REVIEW ARTICLE DOI: https://doi.org/10.18502/fem.v8i1.14895

Prevalence of cardiovascular diseases following man-made disasters; a systematic review

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Published online: 2024-02-01

Abstract: **Objective:** Disasters increase the incidence of infectious and contagious diseases, non-communicable diseases, and trauma. This systematic review aims to investigate the impact of man-made disasters on cardiovascular diseases (CVDs).

Methods: This is a systematic review conducted following the PRISMA protocol. The population, intervention, control, outcome (PICO) framework utilized for this research is as follows: P: people with CVDs; I: various man-made disasters; C: no intervention is being compared; O: prevalence, treatment, and management of the disease. In the present study, English-language articles published until November 9, 2022 that investigated CVDs in human-made disasters were included. We conducted an extensive search in Medline, Web of Science, Embase, and SCOPUS.

Results: The primary search of the databases resulted in 1878 articles, from which 1219 non-duplicate records. Finally, 18 articles were included; 13 studies were in the area of nuclear and atomic accidents, four studies were related to the sulfur mustard gas, and one was related to methyl chloride.

Conclusion: CVDs increased in prevalence after man-made disasters, particularly among high-risk individuals. The likelihood of developing CVDs is higher with increasing dose, intensity, and duration of exposure.

Keywords: Cardiovascular Diseases; Chemical Hazard Release; Disaster; Man-made Disasters; Radioactive Hazard Release

Cite this article as: Pashaei Asl Y, Meshkini M, Faridaalaee Gh. Prevalence of cardiovascular diseases following man-made disasters; a systematic review. Front Emerg Med. 2024;8(1):e7.

1. Introduction

The united nations office for disaster risk reduction (UNISDR) defines a disaster as a significant disruption caused by risk in the functioning of society at different scales, resulting from the interplay between vulnerability, exposure to risk, and our capacities (1). Disasters are categorized into natural disasters such as earthquakes, floods, and volcanoes, and man-made disasters such as nuclear and chemical events, war, and more (2).

Disasters result in irreversible economic and life losses, including the destruction of infrastructure like houses, roads, drinking water systems, and other economic damages (3). They also lead to an increase in the incidence of infectious and contagious diseases, non-communicable diseases, and trauma (3). During and after disasters, vulnerable individuals and groups are more exposed to risks from accidents and suffer from health problems (4). Factors such as psychological issues, physical problems, and the lack of medical centers can exacerbate underlying diseases and pose challenges for affected individuals (4). cardiovascular diseases (CVDs) are a prevalent health issue globally, and they are among the top causes of mortality and morbidity (3). The world health organization (WHO) estimates that more than 17.9 million people die annually due to CVDs (3). Some studies have shown that disasters can have a significant impact on the prevalence and exacerbation of CVDs (5). Understanding the effects of disasters on CVDs can potentially help to inform disaster response planning and improve the health outcomes of affected individuals. While previous studies have examined the impact of natural disasters on CVDs (3), this systematic review aims to investigate the impact of man-made disasters on CVDs.

2. Methods

This is a systematic review conducted following the PRISMA protocol. The population, intervention, control, outcome (PICO) framework utilized for this research is as follows: P: people with CVDs; I: various man-made disasters; C: no intervention is being compared; O: prevalence, treatment, and management of the cardiovascular diseases.

2.1. Eligibility criteria

In the present study, English-language articles published until November 9, 2022 that investigated CVDs in human-made disasters such as nuclear and radiation accidents, and chemical accidents were included. The criteria for selection included CVDs such as myocardial infarction, acute coronary syndrome, hypertension, pulmonary edema, and heart failure in man-made disasters like chemical bombs, radioactive and atomic accidents. Articles that were published in the forms of conferences, commentaries, editorials, and case reports were excluded. Non-English language articles were excluded as per the exclusion criteria.

2.2. Search strategy

To achieve the study's goals, we conducted a thorough search using MeSH and Emtree databases, consulted with experts, and searched for related articles by examining their titles and abstracts under the supervision of an expert in emergency medicine and a PhD in health management of disasters. We conducted an extensive search in electronic databases and article sources, Medline, Web of Science, Embase, and SCOPUS, up to November 9, 2022. The search strategy used in the Medline database is presented in table 1.

2.3. The process of selecting studies, collecting data, and measuring outcomes

In the present study, English-language articles exploring the relationship between man-made disasters and CVDs were screened based on predefined inclusion and exclusion criteria. Two independent researchers conducted a title and abstract review, followed by the full-text review of eligible articles. The researchers assessed the articles for inclusion and exclusion criteria and selected eligible articles. Additionally, data from selected articles were summarized and entered into a checklist. Finally, two independent people conducted quality assessment on the included articles. The two groups resolved any disagreements through discussion and/or with the assistance of a third researcher. To summarize the articles, a checklist designed based on the PRISMA statement guidelines was used (6). The systematic review investigated the prevalence, mortality, treatment, and management of CVDs in man-made disasters. The extracted information included the first author, year of publication, peer review status of the journal, obtaining permission from the ethics committee or publication committee, outcome statement, exclusion criteria statement, the existence of a control group, and a statement of the statistical analysis method.

2.4. Quality assessment and risk of bias

Because different types of studies were included in this study, we devised a risk of bias assessment tool for this purpose. All articles were qualitatively reviewed in terms of the definition of the outcome, definition of the exclusion criteria, ethic approval, statistical analysis, description of the patient group, and description of the control group.

2.5. Statistical analysis

Descriptive analysis was performed on the data. The studies were organized and categorized based on the variables examined. We would meta-analyze studies, which were homogeneous.

3. Results

3.1. Study characteristics

The primary search of the databases resulted in 1878 articles, from which 1219 non-duplicate records were obtained after removing duplicated records. After reading the title and abstracts of those records, 1174 articles were excluded due to their irrelevance to the study's aim. Out of the remaining records, 14 were case reports, editorials, correspondences, or abstracts presented at the conferences. A total of 31 articles' abstracts met the review criteria, and their full text was obtained. Further screening revealed that 11 studies were not in English and therefore excluded. Two full articles were also reviewed but didn't meet the inclusion criteria. The risk of bias assessment and data extraction included a total of 18 articles. The flowchart depicting the selection process of these articles based on the PRISMA flow diagram can be seen in figure 1.

These articles were classified into two categories: chemical and radiation, with 13 articles related to atomic, nuclear, and radiation accidents and 5 articles related to chemical accidents. Of note, the included articles are observational studies and all were on prevalence.

3.2. Quality of studies and risk of bias

Table 2 displays the results of the qualitative review on the articles. Most of the studies have good quality but in most of the studies, the ethics committee approve is not mentioned.

3.3. CVDs and radiation exposure

Table 3 shows the summary of extracted variables of 18 included studies. Out of the 13 studies reviewed in the area of nuclear and atomic accidents involving radiation, nine of them which concentrated on the survivors of the Hiroshima atomic bomb (7-15) and the impact of the bomb on the CVDs of survivors was examined while four of the studies focused on the aftermath of the Chernobyl nuclear disaster and its effects on CVDs (16-19). All of these studies showed a direct correlation between radiation exposure and an increase in CVDs, whereby the frequency of CVDs and fatalities grew as radiation dose increased. Radiation exposure is associated with an increased risk of developing atherosclerosis, as well as a greater likelihood of experiencing CVDs such as acute coronary syndrome (ACS), ischemic heart disease, hypertension, and myocardial infarction (8-20). The risk of developing

Table 1 Medline search strategy

Database	Search term Disaster, Man-made disasters, , , ,
MEDLINE (PubMed)	1) "Cardiovascular Diseases"[Mesh] OR "Pulmonary Edema"[Mesh] OR "Hypertension"[Mesh] OR "Acute Coronary Syndrome"[Mesh] OR "Myocardial Ischemia"[Mesh] OR "Coronary Disease"[Mesh] OR "Congestive heart failure"[Mesh] OR "Coronary Diseases"[tiab] OR "Myocardial Ischemia"[tiab] OR "Ischemic Heart Diseases"[tiab] OR "Ischemic Heart Disease"[tiab] OR "Chronic heart Diseases"[tiab] OR "Chronic heart Diseases"[tiab] OR "Hypertension"[tiab] OR "High Blood Pressure"[tiab] OR "High Blood Pressures"[tiab] OR "Acute Coronary Syndrome"[tiab] OR "Acute Coronary Syndromes"[tiab] OR "Coronary Artery Disease"[tiab] OR "cardiac disease"[tiab] OR "Congestive heart failure"[tiab] OR "Pulmonary Edema"[tiab] OR "Pulmonary Edemas"[tiab] "Myocardial Ischemia"[tiab] OR "Cardiovascular disease"[tiab] OR "Cardiac Disease"[tiab] OR "Cardiac Diseases" OR "Cardiac Disorder"[tiab] OR "Arrhythmias, Cardiac"[Mesh] OR "Cardiac Arrhythmias"[tiab] OR "Dysrhythmia, Cardiac"[Mesh] OR "Cardiac Dysrhythmia"[tiab] OR "Arrhythmia"[tiab] OR "Heart Diseases"[Mesh] OR "Heart Diseases"[tiab] OR "Cardiac Disorder"[tiab] OR "Myocardial Infarction"[Mesh] OR "Myocardial Infarction"[tiab] 2) "Chemical Hazard Release"[Mesh] OR "Radioactive Hazard Release"[Mesh] OR "Chemical Warfare Agents"[Mesh] OR "Weapons of Mass Destruction"[Mesh] OR "Biological Warfare Agents"[Mesh] OR "Mass Casualty Incidents"[Mesh] OR "Mass Gatherings"[Mesh] OR "Mass Gatherings"[tiab] OR "Chemical Hazard Release"[tiab] OR "Chemical Accidental"[tiab] OR "Chemical Incident"[tiab] OR "Radioactive Hazard Release"[tiab] OR "Nuclear Accident"[tiab] OR "Chemical Warfare Agents"[tiab] OR "Weapons of Mass Destruction"[tiab] OR "Biological Warfare Agents"[tiab] OR "Mass Casualty Incidents"[tiab] 3) 1&2

Table 2 Quality assessment and risk of bias of included articles

First author Publication year	Type of the study	Description of the control group	Definition of the exclusion criteria	Definition of the outcome	Ethic approval	Statistical analysis	Description of the patient group
Ikuno Takahashi (2018)	Quantitative study	+	+	-	-	+	+
Faizi Fakhradian (2007)	Cohort study	+	+	+	-	+	+
Faramarz Fallahi (2009)	Historical cohort study	+	+	+	-	+	+
Shogo Horita (2018)	Quantitative study	+	+	-	-	+	+
V. K. Ivanov (1999)	Cohort study	+	+	+	-	+	+
V. K. Ivanov (2005)	Cohort study	+	+	+	-	+	+
KazulIOri Kotfama (1996)	Cohort study	+	+	-	-	+	+
Aksana V. Kotava (2011)	Quantitative study	+	+	+	-	+	+
Saburo Kusumoto (2014)	Quantitative study	+	+	+	-	+	+
Tomoki Nakamizo (2021)	Cross-sectional study	+	+	+	-	+	+
Atoosheh Rohani (2010)	A case control study	+	+	+	-	+	+
Helmut Schöllnberger (2018)	Cohort study	+	+	+	+	+	+
mahmoud M. Shabestari (2011)	Case-control study	+	+	+	+	+	+
Yukiko Shimizu (2010)	Cohort study	+	+	+	+	+	+
Ikuno Takahashi (2017)	Cohort study	+	+	+	-	+	+
G. S. Bandazhevskaya (2004)	Descriptive-analytical	+	+	+	+	+	+
Vilhjalmur Rafnsson (2014)	Cohort study	+	+	+	+	+	+
Noriyuki Hara (2016)	Cohort study	+	+	+	-	+	+

Table 3 Summary of results

First author and publication year	Exposure	Result
Tomoki Nakamizo (2021)	Radiation	Increase in CVDs and atherosclerosis with radiation
Helmut Schöllnberger (2018)	Radiation	CVDs increase with moderate to high radiation doses
Ikuno Takahashi (2018)	Radiation	There isn't clear association between peripheral artery disease and radiation, but upstroke time as a sensitive marker of early-stage of peripheral artery disease can be associated with radiation dose.
Shogo Horita (2018)	Radiation	Increase in coronary artery diseases, especially in the elderly, with increased radiation dose
Ikuno Takahashi (2017)	Radiation	Relative risk and mortality of CVDs increase with the increase of the received dose of radiation.
Noriyuki Hara (2016)	Radiation	CVDs increase in old exposed patients to the radiation.
Saburo Kusumoto (2014)	Radiation	People with RBBB need more pacemaker implantation, especially in people with high body mass, hypertension and elderly.
Aksana V. Kotava (2011)	Radiation	Increase in CVDs such as IHD and HTN.
Yukiko Shimizu (2010)		Mortality of CVDs increase with increasing doses.
V. K. Ivanov (2005)	Radiation	Increased relative risk in HTN and IHD diseases.
G. S. Bandazhevskaya (2004)	Radiation	CVDs increase with radiation (high blood pressure and abnormal heart sounds). Also, by using pectin powder and food containing fiber in the period of 16 days, the amount of cesium in the body of these people decrease and the changes in their heart rate are improved.
V. K. Ivanov (1999)	Radiation	Increase in ischemic heart diseases, hypertensive disease and peripheral vascular diseases.
KazulIOri Kotfama (1996)	Radiation	Increase myocardial infarction.
Mahmoud M. Shabestari (2011)	Sulfur mustard	Atherosclerosis was not significantly different between exposed and non-exposed groups, but coronary ectasia was more in the exposed group.
Atoosheh Rohani (2010)	Sulfur mustard	The increase in the incidence of CVDs as a late complication.
Faramarz Fallahi (2009)	Sulfur mustard	Increased chest pain and exertional dyspnea in people exposed to mustard gas.
Faizi Fakhradian (2007)	Sulfur mustard	Increase in CVDs due to inactivity and high cholesterol in people exposed to sulfur mustard.
Vilhjalmur Rafnsson (2014)	Methyl chloride	An increase in cardiovascular diseases such as acute coronary artery diseases and finally deaths due to the methyl chloride leakage incident in 1963.

CVD: Cardiovascular disease; IHD: Ischemic heart disease; HTN: Hypertension; RBBB: Right bundle branch block

ACS increases over time and with age, and higher levels of radiation exposure are linked to an even higher probability of developing these conditions (8,9,12,14,16-19). Furthermore, exposure to high doses of radiation results in an increased risk of mortality due to cardiovascular diseases, with the rise in mortality being more pronounced at higher levels of radiation exposure (13,15). Both men and women are at greater risk of experiencing CVDs as a result of radiation exposure, with young women having a lower risk than older women due to the protective effect of female sex hormones on the circulatory system (14). Based on a study that defined peripheral artery disease as an ankle brachial index of 1 or less, and upstroke time as an early marker of peripheral artery disease, exposure to radiation does not appear to be associated with a statistically significant increase in peripheral vascular diseases (7). In a separate study involving children who consumed crops contaminated with cesium, subjects were divided into low, medium, and high categories of contamination. Results indicate that abnormal heart sounds, hypertension, and pathological changes in electrocardiogram (ECG) were directly related to the level of pollution. However, consumption of pectin powder and fiber-rich foods for 16 days significantly reduced contamination levels, improving changes in heart rate over time (16).

3.4. CVDs and chemical exposure

Out of the five studies examined in this case, four are related to the chemical attack that occurred during the Iran-Iraq war where Iraq used sulfur mustard gas (mustard gas) against Iranian soldiers (20-23). The remaining study is about a methyl chloride gas leak that took place in 1963 (24). The studies demonstrate that exposure to mustard gas, similar to radiation accidents, increases the risk of CVDs such as ACS and dilated cardiomyopathy, as well as enlargement of the right ventricle resulting from pulmonary diseases (20,22,23). Level of exposure to the chemical agent has a direct correlation to the rise in CVDs. In people with sedentary lifestyles and high cholesterol levels, individuals not exposed to mustard gas have a higher likelihood of increased CVDs (22). The methyl chloride gas leak at a factory in 1963 increased ACS and ultimately caused a rise in mortality rates, leading to neurological disorders, unemployment, and economic, and social problems that also affect the increase of CVDs (24). One study, however, revealed no significant difference in atherosclerosis damage between the two groups exposed and not exposed to sulfur mustard. Nonetheless, the exposed group showed higher rates of coronary artery ectasia (21).

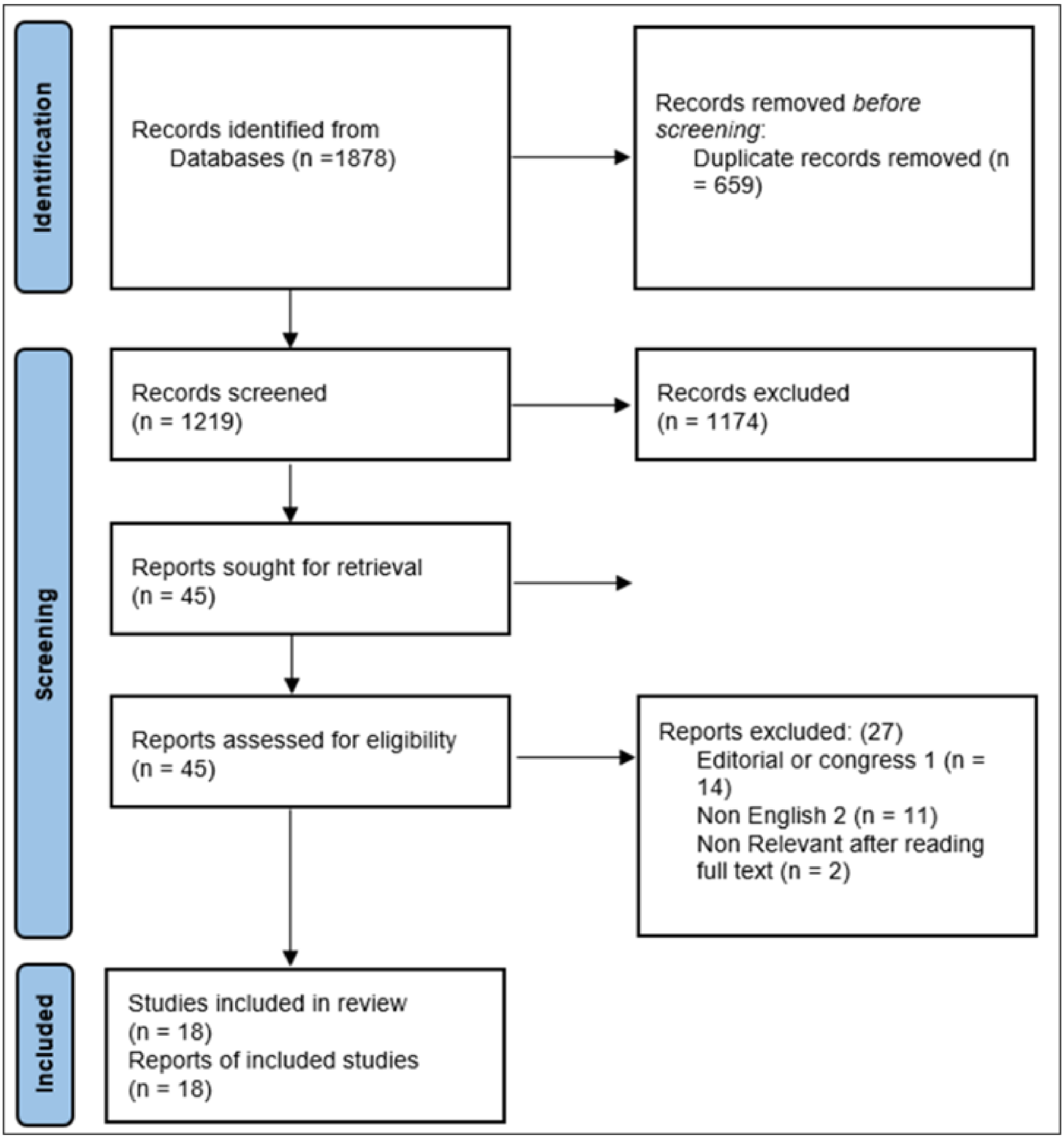

Figure 1 PRISMA flow diagram of study

4. Discussion

This systematic review study suggests that the rate of CVDs increases in the aftermath of man-made disasters. Research has shown a direct relationship between exposure to radioactive rays and the occurrence of CVDs. As the dose, intensity, and duration of exposure to the radioactive substance increase, so do the rate of CVDs and associated complications, including mortality. This phenomenon is similar to the impact of natural disasters on CVDs as both seem to increase the prevalence and occurrence of CVDs (3). Researchers note that even in cases where homes were not destroyed, such as in the Chernobyl accident, the stress of factors like homelessness and the loss of friends and relatives could contribute to higher rates of CVDs after such an event. Exposure to mustard gas is known to increase the prevalence and incidence of CVDs, similar to the impact of radiation accidents. This is due to damage to lung tissue caused by mustard gas, which can lead to pulmonary diseases like COPD and subsequently increase CVDs (20). Additionally, underlying health conditions such as high cholesterol, hypertension, physical inactivity, unemployment, social issues, and old age can intensify the impact of chemical agents and radiation exposure on the occurrence and spread of CVDs. Unlike natural disasters, there has been only one study conducted on man-made disasters to examine how to reduce their effects on CVDs (3,16).

Thus, studying the preparation of healthy food and water following exposure to radioactive materials is crucial in reducing subsequent exposure and preventing the harmful effect of radiation on increasing the prevalence of CVDs. One way to mitigate the harmful effects of radiation on cardiovascular health is by providing access to healthy food and water after exposure to radioactive material, which can significantly reduce subsequent exposure. By taking these measures, the risk of an elevated prevalence of CVDs resulting from radiation exposure can be minimized presumptively.
Considering the increasing number of man-made disasters, it is recommended that further research be conducted on managing and mitigating the impact of these disasters on the occurrence and frequency of CVDs.

5. Limitations

This study excluded non-English articles due to the unavailability of professional translators, resulting in a potential loss of information. In addition, the included studies were heterogeneous in terms of their methodology, so we were not able to meta-analyze them.

6. Conclusion

The prevalence of CVDs has been known to increase after man-made disasters such as exposure to radiation and chemical substances, particularly among high-risk individuals. The likelihood of developing CVDs is higher with increasing dose, intensity, and duration of exposure.

7. Declarations

7.1. Acknowledgement

All authors acknowledge Tabriz University of Medical Sciences research center staff.

7.2. Authors' contribution

All authors: Conceptualization, Methodology and software; YPA, MM and GHF: Abstract reading and data extraction; YPA: Writing original draft; all authors: Reviewing, editing and accepted final manuscript.

7.3. Conflict of interest

None.

7.4. Funding

None.

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