ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
ΙΑΤΡΙΚΗ ΣΧΟΛΗ
ΘΕΡΑΠΕΥΤΙΚΗ ΚΛΙΝΙΚΗ ΝΟΣ. ΑΛΕΞΑΝΔΡΑ

ΠΡΟΓΡΑΜΜΑ ΜΕΤΑΠΤΥΧΙΑΚΩΝ ΣΠΟΥΔΩΝ
«ΚΛΙΝΙΚΕΣ ΜΕΛΕΤΕΣ: ΣΧΕΔΙΑΣΜΟΣ ΚΑΙ ΕΚΤΕΛΕΣΗ»
MSc: "Clinical Trials: Design and Conduct"

Διευθυντής
Ευάγγελος Τέρπος, Καθηγητής Ιατρικής Σχολής ΕΚΠΑ

Καρδιαγγειακή υγεία σε περιόδους οικονομικής κρίσης κατά τον 20ο και 21ο αιώνα: συστηματική ανασκόπηση, Περίπτωση 1

Cardiovascular health in times of economic crisis in the 20th and 21st century: a systematic review, Case 1

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ΑΘΗΝΑ 2021

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Foreword – Acknowledgments

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I dedicate this work to my parents and to all the people who dare to dream!

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Table 1. Terms and abbreviations.

AF	Atrial Fibrillation
AHA	American Heart Association
AHRQ	Agency for Health Research and Quality
AMI	Acute Myocardial Infarction
APC	Annual Percentage Change
ASR	Age Standardised Mortality Rates
BAV	Bicuspid Aortic Valve
BKC	Bankruptcy Count
BMI	Body Mass Index
BRFS	Behavioral Risk Factor Surveillance System
CAD	Coronary Artery Disease
CHD	Coronary Heart Disease
CHD	Congenital Heart Disease
CI	Confidence Interval
CMF	Compressed Mortality Files
COPD	Chronic Obstructive Pulmonary Disease
COVID-19	Coronavirus disease of 2019.
CPI	Consumption Price Index
CTPA	Computed Tomography Pulmonary Angiography
CV	Cardiovascular
CVA	Cerebrovascular Accident
CVD	Cardiovascular Disease
CVMR	Cardiovascular Mortality Rate
DM	Diabetes Mellitus
e.g.	Exempli Gratia *(for example)*
ED	Emmergency Department
EDS	Ehlers-Danlos Syndrome
ELSTAT	Hellenic Statistical Authority
EU	European Union
GDP	Gross Domestic Product
GNP	Gross National Product
GRACE	Global Registry of Acute Coronary Events
HI	High Income
HR	Hazard Ratio
i.e.	Id Est *(that is)*
ICD	International Classification of Diseases
IHD	Ischemic Heart Disease
ILRs	Implantable Loop Recorders
IMF	International Monetary Fund
IRR	Incidence Rate Ratio
IS	Ischemic Stroke
MI	Myocardial Infarction
MS	Marfan Syndrome
NCD	Non-communicable Diseases
NESARC	National Epidemiologic Survey on Alcohol and Related Conditions
NHANES	National Health and Nutrition Examination Survey
Non-RHD	Non-Rheumatic Heart Disease
Non-STEMI/UA	Non-ST-segment Myocardial Infarction and Unstable Angina
NOS	Newcastle Ottawa Scale
NW	Non-Worker
OA	Office Clerk & Administrative Staff
OPEC	Organization of the Petroleum Exporting Countries
OR	Odds Ratio
PAD	Peripheral Arterial Disease
PCI	Percutaneous Coronary Interventions

PE	Pulmonary Embolism
PICO	Patient/Population, Intervention, Comparison and Outcomes
PM	Professional & Manager
PPPs	Purchasing Power Parties
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses Guideline
PRR	Prevalence Risk Ratio
REACH	Reduction of Atherothrombosis for Continued Health
RF	Rheumatic Fever
RGNDI	Gross National Disposable Income
RHD	Rheumatic Heart Disease
RII	Relative Index of Inequality
RR	Rate Ratio / Relative Risk
S&L	Savings and Loans
SES	Socioeconomic Status
SF	Short Form
SII	Slope Index of Inequality
SPECT	Single-Photon Emission Computed Tomography
STEMI	ST-Segment Myocardial Infarction
SW	Skilled Work
TIA	Transient Ischemic Attack
TLoC	Transient Loss of Consciousness
TMCV	Tasa de mortalidad cardiovascular
TT	Tilt Testing
UK	United Kingdom
UN	Unskilled Worker
US/USA	United States of America
USD	United States Dollar
vs	Versus
VTE	Venous Thromboembolism
WHO	World Health Organization

Abstract

Background: It was established that economic crises affect public health worldwide and associated with cardiovascular morbidity and mortality. This systematic review examines the association of factors contributing to CVDs and observes any potential changes in the trends and the severity of the established cardiovascular disease, among the general population living in countries exposed to financial crises.

Methods: A systematic search was conducted in PubMed, EMBASE and Google Scholar databases (end-of-search:May 12,2020). Studies examining the relationship between economic crisis and cardiovascular health in the 20th and 21st century, were included. The quality of included studies was assessed using the Newcastle-Ottawa Quality scale and AHRQ standards.

Results: The 38 eligible studies focused on impact of economic downturns on overall CV incidence, CV mortality, cardiac arrhythmias, and other heart diseases; 27 ecological studies, 6 cohort studies, 2 register-based studies and 3 cohort surveys included. Of those, 21(55%) were considered as high, 15(40%) at moderate, and only 2(5%) at low risk of bias, limiting the conclusions that can be drawn. Even though there were differences across countries and groups, there was some evidence that CVD morbidity increased and deteriorated during the crisis. Perversely, CVD mortality seems to be decreased during economic recessions. Results on self-rated health and other indicators were mixed.

Discussion: Increased levels of psychosocial stress resulting from unemployment, low income, uncertainty, daily habits as well as changes in SES, were the main reasons of cardiovascular health deterioration in times of economic hardship. Additional quantitative analysis on CVD outcomes and economic factors seems desirable.

Keywords: economic crisis; recession; cardiovascular health; heart diseases; systematic review

A. Introduction

A1. Assessment and ascertainment of an economic recession

Financial crises and their subset, banking crises, have become a worldwide phenomenon in recent years. Not only have banking crises occurred in developed countries such as the United States, Japan, and in the Nordic countries, but they have been a feature of the recent economic scene in developing countries as well. In the case of developed countries, banking and financial crises have been costly to the economy, yet the damage that these crises seem to impose on developing countries seems to be far greater than for developed countries (Mishkin, 1996).

A financial crisis – marked by the failure of banks, and/or the sharp decrease in credit and trade, and/or the collapse of an exchange rate regime, etc. -generates extreme disruption of these normal functions of financial and monetary systems, thereby hurting the efficiency of the economy. Unfortunately, financial crises have happened frequently throughout history and, despite constant attempts to eliminate them, it seems unlikely that they will not repeat in the future. Clearly, the last few years have been characterized by great turmoil in the world's financial systems, which even today, does not seem to have a clear solution. Between the meltdown of leading financial institutions in the US and Europe, the sharp decrease in lending and trading activities, and the ongoing challenge to the European Monetary Union, these events exhibit ingredients from several types of financial crises in recent history: banking crises, credit and market freezes, and currency crises. Besides, the events in the real world proved that the different types of crises can occur together and amplify each other in different ways. Historically, financial crises have often been marked with large disturbances in currency markets, which have spilled over to the financial sectors and the real economies of affected countries in various ways. In general, currency crises originate from the attempt of governments to maintain certain financial and monetary arrangements, most notably a fixed-exchange rate regime. Their goal is to stabilize the economy. At times, these arrangements become unstable, which leads to a speculative attack on a fixed exchange rate regime and from there to a financial crisis. (Goldstein and Razin, 2013).

A banking crisis was defined as financial distress that is severe enough to result in erosion of most or all of the capital in the banking system and a currency crisis is defined as a forced change in parity, abandonment of a pegged exchange rate or an international rescue.

Many of the crises in the 19th and early 20th century were international in scope. These international dimensions led to a flow of funds between countries and this in turn could cause a currency crisis. When banking crises and currency crises occur together there is said to be a "twin crisis". Twin crises are typically associated with more severe recessions than banking or currency crises occurring on their own.

In recent years emerging countries have been particularly prone to currency crises and twin crises. Moreover, during the interwar period it was the industrial countries that were particularly

hard hit by crises. They were actually more prone to currency and twin crises than the emerging countries (Fig. 1 and 2) (Allen and Gale, 2007).

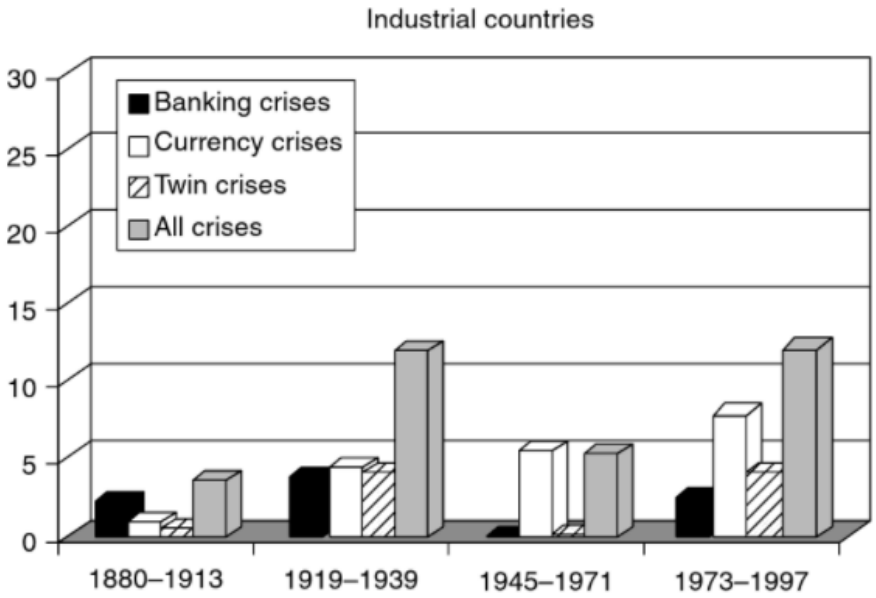

Figure 1. Frequency of crises - distribution by Industrial countries (retrieved by Alen and Gale, 2007).

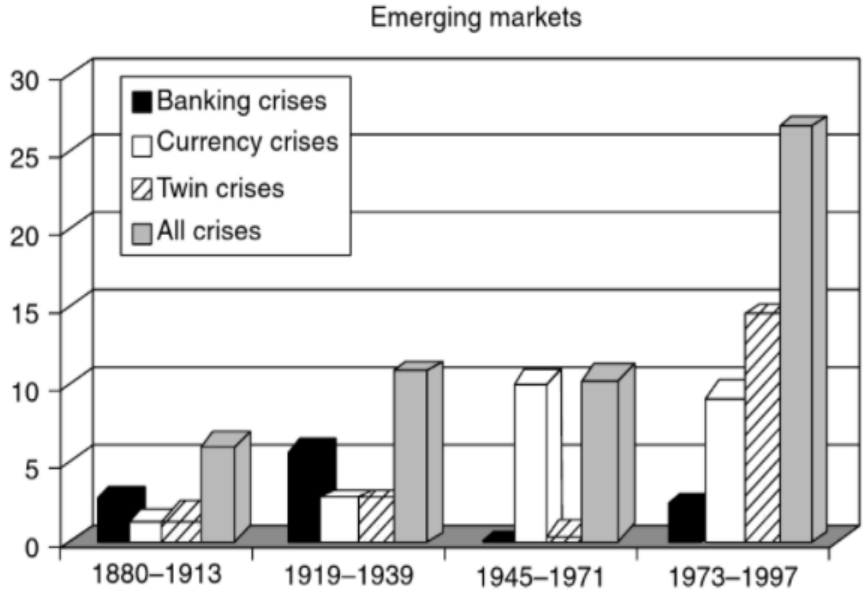

Figure 2. Frequency of crises - distribution by Emerging markets (retrieved by Alen and Gale, 2007).

Recessions following crises exhibit much larger declines in consumption, investment, industrial production, employment, exports and imports, compared to those recessions without crises (Claessens and Kose, 2013).

The macroeconomic activity is measured with several indicators such as the gross domestic product (GDP) per capita; the unemployment rate (labour market statistics); the gross private domestic investment; the consumption price index (CPI); the stock market index; the house price; and the bankruptcy rates. GDP (per capita) is an important indicator for measuring the economic performance of countries, which is a central driver of people's economic well-being (Bolt *et al*, 2014). It is the most widely used indicator for country-level income and has been used in modeling health outcomes, mortality trends, cause-specific mortality estimation, health system performance and finances, and several other topics of interest. A measurement of the duration of a crisis is the trend rate of GDP growth; the duration of the crisis is the amount of time before GDP growth returns to its trend rate. The depth of the crisis is measured by summing the output loss relative to trend for the duration of the crisis (Allen and Gale, 2007). Generally, financial crises tend to have a permanent negative effect on the level of GDP, while could also weigh on the long-term growth of output.

In summary, banking crises, currency crises, and twin crises have occurred under a variety of different monetary and regulatory regimens. Over the last 120 years crises have been followed by economic downturns lasting on average from 2 to 3 years and costing 5 to 10 percent of GDP. Twin crises are associated with particularly large output losses. Recessions with crises were more severe than recessions without them.

The "Bretton Woods" period from 1945 to 1971 was quite special. Countries either regulated bank balance sheets to prevent them from taking risk very much or owned them directly to achieve the same aim. These measures were successful in that there were no banking crises during this time and only one twin crisis.

The "Interwar period" (1919-1939) was also special. Banking crises and currency crises were widespread. Moreover, the output losses from these were severe particularly when they occurred together and there was a twin crisis.

The most recent period does appear more crisis prone than any other period except the interwar years. In particular, it seems more crisis prone than the Gold Standard Era, which was the last time that capital markets were as globalized as they are now (Allen and Gale, 2007).

In economics, dynamics are usually non-linear and characterized by cyclical fluctuations, which are called "business cycles" which are oscillations in the economy because of recessions and expansions (Orlando and Zimatore, 2020). It was acknowledged that business cycles consist of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals, which merge into the expansion phase of the next cycle (Burns and Mitchell, 1946). With regard to cycles, there were mentioned four stages connecting production, stock exchange, public confidence, demand, interest rates, and prices (Table 2).

Table 2. The stages of business cycles.

Stage	Name	Description
I	Expansion	Increase in production and prices while interests' rates are relatively low
II	Crisis	Stock exchanges crash and multiple bankruptcies of firms occur
III	Recession	Drops in both prices and production and rise of interest rates
IV	Recovery	Stock prices recover because of the fall in prices and incomes.

A1.1. Economic crises in the 20th century

A1.1.1. The "Great Depression" in the 1930s (1929-1939)

The economic cataclysm of the 1930s was an international phenomenon experienced by countries in all parts of the globe. Countries as diverse as the United States, Germany, Chile, and Japan all experienced significant depressions in the 1930s. The Great Depression started in most countries at around the same time. Industrial production declined by almost half in the United States and Germany. It fell more slowly and continuously in France and paused rather than fell in Great Britain. National incomes did not fall as far as industrial production since services did not contract as much, but they decreased sharply; real per-capita GNP in the United States fell by one-third. National experiences in the depression varied greatly, but very few countries in the world escaped the economic hardship of the 1930s. Prices fell at the same time as production, by the same amount or more. Unemployment grew dramatically in almost all countries. Unemployment meant distress in the 1930s, most visible in Europe and North America (Romer, 1993). In January 1928, the seeds of the Great Depression, whenever they were planted, began to germinate. For it is around this time that two of the most prominent explanations for the depth, length, and worldwide spread of the Depression first came to be manifest. Without any doubt, the economics profession would come to a firm consensus around the idea that the economic events of the Great Depression cannot be properly understood without a solid linkage to both the behavior of the supply of money together with Federal Reserve actions on the one hand and the flawed structure of the interwar gold standard on the other (Dimand, 2004).The gold-standard mentality and the institutions it supported limited the ability of governments and central banks to respond to adversity; they led to the adoption of policies that made economic conditions worse instead of better. In response to balance-of-payments deficits and gold losses, governments could only restrict credit with the goal of reducing domestic prices and costs until international balance was restored. Critical to this process was the effort to reduce wages, the largest element in costs. The role of the gold standard in the Great Depression has been noted in the historical literature (Eichengreen and Temin, 2000). Other economic downturns have been called a "great depression", but none had been as widespread, or lasted for so long. Various states have experienced brief or extended periods of economic downturns, which were referred to as "depressions", but none have had such a widespread global impact.

A1.1.2. The “Oil crisis” or “Oil Shock” in the 1970s

The 1970s were a period of growing dependence on imported oil, unprecedented disruptions in the global oil market and poor macroeconomic performance in the United States. Hence, it was expected to suspect a causal relationship from oil prices to U.S. macroeconomic aggregates (Barsky and Kilian, 2004). The Arab oil embargo of 1973 had a seismic effect on the world economy. More drastic dislocations have occurred during the aftershock, as the oil-producing countries have tried to maintain control of the international oil market. The embargo was announced in early October of 1973, and the largest drops in the stock market occurred during the 4th quarter of 1973 and throughout 1974. Energy prices (relative to the business GDP deflator) more than doubled by 1981 and were still about 50% higher than their pre-crisis levels after two decades (Alpanda and Peralta-Alva, 2008). The initial nations targeted by the embargo, were Canada, Japan, the Netherlands, the United Kingdom and the United States with the embargo also later extended to Portugal, Rhodesia and South Africa (OPEC Oil Embargo, 2014). Even though it was not generally accepted that exogenous political events in the Middle East cause recessions in the United States, it is undoubtedly true that many recessions since 1972 have been associated with major oil price increases (Barsky and Kilian, 2004).

A1.1.3. The “Early 1990s Recession”

In the early 1990s, the end of the cold war and the slowdown in defense spending, which hit several states hard, led to another recession that lasted from July 1990 to March 1991. Although mainly attributable to the workings of the business cycle and restrictive monetary policy, the 1990-91 recession demonstrated the growing importance of financial markets to the American and world economies. From November 1982 to July 1990 the U.S. economy experienced robust growth, modest unemployment, and low inflation. The "Reagan boom" rested on shaky foundations, however, and as the 1980s progressed signs of trouble began to mount. On October 19, 1987 stock markets around the world crashed. In the U.S., the Dow Jones Industrial Average lost over 22% of its value. Even though the causes of "Black Monday" were complex, many saw the crash as a sign that investors were worried about the inflation that might result from large U.S. budget deficits. In the second half of the 1980s a large number of savings and loan associations went bankrupt. The collapse of the S&L industry negatively impacted the welfare of many American households and precipitated a large government bailout that placed further strain on the budget. Although the 1987 stock market crash and the “Savings and Loan” crisis namely “S&L” crisis were separate phenomena, they demonstrated the growing importance of financial markets—and associated public and private sector debt—to the workings of the American economy. Other causes of the early 1990s recession included moves by the U.S. Federal Reserve to raise interest rates in the late 1980s and Iraq's invasion of Kuwait in the summer of 1990. The latter drove up the world price of oil, decreased consumer confidence, and exacerbated the downturn that was already underway (Carlson, 2006). Though the recession of 1990-1991 relatively short in duration, as lasted just eight months (Temin, 1998), swiftly translated into increased unemployment, with unemployment reaching almost 8% as late as June 1992 (Walsh, 1993). Much of the multisector job growth of the 1980s was dissolved

in the span of one year. Recession losses in the United States were paralleled by decline in other industrialized portions of the world, particularly Japan. Furthermore, the decline of property markets only served to exacerbate the downturn further. Yet while the impact of the early 1990s recession was fairly widespread for at least one year, it is also true that certain regions within the United States, and elsewhere were more severely hit and affected for longer than national figures would suggest (Hackworth, 2002).

A1.1.4. The "Finnish Banking crisis" (1991-1993)

In the 1990s, Finland underwent a deep depression as its GDP dropped about 14% from its peak in 1990 through to 1993. By 1994, unemployment stood at 20%, up from 3% in 1990. On many counts, this economic crisis has been more severe than the depression of the 1930s, but not atypical of other recent turmoil. Finland has witnessed a huge expansion of bank lending following financial market deregulation, major inflows of foreign capital during the boom, speculative currency attacks, and a major banking crisis as part of the depression, to mention just a few symptoms. The crisis went through three stages: overheating, depression and recovery. In contrast to most other European countries, Finland did not experience any major rise in unemployment in the aftermath of the oil crises of the 1970s, or during the gradual disinflation of the 1980s, and its public finances remain balanced. Things changed abruptly around 1986. First, growth accelerated significantly, and the economy entered a period of overheating. Several factors were behind this change: financial market deregulation, which included both the abolition of regulation of domestic bank lending rates and the lifting of restrictions on private borrowing from abroad, led to an explosion of bank credit and large capital inflows. There was a sharp increase (15-20%) in the terms of trade as a result of the fall in energy prices and the rise in world market prices of forest products. Economic policies were not sufficiently restrictive. Moreover, the private consumption and investments pulled GDP growth and were not counterbalanced by fiscal policy. The economy turned around in late 1993 while unemployment continued to rise well into 1994, affecting close to one-fifth of the labour force. The recovery was mostly concentrated in the capital-intensive export industries, while the domestic sector remained relatively depressed until 1995-1996. The Finnish economic crisis had finally ended in late 1996 (Honkapohja and Koskela, 1999).

A1.1.5. The "Asian Financial crisis" in the 1990s (1997-1999)

The "Asian Financial Crisis" burst out in Thailand, in July 1997 and then unfolded to several parts of Asia (Wang, 1999). It is the sharpest and last anticipated financial crisis in years (Radelet and Sachs, 1999). The five East Asian countries hit hardest by the crisis were Indonesia, the Republic of Korea, Malaysia, Thailand and the Philippines. Other Asian countries and areas, such as China, Singapore, Vietnam and Hong Kong have felt milder effects from the crisis. The beginning of the crisis is associated with the floating of the Thai Baht in July 1997, leading to a substantial devaluation in the Thai currency. This rapidly spread to the Republic of Korea, Malaysia, Indonesia, and several other countries (Siddiqi, 2000). There were four main culprits identified as causes of the crisis: (i) weaknesses within the Asian economies,

especially poor financial, industrial, and exchange rate policies; (ii) overinvestment in dubious activities resulting from the moral hazard of implicit guarantees, corruption, and anticipated bailouts; (iii) financial panic, in that what began as moderately-sized capital withdrawals cascaded into a panic because of weaknesses in the structure of international capital markets and early mismanagement of the crisis, and (iv) exchange rate devaluations in mid-1997 in Thailand (and late in the year in Korea), that may have plunged these countries into panic (Radelet and Sachs, 1999). The core of Asian crisis were large-scale foreign capital inflows into financial systems that became vulnerable to panic. Thus, much of the economic activity supported by these inflows was highly productive, and the loss of economic activity resulting from the sudden and enormous reversal in capital flows has been enormous. The crisis was followed by massive capital outflows, devaluation of currencies, the collapse of stock markets, many bankruptcies, the application for the IMF bailout package by the government and steep rises in unemployment in the region (Jang and Sul, 2002). By early 1997, markets expected a slowdown in Thailand but not in the rest of Asia. A combination of panic on the part of the international investment community, policy mistakes at the onset of the crisis by Asian governments, and poorly designed international rescue programs have led to a much deeper fall in output than was either necessary or inevitable (Radelet and Sachs, 1998). By mid-January 1998, the currencies of all emerging market economies in East/Southeast Asia had lost half of their pre-crisis values against the U.S. dollar (Ito, 2007). In some cases, the year 1998 showed even negative growth for the GDP. This decline followed by a moderate recovery in 1999 (Siddiqi, 2000). Moreover, apart from the relatively short period of turmoil in global financial markets resulting from the speculative attack on Hong Kong on October 27, 1997, bond spreads were relatively stable in non-Asian countries during the second half of 1997 (Gaston Gelos and Sahay, 2001).

Even after the Asian crisis was over, other emerging market economies fell into crisis: Russia in 1998, Brazil in 1998-1999, Turkey in 2000-2001, and Argentina in 2000-2001.

A1.1.6. The "Argentine Great Depression" (1998-2002)

Argentine has lived through multiple recessions and periods of hyperinflation, all of which have turned this 19th century powerhouse into an economic miscarriage. This appalling event swept Argentine into one of the most disastrous recessions of its history. Argentine has had a history of turbulent economic, political and monetary problems. The country experienced rapid economic growth during the periods of the early 1900s, mainly due to an enormous increase in exports of goods to the European market. However, due to frequent structural changes in the type of government, the country has for long suffered from unstable political and economic situations. Prior to 1999, the Peso was pegged to the USD in response to the ongoing hyperinflation. The successful growth of the real GDP to 10.3% in 1992 led to an overly optimistic view of the country's growth potential. The policy decision regarding fixed exchange rate caused a major problem later, that triggered the economic crisis of 1999-2002. Due to a reduction in exports, the Aggregate Demand curve shifts left, thereby reducing overall price

level and real GDP of the economy. This signaled the contraction of the economy (Aggarwal *et al*, 2018).

A1.1.7. The "Russian Financial crisis" (1997-1998)

Stock markets in most transition economies fell dramatically in the last quarter of 1997, especially after the October 28 crash, when Hong-Kong equity price collapsed, which is considered to be the peak of the East-Asian crisis. Some transition economies such as Bulgaria, Romania and the Czech Republic had experienced financial turmoil earlier during the year, as the Asian crisis raised concerns about the financial stability in all emerging economies. The Rouble came under attack in November 1997 (Buchs, 1999). The consequence for the Russian savings market was a massive entry in the beginning of the 1990s. In the mid-1990s, however, many new banks had to leave the market again, either suddenly or because they failed to pay the claims of depositors (Carree, 2003). This probably reflected investors' nervousness about tax collection problems and building up of domestic debt. The interbanking crisis was at least partly caused by the low entry barriers (weak enforcement of reserve requirements) for new commercial banks. Yet, the end of May 1998 marked the beginning of the collapse of Russia's financial markets, as investors really started to question the Government's ability to honor its debt and continue to maintain a stable currency (Buchs, 1999)

A1.2. Economic crises in the 21st century

A1.2.1. The "Great Recession" (2008)

The Great Recession was a global economic downturn that devastated world financial markets as well as the banking and real estate industries. The crisis led to increases in home mortgage foreclosures worldwide and caused millions of people to lose their life savings, their jobs, and their homes. It is generally considered to be the longest period of economic decline since the Great Depression of the 1930s. Although its effects were global in nature, the Great Recession was most pronounced in the United States—where it originated as a result of the subprime mortgage crisis-and in Western Europe. Starting in mid-2007, the global financial crisis quickly metamorphosed from the bursting of the housing bubble in the US to the worst recession the world has witnessed for over six decades. Through an in-depth review of the crisis in terms of the causes, consequences and policy responses, this paper identifies four key messages. Firstly, contrary to widely held perceptions during the boom years before the crisis, the paper underscores that the global economy was by no means as stable as suggested, while at the same time the majority of the world's poor had benefited insufficiently from stronger economic growth. Secondly, there were complex and interlinked factors behind the emergence of the crisis in 2007, namely loose monetary policy, global imbalances, misperception of risk and lax financial regulation. Thirdly, beyond the aggregate picture of economic collapse and rising unemployment, this paper stresses that the impact of the crisis is rather diverse, reflecting differences in initial conditions, transmission channels and vulnerabilities of economies, along with the role of government policy in mitigating the downturn. Fourthly, while the recovery

phase has commenced, several risks remain that could derail improvements in economies and hinder efforts to ensure that the recovery is accompanied by job creation. These risks pertain in particular to the challenges of dealing with public debt and continuing global imbalances (Islam and Verick, 2011). The U.S. government's response to the financial crisis and ensuing Great Recession included some of the most aggressive fiscal and monetary policies in history.

A2. Cardiovascular Diseases

A2.1. Epidemiology of Cardiovascular diseases

Non-communicable diseases (NCDs), principally cardiovascular diseases (CVD), chronic respiratory diseases, cancer and diabetes, claim more than 41 million lives annually, accounting for 60-70% of global deaths (Qureshi *et al*, 2021). CVD is a major health problem across the world, including ischemic heart disease (IHD), cerebrovascular disease, peripheral arterial disease (PAD), rheumatic heart disease (RHD), congenital heart disease (CHD), deep vein thrombosis, pulmonary embolism (PE) and other CVD manifestations. CVD is recognized as the leading cause of morbidity and mortality worldwide and it will continue to prevail in future trends in global mortality. According to the World Health Organization (WHO), an estimated 17.9 million people died from CVDs in 2016, representing 31% of all global deaths. Of these deaths, 85% are due to heart attack (myocardial infarction-MI) and stroke, one third occur prematurely in people under 70 years of age, whereas over three quarters (>75%) of CVD deaths occur in low- and middle-income countries. (World Health Organization, 2018. Retrieved from: https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of death)

A2.1.1 Global Burden of Cardiovascular Diseases

The public health burden of CVD events is substantial and is the valid reason to implement programs of prevention of first and recurrent events all over the world. Moreover, in most countries, due to the demographic structure and the overall improvement in treatment, although the clinical onset is mainly acute, CVD often evolves gradually and may interfere with quality of life, physical disability and lifelong dependence on health services and medications. The costs for this burden are huge and are related to health care and social services, illness benefits and retirement, impact on families and caregivers and loss of years of productive life (Panico and Mattiello, 2010).

Cardiovascular disease (CVD) is a significant and ever-growing problem worldwide and leading to significant morbidity. The health status and disease profile of human societies have historically been linked to the level of their economic development and social organization. With industrialization, the major causes of death and disability, in the more advanced societies, have shifted from a predominance of nutritional deficiencies and infectious diseases to those classified as degenerative [chronic diseases such as cardiovascular disease (CVD), cancer, and diabetes]. This shift has been termed “the epidemiologic transition”. At any given time, different countries in the world or even different regions within a country are at different stages of the epidemiologic transition. This transition can occur not only between different disease categories, but also within a specific disease category (Yusuf *et al*, 2001). Five stages of epidemiologic transition were described. Much of sub-Saharan Africa and rural regions of India and South America are in the first stage, in which circulatory diseases are primarily due to rheumatic heart disease and nutritional cardiomyopathies. Stage 2 sees an increase in hypertensive heart disease and hemorrhagic stroke and stage 3 is characterized by early onset

of atherosclerotic CVD, obesity, and diabetes added to the continuing burden of infectious diseases. Developed countries are in stage 4, where NCDs occur primarily at older ages. Stage 5 is a regressive stage caused by social upheaval or war, with resurgence in infectious diseases, and high mortality from both CVD and non-CVD causes (Deaton *et al*, 2011).

While NCDs have traditionally been associated with economic development, the epidemiologic transition has led to a double burden of communicable and non-communicable diseases in low and lower middle-income countries. Estimates from 2012 suggest that 75% of the global mortality from NCDs occurred in low and lower middle-income countries. High income countries have fervently addressed the rising prevalence of CVD burden by using health research to discover disease pathogenesis, develop treatment, enhance health system infrastructures, track and improve outcomes, and target risk factors at person and population levels. Such a trend has been less evident in the low- and lower-middle-income group (Qureshi *et al*, 2021). By 2030, researchers estimated that NCDs will account for more than three-quarters of deaths worldwide; CVD alone will be responsible for more deaths in low-income countries than infectious diseases, maternal and perinatal conditions, and nutritional disorders combined (Beaglehole and Bonita, 2008). Thus, CVD is today the largest single contributor to global mortality and will continue to dominate mortality trends in the future (WHO, 2011. Retrieved from: https://www.who.int/healthinfo/global_burden_disease/2004_report_update/en/).

Ischaemic heart disease, consisting principally of coronary heart disease (CHD), is the predominant manifestation of CVD and is responsible for 46 per cent of deaths due to CVD in men and 38 per cent in women, followed closely by cerebrovascular disease at 34 per cent and 37 per cent, respectively (Fig. 3). While the burden of CVD was highest in Western countries during much of the twentieth century, the highest rates of CVD now occur among certain Asian and Middle Eastern regions (Fig. 4).

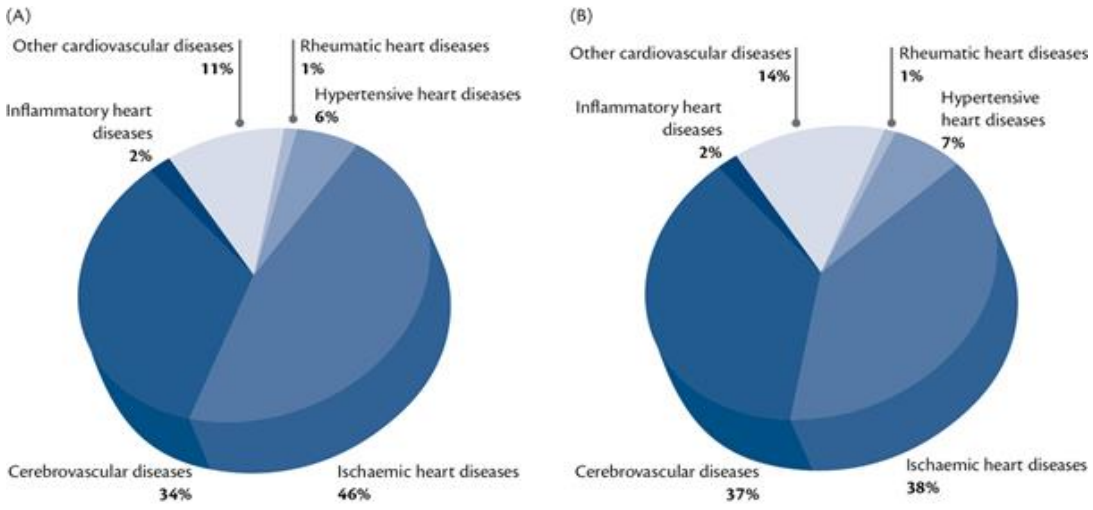

Figure 3. Proportion of deaths from cardiovascular disease (CVD) due to ischaemic heart disease, cerebrovascular disease, and other CVD causes in males (A) and females (B) (retrieved by Wong, 2015).

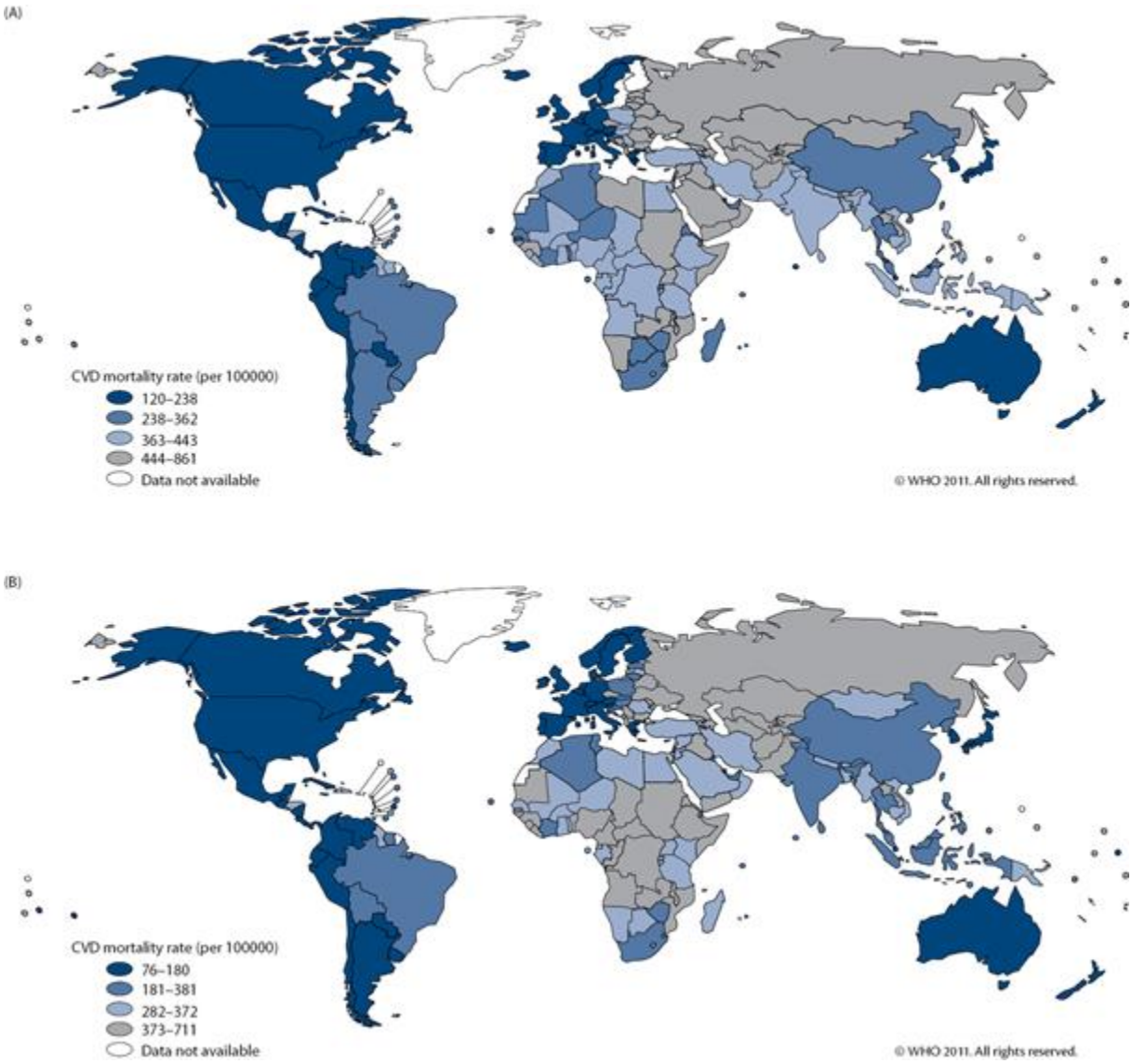

Figure 4. Global distribution of CVD mortality rates in males (A) and females (B), age-standardized per 100,000 (retrieved by Wong, 2015).

CVD has no geographic, socioeconomic, or sex boundaries and is the leading cause of death in developing as well as developed countries. Risk factors that lead to the development of CVD are consistent throughout the world, and many are increasing in prevalence as developing countries transition to more urban, industrialized environments (Deaton *et al*, 2011). The incidence of CVD, as well as the prevalence of key risk factors, varies greatly according to geographical region, gender, and ethnic background. Key risk factors, including hypertension, cigarette smoking, elevated cholesterol, elevated glucose levels/diabetes, obesity, and physical inactivity comprise the top six leading causes of death globally (Wong, 2015).

There are several reporting metrics of CVD global burdens used to define fatal and nonfatal CVD. A standard definition of health conditions must be applied globally for these specific metrics to be comparable to each other. The ICD-11 is the eleventh revision of the International

Classification of Diseases. It will eventually replace the ICD-10 as the global standard for coding health information and causes of death. The ICD-11 is developed and regularly updated by the World Health Organization (WHO) (Pickett and Anderson, 2018) and is used to code all health diagnoses, and most member states use it to define primary mortality diagnosis.

A.2.2. CVDs mortality and morbidity

A.2.2.1. CVD mortality

As mentioned above, CVDs, defined as diseases of the heart and circulatory system that are the main cause of death all over the world and it is well established that account for nearly half of NCDs (Laslett *et al*, 2012). Clearly, CVDs remain the leading global cause of death, accounting for over 17.3 million deaths globally each year (31.4% of all deaths, in 2016), a number that is expected to grow to 23.6 million by 2030 (Wong, 2014). Increasingly, the populations affected are those in low- and middle-income countries (LIMC), where 80% of these deaths occur, usually at younger ages than in higher income countries, and where the human and financial resources to address them are most limited (Lawrence *et al*, 2012 & Mendis *et al*, 2011). The lowest age-adjusted mortality rates are in the advanced industrialized countries and parts of Latin America, whereas the highest rates today are found in Eastern Europe and a number of low and middle income countries (Institute of Medicine (US), 2010).

Coronary heart disease (CHD) and stroke are the main forms of CVD. In 2016, IHD was the highest cause of mortality at 9.4 million, accounting for 16.6% of all mortality. The second most common cause of death was stroke, responsible for 5.8 million deaths, representing 10.2% of global mortality (World Health Organization, 2014. Retrieved March 13, 2021 from: http://www.who.int/healthinfo/global_burden_disease/en/).

Geographically the mortality burden for CVD varies widely. Overall, Europe carried the greatest mortality burden in 2012 due to CVD. There is a decrease from 2000, but CVD still accounts for nearly half of all mortalities in the WHO European Region. The mortality rate is significantly greater than the global rate calculated. Within Europe itself, there is considerable heterogeneity in the burden of CVD across regions, Eastern Europe being the driving force behind high CVD mortality rates. The highest per capita CVD burden is attributed to Eastern Europe and Central Asia. Explanation for some of these wide variations can be attributed to the prevalence of classic risk factors for CVD, like tobacco smoking, high blood pressure, and dietary risks. However, the cardiovascular mortality burden differs greatly, due to multiple factors including socioeconomic status, disease risk factor exposure, and population specifics. Analysis of the Americas demonstrated that CVD mortality for the region was 33.7% in 2000, with particularly high rates amongst women. Over the last 12 years the Americas have seen a 20% reduction in mortality, which has mainly been driven by the high-income (HI) countries in the region. A further study in Brazil observed CVD death rates were falling, but slower than wealthier countries. Such large variations amongst countries in the same region are observed

and are likely to be accountable for, at least in part, by access to health care and local preventative policies (McAloon, 2016).

A.2.2.2. CVD premature mortality

The proportion of deaths from CVD increases with age, and it is clear that CVD is a less common cause of death in younger age groups. However, CVD still causes over 1.4 million deaths in those aged under 75 years and close to 700.000 deaths for those under 65. In contrast to the greater proportion of deaths from CVD in women overall, similar proportions of women (36%) and men (35%) under the age of 75 years die from CVD, while 30% of deaths in men under the age of 65 years are as a result of CVD compared with 26% for women (Townsend *et al,* 2015).

A.2.2.3. Case fatality rates

Most countries for which data are available have shown substantial reductions in hospitalized case fatality rates for acute myocardial infarction (AMI), hemorrhagic, and ischaemic stroke over the last 5 years. Similar to mortality rates, there are variations in the magnitude of these changes and the overall case fatality rates between countries (Townsend *et al*, 2015).

A.2.2.4. CVD morbidity

The most comparable data available to track the burden of CVD morbidity across European countries are hospital discharge data, with prevalence and incidence data for CVD largely unavailable from a central source. These data show that the population-based rates of hospitalization for CVDs have increased since the early 2000s with more countries experiencing increases in hospital discharge rates for CVD than decreases. A similar pattern was found for stroke, with 32 countries showing an increase in hospitalization for cerebrovascular disease compared with 18 with a decrease, while for CHD, almost an equal number of countries showed increases and decreases in hospitalization. It should be noted, however, that these rates are not age standardized, so any increase in hospitalization over time could be a result of ageing populations throughout Europe. Variations between countries may indicate some differences in incidence as well as rates at which incident cases result in death before or without hospitalization or may be due to differences in health system organization and efficiency, coding practices, etc. These high rates of hospitalization also highlight the burden of CVD on healthcare systems and can be considered alongside other treatment data presented below (Townsend *et al*, 2015).

A.2.2.5. CVD incidence

The global incidence of CVD is increasing as the world's population ages and as lifestyles and hence, risk factors in lower- and middle-income countries become more akin to those of wealthier nations. Future cardiovascular burden is likely to be exacerbated not just by the aging population, but also by the epidemic of obesity and related cardiovascular risk factors, both of

which are increasing in prevalence. The "Reduction of Atherothrombosis for Continued Health (REACH) Registry", which collected global data on atherosclerosis risk factors from 67,888 patients aged 45 years in 44 countries, found that classic cardiovascular risk factors (hypertension, high cholesterol levels, diabetes, obesity, and smoking) confirm the findings from the INTERHEART study and are consistent and common in diverse ethnic populations, even if they do tend to be undertreated and under-controlled in many regions of the world. Thus, although the problem of CVD may be pandemic, prevention can be based on the same principles worldwide. REACH also found regional differences in the distribution of different categories of CVD (coronary artery disease [CAD], cerebrovascular disease, and peripheral arterial disease) (Dahlöf, 2010).

When comparing CVD incidence rates in the latest years, it should be noted that the new more sensitive diagnostic tools, which affected the recent changes in the diagnostic criteria of coronary events and the diffusion of coronary revascularization make it difficult to compare past and recent trends in CVD. Data from many countries have indicated a potential increase in diagnosis that may differ in different settings; however, this fact does not seem to interfere with the interpretation of the overall picture, since it has become relevant only in the recent years (Panico and Mattiello, 2010). The incidence of CVDs increases in developed countries in the early 20th century and in developing countries more recently whereas it is suggested that hypertension, cholesterol, poor nutrition, obesity, smoking, physical inactivity, and psychosocial stress as the leading factors contributing to heart disease (Institute of Medicine (US), 2010).

A.2.3. Specific CVD conditions

A.2.3.1. Cardiac arrhythmias

The main types of arrhythmia are atrial fibrillation (AF), supraventricular tachycardia, bradycardia, heart block and ventricular fibrillation. Atrial Fibrillation is the commonest cardiac arrhythmia worldwide and it has been estimated that 33.5 million people worldwide have AF (Chugh *et al*, 2014). Even if AF is not a life-threatening arrhythmia, it influences quality of life significantly as a result of its anatomic, hemodynamic, and hemocoagulative consequences. In addition, AF is frequently associated with disturbing symptoms and very important socioeconomic problems, such as permanent disability, cognitive disturbance, hospitalization, and absence from work (Zoni-Berisso *et al*, 2014). Arrhythmias can affect all age groups, but increasing age was directly associated with AF prevalence, as the population ages the AF prevalence increases from 0.5% aged 50–59years going up to almost 9% at age 80–89 years. Moreover, a difference in AF between different world regions is demonstrated (McAloon, 2016). AF is associated with increased overall mortality, stroke, myocardial infarction, heart failure, and other severe CVDs (Yue *et al,* 2021). Advanced age, male sex, hypertension, diabetes mellitus (DM), obesity, congestive heart failure, myocardial infarction, and valve disease, are traditional risk factors contributing to the AF incidence (Benjamin *et al*, 1994).

A.2.3.2. Pulmonary Embolism (PE)

Pulmonary embolism (PE) is a severe condition that can lead to sudden death and can be caused by a venous thromboembolism (VTE) that has broken free from the vein wall (Liu *et al*, 2021). PE is the third most common cause of death from CVD after heart attack and stroke (Goldhaber and Bounameaux, 2012). The occurrence of PE is influenced by several factors including aging, cancer and/or hormone replacement therapy. Annual incidence rates of VTE vary significantly and range from 62 to 143 per 100,000 persons. Data from the USA reported that the VTE incidence increased by 82% from 73 to 133 per 100.000 population in the period 1985–2009, that is mainly attributed to an increase in PE and use of Computed Tomography Pulmonary Angiography (CTPA). The differentiation may be based on characteristics of the population studied, including age and nationality, on availability of reliable data sources, data from the patients' medical records only, and on insufficient assessment of primary and recurrent episodes (Raptis *et al*, 2020).

A.2.3.3. Other heart diseases

A.2.3.3.1. Rheumatic heart disease

Rheumatic heart disease (RHD) is a potentially fatal yet preventable condition which begins with a sore throat and results in damage to the valves of the heart (Abrams *et al*, 2020). RHD occurs after one or more episodes of rheumatic fever (RF), a condition associated with an inappropriate host immune response to infection with group A streptococcus (Strep A) (Russell *et al*, 2018) and is responsible for about 300,000 deaths annually, most of which are children and young adults from resource-constrained settings (Abrams *et al*, 2020). RHD is a condition of global health importance that is estimated to affect over 33 million people, most in low and middle-income countries where there is an endemic pattern of disease. While RHD is now rare in high income countries, it remains an important cause of preventable heart disease in some Indigenous populations, including Canadian First Nations people, New Zealand Māori and Australian Aboriginal and Torres Strait Islander peoples, who are often subject to environmental disadvantage and reduced access to primary and specialist health care. It has been suggested that the improved diagnosis of RHD via echocardiography, as well as medical and surgical management, have led to a greater survival of those with RHD, resulting in a greater reporting of the disease in WHO regions outside of Europe. This is despite the incidence of rheumatic fever (RF) decreasing in most regions. The most common heart valves affected by RHD are the mitral and aortic valves, less commonly the tricuspid valve, and rarely the pulmonary valve. The majority of RHD patients are only mildly affected and only a small minority have more severe disease or complications requiring intervention (Russell *et al*, 2018).

A.2.3.3.2. Non rheumatic (valvular) heart disease

Since the term non valvular heart disease is not generally used; it is defined as "that form of heart disease in which myocardial insufficiency with or without myocarditis has developed in

the absence of lesions of heart valves or pericardium." (Non-Valvular Heart Disease, 1951. Retrieved from: https://jamanetwork.com/journals/jama/article-abstract/1157211).

A.2.3.3.3. Diseases of the myocardium or cardiac chambers - Cardiomyopathy

Cardiomyopathies are diseases of the heart muscle, characterized by abnormal findings of chamber size and wall thickness, or functional contractile abnormal findings-mainly systolic or diastolic dysfunction in the absence of coronary artery disease, hypertension, valvular disease, or congenital heart disease (Elliott *et al*, 2008). Cardiomyopathies are classified as either primary or secondary. Primary cardiomyopathies consist of disorders solely or predominantly confined to the heart muscle, which have genetic, non-genetic, or acquired causes. Secondary cardiomyopathies are disorders that have myocardial damage as a result of systemic or multiorgan disease (Jefferies and Towbin, 2010). Dilated cardiomyopathy is the most common cardiomyopathy worldwide and has many causes and is associated with sudden cardiac death. Although the term "cardiomyopathy" could theoretically apply to almost any disease affecting the heart, it is usually reserved for "severe myocardial disease leading to heart failure." (World Health Organization, 2018). Dilated cardiomyopathy is characterized by left ventricular dilation that is associated with systolic dysfunction. Diastolic dysfunction and impaired right ventricular function can develop. Affected individuals are at risk of left or right ventricular failure, or both. Prevalence in the general population remains undefined. This disorder develops at any age, in either sex, and in people of any ethnic origin. In adults, dilated cardiomyopathy arises more commonly in men than in women. In adults, the prevalence is one in 2500 individuals, with an incidence of seven per 100 000 per year (but it could be underdiagnosed). In many cases, the disease is inherited, and is called familial dilated cardiomyopathy. The familial type might account for 20–48% of all cases. Common symptoms include dyspnea (breathlessness) and peripheral oedema (swelling of the legs). Those with cardiomyopathy are often at risk of dangerous forms of irregular heart rate and sudden cardiac death (World Health Organization, 2018). Diagnosis is dependent on patient history, and clinical, echocardiographic, or cardiac MRI features of dilated cardiomyopathy or heart failure, or both. Echocardiographic findings are left ventricular dilation and systolic dysfunction, with or without mitral regurgitation. Additionally, pericardial effusion and rhythm irregularities can be noted. Chest radiographs often show cardiomegaly and increased pulmonary vascular markings that are consistent with pulmonary oedema. In some cases, patients have complications related to dilated cardiomyopathy, such as thromboembolic disease, including stroke (Jefferies and Towbin, 2010). Cardiomyopathy and myocarditis resulted in 443,000 deaths in 2013, up from 294,000 in 1990 (World Health Organization, 2018).

A3. Aim

National and global economics generally oscillate between cycles of growth and recession of variable duration. The influence of financial parameters on public health indices has been subjected to scientific research. Yet, relevant studies have provided rather mixed findings, with various potential explanations. Rather unpredictably, the relatively smooth financial cycles may be interrupted by periods of economic crisis. The latter may consist of bursting of financial bubbles, bank bankruptcies, sudden depreciation of the stock market or of other financial products, currency crises or inability of national governments to repay their debts. Impacts of crises are seen in many areas of financial activity, affecting various aspects of life and especially health (Falagas *et al*, 2009). It is generally known that financial crises increase inequalities, even though it is difficult to determine a clear pattern as each crisis has its own characteristics. Nevertheless, there has been increasing interest in going into more detail and analyzing the impact on health inequalities only. The literature shows evidence of an increase in health inequalities during crisis periods, both previous and current. These health inequalities have been seen in different health variables: mortality, mental health, self-perceived health, excessive alcohol consumption, health-related quality of life, long-standing illness, and disability (Maynou and Saez, 2016). However, to the best of our knowledge, no recent systematic review has investigated the overall significance and clinical impact of the findings of relevant studies.

The aim of this systematic review is to examine evidence from relevant studies on factors influencing cardiovascular health and to observe any potential changes in the trends and the severity of the established cardiovascular disease, among the general population living in countries exposed to financial crises.

B. Methods

A systematic review was conducted in order to detect current scientific literature referring to the correlation between the economic crises during the 20th and 21st centuries and cardiovascular health.

B1. Literature search and eligibility criteria

A literature search was based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Liberati *et al*, 2009). The protocol of the wider systematic review was prepared and agreed in advance by the two independent evaluators (DT, MB) and approved by the supervisor (TNS). The protocol has subsequently been adapted to the purpose of this study that is provided as Appendix 1.

Eligible studies were identified in PubMed, Embase, and Google Scholar and the end-of-search date was May 12, 2020. No restrictions regarding publication language, publication status, geographical region or participant age were adopted. The details about the search algorithm are provided in Supporting Information Methods Appendix 1 (Protocol, section #8).

Studies examining the relationship between economic crisis and cardiovascular health in the 20th and 21st century, were included. Case-control, cohort, cross-sectional, ecological studies, surveys, registries, investigating any potential changes in the incidence and severity of cardiovascular disease (CVD), (namely overall incidence of CVD, overall mortality from CVD, Ischemic Heart Diseases (IHDs), hypertension, cerebrovascular diseases, cardiac arrhythmias, heart failure (HF), embolism/peripheral thrombosis, other) were eligible. The studies therefore had to present at least two time points of observation (pre- and/or during, and post-crisis periods); comparisons performed in terms of descriptive statistics or with the use of statistical hypothesis testing, were deemed eligible.

Papers, the title or abstract of which did not contain the keywords or the content of which did not explicitly refer to the correlation between economic crisis and CVD were excluded from further review. The following groups of studies were excluded:

- *In vitro* studies, animal studies.
- Case reports, case series, reviews and meta-analyses.
- Studies looking at the impact of macroeconomic indicators on health outcomes without clearly defining the period of the crisis.
- Studies on impact of economic crises on health system performance and general health effects of poverty, unemployment, socioeconomic status without a direct link to economic crises.
- Studies reporting on outcomes of health care utilization (i.e., not on health outcomes).

- Conference proceedings, symposium/consensus reports, posters' abstracts, oral presentations, commentaries/letters to the Editor, editorials, that did not present relevant original data.
- Studies not referring to CVDs or incidence/mortality.
- Studies reporting only on risk factors.
- Studies reporting different times of economic crisis and CVDs assessment.

B2. Study selection process

Two reviewers (DT and MB) independently screened the search results by title, abstract and full text, for relevance to the topic. Disagreements were resolved by discussion with the supervisor (TNS) and team consensus. Results from the bibliographic databases were merged and duplicates were removed. A systematic search in the reference lists and citations of the selected papers and relevant reviews for potentially eligible articles was performed ("snowball" procedure).

B3. Data extraction and analysis

Data were extracted using a standardised data extraction form that included: first author's name, publication year, study design, study period, geographical region, demographics (males' percentage, mean age, age range), health outcome, definition and ascertainment of economic crisis, categorization (comparison) of economic crisis, adjusting factors, type of effect estimate, main findings. Additionally, regarding cohort studies, the cohort size, number of incident cases, cohort characteristics and definition/features of CVDs in cohort were abstracted.

In case of overlapping study populations, the larger study was ultimately included; however, if an overlapping study reported an additional health outcome, the latter was evidently retained. Two reviewers (DT, MB) independently performed the selection of studies; in case of disagreement, the final decision was reached by consultation with the supervisor (TNS) and team consensus.

For the purpose of this study, are presented studies that analyzed the following topics regarding CVD outcomes: overall CVD incidence and mortality; cardiac arrhythmias; pulmonary embolism and other heart diseases. The custom data extraction tables are provided in the Appendix 2-5.

B4. Risk of bias assessment

The quality of included studies was assessed using the Newcastle-Ottawa Quality scale (Wells *et al*, 2011). With respect to ecological and cohort studies, the cut-off value was *a priori* set at 1 year regarding the desirable length of follow-up, whereas the cut-off value for completeness of follow-up was set at 85%. The studies were rated by two independent reviewers (DT and MB); in case of disagreements, final decision was reached by team consensus. A 'star system'

was used to assess each eligible study on three broad perspectives: the selection of the study groups; the comparability of the groups; and the ascertainment of outcome, respectively.

Studies were given a rating for each domain according to the thresholds for converting the Newcastle-Ottawa scales to AHRQ standards (Wells *et al*, 2014) (good, fair, and poor) as following:

- Good quality: 3 or 4 stars in selection domain AND 1 or 2 stars in comparability domain AND 2 or 3 stars in outcome domain.
- Fair quality: 2 stars in selection domain AND 1 or 2 stars in comparability domain AND 2 or 3 stars in outcome domain.
- Poor quality: 0 or 1 star in selection domain OR 0 stars in comparability domain OR 0 or 1 star in outcome domain.

The evaluation of the eligible studies custom table is provided in the Appendix 6.

C. Results

C1. Characteristics of included studies

The results of the review process are shown in Fig. 5. Initially, 9314 studies were identified and screened by title and abstract for possible inclusion in the review. In total, 9002 non-duplicate items were obtained and assessed for eligibility. Fifty-eight studies met the eligibility criteria and were included in the initial systematic review which assessed all the selected CVDs outcomes. Of these, 38 (Mattei *et al*, 2014; Gurfinkel *et al*, 2005; Kim *et al*, 2003; He *et al*, 2019; Patel *et al*, 2019; Olfson *et al*, 2018; Noelke and Avendano, 2015; Ruhm, 2015; Schwartz *et al*, 2012; Stuckler *et al*, 2012; Kaviratne *et al*, 2012; Raptis *et al*, 2020; Vardakas *et al*, 2019; Sanidas *et al*, 2018; Panagiotakos *et al*, 2013; Laliotis *et al*, 2016; Vlachadis *et al*, 2014; Voulgari *et al*, 2019; Regidor, Mateo *et al*, 2019; Regidor, Rouda *et al*, 2019; Nolasco *et al*, 2018; Khang *et al*, 2005; Kim *et al*, 2004; Guojónsdóttir *et al*, 2012; Birgisdóttir *et al*, 2017; Sosa Liprandi *et al*, 2012; Valkonen *et al*, 2000; Verso and Picciotto, 2014; Chang, 2020; Blakely *et al*, 2008; Men *et al*, 2003; Guberan, 1979; Astell-Burt and Feng, 2013; Niedzwiedz *et al*, 2019; Lin, 2009; Toffolutti and Suhrcke, 2014; De León *et al*, 2018; Tapia Granados and Ionides, 2017) were related to the purpose of this study.

Especially, thirteen (n=13) studies (Kim *et al*, 2003; He *et al*, 2019; Patel *et al*, 2019; Olfson *et al*, 2018; Noelke and Avendano, 2015; Kaviratne *et al*, 2012; Panagiotakos *et al*, 2013; Guojónsdóttir *et al*, 2012; Birgisdóttir *et al*, 2017; Verso and Picciotto, 2014; Chang, 2020; Astell-Burt and Feng, 2013; Niedzwiedz *et al*, 2019) investigated the relationship between economic crisis and **overall incidence of CVDs**.

Twenty-three (n=23) (Mattei *et al*, 2014; Gurfinkel *et al*, 2005; Ruhm, 2015; Schwartz *et al*, 2012; Stuckler *et al*, 2012; Vardakas *et al*, 2019; Laliotis *et al*, 2016; Vlachadis *et al*, 2014; Regidor, Rouda *et al*, 2019; Nolasco *et al*, 2018; Khang *et al*, 2005; Kim *et al*, 2004; Birgisdóttir *et al*, 2017; Sosa Liprandi *et al*, 2012; Valkonen *et al*, 2000; Verso and Picciotto, 2014; Blakely *et al*, 2008; Men *et al*, 2003; Guberan, 1979; Lin, 2009; Toffolutti and Suhrcke, 2014; De León *et al*, 2018; Tapia Granados and Ionides, 2017) were related with **overall mortality from CVDs**.

Three (n=3) (Gurfinkel *et al*, 2005; Vardakas *et al*, 2019; Sosa Liprandi *et al*, 2012) were related with **cardiac arrhythmias**. One article (n=1) (Raptis *et al*, 2020) was related with **pulmonary embolism**. Three (n=3) (Gurfinkel *et al*, 2005); Vardakas *et al*, 2019); Sosa Liprandi *et al*, 2012) were related with **other heart diseases**. Tables 2-5 in the Appendix 2-5 presents the data extraction of the papers that were included in this study.

The content of this work assesses the impact of the economic crisis on cardiovascular health in the 20th and 21st centuries.

The vast majority of the papers focused on the **United States of America** (n=7) (Patel *et al*, 2019; Olfson *et al*, 2018; Noelke and Avendano, 2015; Ruhm, 2015; Schwartz *et al*, 2012; Stuckler *et al*, 2012; Kaviratne *et al*, 2012) and **Greece** (n=7) (Raptis *et al*, 2020; Vardakas *et*

al, 2019; Sanidas *et al*, 2018; Panagiotakos *et al*, 2013; Laliotis *et al*, 2016; Vlachadis *et al*, 2014; Voulgari *et al*, 2019). Other countries included were **Spain** (n=3) (Regidor, Mateo *et al*, 2019; Regidor, Rouda *et al*, 2019; Nolasco *et al*, 2018), **Korea** (n=3) (Kim *et al*, 2003; Khang *et al*, 2005; Kim *et al*, 2004), **Iceland** (n=2) (Guojónsdóttir *et al*, 2012; Birgisdóttir *et al*, 2017), **Argentina** (n=2) (Gurfinkel *et al*, 2005; Sosa Liprandi *et al*, 2012), **Finland** (n=1) (Valkonen *et al*, 2000), **Italy** (n=2) (Verso and Picciotto, 2014; Mattei *et al*, 2014), **China** (n=1) (He *et al*, 2009), **Taiwan** (n=1) (Chang, 2020), **Russia** (n=1) (Men *et al* 2003), **New Zealand** (n=1) (Blakely *et al*, 2008), **Switzerland** (n=1) (Guberan, 1979) and the **United Kingdom** (n=1) (Astell-Burt and Feng, 2013). Five papers (Niedzwiedz *et al*, 2019; Lin, 2009; Toffolutti and Suhrcke, 2014; De León *et al*, 2018; Tapia Granados and Ionides, 2017) used data from **more than one** country, either to collectively analyze the data or to compare outcomes across countries.

The eligible studies reflect the following economic crises: the **Great Depression** (started in 1929) (n=1) (Stuckler *et al*, 2012), **Oil Crisis** (1970s) (n=1) (Guberan, 1979), the **Finnish Banking Crisis** (1991-1993) (n=1) (Valkonen *et al*, 2000), **Asian Financial Crisis** (1997-1999) (n=4) (Kim *et al*, 2003; Khang *et al*, 2005; Kim *et al*, 2004; Lin, 2009), **Russian Financial Crisis** (1998) (n=1) (Men *et al*, 2003), **Argentina Great Depression** (1998-2002) (n=1) (Gurfinkel *et al*, 2005) and the **Global Economic Crisis** (n=8) (Mattei *et al*, 2014; He *et al*, 2019; Verso and Picciotto, 2014; Chang, 2020; Niedzwiedz *et al*, 2019; Toffolutti and Suhrcke, 2014; De León *et al*, 2018; Tapia Granados and Ionides, 2017), which encompasses the **US Great Recession** (2007–2008) (n=5) (Patel *et al*, 2019; Olfson *et al*, 2018; Ruhm, 2015; Schwartz *et al*, 2012; Kaviratne *et al*, 2012), the **Icelandic Financial Crisis** (2008-2011) (n=2) (Guojónsdóttir *et al*, 2012; Birgisdóttir *et al*, 2017), the **UK Financial Crisis** (which started in 2008) (n=1) (Astell-Burt and Feng, 2013), the **Greek Financial Crisis** (which started in 2008) (n=7) (Raptis *et al*, 2020; Vardakas *et al*, 2019; Sanidas *et al*, 2018; Panagiotakos *et al*, 2013; Laliotis *et al*, 2016; Vlachadis *et al*, 2014; Voulgari *et al*, 2019) and the **Spanish Financial Crisis** (which started in 2008) (n=3) (Regidor, Mateo *et al*, 2019; Regidor, Rouda *et al*, 2019; Nolasco *et al*, 2018). Three papers analyzed **more than one** economic crisis (Noelke and Avendano, 2015; Sosa Liprandi *et al*, 2012; Blakely *et al*, 2008).

Of the 38 selected studies, **27** (Mattei *et al*, 2014; He *et al*, 2019; Patel *et al*, 2019; Ruhm, 2015; Schwartz *et al*, 2012; Stuckler *et al*, 2012; Raptis *et al*, 2020; Vardakas *et al*, 2019; Laliotis *et al*, 2016; Vlachadis *et al*, 2014; Regidor, Mateo *et al*, 2019; Regidor, Rouda *et al*, 2019; Nolasco *et al*, 2018; Khang *et al*, 2005; Kim *et al*, 2004; Birgisdóttir *et al*, 2017; Sosa Liprandi *et al*, 2012; Valkonen *et al*, 2000; Verso and Picciotto, 2014; Blakely *et al*, 2008; Men *et al*, 2003; Guberan, 1979; Niedzwiedz *et al*, 2019; Lin, 2009; Toffolutti and Suhrcke, 2014; De León *et al*, 2018; Tapia Granados and Ionides, 2017) were **ecological** studies, **6** (Gurfinkel *et al*, 2005; Olfson *et al*, 2018; Sanidas *et al*, 2018; Panagiotakos *et al*, 2013; Voulgari *et al*, 2019; Chang, 2020) were **cohort** studies, **2** (Kaviratne *et al*, 2012; Guojónsdóttir *et al*, 2012) were **register-based** studies and 3 (Kim *et al*, 2003; Noelke and Avendano, 2015; Astell-Burt and Feng, 2013) were **cohort surveys**. Study characteristics are shown in custom Appendix 2-5.

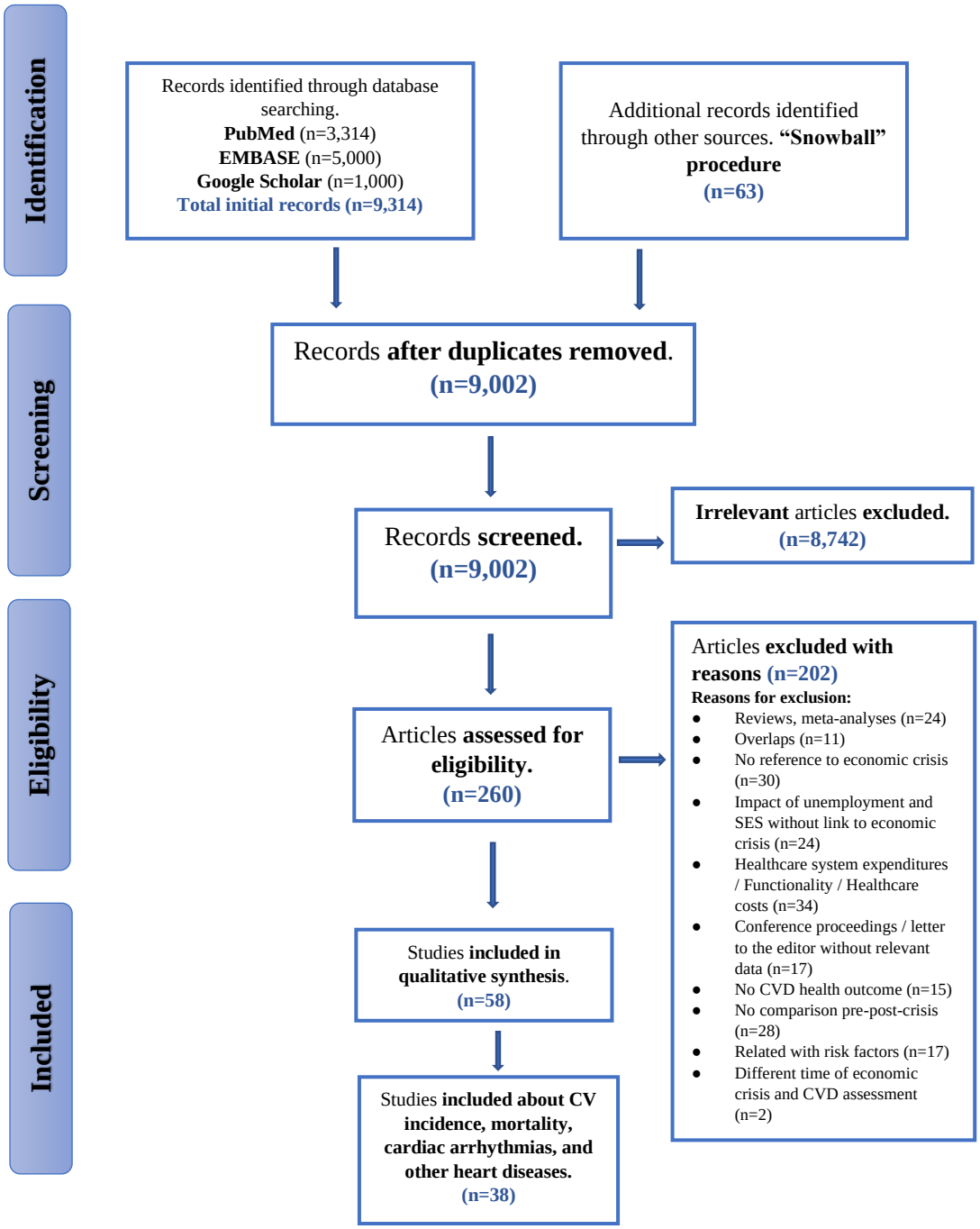

Figure 5. PRISMA flow diagram 2009 describing the selection of studies.

C2. Risk of bias assessment

The quality of the studies was assessed, considering the following components: selection, comparability and outcome. From the 38 studies reviewed, twenty-one (55%) were rated as poor, showing a high risk for bias in at least three domains. Fifteen studies (40%) were rated as fair, showing a high risk for bias in up to two domains. Only two studies (5%) were rated as good in the overall risk assessment (full details are provided in the Appendix 6). Allowing for the acknowledged limitations of ecological studies, the selection of non-exposed, the demonstration that outcome of interest was not present at start of study and the adequacy of follow-up, were the weakest areas in the majority of studies reviewed.

C3. Cardiovascular Diseases and economic crises

C3.1. Overall incidence of CVDs

The 11 out of 13 relevant studies reported a significant increase in CVDs (Kim *et al*, 2003; He *et al*, 2019; Patel *et al*, 2019; Olfson *et al*, 2018; Noelke and Avendano, 2015; Kaviratne *et al*, 2012; Panagiotakos *et al*, 2013; Guojónsdóttir *et al*, 2012; Birgisdóttir *et al*, 2017; Verso and Picciotto, 2014; Chang, 2020; Astell-Burt and Feng, 2013) during and after the financial crisis and found that men and unemployed were more significantly affected.

Asian financial crisis in 1990s (1997- 1999)

The study by Kim *et al*. (Kim *et al*, 2003) examined and quantified the impact of the Asian financial crisis on CV morbidity in the Republic of Korea. The study took place in 1995 and 1998 and indicated that the CVD morbidity rates significantly increased as CVD disease morbidity was 262 per 22,675 persons (1.16) before crisis and 800 per 43,682 persons (1.83) after crisis ($p<0.01$).

Great Recession (2008)

A cross-European study by Niedzwiedz *et al*. (Niedzwiedz *et al*, 2019) investigated the impact of regional employment levels and individual worklessness on health during the period of the Great Recession across 16 European countries. It was suggested that there was little difference in the strength of the associations when comparing the relationship between the 2008 and 2013 regional employment rates and the health outcomes [in 2008: PRR=0.973 (95%CI: 0.955-0.991), in 2013: PRR=0.973 (0.953-0.993)]. It was found that higher regional employment levels were associated with lower risk of poor health and a PRR of below one. The strongest association between the average regional employment rate and the health outcomes was observed for heart and circulation problems where the PRR (95%CI) was 0.971 (0.951-0.991), $p<0.01$ in the period 2008-2013. Worklessness was associated with higher risk of adverse health outcomes. Difference in employment rates and heart/circulation problems during the period 2008-2013 for PRR (95%CI) was 0.993 (0.943-1.0.45) which was non-statistically significant.

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Evaluating data from years preceding and following the year 2008 Verso & Picciotto, (Verso and Picciotto, 2014) mentioned that during a ten-year period (2002-2012) an increased incidence of cardiac cases in Italy and Sicily.

Yu-Hung Chang (Chang, 2020) examined CVD hospitalizations of 4,673 participants aged 20 and above, in Taiwan, before and during the 2008 financial crisis among five occupational groups (i.e., professional & manager (PM), office clerk & administrative staff (OA), skilled work (SW), unskilled worker (UW) and non-worker (NW)) and found that CVD hospitalization of all occupations were affected by the financial crisis; although non-workers were the early victims, skilled workers were the most vulnerable in the 2008 financial crisis. For all these groups, the incidence rates of CVD hospitalization reached the peak in the third year (2008) (PM: IRR (95%CI)=2.68(1.05-6.83); OA: IRR=2.70(1.18-6.19); SW: IRR=5.13(2.89-9.09); UW: IRR=2.12(1.02-4.41); NW: IRR=1.85(1.18-2.67). In China, He *et al*. (He *et al*, 2019), observed that China's economic growth (2005-2008) reduced CVD incidence. During the financial crisis (2008-2010) the CVD incidence rate was significantly increased. During the period of sustained economic downturn (2011-2013), the CVD morbidity rate remained as was in the period 2005-2008. In the new normal stage of the economy (2013-2017), the inhibitory effects of CV morbidity were weakened.

Three studies examined the incidence of CVDs during the U.S. Great Recession. The two of them by Olfson *et al*. (Olfson *et al*, 2018) and Patel *et al*. (Patel *et al*, 2019) revealed a statistically significant increase in CVDs after the onset of the crisis. The latter mentioned that in participants with high SES, the mean CV health score decreased from 9.4 (95%CI: 8.9-9.8) in 2007-2010 to 8.7 (95%CI: 8.2-9.3) in 2015-2016. Thus, in the higher socioeconomic strata, there was a decline in the prevalence of ideal CV health from 51% in 2007-2010 to 42% in 2015-2016. Among lower socioeconomic strata, the adjusted mean CV health score increased from 7.4 (95%CI: 6.6-8.1) in 2007-2010 to 8.4 (95%CI: 7.7-9.2) in 2011-2012 and then subsequently declined to 7.0 (95%CI: 6.0-8.0) in 2015-2016 thus, the prevalence of ideal CV health increased from 16% in 2007-2010 to 26% in 2011-2012 and then declined to 13% in 2015-2016. No trend in the mean CV health score or the prevalence of ideal CV health was noted among participants in the middle socioeconomic stratum. It was demonstrated that the ideal CV health continued to decline despite the economic recovery across all socioeconomic strata. Kaviratne *et al*. (Kaviratne *et al*, 2012) mentioned that the overall prevalence of CVD remained stable for five years (2005-2010); in the course of which the national unemployment rate increased (from 4.7% in 2001 to high of 9.6% in 2010).

The Icelandic financial crisis was associated with a sharp short-term increase of CVD incidence and attendance at the cardiac emergency departments, particularly among women on whom attendance at the cardiac ED increased by more than 40% in 2008, according to Guðjónsdóttir *et al*. Moreover, compared with the preceding weeks before crisis, the economic collapse in 2008 was associated with a distinct increase in the total number of visits to the cardiac ED (RR=1.26; 95%CI:1.07-1.49), particularly among women (RR=1.41; 95%CI:1.17-1.69) and marginally among men (RR=1.15; 95%CI: 0.96-1.37) (Guðjónsdóttir *et al*, 2012).

Contrariwise, Birgisdóttir *et al* (Birgisdóttir *et al*, 2017) found an inverse relationship between the economic recovery indicator (in 2012) and CVD incidence as a decreased probability of CVD was observed for females during the economic recovery period by 4.14 percentage points compared to the pre-crisis period.

In Greece, Panagiotakos *et al*, (Panagiotakos *et al*, 2013) revealed a 9.9% (95%CI: 3.5%-16.7%) relative annual increase in the prevalence of CVD for the period 2006-2012. The peak in the prevalence of CVD was observed in 2009 and 2010 when the Greek financial crisis dominated.

Astell-Burt & Feng (Astell-Burt and Feng, 2013) examined the UK financial crisis analyzing a sample of 1.36 million people and observed that CV health problems were at 3.7% in January-March 2006 whereas in January-March 2008 increased by 0.2% comparatively to the beginning of the economic recession and then climbed between January-March 2008 and October-December 2010 by 0.6%, during the recession.

Multiple economic crises

Noelke & Avendano (Noelke and Avendano, 2015) evaluated two economic downturns; the early 1990s recession and the Great Recession, in the 1992-2010 interval and they mentioned that among workers who experienced job loss, recessionary labor market conditions at the time of job loss were associated with a significantly higher CVD risk (HR=2.54 (95%CI: 1.39-4.65). In contrast, among workers who did not experience job loss, recessionary labor market conditions were associated with a lower CVD risk (HR=0.50 (95%CI: 0.31-0.78)). These results suggested that recessions might be protective in the absence of job loss but hazardous in the presence of job loss.

Characteristics of eligible studies about overall CV incidence are provided in the Appendix 2.

C3.2. Overall mortality from CVDs

Seventeen out of twenty-three relevant studies showed a significant decrease in CV mortality during the period of economic crises (Mattei *et al*, 2014; Vardakas *et al*, 2019; Laliotis *et al*, 2016; Vlachadis *et al*, 2014; Regidor, Rouda *et al*, 2019; Nolasco *et al*, 2018; Khang *et al*, 2005; Birgisdóttir *et al*, 2017; Sosa Liprandi *et al*, 2012; Valkonen *et al*, 2000; Verso and Picciotto, 2014; Blakely *et al*, 2008; Guberan, 1979; Lin, 2009; Toffolutti and Suhrcke, 2014; De León *et al*, 2018; Tapia Granados and Ionides, 2017). Referring to CV mortality, women revealed to be less affected by economic fluctuations than men.

Great Depression in 1930s (1929-1939)

In the study by Stuckler *et al*. (Stuckler *et al*, 2012) in the U.S. during the Great Depression, deaths due to heart disease increased by about 19.4% and heart disease rates could plausibly be linked to short-term economic shocks; reductions in income levels correlated with significant rises in CVDs. A 10% rise in bank suspensions was associated with percentage changes in mortality due to heart disease [effect size (95%CI): -0.17 (-0.73 to 0.26)]. In addition, there was

an association of a 10% rise in GDP per capita with percentage changes in mortality due to heart disease [effect size (95%CI): -0.49 (-0.90 to -0.08) and an association of a 10% decline in GDP per capita attributable to the banking collapse with percentage changes in mortality due to heart disease [effect size (95%CI): -0.66 (-2.80 to -1.00)].

Oil crisis or oil shock (1970s)

E. Guberan (Guberan, 1979) reported that from 1951 to 1976 in Switzerland, the age-standardised death rate from all diseases of the circulatory system decreased by 22% in males and by 43% in females.

Finnish Banking Crisis (1991-1993)

The study by Valkonen *et al*. (Valkonen *et al*, 2000) referred to the way social class differences in mortality changed in Finland during 1981-1995, a period which saw drastic economic fluctuations. A continuous decline in CVD mortality was marked; the larger decrease was noted in the non-manual class from 1981-1985 to 1991-1995. In contrast to the 1980s, CVD mortality diminished more in the manual than in the non-manual class. However, the proportion of CVD deaths was smaller among women than among men.

Asian financial crisis in 1990s (1997-1999)

Three studies focused on the impact of the Asian financial crisis on CVD mortality. Lin (Lin, 2009) using panel data for eight countries in the Asia Pacific region from 1976 to 2003, mentioned that 1% increase in the unemployment rate significantly lowers the predicted fatalities from CVDs by 0.9 (R^2=0.98). In South Korea, Khang and colleagues (Khang *et al*, 2005) computed age-standardized CV mortality rates by sex before and after the economic crisis and found a decrease in the mortality rate ratios between 1996-2002 in diseases of circulatory system cause of death with $RR_{(1998/1996)}$=0.94 for males, $RR_{(2002/1996)}$=0.54 for females aged 1-14, $RR_{(1998/1996)}$=0.98 for males, $RR_{(1996/2002)}$=0.70 for females aged 15-34, respectively. Kim *et al*. (Kim *et al*, 2004) found that there was an annual increase of 353 deaths due to CVD after the economic crisis. Excess mortality per 100,000 population was 12.6 in 1998 and 19.6 in 1999.

Russian Financial Crisis (Ruble crisis or Russian Flu) (1998)

Men *et al*. (Men *et al*, 2003) analyzed trends of CV mortality for 1991-2001 for Russia overall and for seven federal districts and found that in the period 1998-2001 there was a modest increase in deaths from circulatory disease, like that seen in the earlier increase in the 1991-1994 and a decrease between 1994 and 1998.

Argentine Great Depression (1998-2002)

Analyzing data from 3,220 patients from the Argentine cohort of the international multicenter Global Registry of Acute Coronary Events (GRACE), Gurfinkel *et al*. (Gurfinkel *et al*, 2005) found that the financial crisis may have had a negative impact on CV mortality during

hospitalization as the incidence proportion of CV mortality was 6.2%, higher than that in after crisis period (5.1%). Moreover, the crude OR for mortality was 1.2 (95% CI: 0.87-1.7).

Great Recession (2008)

Thirteen studies investigated the impact of Great Recession on CV mortality. In Italy, the study by Verso & Picciotto (Verso and Picciotto, 2014) reported that during the decade 2002-2012, there has been a significant reduction in the number of deaths due to CVDs as the in-hospital CVD mortality which in 2012 stands at around 10%, in 2002 was 30%. On the other hand, Mattei *et al*. (Mattei *et al*, 2014) mentioned that CVD mortality was associated with the rate of unemployment (b=0.73, p=0.03) and showed a significant increase in 2010 (CVD mortality rate x 10,000=37.78 in 2010 vs. 41.9 in 2000). Two other studies by Toffolutti & Suhrcke (Toffolutti and Suhrcke, 2014) and Tapia Granados & Ionides (Tapia Granados and Ionides, 2017) pointed out that the Great Recession has had a beneficial health effect on average across EU countries. Specifically, using a panel for 23 and 27 European Union countries, respectively, found that at ages below 65 a one-percentage point increase in the standardised and national unemployment rate was associated at high levels of statistical significance with a 3.7% reduction of mortality due to CVD. In the second study, the greatest reduction observed in the group of countries with the "most severe" recession in 2007–2010; a one-percentage point increase in unemployment was associated with reductions of age-standardized mortality from CVD by 0.3%. Considering mortality at all ages, there were found associations with a 0.4% reduction of CVD mortality ($p<0.001$).

Using data from an Icelandic representative sample in 2007, 2009 and 2012, Birgisdóttir *et al*. (Birgisdóttir *et al*, 2017) reported that mortality rates due to circulatory diseases were distinctly downward trending both before and throughout the study period.

Three Greek studies used data from the Hellenic Statistical Authority (ELSTAT) but applied different analyses. Using data from 1955-2015 Vardakas *et al*. (Vardakas *et al*, 2019) found that CVD mortality declined almost continuously from 3.01/1000 in 2000 to 2.58/1000 in 2014. Moreover, the annual rate increased during the crisis (0.05/1000) compared to the annual rate before the crisis (0.02/1000), which should be primarily attributed to the decrease in deaths due to heart diseases. Using interrupted time-series analysis from 2001 to 2013, Laliotis and colleagues (Laliotis *et al*, 2016) found that compared with before the crisis, deaths from circulatory diseases continued to fall, but to a lesser extent. This decline was more evident for females than for males. Older age groups experienced more negative changes in mortality from circulatory diseases after the onset of the Greek financial crisis. Vlachadis *et al*. (Vlachadis *et al*, 2014) mentioned that CVD mortality in 2004–2008 declined overall by 15%, and these decreasing trends remaining unaffected during the crisis period 2008–2012, as from 2008 through 2012, CVD mortality rates decreased by 13%. Therefore, the authors supported that age-standardized mortality attributable to CVD was not adversely affected by the economic recession.

Of the two studies on Spanish financial crisis, Regidor and colleagues (Regidor, Mateo *et al*, 2019) using 2001-2016 data from the national mortality register from Spain, found that the

mortality rates from CVDs declined each year with respect to the previous one, except in 2003 and 2015. The decline in the second part of the economic crisis and during the austerity policies (2011-2013) was slightly greater than before the crisis (2001-2007). Similarly, Nolasco *et al*. (Nolasco *et al*, 2018) used national data from 2002-2013 and concluded that the CVD mortality rate declined more during the first 4 years of the crisis period (2008-2011) than in the 4 years preceding the crisis (2004-2007), especially in low socioeconomic groups. On the other hand, Cabrera de León *et al*. (De León *et al*, 2018) mentioned that from 2000 to 2010, mortality from CVDs in Spain showed a sharp increase beginning in 2011 whereas during this period, CVD mortality in the United States continued to show the declines recorded in the preceding decade.

Two studies investigated the US Great Recession's impact on CV mortality. On the one hand, C. J. Ruhm (Ruhm, 2015) showed that there was a strong procyclicality of CVD mortality which was equal to -0.0036 (p=0.0013) and -0.0041 (p=0.0017) in 1976-1995 and in 1991-2010, respectively. This procyclicality of CV deaths was attributed to the likelihood that short-term behavior changes (e.g., smoking, diet and exercise) strongly influenced the risk of CVD deaths. On the other hand, Schwartz, and colleagues (Schwartz *et al*, 2012) indicated that marked increases were observed in total and cardiac death rates in December 2005 and in February 2008 at times when the stock market was relatively stable.

Multiple economic crises

Investigating how the early 1990s and the early 2000s recessions affected CV mortality by using data from repeated cohort studies, Blakely, and colleagues (Blakely *et al*, 2008) noted a strong decrease in mortality from CVD for all income groups throughout the period 1981-2004, in New Zealand. This decline probably reflected both reduction in exposure to risk factors and improvement in access to and effectiveness of clinical treatment. In addition, CV mortality rates decreased from 45% in 1981-4 to 33% in 2001-4 for males, and from 50% to 29% for females. Sosa Liprandi *et al*. (Sosa Liprandi *et al*, 2012) examined two economic crises: The Southeast Asia crisis (1998-1999) and the convertibility system crisis (2001-2002) and they found that although a decrease in cardiovascular mortality was observed, this trend was not linear and changes in the slope (always downward) were evidenced in temporal coincidence with the economic events identified. Between 1995-2005 the CVMR decreased by 24.72% (from 474.9 to 357.5 per 100,000). Initially, from 1995 to 1997 (the pre-crisis period), the aforementioned rate decreased by 9.52%. Then, between 1997 and 2002 (the crisis period), there was an increase in the CVMR of 5.38% while in the period 2002-2005 (the after-crisis period) a decrease in the CVMR of 7.65% it was observed.

Characteristics of eligible studies about overall CV mortality are provided in the Appendix 3.

C3.3. Cardiac arrhythmias

Following the review of three relevant studies, it was noticed that there was an exacerbation of cardiac arrhythmias with economic recessions.

Argentine Great Depression (1998-2002)

Gurfinkel *et al*. (Gurfinkel *et al*, 2005) analyzing data from 3,220 patients resulted in a higher incidence of sustained in-hospital complications of ventricular tachycardia (3.4%, n=75 vs. 2.9%, n=28) in the crisis period versus post-crisis, respectively.

Great Recession (2008)

Vardakas *et al*. (Vardakas *et al*, 2019) examined mortality changes in Greece prior to and during the financial crisis and found that mortality due to cardiac arrhythmias showed an increase during the crisis. Similarly, Voulgari *et al*. (Voulgari *et al*. 2019) followed a retrospective analysis of patients admitted to "G. Gennimatas" hospital of Athens during 1995-2018 and argued that impairment/disability/death after the economic crisis were more frequent as clinical outcomes ($p<0.001$) and were significantly associated with arrhythmia ($p=0.04$) after crisis. Besides Voulgari *et al*. (Voulgari *et al*. 2019) followed a multivariate-logistic-regression analysis and resulted that patients after the economic crisis were found to have a higher incidence of atrial fibrillation ($p<0.001$) compared to patients hospitalized in pre-crisis period.

Characteristics of eligible studies about cardiac arrhythmias are provided in the Appendix 4.

C3.4. Other heart diseases

Four studies examined other heart diseases such as non-rheumatic heart disease (non-RHD), diseases of the myocardium or cardiac chambers e.g., cardiomyopathy and pulmonary embolism (PE) in relation to economic conditions.

Oil crisis or oil shock (1970s)

In Switzerland, E. Guberan (Guberan, 1979) found that for mortality due to non-RHD a steady decline of 40% occurred in females; the male death rate, however, fluctuated until 1963, then decreased until 1973 (-24%) and finally rose sharply between 1973 and 1976 (+12%), which resulted in an overall decline from 1951-1976 of 13%. The advent of the economic recession was associated with a sudden rise in mortality from non-RHD in 1974-76. which increased sharply in males and slightly in females.

Finnish Banking Crisis (1991-1993)

Using records on all deaths in 1981-1985 by Statistics Finland, Valkonen *et al*. (Valkonen *et al*, 2000) found that the absolute increase in the deaths from other CVDs was 4 deaths per 100,000 among women and 6 deaths per 100,000 in men from 1981-1985 to 1986-1990 intervals.

Asian financial crisis in 1990s (1997-1999)

In South Korea, Khang *et al*. (Khang *et al*, 2005) observed a decrease in the mortality rates between 1996-2002 among both sexes aged 35-64 years for cardiomyopathy [$RR_{(1998/1996)}=0.89$,

$RR_{(2002/1996)}$=0.42 for males and $RR_{(1998/1996)}$=0.91, $RR_{(1996/2002)}$=0.48 for females]. A similar decline was noted among both sexes aged 65-79 years.

Great Recession (2008)

Obtaining data on hospital admissions for pulmonary embolism (PE) between 1999 and 2012 by the Hellenic Statistical Authority of Greece, Raptis *et al*. (Raptis *et al*, 2020) investigated the incidence of PE at the Greek population. The annual incidence of PE showed an upward trend ranging from 14 (1999) to 30 (2012) cases per 100,000 population. In the years before and after the Greek financial crisis it were observed statistically significant differences of PE incidence for the two different periods (1999-2008 vs. 2009-2012) as was 14.49 vs. 23.06 respectively, p=0.002. The available data revealed a female predominance (16.48 cases for females vs. 13.69 cases for males per 100,000 population, p=0.031) mainly attributed to the age group of >70 years. The incidence rate increased with age for both genders with a peak in the "80-89" age group for females and >90 years for males. It demonstrated a statistically significant increase in PE incidence between two-time frames, 1999-2008 and 2009-2012 that corresponds to the economic crisis.

Characteristics of eligible studies about other heart diseases are provided in the Appendix 5.

D. Discussion

Examining the impact of financial crises upon CVD outcomes, this systematic review highlighted a variety of findings and associations. Most of the studies demonstrated that an increased prevalence of CVDs coincided with the outbreak of the crisis, irrespective of region or health system (Kim *et al*, 2003; Niedzwiedz *et al*, 2019; Verso and Picciotto, 2014; Chang, 2020; He *et al*, 2019; Olfson *et al*, 2018; Patel *et al*, 2019; Guojónsdóttir *et al*, 2012; Birgisdóttir *et al*, 2017; Panagiotakos *et al*, 2013; Astell-Burt and Feng, 2013; Noelke and Avendano, 2015). Various explanations may account for this result. In the background of financial problems (i.e., low income), individuals may adopt unhealthy dietary habits and be exposed to numerous pressures and stressful situations that can also trigger mental problems such as depression and anxiety. It should be taken into account the importance of patients' non-adherence to medical treatment which may worsen the health status (Michas *et al*, 2019). It is acknowledged that stress perception affects biochemical and physiological parameters, such as a reduced condition of immunity, an increased release of cortisol or an increase in the cholesterol concentration. It has been suggested that the biological mechanism which links stressful situations to ill-health involves the process of inflammation; a common cause of CVDs. Inflammation, measured by interleukin-6, C-reactive protein and fibrinogen, is predictive of CVD in populations with depressed mood (Zagożdżon *et al*, 2014). Moreover, it is found that negative effects of economic hardships on CV health are most likely to occur when economic declines are rapid, as was the case of the Great Recession, in 2008.

However, some studies portrayed a different perspective. For instance, studies focusing on CVD mortality (Laliotis *et al*, 2016; Regidor, Ronda *et al*, 2019; Nolasco *et al*, 2018; Valkonen *et al*, 2000; Parmar *et al*, 2016) seemed to show a greater decrease during economic downturns. These results are in line with several studies which concluded that this was probably due to fewer working hours and healthier lifestyles during years of economic difficulties (Parmar *et al*, 2016). Remarkably, various authors have referred that potential mechanisms which are responsible for this reduction are the decline in smoking and drinking due to reduced purchasing power, together with slower rhythms of work and shorter overtime, leading to less occupational stress and more time for physical activity (Regidor, Ronda *et al*, 2019) Moreover, greater access to health services and improvements of the CVDs' treatment and secondary prevention of CVDs, are also implausible as determinants of the increased survival (Regidor, Ronda *et al*, 2019). Also, individuals of high socioeconomic status have better access to such new treatments when they are not yet widely available. The positive correlation between the impact of the crisis and the decrease of CVD mortality seems to verify the paradox that periods of economic slowdown may bring beneficial effects on health, which give rise to the "pro-cyclical theory" (Nolasco *et al*, 2018) that associates the economic crisis with positive health outcomes (Ruhm, 2015; Lin, 2009; Tapia Granados and Ionides, 2017; Nolasco *et al*, 2018).

The main findings shed some light on the groups most affected during the financial crisis. The results on demographic factors such as gender and age were somehow contradictory, but,

overall, men seemed to be more severely affected, as figured by CVD trends and self-rated health. It is commonly believed that cardiovascular diseases seem to reflect differently on genders. This is due to the fact that men and women have dissimilarities on epidemiology, pathophysiology, treatment response and outcomes of some common heart diseases. Interestingly, plenty of studies showed a different timing of response across genders; with males showing a more immediate response and descending with time, and females showing a delayed response during the economic recovery as opposed to the height of the crisis. This later-time appearance indicates a lingering female response that may have taken longer to come through (Birgisdóttir *et al*, 2017; Jarroch *et al*, 2021), in consistence with previous studies was found that women tend to develop cardiovascular disease about 10 years later in life than men (EUGenMed *et al*, 2016).

These general results match with other studies which proved that although the incidence of CVD in women is usually lower than in men, women have a higher mortality and worse prognosis after acute cardiovascular events.

It should be borne in mind that the crisis slowed the overall decline in mortality in different ways among older age groups and had varied effects by cause of death. There was a consistent pattern according to age as it was observed that elders experienced more negative changes in CVD mortality than the younger population after the onset of the Greek financial crisis (Laliotis *et al*, 2016; Raptis *et al*, 2020; Makaris *et al*, 2013) There are many possible explanations for this pattern, including an effect from substantial reductions in pensions for those adults age 65 and older, or a decline in health-care facilities and resources, both preventive and therapeutic, affecting primarily the frailest individuals (Laliotis *et al*, 2016). Although, Tapia-Granados mentioned that at ages 75 and older, mortality of the elderly improved more during the recession in countries most affected by the crisis such as Greece, Spain, Baltic states and Slovenia (Tapia Granados and Ionides, 2017)

Unemployment is a major socio-political problem following economic transitions which according to the literature, is generally associated with a high cardiovascular event rate. Most of the included studies related to unemployment, demonstrated that economic downturns were important stressors that had a negative impact on the CV health of workers and the general population, irrespective of region or system. As far as is known, the negative effects of unemployment are thought to be manifest predominantly in the target organs of the cardiovascular system and gastrointestinal tract (Weber and Lehnert, 1997). Furthermore, CVDs are becoming increasingly important with regard to morbidity and mortality in the industrialized countries affected by worklessness. This is pertained to distress, individuals' daily habits and changes in socioeconomic status. Moreover, behavioral and lifestyle risk factors may be involved in responsible mechanisms for CVD. Unemployment is associated with a higher prevalence of smoking, hypertension and hypercholesterolemia and correlates with physical inactivity and BMI, the latter occurring only in women. However, some CV risk factors can be diminished during persistent unemployment. It is also known that residence in more deprived areas is associated with increased mortality and increased exposure to

cardiovascular risk factors, independent of individual socio-economic characteristics (Zagożdżon *et al*, 2014). Thus, from a scientific point of view, there is an urgent need for methodologically valid longitudinal studies which sufficiently take into consideration the complex interaction between socio-economic factors and health or disease. Longitudinal data on smoking, alcohol intake, diet and other lifestyle factors including socio-economic determinants are needed to confirm this hypothesis.

Strengths and limitations of study

This study is subject to certain limitations. First of all, most of the eligible studies were ecological, cohort surveys and register-based, while only 6 were cohorts. It is well-established that ecological studies have substantial limitations as unmeasured and uncontrolled confounding make them weak for hypothesis testing. It is widely acknowledged that the term "ecological fallacy" is usually given to conclude on the individual level from data collected on an aggregate level (Cohen, 2005). In addition, there are potential differences in the coding, classification, and diagnosis of the diseases as in the measurement of exposures among various countries. Furthermore, the fact that the exposed individuals in the crisis may not be the same people in the population who were not exposed, was frequently observed.

All the studies included in the present dissertation focuses on the impact of economic crisis on cardiovascular health outcomes. Of the 38 studies that met the inclusion criteria and were analyzed, the vast majority centered on the Great Recession which was the most severe and widespread financial crisis, since the second half of the 20th century, after the Great Depression. Unsurprisingly, the United States, Spain and Greece were overrepresented in eligible studies. It is well known that this deep and prolonged recession began with the housing price crisis in the United States and affected critically many sectors of the economy and several countries (James *et al*, 2008). The most afflicted than any other European country, was Greece that faced tremendous unemployment rates and huge debt loads of the Greek government. Furthermore, Spain attracted the attention, as it presents a similar profile to Greece.

Moreover, a considerable risk of bias was noted in the majority of studies synthesized in the present systematic review. There were only two studies that were rated as "good" in the overall risk assessment; the studies by Astell-Burt & Feng, (Astell-Burt and Feng, 2013), and Regidor *et al*. (Regidor *et al*, 2019). The first two authors claimed that there were increases for cardiovascular health problems during the UK financial hardship whereas the latter authors' team observed a decrease in CV mortality in the group of individuals with occupation in 2001, during the Great Recession, in Spain.

There is also some concern regarding the statistical methods while there is a difficulty in controlling the confounding factors (Cohen, 2005). Another limitation which may lead to selection bias is that the data used may have initially been collected for other purposes.

One more restriction is that most of the studies have used self-reports rather than the objective parameters. Also, some of the selectable studies were not full-text and their abstracts may

contain less information which may lead to allegiance biases. One more restraint is the exclusion of "grey literature" such as papers that did not report a defined recession.

Moreover, it has to be taken into consideration that a country which was hit by an economic hardship is not necessarily linked with individuals' bankruptcies. Last but not least, this study undertook qualitative synthesis, rather than meta-analysis, but this was due to the marked variability of selectable studies' designs, outcomes and exposures. In addition, several studies were excluded if their abstract or title were not relevant with the main topic.

Despite these limitations, the present work is characterized by a plethora of important strengths. At first, it was performed an updated search via three online databases that cover the most of germane literature and it was not subject to any restriction such as language, geographical region, participant age etc. Other key strengths of this work include the broad search algorithm, the strict and meticulous adherence to the PRISMA guidelines (Liberati *et al*, 2009) as well as the careful, systematic search in reference lists (''snowball'' procedure) for the maximization of eligible articles. It is noteworthy that this is the first study of the literature focused on the effect of the financial crises - that plagued the global community over the last two centuries - on cardiovascular mortality and morbidity. From this point of view, the main findings of this research can be inspiring for a wider range of studies looking at the effects of socioeconomic factors on health.

Future research

The preponderance of studies that investigated the role of economic recessions in CVD health covered a short period of time after a financial downturn, albeit it is well-established that a longer follow-up was needed. Investigating the recession's physiological adverse events in long-term, will stimulate interest and give added impetus to further cardiovascular research, as well as these events tend to appear many years later.

Moreover, a quantitative analysis could provide a more precise estimate of the effect size and increases the generalizability (Lee, 2019), as this approach, offers the opportunity to critically evaluate and statistically combine results of comparable studies (Fagard *et al*, 1996).

Remarkably, the economic disaster of COVID-19 pandemic will bring back to the limelight the significance of the linkage of health evolution in the heart of tough economic conditions. By focusing on health outcomes exclusively, it was not studied how the macroeconomic catastrophes weaken health systems and health expenditures. Hence, a review of this literature is left for future research, bearing in mind that financial shocks are expected to happen again.

Conclusions

This study adds to the strand of literature, concerning the connection between economic crises and CV health. The results about this topic are equivocal, and the data and methodologies used in many studies are at risk of substantial bias. This study therefore emphasizes that gender, age and unemployment were the three key factors which interacted most with CVDs. It is necessary to examine further each specific cause or group of causes. More empirical studies and better quality of data are needed to explore the impact of the crisis on health and, more importantly, investigate the mechanisms that affect CVD outcomes.

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F. Appendices

Appendix 1. Protocol of the systematic review, according to the PRISMA guidelines.

Section/topic	#	Checklist item	
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Cardiovascular incidence, cardiovascular mortality, cardiac arrhythmias, and other heart diseases in times of economic crisis in the 20th and 21st century: a systematic review.
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	The relationship between business cycles and health has been studied to a significant extent. Economic crisis constitutes an enormous threat to public health worldwide and has been linked to cardiovascular morbidity and mortality. The Great Recession has attracted interest and opportunities to pursue this line of research further. The relationship between economic downturns and cardiovascular health is intricate. Both the short and longer-term impacts of economic conditions on cardiovascular disease are ambiguous, due to the multitude of determinants of cardiovascular health. Cardiovascular events have been shown to be responsive to stressful factors. For this reason, cardiovascular outcomes have been of interest in the health and business cycle literature. However, to the best of our knowledge, no recent systematic review has investigated the overall significance and clinical impact of the findings of relevant studies. The aim of this systematic review is to examine evidence from relevant studies

			on factors influencing cardiovascular health and to observe any potential changes in the trends and the severity of the established cardiovascular disease, among the general population living in countries exposed to financial crises.
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	To investigate factors influencing cardiovascular health and to observe any potential changes in the trends and the severity of the established cardiovascular diseases. Studies will be included if they examine: (i) exposure to a specific economic crisis (ii) changes in cardiovascular health outcomes or behaviors over time; and (iii) statistical data on associations of cardiovascular health risk and/or protective factors with health outcomes/behaviors. Case-control, cohort, cross-sectional, register-based, ecological studies, surveys and cohort-surveys will be reviewed and included in the analysis. The respective PICOS are described below. PICOS: (P) General population, (I) Economic crisis, (C) pre- and/or during, and post-crisis periods (O): cardiovascular health outcomes, (S): case-control, cohort, cross-sectional, register-based, ecological studies, surveys and cohort-surveys will be reviewed and included in the analysis.
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	Protocol registration will not be performed.
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	All studies examining the relationship between economic crisis and cardiovascular health in the 20th and 21st century, will be included. Case-control, cohort, cross-sectional, register-based, ecological studies, surveys and cohort surveys investigating any potential changes in the trends and the severity of the established cardiovascular disease (overall incidence of CVD; mortality from CVDs; cardiac arrhythmias, other heart diseases); studies should present a comparison between a pre- vs. during and/or post-crisis periods. Comparisons performed in terms of descriptive statistics or with the use of hypothesis testing were deemed eligible. We will exclude in vitro studies, animal studies, case reports, case-series, reviews and meta-analyses, studies looking at the impact of macroeconomic indicators on health outcomes without clearly defining the period of the crisis, studies reporting on outcomes of health care utilization (i.e., not on health behaviors or outcomes), studies on impact of economic crises on health system performance and general health effects

			of poverty, unemployment, socioeconomic status without a direct link to economic crises/shocks/recession, conference proceedings, symposium/consensus reports, posters' abstracts, oral presentations, commentaries/letters to the editor, editorials, that did not present relevant original data, studies not referring to CVDs or incidence/mortality, studies reporting only on risk factors, studies reporting different times of economic crisis and CVDs assessment. No language, publication date, publication status, geographical region or participant age restrictions will be imposed.
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	Studies will be identified by searching in the electronic databases, scanning reference lists of articles and consultation with experts in the field. The search will be applied to PubMed, Google Scholar and EMBASE. No language, publication date or publication status restrictions will be imposed.
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	We will use the following algorithm to search in the selected databases: (recession OR austerity OR "economic shock" OR "economic crisis" OR "financial crisis" OR "fiscal crisis" OR "banking crisis" OR "economic depression" OR "economic hardship" OR "economic insecurity" OR "economic downturn" OR "economic breakdown" OR "economic turmoil" OR "economic stagnation" OR "economic turbulence" OR "macroeconomic fluctuation" OR "financial shock" OR "financial depression" OR "financial hardship" OR "financial insecurity" OR "financial constraint" OR "financial downturn" OR "financial breakdown" OR "financial turmoil" OR "financial stagnation" OR "financial turbulence" OR "stock market crash" OR "great depression" OR bankruptcy) AND (cardiovascular OR vascular OR cerebrovascular OR stroke OR heart OR infarction OR ischemia OR ischaemia OR ischemic OR ischaemic OR arterial OR angina OR coronary OR fibrillation OR arrhythmia OR thrombosis OR embolism OR hypertension OR tachycardia OR bradycardia OR "heart rate" OR aortic OR aorta OR mitral OR aneurysm).
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Eligibility assessment will be performed independently in a blinded standardized manner by 2 reviewers (MB, DT) and disagreements will be resolved by consensus. If no agreement is reached, the decision will be made by consultation with a third independent referee (TNS) and team consensus.
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from	Extraction of articles will be performed independently and in duplicate by two reviewers (MB, DT) and recorded in a predeveloped data extraction sheet.

		investigators.	
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Information will be extracted from each included study on first author's name, publication year, study design, design code, study period, geographical region, percentage of males, mean age, age range, health outcome, definition and ascertainment of economic crisis, categorization of economic crisis, adjusting factors, type of effect estimate and main findings. In case of cohort studies the cohort size, cases in cohort, follow-up (in years) cohort characteristics and definition/features of CVDs in cohort will be recorded.
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	For non-randomized studies (ecological, cohort, register-based, cross-sectional, case-control studies, cohort surveys and surveys) the Newcastle-Ottawa Scale and AHRQ standards will be used.
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	N/A
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	N/A
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/A
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	

Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	This systematic review has no funding source.

Appendix 2. Characteristics of eligible studies about overall CV incidence.

First author (Year)	Design	Cohort size	Cases in cohort	Study period	Region	Males (%)	Mean age	Age range	Cohort Characteristics	Definition/features of CVDs	Definition and ascertainment of economic crisis	Categorization (comparison) of economic crisis	Adjusting factors	Main findings regarding overall CVD incidence
Asian Financial Crisis (1997-1999)														
Kim (2003)	Cohort survey	66,357	NR	1995, 1998	Republic of Korea	48.4 (1995), 48.9 (1998)	NR	All ages	Data obtained from the survey of 1995 (22,675 people from 6,791 households) and from the survey of 1998 (43,682 people from 12,283 households).	CVDs and hypertension, among others. Chronic disease was defined as a disease that lasted for more than three months. All other conditions from which the respondents had been suffering during the two weeks before the interview were defined as acute diseases.	The national economic crisis in the Republic of Korea (Asian Financial Crisis). On 3 December 1997, the Republic of Korea was obliged to receive financial support from the IMF because of a foreign currency crisis. After 1995, the economy grew rather sluggishly until the first three quarters of 1997, and this growth rate continued to decline until the fourth quarter of 1998. In 1999 the economy began to show definite signs of a recovery.	Before (1995) and after (1998) economic crisis	Sex, age, self-evaluated economic status, health insurance type, and maturation	Over the period of economic crisis of the 1990s, the CVD morbidity rates significantly increased as CVD morbidity was 262 per 22,675 persons (1.16%) before crisis and 800 per 43,682 persons (1.83%) after crisis ($p<0.01$).
Great Recession (2008)														
Astell-Burt (2013)	Cohort survey	1,361,216	~103,452 (people with CVDs)	2006-2010	United Kingdom (20 geographical regions)	50.5	NR	16-64 years	This study focused on the health of the working-age population, especially in women aged 16 y–59 y and men aged 16 y–64 y (reflecting gender differences in the national retirement age). This left a sample of 1.36 million survey responses, approximately 57% of the original dataset surveyed across 20 quarters from 2006 to 2010.	Cardiovascular (''Heart, blood pressure or blood circulation problems'').	2008 Economic Recession (Great Recession).	Prior to the beginning, during and after the economic recession.	Age, gender and time	The most reported health problems were CV (7.6%) that were at 3.7% in Jan-Mar 2006 whereas in Jan-Mar 2008 increased by 0.2% comparatively to the beginning of the economic recession and then climbed between Jan-Mar 2008 and Oct.-Dec. 2010 by 0.6%, during the recession. CV health problems seemed to increase much later from Oct-Dec '09 onwards. Fully adjusted association between unemployment and CV health problems was OR=1.05 (95%CI: 1.01-1.09).

Birgisdóttir (2017)	Ecological study	9,807	NR	2007, 2009, 2012	Iceland	NR	Males 55.08 (2007) 60.08 (2012) Females 52.06 (2007) 57.06 (2012)	18-79	A stratified random sample of 9,807 individuals 18-79 years old was drawn. In 2007, 9,711 individuals received questionnaires with a response rate of 60.9% (5,909 returned questionnaires). The 2009-sample included 5,294 of the original individuals who had agreed to be contacted again. For the 2009 survey the response rate was 69.3% (4,092 individuals). In 2012 the sample of original participants who had agreed to be contacted for follow-up studies consisted of 3,659 individuals. The response rate was 88.5% (3,238 individuals), corresponding to 33.0% of the original sample. Additionally, in 2012, a sample of 3,506 new subjects was added.	Hypertension (main outcome variable); coronary thrombosis; coronary disease; stroke; and cardiovascular disease, and a binary variable indicating whether participants had any cardiovascular disease (CVD), i.e., coronary thrombosis, coronary disease, or stroke.	The Icelandic economic collapse that can be pinpointed almost to a specific date; October 6th, 2008 when Iceland's Prime Minister announced the risk of national bankruptcy. Subsequently, the Icelandic economy contracted by 6.6% in 2009 and 4.1% in 2010 and was among the hardest hit in the world. Exposure to certain economic conditions is measured with time indicators.	2007, 2009, 2012 with data from periods of economic boom, bust, and recovery.	Age, age squared, number of children, marital status, residence, education, prescription medication, and short-term crisis coefficient (t2009).	It was found an inverse relationship between the economic recovery indicator (in 2012) and CVD incidence as a decreased probability of CVD was observed for females during the economic recovery period by 4.14 percentage points compared to the pre-crisis period.
Chang (2020)	Retrospective cohort study	4,673 participants	NR	Sept.2005-Aug.2008 & Sept. 2008-Aug.2011	Taiwan	NR	NR	Aged 20 and above	Aged 20 and above, categorized into five types of occupations, i.e., professionals & managers (PM), office clerks & administrative staff (OA), skilled workers (SW), unskilled workers (UW) and non-workers (NW).	CVD hospitalization	2008 financial crisis in September 2008 to August 2011 (Great Recession)	Before and during the 2008 financial crisis	Adjusting for covariates including age, sex, education, smoking, alcohol drinking, exercise, and BMI.	CVD hospitalization of all occupations were affected by the financial crisis; although non-workers were the early victims, skilled workers were the most vulnerable in the 2008 financial crisis. For all these groups, the incidence rates of CVD hospitalization reached the peak in the third year (2008) (PM: IRR (95%CI)=2.68(1.05-6.83); OA: IRR=2.70(1.18-6.19); SW: IRR=5.13(2.89-9.09); UW: IRR=2.12(1.02-4.41); NW: IRR=1.85(1.18-2.67). In China, He et al.[9], observed that China's economic growth (2005-2008) reduced CVD incidence. During the financial crisis (2008-2010) the CVD incidence rate was significantly increased. During the period of sustained economic downturn (2011-2013), the CVD morbidity rate remained as was in the period 2005-2008. In the new normal stage of the economy (2013-2017), the inhibitory effects of CV morbidity were weakened.

Guojónsdóttir (2011)	Population-register-based study	N=140,997 (2006), N=145,380 (2007) and N=151,530 (2008)	NR	10-week period in 2006, 2007, 2008	Iceland (Reykjavík)	Cardiac ED: 52.3 (2006), 49.3 (2007), 54.8 (2008)	NR	≥18 years	Population information on all adult individuals (≥18 years) living in the larger capital area on 1 July in 2006 (N=140,997), 2007 (N=145,380) and 2008 (N=151,530) were obtained.	All discharge diagnoses considered are made by the attending cardiologist and registered according to the ICD-10. Diagnoses of the CV system (I00-I99), ischaemic heart disease (I20-I25), relevant symptom diagnoses of the CV system (R00-R09). The RR of visits with ischaemic heart disease as the discharge diagnosis was calculated by ICD-10 (I20-I25).	The national economic collapse in Iceland in early October 2008.	10-week period, before (weeks 37 & 40) and after (weeks 41 & 46) the economic collapse in Iceland in October 2008.	Gender	The average weekly attendance at the cardiac ED in weeks 37-46 increased from 155.5 (2006), to 160.1 (2007) and 171.0 (2008). The weekly attendance rate to the general ED decreased from 184.9 (2006), to 181.5 (2007) and 157.4 (2008) (p<0.001). The total attendance rate to both ED receiving CV discharge diagnoses (I00-I99) diminished during the study period from 74.0 (2006), to 71.1 (2007) and 65.8 (2008) (p=0.008). A distinct 26% increase in visits was observed in the cardiac ED during week 41. There seems to be a small decrease in attendance at the cardiac ED during the same period in 2006 and 2007. The attendance rates at the general ED were somewhat stable during the 10-week period in 2006 and 2007 and decreased modestly in 2008. The RR were overall amplified in weeks 41 and 42 while reaching 1.0 at week 43, going below 1.0 in week 44 and then again towards 1.0 in weeks 45 and 46. The RR (95%CI) of all visits in week 41 were 1.26 (1.11-1.43) in 2008, 0.92 (0.79-1.06) in 2007 and 0.97 (0.84-1.12) in 2006. The RR of visits to the general ED in week 41 were 0.99 (0.87-1.14) in 2008, 1.03 (0.90-1.17) in 2007 and 0.96 (0.84-1.10) in 2006. The RR of female and male visits in week 41 to cardiac ED were 1.41 (1.17-1.69) and 1.15 (0.96-1.37), respectively. In 2007 the RR of female and male visits in week 41 were 1.00 (0.81-1.22) and 0.85 (0.69-1.04), respectively; for 2006 the corresponding RR were 1.06 (0.86-1.30) and 0.89 (0.73-1.10).

He (2019)	Ecological study	NR	NR	2005-2017	China	NR	NR	NR	The original data are from the website of the National Bureau of Statistics, the website of the People's Bank of China, the Wine database, and the China Health Statistics Yearbook.	The number of cardiovascular patients is taken as the proxy variables of the incidence of cardiovascular diseases.	China's economy experienced a period of steady development in the global financial crisis in 2008. During the period of 2010 Q3-2017 Q4, China's economic growth declined markedly, and the economy entered a recession. (Great Recession)	Four stages: stable economic growth period (2005-2008), financial crisis period (2008-2010), sustained downward economic period (2011-2013) and new normal economic situation (2013-2017).	NR	China's economic growth (2005-2008) reduced CVD incidence. During the financial crisis (2008-2010) the CVD incidence rate was significantly increased. During the period of sustained economic downturn (2011-2013), the CVD morbidity rate remained as was in the period 2005-2008. In the new normal stage of the economy (2013-2017), the inhibitory effects of CV morbidity were weakened.
Kaviratne (2012)	Registry-based study	NR	2001:935, 2005:1,977, 2010:1,029 PCI cases	2005-2010	New Hampshire, Maine, and Vermont.	NR	NR	NR	The PCIs were obtained through Dartmouth dynamic registry, which has a catchment area that encompasses New Hampshire, Vermont and Maine. Regional and National unemployment data were obtained through the Department of Labor and Statistics. National and State specific insurance rates were obtained through the US Census data for 2001-2010	State specific cardiovascular prevalence rates and PCI were obtained through individual state specific CDC epidemiology department's Behavioral Risk Factor Surveillance System (BRFS) questionnaire.	Economic crisis in 2008 (Great Recession)	Before and after the economic crisis.	NR	The overall prevalence of CVD remained stable for five years (2005-2010); in the course of which the national unemployment rate increased (from 4.7% in 2001 to high of 9.6% in 2010).
Niedzwiedz (2019)	Ecological study	23,078	22,433 patients	2008-2016	16 European countries (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Netherlands, Norway, Poland, Portugal, Spain, Sweden and the United Kingdom).	NR	NR	15-64 years	People aged 15-64 years (N=23,078). Individuals were asked about their main activity seven days before the initiation of the study: in paid work, in education, unemployed and actively looking for a job, unemployed and not actively looking for a job, permanently sick or disabled, retired, in community or military service, doing housework, or looking after children or other persons. Individuals who did not report being in paid work were defined as workless and this was used as the main individual level exposure variable. Thus, individuals were categorized into those who were workless versus those who were not. Students were included in the workless group.	Self-reported heart or circulation problems, high blood pressure. Participants were coded 'yes' if they reported having the condition over the past 12 months and 'no' if they did not. Poor self-rated health was defined as those reporting their health as 'bad' or 'very bad', as opposed to 'very good', 'good' or 'fair'.	The economic downturn which started in late 2007 is referred to as the 'Great Recession' and it was characterized by unemployment rates of around 8.5% in the UK and the USA, 10% in France and more than 20% in Spain. National economic wealth (i.e., GDP) has long been considered as a major global determinant of population health. Unemployment rates alone only capture one aspect of recession and local labour market conditions, whereas employment rates also consider potential increases in those out of work due to sickness, disability and caring responsibilities. At the regional level, the employment rate of those aged 15–64 years during	Intervals: during 2008 that represent a period near the beginning of the Great Recession; during 2013 that represent the time at the end of the Great Recession-during a period of austerity in some European countries; between 2008 and 2013.	Age (years), gender, education level (tertiary versus non-tertiary) and marital status (married/cohabiting versus not married/cohabiting).	there was little difference in the strength of the associations when comparing the relationship between the 2008 and 2013 regional employment rates and the health outcomes [in 2008: PRR=0.973 (95%CI: 0.955-0.991), in 2013: PRR=0.973 (0.953-0.993)]. It was found that higher regional employment levels were associated with lower risk of poor health and a PRR of below one. The strongest association between the average regional employment rate and the health outcomes was observed for heart and circulation problems where the PRR(95%CI) was 0.971 (0.951-0.991), p<0.01 in the period 2008-2013. Worklessness was associated with higher risk of adverse health outcomes. difference in employment rates and heart/circulation problems during the period 2008-2013 for

											2008 was included and during 2013. The average employment rate between 2008 and 2013 and the difference in the employment rate between 2008 and 2013 were also examined.			PRR(95%CI) was 0.993 (0.943-1.0.45) which was non-statistically significant.
Olfson (2018)	Cohort study	79,402	NR	2001-2002 & 2012-2013	United States	NR	NR	≥18 years	Data were obtained from NESARC surveys that oversampled young adults, African Americans, and Hispanics. All people aged ≥18 years. Study participants (n=79,402) included 43,093 in the 2001-2002 cohort and 36,309 in the 2012-2013 cohort. Demographic measures included self-reported age (18-44, 25-44, 45-54, and ≥55 years) sex, race/ethnicity (white, non-Hispanic; black, non-Hispanic; Hispanic; others), and education (high school or less, some college, college graduate).	Cardiac disease included being told by a health-care professional in the past year that the respondent had chest pain or angina, a rapid heartbeat or tachycardia, a heart attack or a myocardial infarction, or any other heart disease. Hypertension was defined with analogous items.	Economic crisis of 2008-2009. (Great Recession) Associations are evaluated between changes in common medical, substance abuse, mental health, social, and economic risk factors and trends in SF-6D scores.	Data are analyzed from nationally representative surveys performed in 2001–2002 and 2012–2013, a period spanning the economic crisis of 2008-2009.	Age, sex, race/ethnicity, education	The lowest unadjusted mean SF-6D scores were associated with cardiac diseases. Changes in cardiac disease were associated with the largest shares of the decrease in SF-6D scores 7.6% (2001-2002) vs.10% (2012-2013), p<0.0001. Change in period effect: Unadjusted, %(95%CI) 10.4 (10.3-10.5), adjusted 8.2 (8.1- 8.3)
Panagiotakos (2013)	Cohort study	10,141	NR	2006-2012	Greece	47%	39±15 years	18-95	A large-scale, nationwide health survey in Greek population, aged 18-95, between 2006-2012.	A structured, semi-quantitative questionnaire was used to retrieve information about CVD risk. Self-reported medical history of hypertension, CVD and family history of CVD were recorded. The Framingham heart score for the10-year risk of fatal CVD events was calculated classifying the participants as high (N10%) or	2009 and 2010 were the years where the Greek financial crisis dominates (Great Recession)	Before and after economic crisis	Age, sex	Time-series, age-sex standardized analysis for the period 2006-2012 revealed a 9.9% (95%CI: 3.5%-16.7%) relative annual increase in the prevalence of CVD for the period 2006-2012. The peak in the prevalence of CVD was observed in 2009 and 2010 when the Greek financial crisis dominated.

										low-moderate risk (<10%).				
Patel (2019)	Ecological study	10,500	NR	2007-2016	United States	49 %	45 years (NHANES 2007-2010), 46 y (NHANES 2011-2012), 46 y (NHANES 2013-2014), 47y (NHANES 2015-2016)	>20 years	Participants prior to 2007-2008 (pre-recession period) were not included in the study because of significant changes in the measurement and coding of physical activity in NHANES from 2007-2008 onward. Age and sex were self-reported. Self-reported race and ethnicity was categorized into 4 levels: non-Hispanic whites, non-Hispanic blacks, Mexican American, and others. Health insurance status and the total number of health care visits in the past 1 year were also self-reported. The mean age of study participants was 45 years, 51% were females, and ~ 67% were non-Hispanic whites from 2007-2010 through 2015-2016. The proportion of participants in the different strata of socioeconomic status (a combination of education and income status) remained similar during the study period.	The CV health metrics were identified using the AHA's Life's Simple 7 behavioral and health factors which are grouped into the ideal health behaviors (i.e., smoking status, BMI, physical activity, and healthy diet score) and ideal health factors (i.e., total cholesterol, blood pressure and fasting plasma glucose). Each CV health metric was categorized into the 'ideal', 'intermediate', and 'poor' categories and given a point score of 2, 1, and 0, respectively.	From the mid-2000s to 2010, there was a significant economic decline with a concomitant deterioration in population-level health. This period was characterized by a staggering rise in unemployment and financial losses and has, therefore, been widely accepted as a period of economic recession (Great Recession). The poverty income ratio and years of education were used to categorize socioeconomic status.	Between economic recession (2007-2010) and economic recovery (2011-2016). Data sets from NHANES survey (2007 to 2010) were merged into one period and classified as a period of the economic recession; and the data from the NHANES survey of years 2011 to 2016 were treated as separate data sets to assess trends in the post-recession or economic recovery period.	Age, sex, race, insurance status, and number of health care visits.	It was found a statistically significant increase in CVDs after the onset of the crisis. The latter mentioned that in participants with high SES, the mean CV health score decreased from 9.4 (95%CI: 8.9-9.8) in 2007-2010 to 8.7 (95%CI: 8.2-9.3) in 2015-2016. Thus, in the higher socioeconomic strata, there was a decline in the prevalence of ideal CV health from 51% in 2007-2010 to 42% in 2015-2016. Among lower socioeconomic strata, the adjusted mean CV health score increased from 7.4 (95%CI: 6.6-8.1) in 2007-2010 to 8.4 (95%CI: 7.7-9.2) in 2011-2012 and then subsequently declined to 7.0 (95%CI: 6.0-8.0) in 2015-2016 thus, the prevalence of ideal CV health increased from 16% in 2007-2010 to 26% in 2011-2012 and then declined to 13% in 2015-2016. No trend in the mean CV health score or the prevalence of ideal CV health was noted among participants in the middle socioeconomic stratum. It was demonstrated that the ideal CV health continued to decline despite the economic recovery across all socioeconomic strata.
Verso (2014)	Ecological study	NR	242,000 (deaths due to CVDs)	2002-2012	Italy and Sicily	NR	NR	15-69	The number of residents and migrants, including births and deaths; the number of marriages and separations; and data related to the number and percentage of workers in the various sectors were evaluated. Data provided by the monitoring system "PASSI" of the National Institute of Health for the period of 2009-2012.	CVDs, myocardial infarction, unstable angina, heart attack, sudden cardiac death.	Economic crisis that started in 2008 (Great Recession).	Period before and following 2008, roughly 2002 to 2012	NR	During a ten-year period (2002-2012) there has been an increased incidence of CVD cases.

Multiple economic crises														
Noelke (2015)	Multicohort panel survey	8,837	990 (MIs and strokes)	1992-2010	United States	NR	53 years	45-66 years	All individuals between the ages of 45 and 66 years who were observed in a dependent employment relationship and therefore were at risk of job loss during the observation period (1992–2010) were included. Individuals who reported that had a stroke or MI before the baseline interview were excluded. Jobs that lasted less than 1 year, paid zero earnings, entailed less than 36 weeks of work per year, or required less than 16 hours of work per week were also excluded. Individuals were classified as having experienced a job loss ("treated") if they reported having lost their job because of a layoff or business closure between age 45 years and their cohort-specific full retirement age (~66 years of age). All other individuals were part of the comparison group (controls); this group included workers who remained employed throughout the observation period or had other labor force transitions, such as retirement, transitions to disability, or health-related work exits. Control subjects whose employment spells ended before the individual was 45 years of age or started after the individual's full retirement age were excluded to set a common age range over which treated individuals and controls were observed.	Initial MI or stroke. At each survey, respondents were asked, "Did you have a heart attack or MI?" and "Has a doctor ever told you that you had a stroke?" Participants who answered in the affirmative were also asked the year of the event. If respondents were not available, for example, following a fatal MI or stroke, the information was obtained from proxy informants, predominantly spouses.	The "recession of the early 1990s" that ended in March of 1991 and the "Great Recession" in 2009 and 2010. Annual country unemployment rates from 1992 to 2010 used to measure fluctuations in economic conditions at a local level and capture both opportunities for reemployment (for unemployed workers) and levels of commercial activity and demand for work hours (for employed workers).	Boom vs. during recession.	Place of birth, sex, ethnicity, parental educational level, own educational level, year fixed effects, marital status, household wealth, household income, individual earnings, hours worked, weeks worked, state of residence, inflation differences in household size, health insurance coverage, year of first interview, BMI, smoking, number of alcoholic drinks consumed per day, depression symptoms, self-rated health, self-rated memory, cancer- diabetes diagnosis, high blood pressure, heart problems.	Among workers who experienced job loss, recessionary labor market conditions at the time of job loss were associated with a significantly higher CVD risk (HR=2.54 (95%CI: 1.39-4.65). In contrast, among workers who did not experience job loss, recessionary labor market conditions were associated with a lower CVD risk (HR=0.50 (95%CI: 0.31-0.78)). These results suggested that recessions might be protective in the absence of job loss but hazardous in the presence of job loss.

Appendix 3. Characteristics of eligible studies about overall CV mortality.

First author (Year)	Design	Cohort Size	Cases in cohort	Study period	Region	Males (%)	Mean age	Age range	Cohort Characteristics	Definition/features of CVDs	Definition and ascertainment of economic crisis	Categorization (comparison) of economic crisis	Adjusting factors	Main findings regarding overall CVD mortality
Great Depression in 1930s (1929-1939)														
Stuckler (2011)	Ecological study	NR	NR	1929-1937	United States (114 US cities, which were located in 36 US states)	NR	NR	NR	Data on 50 leading causes of death in the 114 US cities, which were located in 36 US states, were taken from the US Bureau of the Census for the years 1929-1937. Mortality in 114 cities covered roughly 30% of the 1930 US census estimate of 123 million US population.	Mortality due to heart disease, data obtained from death certifications.	The Great Depression in the USA is usually dated from 'Black Tuesday,' 29 October 1929, when the American stock market crashed. Recovery began in early 1933.	During and after Great Depression	NR	Contemporary reductions in income levels are correlated with significant rises in CVD in the U.S. during the Great Depression, deaths due to heart disease increased by about 19.4% and heart disease rates could plausibly be linked to short-term economic shocks; reductions in income levels correlated with significant rises in CVDs. A 10% rise in bank suspensions was associated with percentage changes in mortality due to heart disease [effect size (95%CI): -0.17 (-0.73 to 0.26)]. In addition, there was an association of a 10% rise in GDP per capita with percentage changes in mortality due to heart disease [effect size (95%CI): -0.49 (-0.90 to -0.08) and an association of a 10% decline in GDP per capita attributable to the banking collapse with percentage changes in mortality due to heart disease [effect size (95%CI): -0.66 (-2.80 to -1.00)].
Oil crisis or oil shock (1970s)														
Guberan (1979)	Ecological study	NR	NR	1951-1976	Switzerland	NR	NR	22-85+ years	There were seven age groups for both sexes: 23-34, 35-44, 45-54, 55-64, 65-74, 75-84, 85+ years	The numbers of deaths by sex and five-year age groups are published each year by the Federal Bureau of Statistics (1955-1977) and since 1951 according to the A-list of the ICD. The 3 subcategories of the 6th and 7th revisions of ICD combined together as	Economic recession in 1975.	Before, during and after the economic crisis.	Age	From 1951 to 1976, the death rate from all diseases of the circulatory system decreased by 22% in males and by 43% in females. The male death rate, however, fluctuated until 1963, then decreased until 1973 (-24%) and finally rose sharply between 1973 and 1976 (+12%), which resulted in an overall decline from 1951-1976 of 13%. Therefore, the male to female ratio of age-standardised death rates rose from 1.3 in 1951 to 1.9 in 1976. Age-standardised death rates per 100,000 population for all diseases of the circulatory system in males, in 1951 were

										"non-rheumatic heart disease and hypertension": arteriosclerotic and degenerative heart diseases (A81); other diseases of the heart (A82); hypertension with heart disease (A83); and hypertension without mention of heart (A84) as the subcategories of 8th rev. of ICD: IHD (A83); other forms of heart disease (A84); hypertensive disease (A82)				500.7 and in 1976 were 390.8, 1951-1976 change was -21.9% and total reduction in deaths was 34.2%. For females, in 1951 were 411.2, in 1976 were 234.9 (1951-1976), change was -42.9% and total reduction in deaths was 45.1%.
Finnish Banking Crisis (1991-1993)														
Valkonen (2000)	Ecological Study	NR	1981-1985:40,771 1986-1990:41,816 1991-1995:39,663	1981 to 1995	Finland	NR	35-64 years	NR	Individuals aged 35-64 years and two occupation-based social classes are distinguished: non-manual workers and manual workers.	Mortality due to CVDs and the analysis was based on the ICD-8 in 1981-1986 and the cause of death classification 1987 of Finland statistics in 1987-1995. The latter classification was based on the ICD-9.	In the second half of the 1980s economic growth was exceptionally rapid, but in 1991-1995 Finland suffered from a very severe economic recession. Economic output declined for 3 years, reaching its low point in early 1993 at less than 90% of the 1990 level. The bankruptcy rate doubled in 3 years.	Before and during crisis (1981-1995)	Age	A continuous decline in CVD mortality was marked; the larger decrease was noted in the non-manual class from 1981-1985 to 1991-1995. In contrast to the 1980s, CVD mortality diminished more in the manual than in the non-manual class. However, the proportion of CVD deaths was smaller among women than among men.

Asian Financial Crisis (1997-1999)														
Khang (2005)	Ecological study	Mid-year population in South Korea	NR	1990-2002	South Korea	NR	NR	Four age groups: 1–14, 15–34, 35–64, and 65–79	Participants' age was categorized into four groups: 1–14, 15–34, 35–64, and 65–79 for both sexes	Mortality due to hypertensive disease, ischaemic heart disease, cardiomyopathy and cerebrovascular disease.	After enjoying uninterrupted economic growth for decades, South Korea underwent a steep economic decline in the late 1990s.	Before and after the economic crisis.	Age	It was observed a decrease in the mortality rate ratios between 1996-2002 in diseases of circulatory system cause of death [RR 1998/1996=0.94, RR 2002/1996=0.54 for males and females aged 1-14, RR 1998/1996=0.98, RR 1996/2002=0.70 for males and females aged 15-34, respectively].
Kim (2004)	Ecological study	Entire country of South Korea	9,534 (deaths due to CVDs in 1998), 15,108 (deaths due to CVDs in 1999)	1995-1999	South Korea	NR	NR	NR	The number of total deaths and the number of cause-specific deaths that occurred in each month from January 1995 to December 1999 (72 months in total) were collected from "The annual report on the cause of death statistics based on vital registration" published by the South Korean National Statistical Office.	Mortality due to CV, IHDs, and cerebrovascular disease.	On December 3, 1997, South Korea received financial support from the IMF (International Monetary Fund) due to a liquidity squeeze. This event marked a national economic crisis unprecedented in South Korean modern history.	Before and after the economic crisis (1995-1999).	NR	There was an annual increase of 353 deaths due to CVD after the economic crisis. Excess mortality per 100,000 population was 12.6 in 1998 and 19.6 in 1999. CVD mortality began to increase immediately after the economic crisis.
Lin (2009)	Ecological study	224	168	1976-2003	Eight countries in the Asia Pacific region: Hong Kong, Japan, South Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand.	NR	NR	15 to ≥65 years	Two groups were assessed: one was the percentage of the population in the country that was male, and the other was the percentage of the population in the country that was divided into two separate age groups, namely, 15–64 years of age and 65 years, respectively.	This study used data from the ICD-9 on hypertensive disease (ICD 401–405) and cerebrovascular disease (ICD 430–438) in order to measure the mortality rate specifically related to CVD.	The 1997 Asian financial crisis. Countries' circumstances changed dramatically in July 1997 as Southeast Asia became engulfed in a major financial crisis. This article adopts the unemployment rate as an indicator of macroeconomic conditions. The specifications of some of the models in this analysis also included GDP per capita in 1990, US dollars converted at 'Geary Khamis' Purchasing Power Parties (PPPs) to serve as an indicator of economic development.	Pre-crisis (1976-1996) post-crisis (1997-2003).	Age, gender, urban population percentage and medical care resources.	One percentage point increase in the unemployment rate significantly lowers the predicted fatalities from CVDs by 0.9% (R^2=0.98). The pre-1997 and post-1997 elasticities are 0.7 (R^2=0.98, p=0.005) and 2.7 (R^2=0.96, p=0.012), respectively.
Russian Financial Crisis (Ruble crisis or Russian Flu) (1998)														
Men (2003)	Ecological study	NR	NR	1991-2001	Russia overall and seven federal regions, five in European Russia (North Western, Central,	NR	NR	All ages (0-70+)	Data obtained from the Russian State statistics committee, including deaths by cause, sex, five-year age group, and calendar year together with corresponding population denominators.	Causes of death in Russia were coded with the Soviet system of disease classification up to 1998, with each category corresponding	Russian economic crisis in 1998.	Before, during and after the economic crisis.	Age	In the period 1998-2001 there was a modest increase in deaths from circulatory disease, like that seen in the earlier increase in the 1991-1994 and a decrease between 1994 and 1998.

					Privolzhski, Southern, and Uralski) and two in Asian Russia (Siberian and Far Eastern)					to groups of items in ICD-9. From 1999, a new system based on the ICD-10 was introduced. Diseases of the circulatory system: rheumatic heart disease, hypertensive disease, ischaemic heart disease, cerebrovascular disease.				
Argentine Great Depression (1998-2002)														
Gurfinkel (2005)	Cohort study	3,220	2,246 (in crisis period)	1999-2004	Argentine	70	66.1 (crisis), 65 (after crisis)	NR	Study sample contains patients enrolled in centers in Argentine between April 1999 and September of 2004. 3,220 patients were enrolled in Argentine. The number of patients younger than 65 years old was 1,527 (47%), representing the proportion of the population normally expected to be economically active. The remainder 1,693 (53%) were older than 65. A final diagnosis of STEMI was made in 1,179, and 2,041 qualified as unstable angina / non-STEMI.	Individuals who had an admission diagnosis of ACS (STEMI and non-STEMI or unstable angina). Non-fatal MI defined by the presence of at least one positive increment of cardiac biochemical marker of necrosis (in case of those in whom MI was the index diagnosis) plus chest pain prolonged more than 10 minutes, or new STEMI seen after the index or qualifying electrocardiogram.	The country paid a high toll of change, with the GDP experiencing a sustained decline from 1998, and unemployment rates reaching approximately 25%. By the end of 2001 a rapid cascade of political and economic events opened the road to deep social turmoil and economic unrest that spiraled until December 2001, when the country experienced a virtual halt of vital areas of the economy. The beginning of the negative slope of the GDP curve was considered as the start of the crisis period, which lasted until the domestic product experienced a sustained increase over a full trimester.	The period of time examined was divided into the crisis period, which was delimited from April 1999 to December 2002, and the post crisis period, which encompassed the time from January 2003 to September 2004.	NR	The financial crisis may have had a negative impact on CV mortality during hospitalization as the incidence proportion of CV mortality was 6.2%, higher than that in after crisis period (5.1%). Moreover, the crude OR for mortality was 1.2 (95% CI: 0.87-1.7).

Great Recession (2008)														
Birgisdóttir (2017)	Ecological study	9,807	NR	2007 and 2009, 2012	Iceland	NR	Males 55.08 (2007) 60.08 (2012) Females 52.06 (2007) 57.06 (2012)	18-79	A stratified random sample of 9,807 individuals 18-79 years old was drawn. In 2007, 9,711 individuals received questionnaires with a response rate of 60.9% (5,909 returned questionnaires). The 2009-sample included 5,294 of the original individuals who had agreed to be contacted again. For the 2009 survey the response rate was 69.3% (4,092 individuals). In 2012 the sample of original participants who had agreed to be contacted for follow-up studies consisted of 3,659 individuals. The response rate was 88.5% (3,238 individuals), corresponding to 33.0% of the original sample. Additionally, in 2012 a sample of 3,506 new subjects was added.	Hypertension (main outcome variable); coronary thrombosis; coronary disease; stroke; and cardiovascular disease, and a binary variable indicating whether participants had any CVD, i.e., coronary thrombosis, coronary disease, or stroke.	The Icelandic economic collapse that can be pinpointed almost to a specific date; October 6th, 2008 when Iceland's Prime Minister announced the risk of national bankruptcy. Subsequently, the Icelandic economy contracted by 6.6% in 2009 and 4.1% in 2010 and was among the hardest hit in the world. Exposure to certain economic conditions is measured with time indicators.	2007, 2009, 2012 with data from periods of economic boom, bust, and recovery.	Age, age squared, number of children, marital status, residence, education, prescription medication, and short-term crisis coefficient (t2009).	Mortality rates due to circulatory diseases are distinctly downward trending both before and throughout the study period.
Cabrera de León (2018)	Ecological study	From 40,544,387 to 46,766,403 according to year (2000-2015), in Spain and from 281,421,906 to 321,418,820 according to year (2000-2015), in the United States.	6,143,078 deaths from 2000-2015 in Spain and 39,779,419 deaths from 2000-2015 in United States	2000-2015	Spain and the United States	NR	NR	NR	NR	Mortality from CVDs.	Toward the end of the first decade of the 21st century, the huge financial crisis that erupted in 2008 in the United States and Europe led to the failure of many banks and immediately resulted in rising unemployment and very high levels of employment precariousness.	Before vs after the 2008 economic crisis	Age	From 2000 to 2010, mortality from CVDs in Spain showed a sharp increase beginning in 2011 whereas during this period, CVD mortality in the United States continued to show the declines recorded in the preceding decade.

Lalioti s (2016)	Ecolog ical study	2,028	There was a mean of 153 deaths per month from circula tory system disease s.	2001-2013	Greece (13 regions)	NR	NR	All ages	Data used from the Hellenic Statistical Authority (ELSTAT), which contains monthly information regarding the number of deaths in Greece during the period January 2001, to December 2013, by age, sex, region, and cause.	The total number of deaths is further disaggregated to 56 causes according to the two-digit ICD classification including deaths from circulatory system diseases.	The global financial crisis began in 2008, in Europe.	Before the crisis (January 2001, to August 2008) and after the onset of the crisis (September 2008, to December 2013)	Age	The mortality rate continued to decline after the onset of the crisis period but at a slower pace than before the recession. This reduction in decline was more evident for females than for males. Trend (95%CI) before crisis -0.12 (-0.13 to -0.098), after crisis -0.073 (-0.091 to -0.054), trend difference (95%CI) 0.043 (0.024 to 0.063), p<0.001 for all trends. Age-standardised mean mortality rates decreased significantly for both sexes and across all age groups after the onset of the crisis (26.88±4.23, p<0.0001) compared with the period before (34.63±5.75 , p<0.0001). People older than 65 years experienced the most substantial increase in death rate after the onset of the crisis, and more than half of that change seemed to be related to an increased death rate from circulatory causes. There was a mean of 153 additional deaths per month from circulatory system diseases.
Mattei (2014)	Ecolog ical study	NR	NR	2000-2010	Italy	NR	NR	>14 years	Data from two Italian government agencies (Italian Institute of Statistics, ISTAT, and Italian Agency of Drugs, AIFA) in the years from 2000 to 2010 were obtained and analyzed, by producing models of multiple linear regressions.	Mortality due to CVDs.	The global economic crisis was sparked by the outbreak of the financial crisis of 2007-2008: the recession began in December 2007 and took a particularly sharp downward turn in September 2008 (National Bureau of Economic Research 2010). In Italy, the Minister of Economics and Finance Giulio Tremonti first referred to the crisis during his speech at the Parliament on October 9th, 2008. The second half of 2008 can be considered the moment in which Italian population really started experiencing the crisis.	Before, during and after the economic crisis.	NR	Along years 2000-2010 the increase in the rate of unemployment was significantly associated with the increase in the rate of mortality due to CVDs which showed a significant increase in 2010. Rate of mortality due to CVDs x 10,000 was: 41.9 (2000), 41 (2001), 41.2 (2002), 41.71 (2003), 37.20 (2006), 37.58 (2007), 37.52 (2008), 37.16 (2009) and 37.78 (2010). Rate of CV mortality and rate of unemployment: b=0.73, p=0.03 Rate of CV mortality and real GDP: b=0.19, p=0.47 (non-statistically significant)

Nolasco (2018)	Ecological study	NR	2,255,761 total deaths in 2002–2007 and 2,323,380 in 2008–2013.	2002-2013	Spain	NR	NR	0-74 years	Residents in Spain, aged 0-74 years. Data obtained from the Spanish National Statistics Institute.	Analysis of amenable mortality; all deaths were considered and grouped into groups: ischaemic heart disease (I20-I25), cerebrovascular disease (I60-I69), hypertensive disease (I10-I13, I15) [coded by ICD-10].	2008 Recession. As a measure of the socioeconomic impact of the crisis, four indices have been considered for each province, based on the percentage evolution of fifteen indicators between 2006 and 2013: Economic Vulnerability Index (evolution of the economic activity and employment, according five indicators: GDP per capita, number of companies, employed population, unemployed population, and foreign trade), Social Vulnerability Index (socio-demographic changes, according five indicators: population and immigration, residential mobility, recipients of unemployment benefits, young people emancipation, and social mobilization), Real-Estate Vulnerability Index (evolution of the real estate market, based on another five indicators: number and value of mortgages, empty completed dwelling, real-estate dwelling transactions, average price of empty dwelling, and mortgage foreclosures), and composite Index of Total Vulnerability (ITV), consisting of an average of the previous three indices, based on a standardised construction process.	Before 2002–2007 and after 2008–2013 the economic Recession.	Age	CVD mortality rate declined more during the first 4 years of the crisis period (2008-2011) than in the 4 years preceding the crisis (2004-2007), especially in low socioeconomic groups
Regidor (2019)	Ecological study	NR	NR	2001-2016	Spain	NR	NR	People younger, aged or older than 65 years old	Data on deaths obtained by 5-year age groups and cause of death between 2001 and 2016 from the mortality register developed by the National Statistics Institute.	Causes of death are those reported on the medical death certificate and are coded using the ICD-10th Revision. They analysed among others, CVDs as specific causes of death. Number of deaths was the outcome	The austerity policies implemented in Spain beginning in 2010 exacerbated the consequences of the 2008 economic crisis, as evidenced by the important increase in mortality observed between 2011 and 2015. Spain began recovering from the recession in 2014 with a 1.4% increase in GDP.	During and after the economic crisis and austerity policies. Periods on the basis of the years the economic crisis began (2008) and ended (2013) and the date that austerity measures were	Age	The mortality rates from CVDs declined each year with respect to the previous one, except in 2003 and 2015. The decline in the second part of the economic crisis and during the austerity policies (2011-2013) was slightly greater than before the crisis (2001-2007).

										variable and person-years an offset variable.		implemented (2010)		
Ruhm (2015)	Ecological study	All deaths: 2222.31	923,419 (deaths due to CVDs)	1976–2010	United States	51.2	NR	(i) groups aged <1, 1–19, 45–54, 55–64, 65–74, 75–84 and ≥85 years old and (ii) groups aged <25, 25–45, 45–64, 65–74, and ≥75 years	Mortality data are from the 'Center for Disease Control and Prevention' Compressed Mortality Files (CMF) which contain information for every death of a U.S. resident.	Cause of death was categorized using the ICD-8 codes. ICD-9 codes were used between 1979 and 1998, and ICD-10 categories since 1999. Crosswalks have been established between ICD-8 and ICD-9 and between ICD-9 and ICD-10 coding systems.	Great recession of 2007–2009.	20-year periods are used with results obtained for 16-windows ranging from 1976-1995 to 1991-2010.	Gender, age, race, state, year dummy variables, state-specific linear time trends	CVD mortality remained strongly procyclical [-0.0036 (p=0.0013) in 1976-1995, -0.0041 (p=0.0017) in 1991-2010, difference=-0.0005 (p=0.0019)]. One point increase in unemployment predicts 466 less fatalities from CVD in 1991-2010 than in 1976-1995 this explains none of the secular change, as the unemployment rate coefficient becomes more negative in later years.
Schwartz (2012)	Ecological study	Annual LA Population	Coronary heart disease deaths in: 1985: 19,510 1996: 16,411 2005: 14,365 2008: 12,580	2005-2008	Los Angeles	NR	NR	NR	From 2005 through 2008, annual LA population estimates were obtained (population estimates also obtained for 2004 and 2009) and daily stock market data.	3 groups of cardiac deaths based on the ICD-10 codes for all circulatory deaths (I00-I99), coronary heart disease deaths (I20-I25), and acute MI deaths (I21).	Stock market crash in autumn 2008 in Los Angeles County.	Before and during the stock market crash.	NR	Marked increases were observed in total and cardiac death rates in December 2005 and in February 2008 at times when the stock market was relatively stable.

Tapia Granados (2017)	Ecological study	27 European countries	NR	2004-2010, the robustness of the results was checked in two longer periods: 2000–2013 and 1995–2013.	27 European countries. Countries with mild or no recession: Austria, Belgium, Finland, France, Germany, the Netherlands, Norway, and Switzerland. Countries with mild recession: Bulgaria, Croatia, Czech Republic, Denmark, Hungary, Italy, Poland, Portugal, Slovakia, Sweden, and the UK. Countries with severe recession: Estonia, Greece, Ireland, Latvia, Lithuania, Slovenia, and Spain.	NR	NR	Ages 30–44 and 75 and over, but not for ages 0–14	Individuals aged 30–44 and 75 and over years.	CVD and a subset of it, ischemic heart disease (IHD)	The Great Recession, a global economic and financial crisis that was particularly severe in many European countries, where there were big increases in unemployment, as well as generalized banking problems, large public and private debts, and austerity policies that have created serious social distress and major financing problems for public services, including health care. 2007 was considered as the last year of the expansion before the recession which openly started in most European countries in 2008.	Three-year period: (2007-2010, Recession period) vs. (2004-2007, Pre-Recession or Expansion period).	Age, space-invariant and time-invariant factors	For CVD mortality rates, the greatest reduction in 2007-2010 occurred in the group of countries in which the recession had been the most severe. It was found to have statistically significant effects consistent with a procyclical oscillation of mortality due to CVDs. A one-percentage point increase in unemployment was also associated with reductions of age-standardized mortality from CVD (by 0.3%). At ages below 65 and using a 2003-2010 panel for 23 European Union countries, a one percentage point increase in the national unemployment rate was associated at high levels of statistical significance with a 3.7% reduction of mortality due to CVD. Considering mortality at all ages, there were found associations with a 0.4% reduction of CVD mortality ($p<.001$). Relative changes of age-standardized death rate from CVD per 100.000 population in 27 countries sorted in 3 groups according to the severity of the economic recession in 2007-2010 as (a) countries with mild or no economic crisis (b) countries with moderate economic crisis (c) countries with severe economic crisis: (a) % change(2004-2007)= -10.6, % change(2007-2010)= -10.4 (b) % change(2004-2007)= -17.6, % change(2007-2010)= -7.2 (c) % change(2004-2007)= -7.5, % change(2007-2012)= -11.4
Toffolutti (2014)	Ecological study	160 (in 2003-2010 sample), 225 (in 2000-2010 sample)	NR	2000-2010	23 European Union countries (Social protection group categorization- Low: Bulgaria, Estonia, Ireland, Latvia, Lithuania, Poland, Romania, Slovakia. Medium:	42.08 %	NR	<65 years	Mortality rates refer to deaths per 100,000 of a European standard population aged less than 65.	As health indicators were selected: the overall mortality rate, selected cause-specific mortality rates, included mortality from CVDs, as well as health behavior proxies (e.g., amount of fruit and vegetables and pure	Great Recession and 'global economic decline' as synonyms, generally defined in the economic literature as starting in 2008 in Europe. Countries were splitted into 3 tertiles according to their respective share of social protection expenditure in GDP in low, medium, high social protection groups.	Before, during and after the economic crisis.	Auto-correlation, age	The biggest cause of death is due to CVDs (mortality rate=70.56±46.91). For the sample 2003-2010 the results indicate that a one percentage point increase in the standardised unemployment rate was significantly associated with a 3.7% decrease (adj. 2.7%) and for the 2000-2010 sample a 3.4% (adj. 2.4%) decrease in CVD mortality. Health effects of recession on a one-percentage point increase in unemployment rate (subgroup analysis by level of social protection): low: 5.8% (adj. 4.3%), medium: 0.5%, high:

					Finland, Greece, Hungary, Italy, Portugal, Slovenia, Spain, United Kingdom. High: Austria, Belgium, Denmark, France, Germany, The Netherlands, Sweden)					alcohol consumption).				0.8% (adj.1.1%) decrease in CVD mortality.
Vardakas (2019)	Ecological study	NR	NR	2000-2015	Greece	Mean male population during the crisis (31,284/year) before crisis (15,755.9/year)	NR	0-85 or older	Individuals in age groups (0-19, 20-39, 40-55, 56-69,and 70 or older), from geographic regions (North and South Greece) for the period 2000-2015. Additional data (1955-1999) were incorporated to evaluate if changes in mortality occurred long before the study period. To calculate mortality rates, the population was divided into 18 age subgroups, i.e. 0-4 years, 5-9 years etc., till 80-84 years and ≥85 years.	All death causes were categorized into 16 groups based on the relevant list provided by the ELSTAT and were among others: heart diseases and cerebrovascular disease.	In 2007 Greece experienced its 9th year of recession (2009-2017). Although the financial crisis appeared in late 2008, its effects in the Greek population became evident in 2010, when cuts in salaries and public investments were imposed and unemployment rose above 10%. The years 2010-2015 were selected as the financial crisis period. The indicator used as a measurement of recession (GDP, unemployment, GDP per capita), the duration or the type of the recession (normal fluctuation or severe crisis), the pre-existing levels of vulnerability (public infrastructure, social safety nets, access to effective healthcare, and education), the quality of responses to a crisis (cuts in public spending and health expenditures), and the population(s) under study (developed or developing countries, individual or aggregate relationships).	Prior to (2000-2009) and during (2010-2015) the financial crisis. Reference year: 2001	Age	Heart diseases were the commonest cause of death throughout the study period, but mortality declined almost continuously (from 3.01/1000 in 2000 to 2.58/1000 in 2014). Moreover, the annual rate of decline during the crisis increased (0.05/1000) compared to the one before the crisis (0.02/1000), which should be primarily attributed to the decrease in deaths due to heart diseases. Higher unemployment was associated with lower mortality overall, also for specific causes, including CVDs.
Verso (2014)	Ecological study	NR	242,000 (deaths due to CVDs)	2002-2012	Italy and Sicily	NR	NR	15-69	The number of residents and migrants, including births and deaths; the number of marriages and separations; and also data related to the number and percentage of workers in the	CVDs, MI, unstable angina, heart attack, sudden cardiac death.	Economic crisis that started in 2008.	Period before and following 2008, roughly 2002 to 2012.	NR	In Italy there are approximately 5 million patients and 242,000 people die from CVD, the primary cause of death which are responsible for more than 4 out of 10 deaths (44% of the total).

									various sectors were evaluated. data provided by the monitoring system "PASSI" of the National Institute of Health for the period of 2009-2012.					During the decade 2002-2012, there has been a significant reduction in the number of deaths. The in-hospital mortality from CVD, which in 2012 stands at around 10%, in 2002 was 30%. In the North, there is an incidence rate of 221.5 per 100,000 males and 93 per 100,000 women, in the center of 228 per 100,000 males and 100.2 per 100,000 women in the South and the incidence rate is 238,9 per 100,000 males and 104.2 per 100,000 women.
Vlachadis (2014)	Ecological study	NR	NR	2004-2012	Greece	NR	NR	NR	NR	Trends in CV mortality in Greece, defined as the number of deaths attributable to CVD (ICD-9 codes 390–459) per 100,000 inhabitants, during 2004-2012. CV mortality rates were standardized to the 2008 population of Greece using direct standardization.	2008 financial crisis.	Pre-crisis quadrennium 2004-2008, during the crisis period 2008-2012.	Age	Pre-crisis, there was a significant decreasing trend in CV mortality overall and for both men and women ($p<0.001$). CV mortality in 2004–2008 declined overall by 15% and by 16% in men and 15% in women ($p<0.001$), these decreasing trends remaining unaffected during the crisis period 2008-2012. From 2008 through 2012, CV mortality rates decreased by 13% overall and by 12% in men and 15% in women ($p<0.001$). The relative reduction in CV mortality was more pronounced (14%, $p<0.001$ for trend, $p<0.001$) for older individuals (aged≥65 years), whereas the corresponding decline in premature CV death rate (<65 years) was 4% ($p=0.02$ for trend, $p=0.05$). Following a 7-year period of an overall 26% decrease (25% for men and 27% for women, $p<0.001$ for trend, $p<0.001$), CV mortality rates did not differ between 2011 and 2012 overall ($p=0.75$) and for both men and women ($p=0.70$ and $p=0.37$). The age-standardized mortality attributable to CVD was not adversely affected by the economic recession. During the period 2008-2012, CV mortality rates decreased for men and women at a similar rate as the pre-crisis quadrennium 2004-2008. The financial crisis did not affect CV death rates in Greece. There was a plateauing of CV mortality during 2011-2012, which probably caused by longer term non-adherence to medical

														treatment which could lead to complications of chronic conditions.
Multiple economic crises														
Blakely (2008)	Ecological study	Total New Zealand population	1981-1984: 37578 1986-1989: 36606 1991-1994: 34146 1996-1999: 32721 2001-2004: 30135 deaths	1981-2004	New Zealand	NR	NR	1-74 years	All groups stratified by sex, age, and income, except for 25-44 year olds of both sexes on low incomes among whom there was little change.	Cardiovascular mortality	New Zealand underwent major structural reform from 1984 to the early 1990s. There was an economic recession in the early 1990s, with the real gross national disposable income (RGNDI) per capita falling 10% between 1990 and 1992. From 1992 to 2004, however, this grew steadily by an average of 2.5% a year.	Before and after the crisis (1981-2001)	Sex, age, ethnicity and small area deprivation.	It was noted a strong decrease in mortality from CVD for all income groups throughout the period 1981-2004, in New Zealand. This decline probably reflected both reduction in exposure to risk factors and improvement in access to and effectiveness of clinical treatment. In addition, CV mortality rates decreased from 45% in 1981-4 to 33% in 2001-4 for males, and from 50% to 29% for females.
Sosa Liprandi (2012)	Ecological study	NR	NR	1995-2005	Argentine	NR	NR	NR	The population estimates used as the denominator were obtained from the National Institute of Statistics and Censuses.	CVMR was calculated using 9th and 10th ICD. The following causes of death were considered: heart failure (HF), acute myocardial infarction (AMI), chronic coronary artery disease (CAD) and stroke (CVA).	Two economic crises were identified: the Southeast Asia crisis (1998-1999) and the end of the convertibility system (2001-2002).	Before and after the economic crises.	NR	Although a decrease in cardiovascular mortality was observed, this trend was not linear and changes in the slope (always downward) were evidenced in temporal coincidence with the economic events identified. Between 1995-2005 the CVMR decreased by 24.72% (from 474.9 to 357.5 per 100,000). Initially, from 1995 to 1997 (the pre-crisis period), the aforementioned rate decreased by 9.52%.Then, between 1997 and 2002 (the crisis period), there was an increase in the CVMR of 5.38% while in the period 2002-2005 (the after-crisis period) a decrease in the CVMR of 7.65% it was observed.

Appendix 4. Characteristics of eligible studies about cardiac arrhythmias.

First author (Year)	Design	Cohort size	Cases in cohort	Study period	Region	Males (%)	Mean age	Age range	Cohort Characteristics	Definition/features of CVDs	Definition and ascertainment of economic crisis	Categorization (comparison) of economic crisis	Adjusting factors	Main findings regarding cardiac arrhythmias
Argentine Great Depression (1998-2002)														
Gurfinkel (2005)	Cohort study	3,220	2,246 (in crisis period)	1999-2004	Argentine	70	66.1 (crisis), 65 (after crisis)	NR	Study sample contains patients enrolled in centers in Argentine between April 1999 and September of 2004. 3,220 patients were enrolled in Argentine. The number of patients younger than 65 years old was 1,527 (47%), representing the proportion of the population normally expected to be economically active. The remainder 1,693 (53%) were older than 65. A final diagnosis of STEMI was made in 1,179, and 2,041 qualified as unstable angina / non-STEMI.	Individuals who had an admission diagnosis of ACS (STEMI and non-STEMI or unstable angina). Non-fatal MI defined by the presence of at least one positive increment of cardiac biochemical marker of necrosis (in case of those in whom MI was the index diagnosis) plus chest pain prolonged more than 10 minutes, or new ST-segment deviation seen after the index or qualifying electrocardiogram.	The country paid a high toll for this change, with the GDP experiencing a sustained decline from 1998, and unemployment rates reaching approximately 25 percent. By the end of 2001 a rapid cascade of political and economic events opened the road to deep social turmoil and economic unrest that spiraled until December 2001, when the country experienced a virtual halt of vital areas of the economy. The beginning of the negative slope of the GDP curve was considered as the start of the crisis period, which lasted until the domestic product experienced a sustained increase over a full trimester.	The period of time examined was divided into the crisis period, which was delimited from April 1999 to December 2002, and the post crisis period, which encompassed the time from January 2003 to September 2004.	NR	In the crisis period, there was a higher incidence of sustained ventricular tachycardia (3.4%, n=75 Vs 2.9%, n=28).

Great Recession (2008)														
Vardakas (2019)	Ecological study	NR	NR	2000-2015	Greece	Mean male population during the crisis (31,284/year) before crisis (15,755.9/year)	NR	0-85 or older	Individuals in age groups (0-19, 20-39, 40-55, 56-69,and 70 or older), from geographic regions (North and South Greece) for the period 2000-2015. Additional data (1955-1999) were incorporated to evaluate if changes in mortality occurred long before the study period. To calculate mortality rates, the population was divided into 18 age subgroups, i.e., 0-4 years, 5-9 years etc., till 80-84 years and ≥85 years.	All death causes were categorized into 16 groups based on the relevant list provided by the ELSTAT and were among others: heart diseases and cerebrovascular disease.	In 2007 Greece experienced its 9th year of recession (2009-2017). Although the financial crisis appeared in late 2008, its effects in the Greek population became evident in 2010, when cuts in salaries and public investments were imposed and unemployment rose above 10%. The years 2010–2015 were selected as the financial crisis period. The indicator used as a measurement of recession (GDP, unemployment, GDP per capita), the duration or the type of the recession (normal fluctuation or severe crisis), the pre-existing levels of vulnerability (public infrastructure, social safety nets, access to effective healthcare, and education), the quality of responses to a crisis (cuts in public spending and health expenditures), and the population(s) under study (developed or developing countries, individual or aggregate relationships).	Prior to (2000-2009) and during (2010-2015) the financial crisis. Reference year: 2001.	Age	Mortality due to arrhythmias showing an increase during the crisis.
Voulgari (2019)	Retrospective cohort study	1,000	NR	1995-2018	Greece	48.5 (after crisis) 46.6 (before crisis)	75.2 (after crisis), 77.9 (before crisis)	NR	Patients admitted after the economic crisis outbreak (429 patients, 221 women/208 men, 75.2±9.5years) compared to those hospitalized before the financial crisis (571 patients, 305 women/ 266men, 77.9±8.9years) were found to be younger ($p<0.001$), more frequent, and heavier tobacco smokers ($p=0.002$), as well as casual alcohol users ($p=0.04$).	Atrial fibrillation, arrhythmias, stroke, hypertension.	Economic crisis in 2008. 2008 was used as the transitional year.	Before and after the economic crisis.	NR	Impairment/disability/death after the economic crisis were more frequent as clinical outcomes ($p<0.001$) and were significantly associated with arrhythmia ($p=0.04$) after crisis. Patients after the economic crisis were found to have a higher incidence of atrial fibrillation ($p<0.001$) compared to patients hospitalized in pre-crisis period.

Appendix 5. Characteristics of eligible studies about other heart diseases.

First author (Year)	Design	Cohort size	Cases in cohort	Study period	Region	Males (%)	Mean age	Age range	Cohort characteristics	Definition/features of CVDs	Definition and ascertainment of economic crisis	Categorization (comparison) of economic crisis	Adjusting factors	Main findings regarding other heart diseases
Oil crisis or oil shock (1970s)														
Guberan (1979)	Ecological study	NR	NR	1951-1976	Switzerland	NR	NR	22-85+ years	There were seven age groups for both sexes: 23-34, 35-44, 45-54, 55-64, 65-74, 75-84, 85+ years	The numbers of deaths by sex and five-year age groups are published each year by the Federal Bureau of Statistics (1955-77) and since 1951 according to the A-list of the ICD.The 3 subcategories of the 6th and 7th revisions of ICD combined together as "non-rheumatic heart disease and hypertension": arteriosclerotic and degenerative heart diseases (A81); other diseases of the heart (A82); hypertension with heart disease (A83); and hypertension without mention of heart (A84) as the subcategories of 8th rev. of ICD: ischaemic heart disease (A83); other forms of heart disease (A84); hypertensive disease (A82)	Economic recession in 1975.	Before, during and after the economic crisis.	Age	It was found that for mortality due to non-RHD a steady decline of 40% occurred in females; the male death rate, however, fluctuated until 1963, then decreased until 1973 (-24%) and finally rose sharply between 1973 and 1976 (+12%), which resulted in an overall decline from 1951-1976 of 13%. The advent of the economic recession was associated with a sudden rise in mortality from non-RHD in 1974-76. which increased sharply in males and slightly in females.
Finnish Banking Crisis (1991-1993)														

Valkonen (2000)	Ecological Study	NR	1981-1985:40771 1986-1990:41816 1991-1995:39663	1981 to 1995	Finland	NR	35-64 years	NR	Individuals aged 35-64 years and two occupation-based social classes are distinguished: non-manual workers and manual workers.	Mortality due to CVDs and the analysis is based on the ICD-8 in 1981-1986 and the cause of death classification 1987 of statistics Finland in 1987-1995. The latter classification is based on the ICD-9.	In the second half of the 1980s economic growth was exceptionally rapid, but in 1991-1995 Finland suffered a very severe economic recession. Economic output declined for 3 years, reaching its low point in early 1993 at less than 90% of the 1990 level. The bankruptcy rate doubled in 3 years.	Before and during the crisis (1981-1995).	Sex, age and social class	The absolute increase in the deaths from other CVDs was 4 deaths per 100,000 among women and 6 deaths per 100,000 in men from 1981-1985 to 1986-1990 intervals.
Asian Financial Crisis (1997-1999)														
Khang (2005)	Ecological study	Mid-year population in South Korea	NR	1990-2002	South Korea	NR	NR	Four age groups: 1–14, 15–34, 35–64, and 65–79	Individuals categorized into four age groups: 1-14, 15-34, 35-64, and 65-79, in both sexes.	Mortality due to hypertensive disease, IHD, cardiomyopathy and cerebrovascular disease.	After enjoying uninterrupted economic growth for decades, South Korea underwent a steep economic decline in the late 1990s.	Before and after the economic crisis.	Age	It was observed a decrease in the mortality rate ratios between 1996-2002 among both sexes aged 35-64 in cardiomyopathy and conduction disorders cause of death [RR 1998/1996=0.89 , RR 2002/1996=0.42 for males, RR 1998/1996=0.91, RR 1996/2002= 0.48 for females] and among both sexes aged 65-79 [RR 1998/1996=0.89, RR 2002/1996=0.46 for males and RR 1998/1996=1.06, RR 2002/1996=0.50 for females.
Great Recession (2008)														
Raptis (2020)	Ecological study	9.852.194	27,347 (cases of PE)	1999-2012	Greece	49.3% (1999-2007)	NR	>10 years	The total population, aged >10 years, in each region was derived from the 1991, 2001, 2011 Census of the national statistical service of Greece.	The calculation of PE incidence resulted from the quotient of new cases (discharges) during a comparable year in a region to the total population in the same year in that region expressed per 100.000 population. ICD-10 codes used for PE cases were I26 (I26.0 and I26.9) and ICD-9 code was 415.1.	2008 presents the start of the economic crisis.	Before the crisis (1999-2008), after the crisis (2009-2012).	Age	The incidence of PE at the Greek population. The annual incidence of PE showed an upward trend ranging from 14 (1999) to 30 (2012) cases per 100,000 population. In the years before and after the Greek financial crisis it were observed statistically significant differences of PE incidence for the two different periods (1999-2008 vs. 2009-2012) as was 14.49 vs. 23.06 respectively, p=0.002. The available data revealed a female predominance (16.48 cases for females vs. 13.69 cases for males per 100,000 population, p=0.031) mainly attributed to the age group of >70 years. The incidence rate increased with age for both genders with a peak in the “80-89” age group for females and >90 years for males. It demonstrated a statistically significant increase in PE incidence between two time frames, 1999-2008 and 2009-2012 that corresponds to the economic crisis.

Appendix 6. Evaluation of eligible studies with Newcastle-Ottawa scale and AHRQ standards.

Study	SELECTION					COMPARABILITY			OUTCOME				Quality
	Representativeness	Selection of non-exposed	Ascertainment of exposure	Outcome not present at start	Total	Comparability on age	Comparability on other risk factors	Total	Assessment of outcome	Long enough follow-up (median ≥1 year)	Adequacy (completeness) of follow-up (≥85% response rate)	Total	
Astell-Burt (2013)	*	*	*		3	*	*	2		*	*	2	Good
Birgisdóttir (2017)	*		*		2	*	*	2	*	*		2	Fair
Blakely (2008)	*		*		2	*	*	2	*	*		2	Fair
Cabrera de León (2018)	*				1	*		1	*	*		2	Poor
Chang (2020)	*	*			2	*	*	2	*	*	*	3	Fair
Guberan (1979)	*		*		2	*		1	*	*		2	Fair
Guojónsdóttir (2011)			*		1		*	1	*			1	Poor
Gurfinkel (2005)			*		1			0	*	*		2	Poor
He (2019)	*		*		2			0	*	*		2	Poor
Kaviratne (2012)			*		1			0	*	*		2	Poor
Khang (2005)	*		*		2	*		1	*	*		2	Fair
Kim (2003)	*		*		2	*	*	2		*		1	Poor

Kim (2004)	*		*		**2**			**0**	*	*		**2**	Poor
Laliotis (2016)	*		*		**2**	*		**1**	*	*		**2**	Fair
Lin (2009)	*		*		**2**	*	*	**2**	*	*		**2**	Fair
Mattei (2013)	*		*		**2**			**0**	*	*		**2**	Poor
Men (2003)	*				**1**	*		**1**	*	*		**2**	Poor
Niedzwiedz (2019)	*		*		**2**	*	*	**2**		*		**1**	Poor
Noelke (2015)	*		*	*	**3**		*	**1**		*		**1**	Poor
Nolasco (2018)	*		*		**2**	*		**1**	*	*		**2**	Fair
Olfson (2018)	*				**1**	*	*	**2**		*		**1**	Poor
Panagiotakos (2013)		*			**1**	*	*	**2**		*		**1**	Poor
Patel (2019)	*				**1**	*	*	**2**	*	*		**2**	Poor
Raptis (2020)			*		**1**	*		**1**	*	*		**2**	Poor
Regidor (2019) PMID: 31095411	*		*		**2**	*		**1**	*	*		**2**	Fair
Regidor (2019)	*	*	*		**3**	*	*	**2**	*	*		**2**	Good

Ruhm (2015)	*		*		**2**	*	*	**2**	*	*		**2**	Fair
Sanidas (2018)					**0**			**0**	*	*		**2**	Poor
Schwartz (2012)	*		*		**2**			**0**	*	*		**2**	Poor
Sosa Liprandi (2012)	*		*		**2**			**0**	*	*		**2**	Poor
Stuckler (2011)	*		*		**2**			**0**	*	*		**2**	Poor
Tapia Granados (2017)	*		*		**2**	*	*	**2**	*	*		**2**	Fair
Toffolutti (2014)	*		*		**2**	*	*	**2**	*	*		**2**	Fair
Valkonen (2000)	*		*		**2**	*		**1**	*	*		**2**	Fair
Vardakas (2019)	*		*		**2**	*		**1**	*	*		**2**	Fair
Verso (2014)	*		*		**2**			**0**	*	*		**2**	Poor
Vlachadis (2014)	*		*		**2**	*		**1**	*	*		**2**	Fair
Voulgari (2019)					**0**			**0**	*	*		**2**	Poor

Appendix 7. Studies excluded with their reason for exclusion.

Study	Title	Reason for exclusion
No reference to specific economic crisis		
Albert (2017)	Cumulative psychological stress and cardiovascular disease risk in middle aged and older women: Rationale, design, and baseline characteristics.	This study concerns how cumulative stressors vary by socioeconomic status, how they affect health behavior, how they affect psychological status and social ties and how these factors affect CVD outcomes without reference to specific economic crisis.
Brenner (1982)	Economic change and sex-specific cardiovascular mortality in Britain.	In this study, a multivariate model of the impact of more fundamental changes in the socioeconomic and bio-physical environments has been developed and applied to cardiovascular disease mortality rates, by sex, in England and Wales and Scotland during 1955-1976, without reference to specific economic crisis.
Carvalho (2020)	Mortalidade por Doenças Cardiovasculares Segundo o Sistema de Informação sobre Mortalidade e as Estimativas do Estudo Carga Global de Doenças no Brasil, 2000-2017.	This article aims to compare historical series of CVD mortality based on data in the 2000-2017 period without reference to specific economic crisis or recession.
Dadgar (2020)	Is there a link between cardiovascular mortality and economic fluctuations?	The main aim of this study was to estimate the association between the unemployment rate and mortality from CVD and from coronary heart disease (CHD) without reference to specific economic crisis.
Economou (2008)	Are recessions harmful to health after all? Evidence from the European Union.	The purpose of this paper is to investigate the effects of national unemployment rates on overall age and cause-specific mortality rates in a sample of 13 European Union countries without reference to specific economic crisis.
Fernandes (2020)	A 10-Year Trend Analysis of Heart Failure in the Less Developed Brazil.	This study determines the HF morbidity and mortality in Paraiba and Brazil and its 10-year trends without reference to a specific economic crisis.
Ferrie (2003)	Future uncertainty and socioeconomic inequalities in health: the Whitehall II study.	This study concerns socioeconomic gradients in morbidity and cardiovascular risk factors and examines the contribution of job and financial insecurity with health measures but there is no specific reference to economic crisis or recession.
Gupta (2012)	Regional variations in cardiovascular risk factors in India: India Heart Watch.	This article examines cardiovascular risk factors without reference to a specific economic crisis period.
Hagström (2017)	Psychosocial stress and major cardiovascular events in patients with stable coronary heart disease.	This study concerns psychosocial stress coming from bad economic conditions without reference to a specific economic crisis.
Handberg (2013)	Clinical implications of the women's ischemia syndrome evaluation: interrelationships between symptoms,	This review focuses on symptom presentation for chest pain, and its relationship to CVD morbidity and mortality, quality of life, healthcare costs, and

	psychosocial factors and cardiovascular outcomes.	psychosocial predictor variables without reference to specific economic crisis.
Iversen (2012)	Psychosocial risk factors, weight changes and risk of obesity: the Copenhagen City Heart Study.	This study refers to economic hardship but there is not a specific reference to economic crisis and examines the psychosocial factors such as vital exhaustion, social network, economic hardship, and daily use of sleep medication.
Kopp (2007)	Chronic Stress and Social Changes Socioeconomic Determination of Chronic Stress.	This article refers to economic changes between 1960-2005 in the introduction and includes as an example the results of the "Hungarostudy 2002 survey" which conducted in the years 2002-2006 without data in the period of a specific economic crisis.
Lampropoulos (2016)	Association between anxiety and depression in patients with acute coronary syndromes due to financial crisis	This study investigates the relation between anxiety and depression in patients presenting with ACS due to financial crisis and whether these two entities could predict long-term cardiovascular mortality, without reference to specific economic crisis.
Lauer (2012)	Advancing Cardiovascular Research.	This study refers to economic turmoil in a general way without reference to specific economic crisis or recession.
Mackenbach (2013)	Changing patterns of mortality in 25 European countries and their economic and political correlates, 1955–1989.	This article refers to economic and political changes in mortality following World War II without reference to specific economic crisis.
Mackenbach (2016)	Changes in mortality inequalities over two decades: register based study of European countries.	This study compares changes in mortality between the lowest and highest socioeconomic groups but there is no reference to specific economic crisis.
Moczulska (2015)	Analysis of socioeconomic factors and their influence on the incidence of complications in patients with acute coronary syndrome in Warmia and Mazury province.	This study assesses the effect of certain socioeconomic factors on the incidence of cardiovascular complications of ACS during hospitalization and 3-month follow-up without reference to specific economic crisis.
Mokdad (2014)	The state of health in the Arab world, 1990–2010: an analysis of the burden of diseases, injuries, and risk factors.	There is not any association with crisis/recession conditions.
Moran (2019)	Financial stress and Risk of Coronary Heart Disease in the Jackson Heart Study.	This study examines whether stress because of financial hardship is associated with incident coronary heart disease in African Americans, without reference to specific economic crisis.
Morris (2019)	Who benefits from social investment? The gendered effects of family and employment policies on cardiovascular disease in Europe.	This research refers to social investment policies on health and government expenditures without reference to specific economic crisis.

Murray (1997)	Alternative projections of mortality and disability by cause 1990–2020: Global Burden of Disease Study.	This study refers to the rates and patterns of ill health which are determined by factors such as socioeconomic, development, educational attainment, technological developments, and their dispersion among populations, as well as exposure to hazards, without reference to specific economic crisis.
Ólafsdóttir (2016)	The tax-free year in Iceland: a natural experiment to explore the impact of a short-term increase in labor supply on the risk of heart attacks.	This study merges and analyzes individual-level, registry-based data on earnings and AMIs including all Icelandic men and women during the period 1982–1992 without reference to specific economic crisis/recession.
Ortega (2020)	Cardiovascular disease behavioral risk factors among Latinos by citizenship and documentation status.	This article examines CVD behavioral risk factors by citizenship / documentation statuses, among Latinos and non-Latino in the 2011–2015, without reference to a specific economic crisis period.
Parekh (2020)	Impact of social determinants of health on cardiovascular diseases.	This article addresses the socio-economic factors (food, housing, financial instability, and healthcare access) that promote the development of risk factors for cardiovascular diseases without reference to specific economic crisis.
Sahle (2020)	Association of psychosocial factors with risk of chronic diseases: a nationwide longitudinal study.	This study refers to financial stress due to economic hardship and focuses on psychosocial factors without reference to specific economic crisis.
Stuckler (2008)	Can a bank crisis break your heart?	This study has the purpose to assess whether a banking system crisis increases short-term population cardiovascular mortality rates, without chronological reference to economic crisis.
Tapia Granados (2008)	Macroeconomic fluctuations and mortality in postwar Japan.	This article refers to co-movements between economic fluctuations and mortality changes in postwar Japan without reference to specific economic crisis/recession.
Troxel (2003)	Chronic stress burden, discrimination, and subclinical carotid artery disease in African American and Caucasian Women.	This study examines the association between a composite index of stress without reference to a specific economic crisis/recession.
Vintro (1985)	Coronary Heart Disease Mortality Trends and Related Factors in Spain	This study investigates CHD mortality trends and related factors in Spain without reference to a specific economic crisis/recession.
Williams (2007)	Psychosocial factors related to cardiovascular disease risk in UK South Asian men: a preliminary study.	This article concerns the exposure to psychosocial factors which were associated with cardiovascular risk without any association with a specific economic crisis/recession period.
Analysis of cardiovascular disease in relation to socioeconomic status (SES) / unemployment, without reference to specific economic crisis		
Agyei (2014)	Relationship between psychosocial stress and hypertension among	This article refers to psychosocial stress as an indicator of financial hardship, which was defined as perceived discrimination, depressive symptoms and or financial stress whether participants had problems paying their

	Ghanaians in Amsterdam, the Netherlands – the GHAIA study.	household bills without reference to specific economic crisis.
Al Hazzouri (2016)	Sustained economic hardship and cognitive function: the Coronary Artery Risk Development in Young Adults Study.	This study concerns low individual income and worse health outcomes. Sustained poverty was defined by the percentage of time participants' household income but there is not any association with specific economic crisis.
Alicandro (2018)	The main causes of death contributing to absolute and relative socio-economic inequality in Italy.	This study aimed at detecting the causes of death with the largest socio-economic inequality in relative and absolute terms in Italy, without comparisons related to the economic crisis.
Alter (2013)	Socioeconomic status, functional recovery, and long-term mortality among patients surviving acute myocardial infarction.	This study concerns the relationship between SES, functional recovery and long-term mortality following acute myocardial infarction (AMI). There is no specific relation to the economic crisis.
Andersen (2014)	Socioeconomic position and incidence of ischemic stroke in Denmark 2003–2012. A Nationwide Hospital-Based Study.	This study refers to the relations between socioeconomic positions, measured as household income and length of education without reference to specific economic crisis.
Brenner (1971)	Economic changes and heart disease mortality.	The present study investigated the relationship between economic change, measured via employment index for nonagricultural industries, and heart disease mortality in New York State and the United States over the period 1900-1967 without reference to specific economic crisis.
Browning (2012)	Effect of job loss due to plant closure on mortality and hospitalization.	This article examines whether job loss due to plant closure causes an increased risk of (cause-specific) mortality and hospitalization for male workers having strong labour market attachment. There is not any specific reference to the economic crisis period.
Chambers (2019)	Relationship between area mortgage foreclosures, homeownership, and cardiovascular disease risk factors: The Hispanic Community Health Study/Study of Latinos.	This study focuses on the individual level and economic factors related to homeownership status.
Conklin (2013)	Socioeconomic status, financial hardship and measured obesity in older adults: a cross-sectional study of the EPIC-Norfolk cohort	This study concerns the SES and the economic hardship after education, social class and home ownership were considered at an individual level.
Di Girolamo (2019)	Progress in reducing inequalities in cardiovascular disease mortality in Europe.	This study focuses on socioeconomic groups and SES without reference to specific economic crisis.
Eliason (2009)	Job loss is bad for your health – Swedish evidence on cause-specific hospitalization following involuntary job loss.	This paper examines the impact of job loss on a number of non-fatal health events and focuses on job loss due only to establishment closures, without any reference to specific economic crisis.
Folyovich (2016)	Higher incidence of stroke on the last day of the month in Hungary—a role	This article proposes that financial insecurity on the days prior to the receipt of a salary might play a role

	for psychosocial factors and financial insecurity?	in the elevation of stroke incidence observed on the last day of the month in Hungary without relation to the economic crisis period.
Gerdtham (2005)	Business cycles and mortality: results from Swedish microdata	This study estimates the relationship between business cycles, measured via unemployment rate, and mortality without reference to specific economic crisis.
Gomez (2020)	Psychological stress, cardiac symptoms, and cardiovascular risk in women with suspected ischemia but no obstructive coronary disease (INOCA).	This article focuses on financial stress which is evaluated according to socioeconomic status without reference to specific economic crisis.
Hackett (2009)	Psychosocial outcomes in StrokE: the POISE observational stroke study protocol.	This study refers to the psychosocial and economic consequences of stroke survivors in relation to the work environment without reference to specific economic crisis.
Halliday (2014)	Unemployment and mortality: Evidence from the PSID	This study uses micro-data to investigate the relationship between unemployment and mortality in the United States without reference to specific economic crisis.
Karlamangla (2005)	Impact of socioeconomic status on longitudinal accumulation of cardiovascular risk in young adults: the CARDIA Study (USA).	This study describes the trajectories of biological risk factors of cardiovascular disease in young adults and studies the association of SES with aggregate risk scores that summarize longitudinal risk accumulation from multiple risk factors without reference to specific economic crisis.
Maniecka-Bryła (2013)	Determinants of premature mortality in a city population: an eight-year observational study concerning subjects aged 18-64.	There is only a reference in the socioeconomic status which may contribute to premature death and there is not any reference to a specific economic crisis period.
Maruthappu (2015)	Unemployment, government healthcare spending, and cerebrovascular mortality, worldwide 1981-2009: an ecological study.	This study determines the effect of changes in unemployment and government healthcare expenditure on cerebrovascular mortality globally without reference to specific economic crisis.
Nolasco (2014)	Trends in socioeconomic inequalities in amenable mortality in urban areas of Spanish cities, 1996–2007.	This study describes inequalities in amenable mortality in relation to socioeconomic status in small urban areas and analyses their evolution over the course of the periods 1996–99, 2000–2003 and 2004–2007 in three major cities without specific relation to the economic crisis.
Svensson (2007)	Do not go breaking your heart: Do economic upturns really increase heart attack mortality?	This study explores the relationship between business cycles and incidence, mortality and lethality in acute myocardial infarction (AMI) in Sweden, without reference to specific economic crisis.
Stuckler (2009)	The public health effect of economic crises and alternative policy responses in Europe: an empirical analysis.	This study investigates how economic changes have affected mortality rates over the past three decades and identified how governments might reduce adverse effects, without reference to specific economic crisis.

Sweet (2013)	The high price of debt: household financial debt and its impact on mental and physical health.	This study investigates the associations of multiple indices of household financial debt with psychological and general health outcomes without reference to specific economic crisis.
Tapia Granados (2005)	Increasing mortality during the expansions of the US economy, 1900–1996.	This study does not include comparisons in times of economic crises.
Healthcare system expenditures / Functionality / Healthcare costs		
Annapuredd y (2018)	Association between financial burden, quality of life, and mental health among those with atherosclerotic cardiovascular disease in the United States.	This study concerns the financial burden due to healthcare expenditures and it is not related to the CVDs incidence or mortality.
Baron-Esquivias (2006)	Cost of diagnosis and treatment of syncope in patients admitted to a cardiology unit.	This study focuses on the in-hospital cost of management of syncope patients.
Baugh (2015)	National cost savings from observation unit management of syncope.	This article refers to national cost savings, reduction in inpatient hospitalization for managing selected patients with syncope.
Beech (1996)	Hospital Services for Stroke Care.	This study represents how stroke, impact on mortality and morbidity and its consumption of healthcare resources and costs.
Blomgren (2016)	Over-indebtedness and chronic disease: a linked register-based study of Finnish men and women during 1995–2010.	This study analyses long-term health consequences of severe over-indebtedness.
Davis (2012)	Tilt testing is more cost-effective than implantable loop recorder monitoring as a means of directing pacing therapy in people with recurrent episodes of suspected vasovagal syncope that affect their quality of life or present a high risk of injury.	This study aims to assess the cost-effectiveness of implantable loop recorders (ILRs) and tilt testing (TT) to direct pacing therapy in people with recurrent episodes of transient loss of consciousness.
Davis (2012)	Implantable loop recorders are cost-effective when used to investigate transient loss of consciousness which is either suspected to be arrhythmic or remains unexplained.	A cost-effectiveness study of implantable loop recorders (ILRs) in people with transient loss of consciousness (TLoC), which, after initial assessment and specialist cardiovascular assessment, is either suspected to be arrhythmic in origin or remains unexplained.
Del Rosso (2000)	Social costs of syncope.	This study refers to the costs for the evaluation and treatment of syncope.
Dominguez-Rodriguez (2013)	An appropriate use criterion is very important to reduce overuse for SPECT in coronary heart disease: economic burden in time of crises.	This article refers to Single-Photon Emission Computed Tomography Myocardial Perfusion Images (SPECT) in the after-crisis period.

Fanourgiakis (2013)	Catastrophic healthcare expenditure during economic recession in the field of cardiovascular disease.	This article refers to the effects of health expenditure on national economies and household finances and to the cost-of-illness.
Gheorghe (2018)	The economic burden of cardiovascular disease and hypertension in low- and middle-income countries: a systematic review.	This article synthesizes the available data on the economic burden of CVD and hypertension in LMICs to households, health systems and society.
Hauser (1985)	The cost of tachyarrhythmia management.	This article refers to health economy measures in the United States in relation to physicians' development of more cost-effective approaches to the management of patients who have tachyarrhythmias.
Izon (2015)	Cost inefficiency under financial strain: a stochastic frontier analysis of hospitals in Washington State through the Great Recession.	This study analyzes cost inefficiency of hospitals between 2005 and 2012, with controls for patient burden of illness, hospital process of care quality, and hospital outcome quality.
Jeon (2009)	Economic hardship associated with managing chronic illness: a qualitative inquiry	This study examines the experiences of people affected by chronic diseases and provides a first level, qualitative understanding of the economic impact of chronic illness
Kenny (2013)	Epidemiology of syncope/collapse in younger and older Western patient populations.	This article refers to adult's syncope as a major cause of morbidity and mortality with enormous personal and wider health economic costs. There is not any association with economic crisis or recession.
Keskimaki (2003)	How did Finland's economic recession in the early 1990s affect socio-economic equity in the use of hospital care?	This study evaluates the changes in socio-economic equity in the use of general hospital care but with no specific references to CVDs.
Kontos (2017)	The effect of financial crisis on the profile of the patients examined at the surgical emergencies of an academic institution in Greece.	This article refers to the crisis impact on the provision of services in public and university hospital units and the reductions in health expenditure followed by lack of appropriate equipment for surgical interventions, resulting in problematic provision of surgical healthcare services and thus deterioration of surgical patients' health.
Krahn (1999)	The high cost of syncope: cost implications of a new insertable loop recorder in the investigation of recurrent syncope.	This study refers to the relative cost-effective profile of the investigative tools used in patients with syncope.
Kyriopoulos (2014)	Barriers in access to healthcare services for chronic patients in times of austerity: an empirical approach in Greece.	This study investigates the magnitude of barriers in access to health services for chronic patients and the socioeconomic and demographic characteristics that affect them.
Le Roux (2010)	Outcome and cost of aneurysmal subarachnoid hemorrhage.	This study examines the cost impact factor of aneurysmal subarachnoid hemorrhage as from a

		financial perspective as well as from a patient perspective.
Logan (2013)	The burden of chronic diseases in a rural North Florida sample.	This article refers to patients' access to quality health care systems and the burden of disease.
Mattei (2015)	Occupational health physicians and the impact of the Great Recession on the health of workers: a qualitative study.	This article concerns the impact on workers' health of the economic recession in the industrial district of Sassuolo and the psychological and social needs of workers.
Maynou (2016)	Economic crisis and health inequalities: evidence from the European Union.	The main objective in this paper was to show the impact of the economic crisis on convergence. The aim was to observe whether the economic crisis (from 2008 onwards) has in fact had an effect on health inequalities within the EU.
Merry (2012)	More for less: best patient outcomes in a time of financial restraint.	This article refers to the ability to continue providing cardiac surgery in the face of constrained economic times and concerns health care costs and expenditures.
Pearlman (2014)	The economic burden of preventable chronic diseases in Rhode Island.	This report examines the prevalence of arthritis, current asthma, diabetes, and cardiovascular disease, with and without current obesity and current depression, to estimate the public health burden of preventable chronic diseases. It also explores the economic impact of these chronic conditions on Rhode Island's health care system.
Pinilla (2019)	Trends in horizontal inequity in access to public health care services by immigrant condition in Spain (2006–2017).	The objective of this research is to analyze trends in horizontal inequity in access to public health services by immigration condition in Spain throughout the period 2006–2017.
Sacco (2017)	Racial-ethnic disparities in acute stroke care in the Florida-Puerto Rico collaboration to reduce stroke disparities study.	This study examines race ethnic disparities in acute stroke performance metrics in a voluntary stroke registry and focuses on social disparities and health system problems.
Schillinger (2000)	Admission for syncope: evaluation, cost and prognosis.	This study determines the application and cost of diagnostic tests, cost of hospital stay, success of evaluation and prognosis of patients admitted via the emergency department after syncope.
Shin (2013)	Standardized approaches to syncope evaluation for reducing hospital admissions and costs in overcrowded emergency departments.	This study examines the financial impact of syncope on health care which imposes a significant socioeconomic burden.
Simpson (1999)	A cost-effective approach to the investigation of syncope: relative merit of different diagnostic strategies.	This study compares the cost effectiveness of a conventional diagnostic work-up with that of several different diagnostic cascades for the investigation of undifferentiated syncope.
Steinberg (2005)	Syncope in children: diagnostic tests have a high cost and low yield.	This study aims to assess the use, yield, and cost-effectiveness of diagnostic tests used in the evaluation of syncope in children.

Swanson (2015)	Primary care in Cuba: a public health approach.	This article presents an update on Cuba's primary health care delivery system.
Viqar-Syed (2013)	Syncope units: impact on patient care and health-related costs.	This study refers to health-related costs and not to CVDs incidence/mortality in times of economic crisis.
Zilidis (2020)	Use of amenable mortality indicators to evaluate the impact of financial crisis on health system performance in Greece.	This study sought to identify changes in health system performance during a period of austerity in Greece.
Conference/symposium/consensus reports / posters' abstracts / Oral Presentations that did not present relevant original data		
Florou (2017)	The impact of the economic crisis on hypertension in children.	The purpose of the study is to determine the existence of an inverse relationship between childhood obesity, and by extension of childhood hypertension, and the economic crisis plaguing Greek households.
Foskolou (2017)	Financial crisis and health of older Mediterranean adults: the multinational MEDIS study (2005-2015).	This study investigates how the financial crisis has affected the behaviors and the health status of older people living in the Mediterranean islands according to clinical, lifestyle, socio-demographic characteristics, presence or absence of smoking, physical activity, MedDietScore and Geriatric Depression Scale.
Gikas (2017)	Cardiovascular diseases in times of economic crisis: New challenges for medical and community research	This article refers to CVDs in times of economic crises, without reported data in this time-period.
Korantzopoulos (2018)	Contemporary diagnostic yield of implantable loop recorders in patients from Northwestern Greece in the setting of economic crisis.	The aim of this study was to investigate the utility and diagnostic yield of ILRs in an adult population in the setting of the Greek economic crisis.
Wright (2019)	What moderates the scarring effect of youth unemployment on later life mental health?	This presentation focuses on mental health and unemployment rates which followed the global financial crisis but not to CVDs.
No specific report of CVDs or incidence/mortality		
Borowy (2011)	Similar but different: Health and economic crisis in 1990s Cuba and Russia.	This study refers to fundamental social, political and cultural differences in two countries and the respective specificities of the crisis, including different long-term health trajectories and different traditions of health-related agenda setting without specific reference to CVDs.
Bourdon (2015)	The impact of economic recession on the use of treatment technology for peripheral arterial disease.	This study investigates whether economic changes may have affected the treatment of one of the major diseases in Germany, peripheral arterial disease (PAD), using femoropopliteal stent angioplasty.

Cutler (2002)	Financial crisis, health outcomes and ageing: Mexico in the 1980s and 1990s.	This article analyzes the effects of the economic crisis on mortality rates in Mexico, in 1995. It is noted at the outset that mortality is only one measure of health status and not likely to be the most responsive or easily observable indicator of the effect of economic crisis.
Cutler (2019)	Do economic crises harm mental health? Effects of the Great Recession on older Americans.	This study focuses on mental health effects and not on CVDs.
Finch (2019)	The Great Recession and adverse birth outcomes: evidence from California, USA.	This study examines the spatially and temporally heterogeneous effects of the Great Recession on adverse birth outcomes without reference to specific CVDs.
Hiyoshi (2013)	Inequalities in self-rated health in Japan 1986–2007 according to household income and a novel occupational classification: national sampling survey series.	This article examines whether health inequalities increased over the period of economic stagnation and substantial social change without references to CVDs.
Kyriopoulos (2019)	Does economic recession impact newborn health? Evidence from Greece.	This article refers to the economic crisis, but there is no specific reference to CVDs.
Mazeikaite (2019)	The Great Recession, financial strain and self-assessed health in Ireland.	This study examines the effects of the 2008 economic crisis on general health in Ireland, the relationship between compositional changes in demographic and socio-economic factors, and changes in the prevalence of poor self-assessed health over a 5-year period (2008-2013) without specific reference to CVDs.
Mitonas (2016)	COPD patients' medical care and support in Greece during financial crisis.	This study attempts to investigate the profile of patients with COPD in specific community settings in Greece. There is only a simple reference in heart disease as a comorbidity.
Nena (2014)	Greek financial crisis: From loss of money to loss of sleep?	This study refers to Greek economic recession and analyzed how job insecurity is associated with poor self-rated health and minor psychiatric morbidity, without reference to CVDs.
Regidor (2019)	Reversal of upward trends in mortality during the Great Recession by employment status at baseline in a national longitudinal study.	This study focuses on employment status during the Great Recession without any association with CVDs.
Seeman (2018)	The Great Recession worsened blood pressure and blood glucose levels in American adults.	This study examines the association of Great Recession with increases in blood pressure and glucose, without further information on CVDs.
Tapia Granados (2009)	Life and death during the Great Depression.	This article analyzes causes of death during the Great Depression but examines CVDs with renal diseases or with respiratory diseases. There were not presented results for CVDs.

Wang (2020)	The impact of the great economic crisis on mental health care in Italy.	This paper investigates the impact of the economic crisis on hospital admissions for severe mental disorders in Italy and assesses whether there are heterogeneous effects across areas with distinct levels of income without reference to CVDs.
Yumar (2019)	Economic crisis and obesity in the Canary Islands: an exploratory study through the relationship between body mass index and educational level.	This research examines the education-related inequalities in adult obesity in the Canary Islands and their evolution in recent years, considering the possible impact of the economic recession without association with CVDs.
Commentaries/Letters to the editor /Editorials that did not present relevant original data		
Catalano (2005)	If economic expansion threatens public health, should epidemiologists recommend recession?	This commentary provides general information based on bibliographic data but does not present relevant original data.
Davlouros (2013)	DES thrombosis related to antiplatelet therapy noncompliance: a consequence of the Greek financial crisis.	This letter concerns a case report which is excluded from review as described in the protocol.
Grubb (2013)	Economical selection of syncope patients for permanent cardiac pacing: a tilted view.	This is an editorial about patients who might potentially benefit from therapies in the most economical manner without relation to CVDs and economic crises.
Kim (2003)	Regarding "Changes in mortality after the recent economic crisis in South Korea" (multiple letters)	These letters refer to the article "Changes in mortality after the recent economic crisis in south Korea" by Kim et. al. which was included in our review.
Murthy (2014)	Decompressive craniectomy--the price is right?	Comment on "Economic evaluation of decompressive craniectomy versus barbiturate coma for refractory intracranial hypertension following traumatic brain injury" which was evaluated for selection.
Panagiotakos (2019)	Cardiovascular disease risk status during the years of the financial crisis: the Greek case.	This article refers to findings from the 10-year follow-up (2002-2012) of the ATTICA epidemiological study without any statistical data.
Panayiotou (2015)	Financial crisis, drug compliance and cardiovascular health-the GREECS case?	This is a supplementary comment on study by *Notara et. al.* with the results from the 10-year follow-up (2004-2014) of a nationally representative study in Greece on Acute Coronary Syndrome (ACS) incidence and all-cause mortality in cardiac patients (the GREECs study) which is included in our review.
Popovic (2019)	The effects of Economic crisis on health of the Serbian population: What do we know so far?	This letter refers to trends in socioeconomic and health status indicators and identifies a possible association between economic recession and health of the Serbian population without specific reference to CVDs before the crisis.
Stefanadis (2013)	Economic crisis: the role of cardiovascular medicine.	This is an editor's page with not reported statistics. There is a discussion of the connection of the economic crisis with CV medicine.
Stolinsky (1984)	Recessions and increased mortality.	This article was based on a review of drugs without any statistical data.

Tapia Granados (2006)	Mortality effects of the economic crisis in South Korea.	The paper tries to establish mortality effects of the strong depression affecting the South Korean economy in the late 1990s without statistical data.
Tosoulis (2017)	Socioeconomic status and cardiac disease in Europe: a modern-day problem in the era of economic crisis	This is a letter to the review article by *Psaltopoulou et. al*. about the association of socioeconomic status with dietary habits and how dietary patterns change from unhealthy to healthy over the range of educational and income status without any statistical data.
Studies not presenting comparisons pre vs. during/post crisis		
Andrikopoulos (2015)	Impact of income status on prognosis of acute coronary syndrome patients during Greek financial crisis.	This article classified patients as "low" or "high" income status during the period of economic crisis in Greece, without any comparison with the previous economic state.
Andrikopoulos (2015)	Impact of income status on prognosis of acute coronary syndrome patients during a period of financial crisis-insights from a Greek prospective multicenter observational study.	In this paper patients were classified as low- or high-income based on the reported net annual household income using as a cut-off point the relative poverty threshold for Greece without comparisons pre vs. post crisis.
Avendano (2016)	Are some populations resilient to recessions? Economic fluctuations and mortality during a period of economic decline and recovery in Finland.	This study examines the health effects of economic fluctuations during a period of economic decline (1989–1996) and recovery (1997–2007) in Finland without data of comparison among pre/post crisis periods.
Birgisdóttir (2020)	The effect of the economic collapse in Iceland on the probability of cardiovascular events.	This study explores whether the economic collapse in 2008 and subsequent economic crisis affected the probability of ischemic heart disease (IHD) events, independent of regular cyclical effects that can be attributed to typical economic conditions without a report of pre- post-crisis data.
Edwards (2008)	Who is hurt by procyclical mortality?	This article examines mortality by individual characteristic during the 1980s and 1990s and focuses on the procyclical effect without comparisons in pre- or post-crisis periods.
Hanchate (2010)	Identifying socioeconomic gradients and racial/ethnic disparities in outcomes from ischemic stroke hospitalizations.	This article does not contain any comparisons among pre- and post-crisis periods.
Hone (2019)	Effect of economic recession and impact of health and social protection expenditures on adult mortality: a longitudinal analysis of 5565 Brazilian municipalities	This article estimates the association between economic recession and adult mortality in Brazil and whether health and social welfare programs in the country had a protective effect against the negative impact of this recession, without comparison among pre- and post-crisis periods.
Ketilsdottir (2019)	Self-reported health and quality of life outcomes of heart failure patients in the aftermath of a national economic crisis: a cross-sectional study.	This study describes characteristics, health status, and SES of HF patients several years after a national economic crisis but no measures were available on the patient population's profile before the crisis.

Ketilsdottir (2018)	Self-reported health and quality of life outcomes of heart failure patients in the aftermath of a national economic crisis: a cross-sectional study.	This study was conducted in 2014 and describes data from this year without any comparison in the state before the economic crisis in 2008.
Ketilsdottir (2016)	Icelandic heart failure patients at time of economic crisis: patient reported o utcomes.	This poster abstract refers to health status of HF Icelandic patients with data after 2008 economic crisis without comparisons with pre-crisis period and overlaps with the main article's data of *Ketilsdottir et. al. (2019)*
Khatana (2019)	Trends in cardiovascular mortality and economic distress in communities.	This article assesses whether economic distress was associated with trends in cardiovascular mortality rates from 2010 to 2015, without any comparison in time-period before crisis.
Kollia (2016)	Exploring the association between low socioeconomic status and cardiovascular disease risk in healthy Greeks, in the years of financial crisis (2002–2012): The ATTICA study	This study explores the effect of low socioeconomic status (SES) on a 10-year cardiovascular disease (CVD) incidence, in the years of financial crisis without comparison between pre- and post-crisis period.
Kollia (2018)	Trends of Cardiovascular Disease Mortality in Relation to Population Aging in Greece (1956 - 2015).	The purpose of this study was to examine the association between cardiovascular disease (CVD) mortality and demographic indicators, in Greece the past 60 years (1956-2015) without comparisons among the periods of the economic crisis.
Magriplis (2019)	Aims, design and preliminary findings of the Hellenic National Nutrition and Health Survey (HNNHS).	The aim of this study was to assess nutritional intake, health status and various behaviors in a representative sample of the Greek population, in 2013-2015 an after-crisis time-period without comparisons with the previous economic situation.
Marmot (2013)	The Role of Social Determinants in Tackling Health Objectives in a Context of Economic Crisis.	This article examines the impact of the economic crisis on health through its social determinants without comparisons with the pre-crisis conditions.
Modrek (2013)	Health consequences of the 'Great Recession' on the employed: Evidence from an industrial cohort in aluminum manufacturing.	This study explores the health consequences of downsizing on the remaining workforce and focuses on the "recession period" without comparison with the previous / post situation.
Munoz (2015)	The health of adults undergoing an eviction process.	This article analyzes the perceived health status and other health-related indicators in the adult population in Granada undergoing an eviction process from their homes, whether rented or owned, in comparison with health indicators in the general adult population without comparisons in pre- or post-crisis periods.
Ruhm (2000)	Are recessions good for your health?	This study investigates the relationship between economic conditions measured via unemployment rate and health without comparisons in pre- or post-crisis periods.
Ruhm (2015)	Health effects of economic crises.	This analysis summarizes prior research and uses national, state and county level data from the US from 1976-2013 to examine whether the mortality effects of

		economic crises differ in kind from those of the more typical fluctuations without reference to pre- and post-crisis periods.
Seon (2017)	Cardiovascular health status between standard and nonstandard workers in Korea.	This article evaluates if the effect of employment insecurity on employee health is an important public health issue due to the recent effects of neoliberalism and the global financial crisis (2007–2008) on labor markets without a clear comparison between pre- and post-crisis periods.
Strumpf (2017)	Did the Great Recession affect mortality rates in the metropolitan United States? Effects on mortality by age, gender and cause of death.	This study estimates the impacts of increases in unemployment rates on both all-cause and cause-specific mortality across U.S. metropolitan regions during the Great Recession without comparison among pre- and post-crisis periods.
Tapia Granados (2005)	Recessions and mortality in Spain, 1980–1997.	This article refers to the relationship between economic fluctuations and mortality as assessed with data from Spain during the years 1980–1997 without comparisons in pre- or post-crisis periods.
Torbica (2015)	The economic crisis and acute myocardial infarction: new evidence using hospital level data.	The aim of the present analysis was to investigate the relation between the unemployment rate and the incidence of hospital level AMI in the Italian NHS during the period of economic crisis, without comparisons between pre- and post-crisis periods.
Vagero (2016)	Does unemployment cause long-term mortality? Selection and causation after the 1992–96 deep Swedish recession	In this study, mortality events were studied in the post-recession period only.
Vagero (2005)	Self-reported heart symptoms are strongly linked to past and present poverty in Russia: evidence from the 1998 Taganrog interview survey.	The aim of this study was to relate poverty to the presence of self-reported heart symptoms without reference to pre- or post- recession periods.
Walberg (1998)	Economic change, crime, and mortality crisis in Russia: regional analysis.	This study identifies which aspects of socioeconomic change were associated with the steep decline in life expectancy in Russia between 1990 and 1994 a period following the 1990's Recession.
Williams (2012)	The Social Context of Cardiovascular Disease: Challenges and Opportunities for the Jackson Heart Study.	This paper outlines critical research opportunities for the Jackson Heart Study to advance the science base for understanding and effectively addressing racial disparities in CVD without comparison with pre- and post-crises conditions.
Zagożdżon (2014)	Effect of unemployment on cardiovascular risk factors and mental health.	Data were collected between 2009 and 2010 in a period of economic crisis but there is not any comparison in the state before the economic crisis period.
Studies reporting only on risk factors (and not cardiovascular disease, as defined in the study protocol)		
Baumbach (2014)	Impact of financial crisis on selected health outcomes in Europe.	The aim of this study was to analyze the effects of the financial crisis on selected health outcomes at population level in Europe. Study refers to

		cardiovascular risk factors but without specific cardiovascular outcomes.
Bobak (1997)	Political changes and trends in cardiovascular risk factors in the Czech Republic, 1985-92.	This paper examines the trends in cardiovascular risk factors in Czech population over the decade in which a major and sudden change of the political and social system occurred in 1989, and whether the trends differed in relation to age and educational group.
Filippidis (2014)	Trends in cardiovascular risk factors in Greece before and during the financial crisis: the impact of social disparities.	The objective of this study was to assess trends in health-related behaviors and cardiovascular risk factors within Greece before, at the beginning and during the current financial crisis.
Inthachai (2019)	Effects of physical activity and smoking on cardio-ankle vascular index, respiratory muscle strength, and exercise performance in early normal weight adulthood: a cross-sectional study.	This article focuses on risk factors that contribute to CVDs.
Jofre-Bonet (2018)	The impact of the Great Recession on health-related risk factors, behaviour and outcomes in England.	This study examines the impact that the Great Recession had on individuals' health behaviors and risk factors (e.g. diet choices, smoking, alcohol consumption, Body Mass Index), as well as on intermediate health outcomes in England without specific reference to CVDs.
Karaslavova (2011)	Psychosomatic correlates of coronary heart disease during the socio-economic crisis of post-communist Bulgaria.	This study examines the role of psychological factors correlating with Acute Myocardial Infarction (AMI) during the transition period in post-communist Bulgaria and focuses on anxiety and depressive disorders.
Karaslavova (2011)	Risk factors for acute myocardial infarction during the transition period in Bulgaria.	The aim of this study was the analysis of the impact of several socio-economic factors over the development of coronary heart disease during the transition period.
Kastorini (2015)	Defining the path between social and economic factors, clinical and lifestyle determinants, and cardiovascular disease.	The aim of this study was to evaluate how social and economic factors influence modifiable cardiovascular disease risk factors and thus, acute coronary syndrome or ischemic stroke presence.
Marcotte-Chénard (2019)	Prevalence of the metabolic syndrome between 1999 and 2014 in the U.S. adult population and the impact of the 2007-2008 recession: a NHANES study.	The aim of this study was to document changes in prevalence of the metabolic syndrome (MetS) in the U.S. adult population between 1999 and 2014 and to explore how variations in the dietary intakes explain changes in MetS prevalence and its components over time.
Miller (2017)	Metabolic syndrome risks following the Great Recession in rural black young adults.	This study examines metabolic syndrome (MetS) in rural black young adults as a function of their family's economic conditions before and after the Great Recession.
Panagiotakos (2014)	Financial crisis, beliefs and attitudes regarding cardiovascular disease risk	This study evaluates beliefs and knowledge about CVD risk factors of the Greek population, before and after the financial crisis.

	factors: a health survey in 10,141 Greek men and women (2006-2012).	
Pitsavos (2003)	Epidemiology of cardiovascular risk factors in Greece: aims, design and baseline characteristics of the ATTICA study.	This article refers to a population-based health and nutrition survey, the "ATTICA study" to evaluate the levels of several cardiovascular risk factors in Greece.
Psaltopoulou (2017)	Socioeconomic status and risk factors for cardiovascular disease: impact of dietary mediators.	This study examines several risk factors such as family history, diabetes, hypertension, obesity, diabetes, smoking and physical inactivity in relation to the overall cardiovascular risk.
Rodgers (2019)	County-level housing affordability in relation to risk factors for cardiovascular disease among middle-aged adults: The National Longitudinal Survey of Youths 1979.	This survey estimated the associations between the change in median country-level percentage of household income spent on housing (rent/mortgage) between 2000 and 2008 and individual-level risks of risk factors for CVDs from 2008 to 2014.
Samentzas (2016)	The incidence of diabetes mellitus type II in patients with acute coronary syndromes in an urban population during the last decade.	This article examines the importance of DMtII as a major risk factor for ACS and evaluates the incidence of DMtII in men and women with ACS during the period of financial crisis (2008-2012) and didn't refer exclusively to CVDs and their relation to periods of economic crisis.
Tapia-Granados (2018)	Cardiovascular risk factors, depression, and alcohol consumption during joblessness and during recessions in CARDIA young adults.	This article refers to CVD risk factors not to specific disease.
Westerlund (2004)	Organizational instability and cardiovascular risk factors in white-collar employees.	The aim of this study was to determine the effects of organizational instability, on the components of the demand–control model and on the cardiovascular risk factors; fibrinogen, cholesterol, triglycerides, and blood pressure in white-collar employees.
Studies reporting different times of economic crisis and CVDs assessment		
Alessie (2019)	Economic Conditions at Birth and Cardiovascular Disease Risk in Adulthood: Evidence From post-1950 Cohorts	Crisis referring to time of birth and not to time of CVD assessment.
Van den Berg (2011)	Being born under adverse economic conditions leads to a higher cardiovascular mortality rate later in life: evidence based on individuals born at different stages of the business cycle.	This article connects the recent medical and economic literature on the long-run effects of early-life conditions by analyzing the effects of economic conditions in general, on the individual CV mortality rate later in life, using individual data records. Crisis referring to time of birth and not to time of CVD assessment.