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Cardiovascular Disease: Unravelling the Impact of Risk Factors through Observational Research

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Abstract

Background: Cardiovascular ailment (CVD) stays a leading reason of morbidity and mortality international understanding the complicated interplay among danger factors and CVD is vital for effective prevention and remedy strategies. Observational studies, which includes cohort studies, case-control research and go-sectional research, provide precious insights into the institutions among diverse exposures and CVD outcomes.

Objective: This review aims to.

1. Summarize key findings from observational studies on the impact of established and emerging risk factors on CVD.
2. Critically appraise the strength and limitations of observational study designs.
3. Discuss the role of observational study designs.

Methods: A comprehensive literature seek was performed in PubMed, Google Scholer Embase and Scopus databases using relevant keywords.

Studies included in this review met following criteria:

Observational research (cohort, case-control, cross-sectional).

Focus at the affiliation between chance factors and CVD results.

Published in peer-reviewed journals.

Key Findings

Traditional risk factors: Consistent evidence from observational studies supports the strong association between hypertension, dyslipidaemia, smoking, diabetes and obesity with increased CVD risk.

Emerging risk factors: Observational studies have increasingly implicated air pollution, social determinants of health (e.g. socioeconomic status & social isolation), sleep disorder and systemic inflammation as important contributors to CVD risk.

Strengths: Observational studies can investigate real world exposures and outcomes provide valuable insights into the natural history of disease and generate hypotheses for further investigation.

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 2, 2025

Limitations: Potential for confounding, bias (e.g. selection bias & information bias) and difficulty establishing causality.

Future Directions

Advancements in data science and statistical methods can improve the right and interpretability of observational studies.

Integration of data from multiple sources (e.g. electronic health records & biobanks) can enhance the power and generalizability of findings.

Focus on investigating the interplay between multiple risk factors and their cumulative impact on CVD risk.

Conclusion

Identification and measurement of the influence of numerous risk variables on CVD have been made possible by observational research. Despite these drawbacks, observational studies are nonetheless a useful tool for directing clinical judgment, influencing public health policy and deepening our understanding of the intricate etiology of CVD.

Key Words: Diabetes, Hypertension, Dyslipidaemia, Risk factors, Cardiovascular diseases (CVD's), Smocking, Obesity, Air pollution and Observational studies.

1. INTRODUCTION

1.1. Burden of Cardiovascular Disease (CVD)

As the primary cause of death globally, cardiovascular diseases (CVDs) pose a serious threat to global health. In 2019, an estimated 1.79 lakh persons died from CVDs, highlighting the critical need for efficient preventative and control measures (1).

In addition to mortality, CVDs have a substantial burden of morbidity, which includes peripheral artery disease, heart failure and stroke. These conditions have a major influence on productivity and quality of life. Healthcare expenses, lost productivity and disability are just a few of the significant economic effects of CVDs that put a pressure on economies and healthcare systems around the world (2).

Table 1: The Burden of CVD in India.

Disease	Statistics
Ischemic heart disease	Accounted for 2.17 million deaths (2016)
Stroke	Accounted for 1.63 million deaths (2016)
Rheumatic heart disease	Caused 233,000 deaths (2016)
Hypertensive heart disease	Caused 284,000 deaths (2019)
Cardiomyopathy	Prevalence estimated at 1.25 million (2019)

1.2. Importance of Risk Factors Identification

For a number of reasons, it is essential to identify cardiovascular disease (CVD) risk factors.

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 2, 2025

1.2.1. Primary Prevention

Early implementation of preventative actions is possible through the identification of high-risk individuals. This could involve changing one's lifestyle in ways like:

i. Dietary changes: Reducing saturated and trans fats, increasing fruit and vegetable intake.
ii. Regular exercise: Engaging in physical activity most days of the week.
iii. Quitting smoking: Either giving up smoking or limiting your exposure to second-hand smoke.
iv. Keeping a healthy weight or reaching and sustaining a healthy weight decrease is known as weight management.
v. Risk Reduction: The chance of getting CVD or suffering a cardiovascular event like a heart attack or stroke can be considerably decreased with early management (3).

1.2.2. Secondary Prevention

i. Risk Stratification: Finding people who have previously had a CVD event aids in estimating their likelihood of experiencing one in the future.
ii. Personalized Treatment: To reduce the chance of repeat incidents, this data informs the creation of individualized treatment programs that may involve medication and lifestyle changes (3).

1.2.3. Public Health Initiatives

Effective resource allocation for preventative and treatment initiatives is facilitated by the identification of high-risk populations.

Campaigns for public health can be modified to target the particular risk factors that are common in certain areas (4).

1.2.4. Research and Development

The goal of ongoing research is to find novel and developing risk factors for CVD. New therapeutic approaches and diagnostic instruments are developed as a result of this understanding (5).

1.3. Role of Observational Studies

In order to comprehend the intricate relationship between risk variables and CVD outcomes, observational studies are essential.

These studies help in the following ways.

1.3.1. Identifying Risk Factors

i. Cohort Studies: Monitor a group of people over time to determine the incidence of CVD and their exposure to different risk factors, such as food, exercise, and smoking. They aid in establishing connections between risk factors and the onset of disease.

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 2, 2025

ii. Case-Control Studies: In order to discover potential risk factors, these studies compare people with CVD (case) to those without (control), looking at prior exposures.
iii. Cross-Sectional Studies: These studies assist find possible correlations by giving a quick overview of the risk factors and prevalence of CVD in a population at a particular moment in time (6).

1.3.2. Understanding Disease Progression

i. Natural History of CVD: From the earliest stages of the disease to the emergence of complications, observational studies aid in monitoring its course. Strategies for prevention and therapy are informed by this.
ii. Long-Term Impact: By evaluating the long-term effects of risk factors and interventions on CVD outcomes, these studies can offer important management insights for patients (1).

1.3.3. Evaluating Interventions

Effectiveness of Lifestyle Changes: Observational studies can evaluate how changes in food and exercise, for example, affect the risk and consequences of CVD.

Impact of Public Health Policies: These studies can assess how well public health initiative that try to lower the prevalence of CVD in populations are working (2,3).

1.3.4. Generating Hypotheses

Observational studies might generate hypotheses for additional research by revealing possible connections between CVD and newly developing risk variables (such as stress and air pollution).

More through experimental research to prove causation and novel therapies is frequently made possible by the results of observational studies (6).

1.3.5. Strengths of Observational Studies

These studies look at CVD in real-world situations, offering valuable information about the disease's natural course and how risk factors affect day-to-day living.

Large populations were frequently included in observational studies, which increased the statistical ability to identify correlations and reach significant results.

When conducting randomized controlled trials is impractical or unethical, these investigations are frequently used (e.g. investigating the effect of smoking) (1,7).

1.3.6. Limitations of Observational Studies

Only connection, not causality, may be established by observational research. The observed association may be impacted by confounding variables.

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 2, 2025

Recall, selection bias and other biases might compromise the accuracy and dependability of results.

Results from particular populations might not apply to other groups (1,8).

Table 2: Application and Outcomes of Systems-Level Approaches in CVD's.

Systemic Level Approach	Applications	Potential Outcomes
Policy and Advocacy	Putting laws into place that encourage healthy living (such as taxes on junk food and rewards for expiries). Controlling the amount of air pollution. Expanding access to CVD screening and reasonably priced healthcare.	Reduction in CVD risk factors (e.g. smocking & obesity). Improved early detection and management of CVD. Decreased CVD mortality and morbidity.
Healthcare System Interventions	Strengthening primary care capacity for CVD risk assessment and management. Implementing evidence-based guidelines for CVD prevention and treatment. Improving access to cardiac rehabilitation programs.	Enhanced CVD risk factor control. Better adherence to treatment plans. Improved quality of life for CVD patients.
Community-Based Programs	Designing culturally tailored health education programs. Promoting community-based initiative for physical activity and healthy eating. Creating supportive environments for lifestyle changes.	Increased awareness of CVD risk factors. Adoption of healthy behaviours. Reduced CVD disparities within communities.
Research and Innovation	Funding studies to find novel CVD risk factors and create cutting-edge treatments. Enhancing CVD prediction and prevention methods	Development of new diagnostic tools and therapies. Implementation of precision medicine approaches for CVD.

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 2, 2025

	through the use of data science and technology. Fostering collaboration between researchers, policymakers and healthcare providers.	Accelerated progress in reducing the global burden of CVD.

2. TRADITIONAL RISK FACTORS

Traditional risk factors for cardiovascular disease (CVD) are well-established and have been extensively studied over the years. These risk factors are often modifiable, meaning individuals can take steps to reduce their risk of developing CVD (6,9).

Here's are some of the key traditional risk factors.

2.1. Hypertension (HTN), (High Blood Pressure)

HTN is a major risk factor for CVD, including coronary artery disease, stroke and heart failure.

It damages blood vessels, making them more susceptible to atherosclerosis (plaque buildup).

Managing BP through life style changes (diet, exercise & stress management) and, if necessary, medication is crucial for reducing CVD risk (5,10).

2.2. Dyslipidaemia (Abnormal Blood Cholesterol Levels)

High levels of low-density lipoprotein (LDL) cholesterol ("bad" cholesterol) and low levels of high-density lipoprotein (HDL) cholesterol ("good" cholesterol) increases the risk of atherosclerosis and CVD.

Lifestyle modifications (diet & exercise) and medication can help manage cholesterol levels and reduce CVD risk (11,12).

2.3. Diabetes Mellitus

Diabetes, especially when poorly controlled, significantly increase the risk of CVD.

It damages blood vessels and nerves, increasing the risk of heart attack, stroke and peripheral artery disease.

Managing blood sugar levels through lifestyle changes, medication and regular monitoring is essential for reducing CVD risk in individuals with diabetes (10,13).

2.4. Smoking

Smoking is a major risk factor for CVD, as it damages blood vessels, increases blood pressure and reduces oxygen supply to the heart.

Quitting smoking is one of the most effective ways to reduce CVD risk (14).

2.5. Obesity

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 2, 2025

Obesity is associated with various CVD risk factors, including hypertension, dyslipidaemia and diabetes.

Maintaining a healthy weight through diet and exercise can significantly reduce CVD risk (15).

2.6. Physical Inactivity

Lack of regular physical activity increases the risk of CVD.

Engaging in regular exercise can help lower blood pressure, improve cholesterol levels and maintain a healthy weight, all of which contribute to reducing CVD risk (16).

2.7. Unhealthy Diet

A diet high in saturated & trans fats, cholesterol, sodium and added sugars increases risk of CVD.

Adopting a heart-healthy diet rich in fruits, vegetables, whole grains and lean protein can help reduce CVD risk (17).

2.8. Family History of CVD

A family history of CVD, especially in close relatives (parents & siblings) increases an individual's risk of developing CVD.

While family history cannot be modified, individuals with a family history of CVD should be particularly vigilant about managing other risk factors (7).

Table 3: Summarizing Risk Factors, Preventive Measures and Potential Outcomes Related to CVD.

Risk Factors	Preventive Measures	Potential Outcomes
Behavioural	Smoking cessation. Regular physical activity. Healthy diet (low in saturated and trans fats, high in fibre and protein). Maintaining a healthy weight.	Reduce risk of CVD events. Improve BP and cholesterol levels. Enhance quality of life.
Metabolic	Managing BP through lifestyle changes and medication. Controlling cholesterol levels with diet, exercise and medication. Managing diabetes through lifestyle changes, medication and regular monitoring.	Decreased risk of heart attack, stroke and other CVD complications. Improved blood sugar control. Reduced risk of kidney disease and other diabetes and other diabetes related complications.
Environmental	Reducing exposure to air pollution.	Decreased risk of CVD

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 2, 2025

	Creating supportive environments for healthy lifestyles. Access to affordable and healthy food options.	associated with air pollution. Improved community health and well-being. Reduced health disparities.
Genetic	Family history of CVD. Genetic predisposition to certain CVD's.	Early screening and risk assessment. Personalized preventive strategies. Targeted interventions to mitigate genetic risks.

3. EMERGING RISK FACTORS

While traditional risk factors remain crucial consideration, increasing evidence points towards range of emerging risk factors that contribute to the development and progression of CVD. These factors often interact with traditional factors, creating a complex web of risk that requires a comprehensive approach to prevention and management (18).

These are a few of the main new risk factors for CVD.

3.1. Air Pollution

An increased risk of CVD event, such as heart attack, stroke and heart failure, has been associated with exposure to air pollution, especially particulate matter (PM 2.5).

Air pollution can lead to endothelial dysfunction, inflammation and stress, all of which are factors in the development of CVD(19).

3.2. Socioeconomic Factors

A lower socioeconomic level (SES) is linked to a higher risk of cardiovascular diseases.

Chronic stress, poor living conditions and restricted access to healthcare are some of the factors that increase the burden of CVD among underprivileged groups (20).

3.3. Sleep Disorders

Obstructive sleep apnea (OSA) and other sleep disorders have been connected to a higher risk of cardiovascular disease.

Intermittent hypoxia (low oxygen levels), inflammation and oxidative stress are all consequences of OSA that can lead to the development of CVD (21).

3.4. Inflammation

The onset and advancement of CVD are significantly influenced by chronic inflammation.

A higher risk of CVD has been linked to elevated levels of inflammatory markers, such as C-reactive protein (CRC) (22).

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 2, 2025

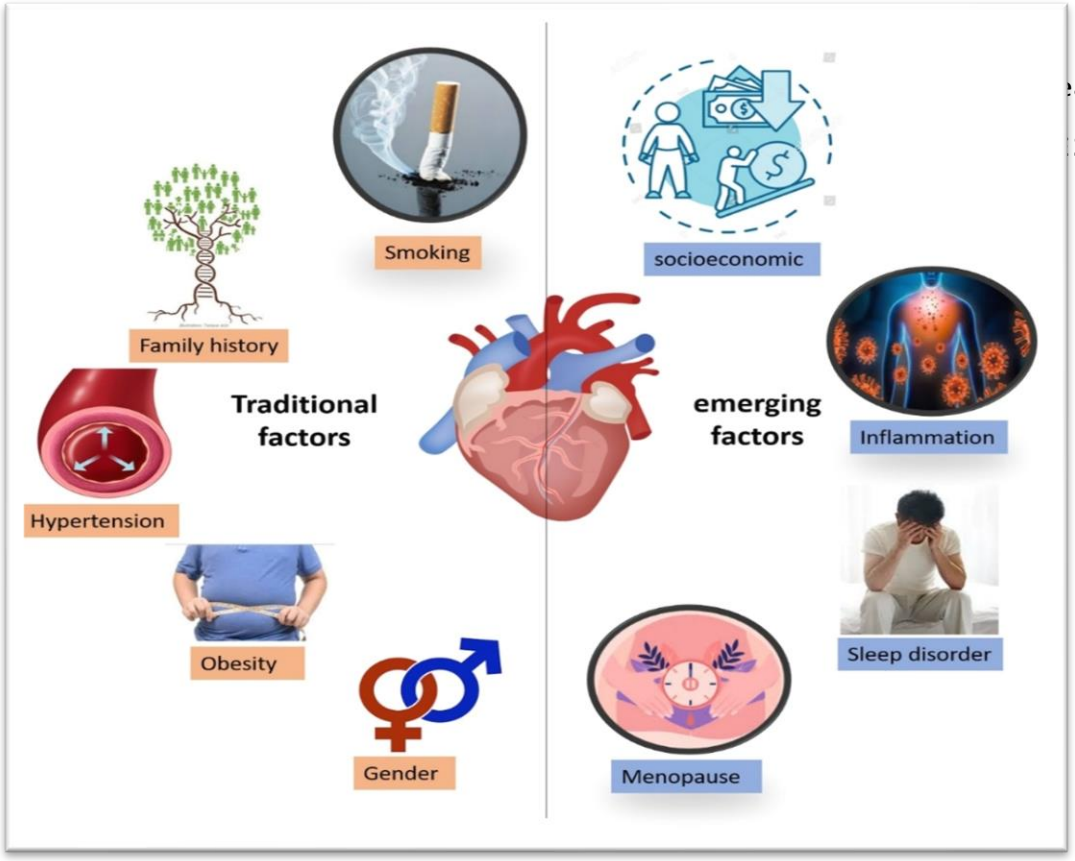
3.5. Kidney Function

One of the main risk factors for CVD is impaired kidney function, especially in the early stages of CKD.

CKD can cause oxidative stress, inflammation and problems with minerals and bones, all of which can lead to the development of CVD (18).

Table 4: The Different Impact of Emerging CVD Risk Factors in Male, Female and Age Groups.

Emerging Risk Factors	Effect on Males	Effect on Females	Age-Wise Impact
Air Pollution.	Increased risk of heart attacks, stroke and heart failure. May have a greater impact on men due to higher occupational exposure.	Increased risk of CVD, particularly in among women living in urban areas with high pollution levels. Growing concern regarding prenatal and early childhood exposure to air pollution and its impact on CVD risk.	Risk increases with increasing age due to cumulative exposure and age-related decline in lung function.
Socioeconomic Factors.	Low socioeconomic status is associated with increased CVD risk in men due to higher rates of smoking, unhealthy diets and stress.	Women from low-income background may face additional challenges such as limited access to healthcare and support systems, exacerbating CVD risk.	Socioeconomic disparities in CVD risk tend to widen with increasing age, particularly in older adults.



Sleep Disorders.	Men are more likely to develop obstructive sleep apnea (OSA), a major disorder linked to CVD.	Women may experience different type of sleep disorders, such as insomnia, which can also contribute to CVD risk.	Sleep disorder become more common with age, increasing the risk of CVD in older adults.
Inflammation.	Chronic inflammation is a significant risk factors for CVD in both men and women.	Women may experience different patterns of inflammation, which can influence their CVD risk profile.	Inflammation increases with age, contributing to the age-related increase in CVD risk.
Psychosocial Factors.	Men may be more likely to experience work-related stress, while women may be more susceptible to stress related to caregiving responsibilities.	Both men and women can experience depression and anxiety, which are associated with increased CVD risk.	The impact of psychosocial factors on CVD risk may vary across different age group.

Fig: 1. Interpretation of Possible Risk Factors of CVD (Traditional and Emerging Risk Factors of CVD)

4. OBSERVATIONAL STUDY DESIGNS

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 2, 2025

The different observational study designs and their applications in understanding the burden of cardiovascular disease (CVD).

4.1. Cohort Studies

Design of the Study

A group of individuals (cohort) is followed over time. Some have exposure to a potential risk factor (e.g. smoking), while others do not. The incidence of CVD is compared between the exposed and unexposed groups.

Applications

Examining the association between air pollution exposure and the development of CVD.

Investigating the impact of socioeconomic factors on the long-term risk of CVD.

Assessing the relationship between sleep disorders and the incidence of heart attacks or stroke (16).

4.2. Case-Control Studies

Design of the Study

Individuals with CVD (cases) are compared to those without CVD (controls). The presence of past exposure to potential risk factors (e.g. history of smoking, low socioeconomic status) is assessed and compared between the two groups.

Applications

Investigating the link between a history of severe infections (a potential inflammatory trigger) and the prevalence of CVD.

Examining the association between psychosocial stressors and the development of CVD (11,23).

4.3. Cross-Sectional Studies

Design of the Study

A snapshot of a population is taken at a specific point of time. The prevalence of CVD and the presence of various risk factors (e.g. obesity & diabetes) are assessed simultaneously.(11)

Application

Estimating the prevalence of CVD in different age groups and genders.

Assessing the relationship between dietary habits and the presence of CVD risk factors (23).

4.4. Choosing the Right Study Design

The choice of study design depends on the research question and the available resources.

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 2, 2025

Cohort studies are ideal for examining the incidence and natural history of CVD over time (16).

Casee-control studies are useful for investigating rare diseases or conditions with long latency periods (24).

Cross-sectional studies are appropriate for determining the population's risk factors and prevalence of CVD at a certain point in time (23).

4.5. Combining Study Designs

In certain situations, combining various study designs can help us comprehend CVD more thoroughly.

A nested case-control study inside a cohort study, for instance, can offer comprehensive data on risk factors for CVD development.

We can obtain important insights into the intricate relationship between risk factors and CVD outcomes by carefully choosing and putting into practice suitable observational study designs , which will ultimately aid in the creation of successful prevention and treatment plans (6,10).

5. METHODOLOGICAL CONSIDERATIONS

We can improve the validity and reliability of their findings and advance our knowledge of CVD risk factors and their effects on public health by carefully examining these methodological issues. Bias is defined as a propensity to favour or oppose an individual or group, which is frequently regarded as unfair, or as systematic manipulation of outcomes for reasons that are not permitted in their deviation.

Understanding bias in research is important for many reasons: bias exists in every research design, and it is a big task to eliminate it. It can also exist in every stage of research design, and bias can interfere with data interpretation and reflect the reliability and validity of data. In the context of CVD bias plays a critical role importantly gender bias because it is perceived as a men's disease and causes a misconception for women diagnosis women are 50% misdiagnosed with a heart attack which causes high mortality in women due to CVD (25).

5.1. Bias and Confounding

Selection Bias: This occurs when the selection of study participants is not representative of the target population. For example, if a study on CVD risk factors only recruits participants from a high-income neighbourhood, the findings may not be generalizable to the entire population (26).

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 2, 2025

Information Bias: This occurs when there are errors in the measurement or collection of data. For example, if participants misreport their dietary habits, it can lead to inaccurate conclusions about the relationship between diet and CVD risk (26).

Confounding: A variable that is connected to both the exposure (risk factors) and the result (CVD) is called a confounder. For instance, people from poorer socioeconomic origins may be more likely to live in locations with greater pollution levels and have less access to healthcare, which can complicate the link between air pollution and CVD (27).

5.1.1. Addressing Bias and Confounding

Careful Study Design: To reduce the possibility of bias and confounding, researchers should carefully plan their experiments. This entails employing suitable sample techniques, guaranteeing precise data gathering precise data gathering and accounting for possible confounders in the study.

Statistical Techniques: To increase estimate accuracy and account for confounding, statistical techniques can be applied.

Sensitive Analyses: Sensitive analyses can be used to evaluate how well results hold up aginst various hypotheses and possible biases (26,27).

5.1.2. Data Quality and Analysis

Data Source: In observational research, the calibre of the data is essential. Electronic health records and national health survey are two examples of trustworthy and validation data sources that researchers should employ.

Data Cleaning: To find and fix flaws in the data, data cleaning is crucial.

Statistical Techniques: Considering the research question and study design, appropriate statistical techniques should be applied while analysing the data.

Interpretation: Carefully interpreting the results should take into account the study's design constraints as well as the possibility of bias and confounding (28).

5.1.3. Other Considerations

Ethical Considerations: Participant informed consent and privacy protection are essential components of ethical observational research.

Transparency and Reporting: To guarantee the accuracy and repeatability of their work, researchers should openly disclose their procedures, conclusions and limits (28).

6. PUBLIC HEALTH IMPLICATIONS

The information highlights a number of important public health consequences associated with cardiovascular diseases (CVD).

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 2, 2025

According to data from the US and India, CVDs continue to be a major cause of death and disability worldwide, affecting both industrialized and developing nations (2).

The frequency and specific type of CVDs vary by demographic and geography, underscoring the necessity of specialized public health strategies (19).

Numerous cardiovascular diseases can be prevented by modifying modifiable risk factors, including smocking, an improper diet and inadequate physical activity (18).

The prevalence of CVD is significantly influenced by socioeconomic determinants, highlighting the need for policies to address health disparities (20).

6.1. Prevention Strategies

The following preventative measures ought to be given top priority in public health initiatives.

6.1.1. Population-Level

i. Policy Interventions: Implement policies promoting healthy lifestyles, such as taxation on unhealthy foods, incentives for physical activity and regulations on air pollution (6).
ii. Health Education: Increase public awareness of CVD risk factors and prevention strategies through targeted campaigns (28).
iii. Community-Based Programs: Promote community-level initiatives for healthy eating and physical activity, creating supportive environments for lifestyle changes (25).

6.1.2. Individual Level

i. Lifestyle Counselling: Encourage individuals to adopt healthy habits, including regular exercise, balanced nutrition, weight management and smoking cessation.
ii. Risk Assessment: Provide accessible CVD screening and risk assessment to identify individuals at high risk.
iii. Patient Education: Support individuals in managing CVD risk factors through education on lifestyle changes and medication adherence (27).

6.2. Early Detection and Intervention

Encourage broad access to blood pressure, cholesterol and blood sugar screenings as part of CVD screening programs.

Encourage medical attention for symptoms and place an emphasis on early detection of CVDs through increased awareness.

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 2, 2025

To avoid complications and enhance results, make sure people with CVDs receive prompt and efficient therapy (29).

6.3. Policy Recommendations

i. Multi-sectoral Collaboration: Foster collaboration between government agencies, healthcare providers and communities to implement comprehensive CVD prenotion programs.
ii. Health Equity: Prioritize policies addressing socioeconomic disparities in CVD risk and access to care.
iii. Investment in Research: Support research on CVD prevention, early detection and innovative treatment.
iv. Data-Driven Decision Making: Utilize data on CVD burden and risk factors to inform public health policies and resource allocation (23).

We can all work together to lessen the worldwide burden of CVDs and enhance population health by addressing these public health implications through comprehensive prevention programs, early detection and intervention efforts and supportive policy suggestions.

7. FUTURE DIRECTIONS

A number of important areas for further study and public health campaigns are highlighted by the data on the burden of cardiovascular diseases (CVD) in the US and India.

7.1. Advancement in Data Science

Large datasets can be analysed by machine learning algorithms to find patterns that humans would miss. This can assist in predicting personal risk, finding new CVD risk factors and creating individualized preventative plans.

AI-powered technologies, such as automated analysis of pictures and electrocardiograms (ECGs), can help in the early identification and detection of CVD.

Sophisticated data visualization methods can support patient education and public health messaging by making complex CVD data easily understandable (29).

7.2. Integration of Data Sources

A thorough understanding of a patient's and treatment results can be obtained by integrated data from electronic health records.

Wearable sensor data, like those from fitness trackers and smartwatches, can offer important insights on sleep habits, physical activity and other lifestyle factors associated with the risk of CVD.

Understanding how environmental factors affect the risk of CVD can be aided by integrating environmental data, such as air pollution levels and availability to green spaces (30).

7.3. Addressing Emerging Challenges

ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 2, 2025

The prevention and management of CVD are made more difficult by the aging of the world's population. Understanding the particular risk factors and solutions for older persons should be the main goal of research.

Chronic respiratory conditions and diabetes are two non-communicable diseases that frequently co-occur with CVD. It is crucial to use integrated care strategies to address these synergies.

Targeted interventions are necessary to address social determinants of health and enhance underprivileged populations access to care in order to resolve persistent health disparities in CVD outcomes (31).

8. CONCLUSION

The alarming numbers from the US and India demonstrate that cardiovascular diseases (CVDs) continue to be a major worldwide health concern. The information emphasizes how common CVDs are, how they rank among the top causes of mortality and how the illness profiles of the two nations differ.

This highlights public health initiatives that put an emphasis on early detection, prevention and efficient management of CVDs. The conclusion drawn from this data have a significant impact on public health, guiding policy recommendations, early diagnosis, intervention initiative and prevention methods.

We can work to lessen the worldwide burden of CVDs and enhance general cardiovascular health by combining these tactics and tackling new issues with data science breakthroughs and cooperative research.

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ISSN: 0975-3583, 0976-2833 VOL16, ISSUE 2, 2025

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