chauhan et al., the sex-definite pathophysiology in soluble epoxide hydrolase resulting in varied responses in relation to ischemic conditions has also been found to significantly contribute to the observed sex differences owing to the protection with regard to preservations of infarct volume and blood flow in women [49]. Also, in women (general), estrogens play an active protective role in both the lipid homeostasis and endothelial functions [50, 51]. Nevertheless, in concurrence with the previous studies findings [52], this systematic review has disclosed that young female adults aged between 30 and 39 years presented a higher burden of atrial fibrillation and flutter. In this regard, it has been noted that an increased prevalence of atrial fibrosis in young adult women with atrial fibrillation is more likely to

increasingly predispose them IHD, ischemic attacks, and even death than their male counterparts within the same age brackets [53]. Further, this study has disclosed that adolescents and young adults reported increased prevalence and incidence rates of IHD, regardless of the gender/sex, even as only females aged between 30 and 39 years presented increased incidence rate of IHD. The higher incidence of CVD burden in adolescents and young adult males than females has additionally been attributed to smoking [47]. The findings of this systematic review, therefore, emphasizes the need to ascertain that sex and age in healthcare services are mainstream, and targeted gender-sensitive health interventions and policies, including screening are implemented to tackle the fast rising challenge of CVDs in adolescents and young adults.

### ***Implications of the study findings***

The observed patterns of the global CVD burden in adolescents and young adults present significant implications at both the public health policy development and clinical practice levels. It is projected that the prevalence rates of CVDs in adolescents and young adults are prone to significantly increase owing to population aging and growth, particularly in low and middle-income nations, with higher adolescent and young adult populations. Promoting cardiovascular health and healthy aging throughout life is essential. Encouraging healthy habits early, such as a balanced diet and exercise, helps prevent cardiovascular diseases and supports better aging. Still, it is important that feasible, accessible, and affordable interventions and strategies are implemented to effectively prevent and control CVD and correctly monitor the outcomes in adolescents and young adults.

### ***Strengths and limitations of this study***

Currently, adolescents and young adults aged between 15 and 39 years account for nearly 38% of the globe's population [54]. As such, it is important that detailed data is provided with regard to CVD burden control interventions and strategies for tackling existing health inequalities and disparities within the distinctive study population. However, regardless of the provision of detailed and consistent data on global prevalence and incidence of CVD burden in adolescents and young adults, alongside the overview of the associated risk factors and comprehensive comparison of the CVD burden trends by aspects of age and sex, and nation, a number of limitations have been observed in this study. Among the notable limitations is the observation

that the data on CVD burden in adolescents and young adults is often incomplete, poor quality, or lacking, as this is always restricted by poor data registration and screening for CVDs. To counter this limitation, this systematic review has increasingly depended on extant epidemiological study findings and utilized various methodologies to minimize inaccuracies and biases. Even though it is not possible to totally rule out biases through such methods, the data calculation criteria remained consistent even as the data quality was assured. The other notable limitation regards the observation that the studies included mainly focused on populations aged between 15 and 39 years, leaving out individuals aged 40 years and above. The implication is that the authors are unable to effectively compare the attributes of the CVD burden and risk factors between adolescents and young adults, and older persons aged 40 years and above. In this regard, it is recommended that prospective studies should focus on evaluation of the difference in CVD burden between adolescents and young adults and older persons aged 40 years and above, as well as the risk factors for CVD burden in the two population sub-groups.

## **Conclusions**

This study has documented the CVD trends in adolescents and young adults across the globe, indicating that CVDs are the biggest contributors to the burden of disease of all disease groups and also a key public health concern resulting in premature mortality and morbidity across the globe. Thus, we have found that CVD burden in adolescents and young adults remains a key public health problem affecting the low and middle income nations, and the high income nations. However, the effects of the CVD burden in adolescents and young adults is most widespread among males and in nations with low- and middle-SDI levels. As such, it is vital that more focus should be placed in development of effective prevention interventions for CVD in adolescents and young adults. The major attributable risk factors for the high burden of CVDs in adolescents and young adults include High SBP, high LDL cholesterol, and high BMI. Moreover, this study has disclosed that the attributable risk factors for CVD burden in adolescents and young adults often vary across nations/regions with significant differences noted in genders, SDI levels, as well as age groups. Therefore, this underscores the significance of customized targeted public health interventions and strategies aimed at addressing the fast rising global public health challenge. Despite the existence of impressive advancements with regard to the capacities to prevent, treat, and manage CVDs globally, there is a need for increased improvement across the

globe, with more focus on the low and middle income nations in which the increase in the prevalence of CVD burden in adolescents and young adults remains the highest globally. The findings of this study may, therefore, serve as an important reference for informing programs and policies for planning effective prevention and management of CVDs in adolescents and young adults, which will, in turn, facilitate the advancement towards attainment of global targets for CVDs reduction.

**Disclaimers: This article has not been submitted to other publications and/or presented at conferences or meetings.**

**Data Availability: The data used in this study was from publicly available published research papers.**

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