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REVIEW

The impact of the COVID-19 pandemic on delayed care of cardiovascular diseases in Europe: a systematic review

Yasmine Khan [1,2,3,*], Nick Verhaeghe [1,4,5], Brecht Devleesschauwer [2,6], Lisa Cavillot [2,7], Sylvie Gadeyne [3], Nele Pauwels [8], Laura Van den Borre [2,3] and Delphine De Smedt [1]

[1]Department of Public Health and Primary Care, Ghent University, Ghent 9000, Belgium; [2]Department of Epidemiology and Public Health, Sciensano, Brussels 1050, Belgium; [3]Department of Sociology, Interface Demography, Vrije Universiteit Brussel, Brussels 1050, Belgium; [4]Research Institute for Work and Society, KU Leuven, Leuven 3000, Belgium; [5]Department of Rehabilitation Sciences, Ghent University, Ghent 9000, Belgium; [6]Department of Translational Physiology, Infectiology and Public Health, Ghent University, Merelbeke 9000, Belgium; [7]Research Institute of Health and Society, University of Louvain, Brussels 1200, Belgium; and [8]Faculty of Medicine, Ghent University, Ghent 9000, Belgium

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Aims

Cardiovascular diseases (CVD) are the leading cause of death worldwide. The coronavirus disease 2019 (COVID-19) pandemic has disrupted healthcare systems, causing delays in essential medical services, and potentially impacting CVD treatment. This study aims to estimate the impact of the pandemic on delayed CVD care in Europe by providing a systematic overview of the available evidence.

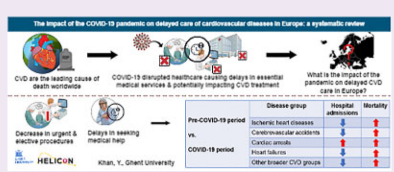
Methods and results

PubMed, Embase, and Web of Science were searched until mid-September 2022 for studies focused on the impact of delayed CVD care due to the pandemic in Europe among adult patients. Outcomes were changes in hospital admissions, mortality rates, delays in seeking medical help after symptom onset, delays in treatment initiation, and change in the number of treatment procedures. We included 132 studies, of which all were observational retrospective. Results were presented in five disease groups: ischaemic heart diseases (IHD), cerebrovascular accidents (CVA), cardiac arrests (CA), heart failures (HF), and others, including broader CVD groups. There were significant decreases in hospital admissions for IHD, CVA, HF and urgent and elective cardiac procedures, and significant increases for CA. Mortality rates were higher for IHD and CVA.

Conclusion

The pandemic led to reduced acute CVD hospital admissions and increased mortality rates. Delays in seeking medical help were observed, while urgent and elective cardiac procedures decreased. Adequate resource allocation, clear guidelines on how to handle care during health crises, reduced delays, and healthy lifestyle promotion should be implemented. The long-term impact of pandemics on delayed CVD care, and the health-economic impact of COVID-19 should be further evaluated.

Graphical Abstract



Keywords

COVID-19 • Cardiovascular diseases • Delayed care • Europe

* **Corresponding author:** Email: yasmine.khan@ugent.be
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Key learning points

What is already known:

- Cardiovascular diseases are a leading cause of death worldwide, and timely diagnosis and treatment are crucial in lowering the disease burden.
- The coronavirus disease 2019 (COVID-19) pandemic has disturbed healthcare systems globally, leading to significant delays in the delivery of essential medical services, including CVD care.
- Delays in CVD treatment during the pandemic can be due to various factors, such as patient hesitation to seek timely care, changes in healthcare priorities, and postponements or cancellations of elective procedures owing to a higher demand for COVID-19-related medical care.

What this study adds:

- This systematic review offers a comprehensive and synthesized overview of available evidence on the impact of the COVID-19 pandemic on delayed CVD care in Europe, including insights on hospital admissions, mortality rates, delays in treatment initiation, and changes in cardiac procedures.
- It also offers insights into the potential long-term effects of delayed CVD care during different waves of the pandemic, shedding light on the evolving impact of the pandemic on CVD management.
- The review highlights the importance of considering the unique challenges faced by each country in Europe when devising targeted strategies to minimize disruptions in CVD care and improve patient outcomes during future health crises.

Introduction

Cardiovascular diseases (CVD) remain the number one cause of death across the globe. In 2019, about 17.9 million deaths worldwide were due to CVDs, representing 32% of all fatalities.[1] Furthermore, CVDs also significantly contribute to overall disability. Over the past three decades, the number of health life years lost due to CVD and years spent living with disability caused by CVDs has doubled from 17.7 million (95% confidence interval (CI): 12.9–22.5 million) to 34.4 million (95% CI: 24.9–43.6 million), as reflected by the dramatic increase in global trends for disability-adjusted life years.[2] In addition to preventive actions, timely diagnosis and treatment are essential to lower the disease burden.[3]

The coronavirus disease 2019 (COVID-19) pandemic has disrupted healthcare systems worldwide and caused significant delays in the delivery of essential medical services, including CVD care.[4] Delays in CVD treatment may be caused by patient delays in seeking timely treatment due to insufficient symptom knowledge and/or symptom confusion,[5] faulty CVD care pathways,[6] or a lack of healthcare coordination.[7] In March 2020, when Europe was experiencing significant outbreaks of COVID-19, there were changes in the availability of medical care due to shifting healthcare priorities. This resulted in postponements and cancellations of elective procedures due to the increased demand for medical care related to COVID-19.[4] Patients were also reluctant to seek for appropriate care because they were afraid of contracting the virus and wanted to avoid straining the healthcare system.[8] While some studies have investigated the effects of the COVID-19 pandemic on acute CVD care, a systematic review evaluating the impact of the pandemic on all CVD and cardiac procedures in Europe is currently lacking. This knowledge gap highlights the need for further research to better understand the indirect impact of the pandemic on delayed cardiovascular disease care. Therefore, the aim of this review is to study and summarize the potential impact of the COVID-19 pandemic in Europe on delayed CVD care by providing a systematic overview of the available evidence.

Methods

Search strategy and selection criteria

A systematic literature study was performed according the to the Cochrane Handbook for Systematic Reviews of Interventions' methodology and compliant with preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines, for which the checklist can be found in the supplementary material.[9] The protocol's registration number on PROSPERO is CRD42022354443 (https://www.crd.york.ac.uk/prospero/).

Three electronic databases were searched up to mid-September 2022: MEDLINE (through PubMed interface), Embase (through embase.com interface), and Web of Science. The search strategy (Supplementary material 1) consisted of four concepts: COVID-19, disruption, care, and CVDs. Creation of the search strategy was assisted by an information specialist (NSP) and further finalized with content experts. A number of inclusion criteria were defined in advance based on our research question and the identification of the PICO elements (*Table 1*).

Selection process

Title and abstract screening, full-text screening, and reference list screening were executed independently by two reviewers (Y.K. and L.C.) to decide whether a study met the inclusion criteria. Rayyan (https://rayyan.qcri.org), a web automation tool, was used for screening and selecting studies and for collaboration among reviewers.

Data extraction

After relevant studies were included in the review, it became apparent that certain disease groups were recurring. Therefore, we classified the papers into the following categories: Ischaemic heart diseases (IHD), cerebrovascular accidents (CVA), heart failure (HF), cardiac arrest (CA), and others (including studies reporting on multiple diseases and/cardiac procedures). Two reviewers (Y.K. and L.C.) independently extracted (a) study design, (b) country, (c) setting, (d) COVID-19 period (i.e. timeframe observed during the pandemic), (e) comparison period (i.e. pre-COVID period to which the COVID-19 period is compared), (f) disease group (i.e. IHD, CVA, HF, CA, others), (g) study population characteristics (population size, age, gender, and comorbidities), (h) outcome(s), (i) main results, and (j) author's conclusion into an Excel file (Supplementary material 2). It is of common practice to extract data from included articles in a systematic review into an Excel sheet for data management and analysis because it allows easy organization, manipulation, and sharing of data.[9] Missing summary statistics were handled by contacting authors. No meta-analysis was performed due to the heterogeneity in outcome measures, as some studies measured relative changes (%) and others used incidence rate

Table 1 Inclusion criteria

Population	Adults (≥18 years of age) diagnosed and/or susceptible to being affected by CVDs
Intervention	Delayed care and reduced health services availability due to the COVID-19 pandemic. Studies related to patients affected with the COVID-19 virus and/or studies estimating the impact of the COVID-19 vaccine on CVDs were excluded.
Comparators	Usual care (i.e. pre-COVID-19 times)
Outcomes	1. Changes in hospital admission: relative change (%) and/or RR (95% CI) 2. Mortality: relative change (%) or case fatality rate 3. Delays in seeking medical help after symptom onset in time: mean or median minutes or hours 4. Delays in treatment initiation mean or median minutes or hours 5. Change in the number of treatment procedures: relative change (%) and/or RR (95% CI)
Context	The COVID-19 pandemic
Region	Europe
Study design	Quantitative studies only
Evidence	Peer-reviewed publications only
Language	English
Publication time frame	Studies published since 1 November 2019 until 18 September 2022

CVD: Cardiovascular disease; RR: Relative risk ratio.

ratios (IRR). Moreover, using a broader timeframe (i.e. studies published since 1 November 2019 until 18 September 2022) led us to include studies with different outcome measures, patient populations, interventions, and measurement methods, which made it challenging to conduct a meaningful meta-analysis too.

Synthesis of findings

First, a synthesis of study characteristics was presented (i.e. country, sample size, gender, population risk profile, study design, and comparison period during the COVID-19 pandemic). Then, the results of the review were categorized based on the five most frequently occurring CVD groups found in the included studies (i.e. IHD, CVA, HF, CA, and others). For all CVD groups, hospital admission (i.e. when a patient is admitted to a hospital/healthcare facility to receive inpatient medical care) and mortality rate results were presented. Delays in seeking medical help after symptom onset, delays in treatment initiation, and the number of treatment procedures were only available for IHD and CVA, as the included studies reporting on those disease groups were focused on these outcomes. For IHD, delays in treatment initiation were reflected by door-to-balloon (DTB) times (i.e. time interval from a patient's arrival at the hospital to the inflation of a balloon catheter to open a blocked coronary artery during a percutaneous coronary intervention (PCI)). For CVA, delays in seeking help after symptom onset were reflected by symptom-to-door times (i.e. time interval between the onset of symptoms in a patient and their arrival at the healthcare facility's door for treatment). Delays in treatment initiation were reflected by door-to-needle (DTN) times (i.e. elapsed time from a patient's arrival at a hospital/medical facility to the start of a specific medical treatment, such as administering a medication/performing a procedure) and door-to-groin (DTG) time (i.e. time required for a patient to reach neuro-interventional radiology suite for mechanical thrombectomy), also for CVA. The level of severity at hospital admission (National Institutes of Health Stroke Scale (NIHSS)) and the level of disability (Modified Rankin Scale (mRS)) post stroke were also presented for CVA. Heart failure reported on symptom severity at the time of hospital admission (New York Heart Association (NYHA) score).

Quality assessment

Two authors (Y.K. and L.C.) independently performed the quality assessment of the included studies in the review using the 14-item QualSyst tool checklist for quantitative research.[10] Out of the 14 components of the tool, three of them (i.e. random allocation to treatment group (a), blinding of investigators (b), and subjects (c)) were not considered as they all relate to intervention studies only. The other items of the checklist are related to the research question, study design, sampling methods, characteristics of subjects, analytical methods, estimation of variance, risk of bias/confounders, results, and conclusion. The two authors determined a summary score (%) for each study, ranging from zero (poor quality) to 100 (excellent quality). Disagreements were resolved by consulting a third reviewer (D.D.S.). A sensitivity analysis to evaluate the impact of studies with lower quality scores on the review's findings was performed. Studies with the lowest quality scores (<50) were identified and removed from the analysis. Then, the data was re-analysed and results with and without low-quality studies were compared. The impact of the low-quality studies on the overall findings of the review were evaluated. Ultimately, the results of the sensitivity analysis in the review were discussed and considered in the implications for the interpretation of the findings.

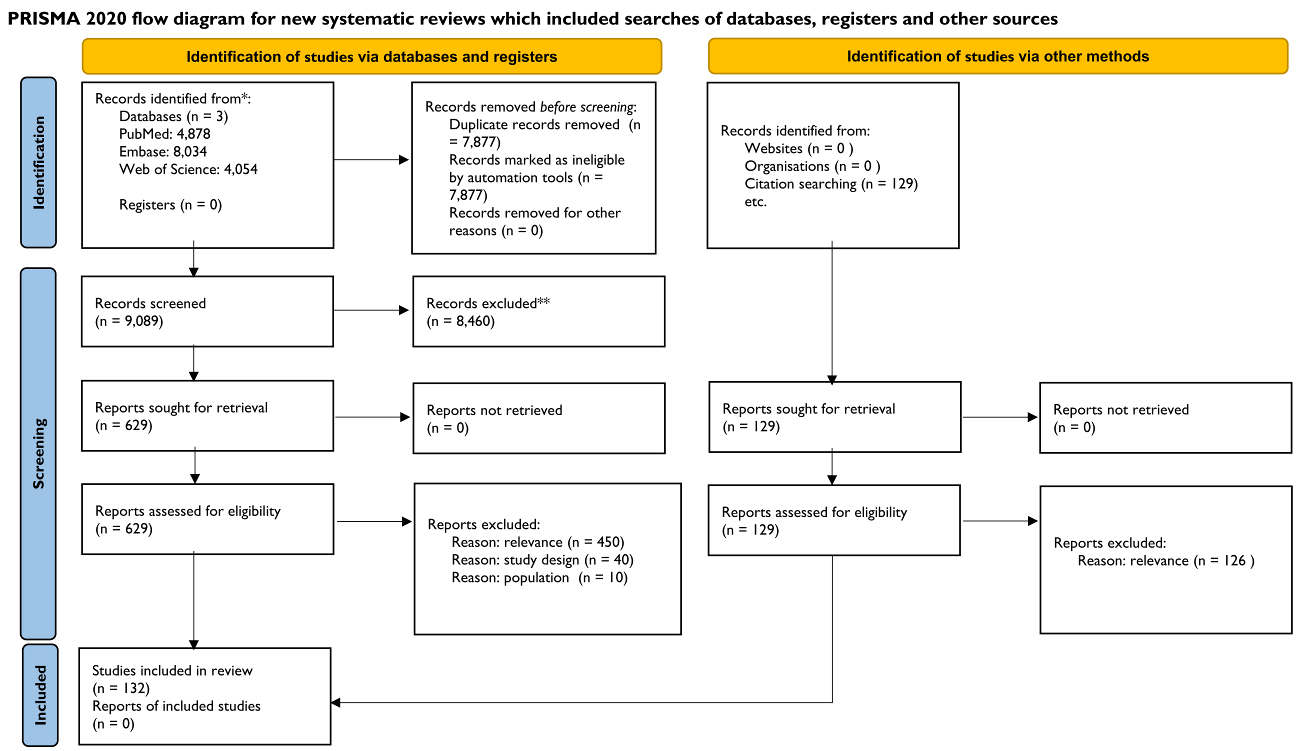
Results

Study selection

The initial search yielded 16 966 articles. After removal of duplications, 9089 references were imported into Rayyan. Two review authors (Y.K. and L.C.) then screened for relevant studies based on the title and abstract of the publication. If disagreements were not resolved through consensus, a third review author (DDS) was consulted. There was a good inter-rater agreement between both reviewers with a weighted kappa statistic of 88%. Next, the remaining 629 references' full-text records were independently evaluated by two authors (Y.K. and L.C.) according to the eligibility criteria, leaving 129 articles. Additionally, three more studies were added after reviewing the reference lists, bringing the total to 132 articles for data extraction. *Figure 1* provides a thorough description of the study screening and selection following the PRISMA 2020 flow diagram.

Study characteristics

Most studies were performed in the UK ($n = 25$), followed by Italy ($n = 23$) and Germany ($n = 17$) but some studies were also performed in France ($n = 14$), Spain, Greece, Portugal, Austria, Switzerland, Lithuania, Norway, Netherlands, Albania, Denmark, Belgium, Poland, Ireland, Romania, Serbia, Hungary, Czech Republic, Slovakia, Croatia, Bulgaria, and Finland. The studies differed in terms of sample size ($n = 32$ to $n = 2\ 055\ 244$), gender (40% male to



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/

Figure 1 PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers, and other sources.

90% male), age (mean age = 18 to mean age = 80), and population risk profile (hypertension: 4–97%; obesity: 12–67%; diabetes: 2–54%; dyslipidaemia: 4–93%; and smoking: 0–77%). All of studies were retrospective observational 82% were case-controls, 8% were prospective, 5% were cross-sectional, and the remaining 5% consisted of longitudinal and population-based studies. For the comparison period, 51% of the studies focused on the period preceding the first lockdown and the first lockdown period (January–April 2020), 36% of the studies looked at the first lockdown and the first post-lockdown period (March/April–May/June 2020), 6% of the studies focused on the first and the second waves, 5% of the studies on the year 2020, and the remaining 2% looked at the first wave until the third wave, and the first wave until the fourth wave of the COVID-19 pandemic. The main results of the review are illustrated in *Table 2*.

Synthesis of findings

Ischaemic heart diseases (IHD)

Sixty-eight studies analysed delayed IHD care during the COVID-19 pandemic. All of them considered myocardial infarctions (ST-elevation myocardial infarction (STEMI), $n = 66$; Non-ST-elevation myocardial infarction (NSTEMI), $n = 35$), seven studies included AP (unstable, $n = 5$; stable, $n = 2$), and two studies analysed CAD. Out of the 68 studies, 47 addressed hospital admissions, 30 discussed mortality, 25 analysed delays in help-seeking after symptom onset or delays in treatment initiation, and 13 analysed the number of treatment procedures.

Acute myocardial infarction (AMI) hospital admissions

Forty-four studies found a significant decline in AMI admissions during the COVID-19 pandemic compared to the pre-COVID-19 period ranging between 12 and 66%.[11–54] One study observed no variation in the number of STEMI admissions during the pandemic compared to pre-pandemic times.[55] An Italian study found a reduction in AMI admissions during the first lockdown period compared to pre-COVID times, but a significant increase in hospital admissions for AMI after the lockdown was lifted.[15] Another Italian study examining figures from 2020, depicting the two first waves of the pandemic, also found a significant increase in AMI hospital admissions compared to the year 2019.[56]

Angina pectoris (AP) hospital admissions

Six studies found a significant decrease in AP admissions with admission rates ranging from 0.63 to 0.92,[27,29,48,52,53,57] whereas one study did not find a significant change compared to pre-COVID-19 times.[47]

Coronary artery disease (CAD) hospital admissions

Two studies focused specifically on CAD and reported a significant increase in hospitalizations during the COVID-19 period compared to pre-COVID times, with rates ranging from 1.2 to 2.4.[52,58]

Delays in seeking help after symptom onset

Thirteen studies found a significant longer median time to medical help after symptom onset for patients with IHD ranging between 15 and 926 min during the COVID-19 period compared to a time ranging between 2 and 439 min during pre-COVID-19 times.[16,28,30,32,35,37,47,56,59–63] Five studies did not find a significant difference in time to medical help after symptom onset during the pandemic in comparison to pre-pandemic times.[14,18,29,64,65]

Table 2 Main results of the included papers in the review

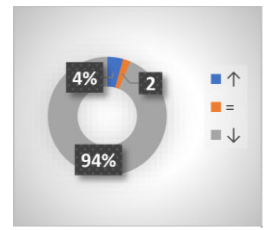
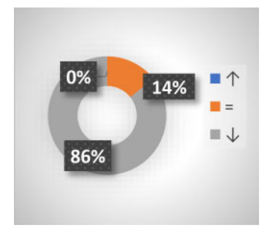
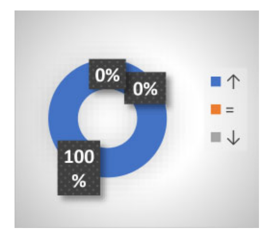
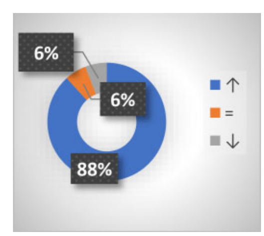
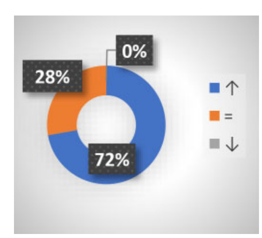
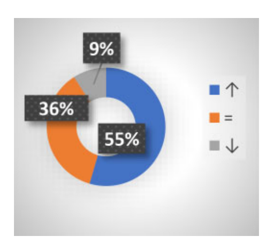
Disease group	Number of studies	Outcomes assessed	Number of studies finding ↑compared to pre-COVID-19	Number of studies finding = compared to pre-COVID-19	Number of studies that found ↓ compared to pre-COVID-19	Overview
Ischaemic heart disease (IHD)	47	Hospital admissions for MI	2	1	44	
	7	Hospital admissions for AP	0	1	6	
	2	Hospital admissions for CAD	2	0	0	
	17	Mortality rate	15	1	1	
	18	Delays in seeking medical help after symptom onset	13	5	0	
	11	Delays to treatment initiation	6	4	1	

Table 2 Continued

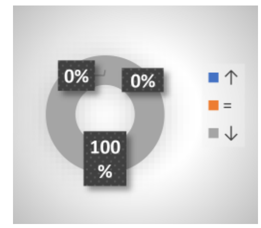
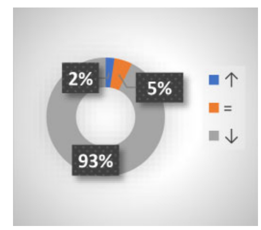
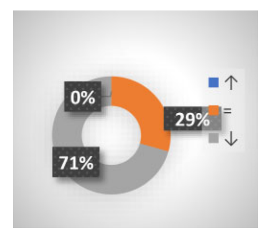
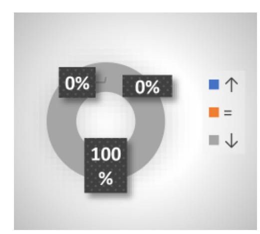
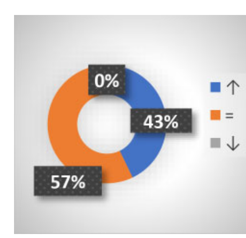
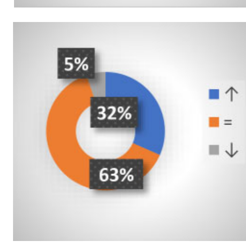
Disease group	Number of studies	Outcomes assessed	Number of studies finding ↑compared to pre-COVID-19	Number of studies finding = compared to pre-COVID-19	Number of studies that found ↓ compared to pre-COVID-19	Overview
	9	Treatment procedures	0	0	9	
Cerebrovascular disease	41	Hospital admissions for strokes	1	2	38	
	17	Hospital admissions for TIA	0	5	12	
	4	Hospital admissions for ICH	0	0	4	
	14	Delays in seeking medical help after symptom onset	6	8	0	
	19	Delays in treatment initiation	6	12	1	

Table 2 Continued

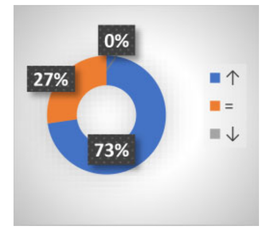
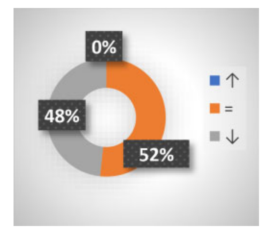
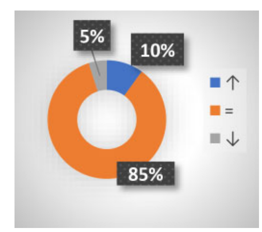
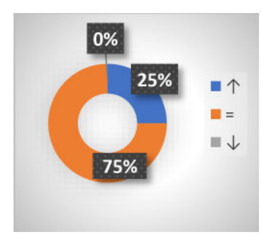
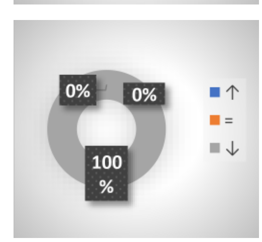
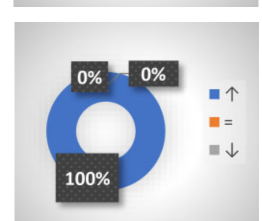
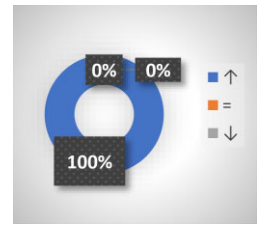
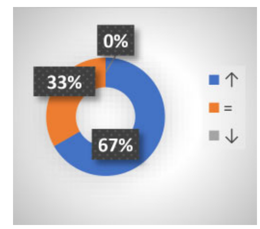
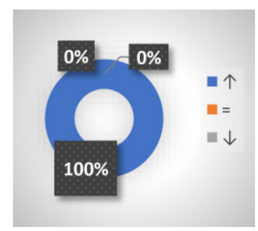
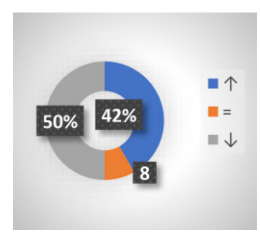
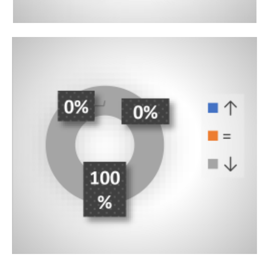
Disease group	Number of studies	Outcomes assessed	Number of studies finding ↑compared to pre-COVID-19	Number of studies finding = compared to pre-COVID-19	Number of studies that found ↓ compared to pre-COVID-19	Overview
	11	Mortality rate	8	3	0	
	29	Treatment procedures	0	15	14	
	20	Level of severity at hospital admission (NIHSS)	2	17	1	
	4	Level of disability (mRS) post stroke	1	3	0	
Heart Failure (HF)	10	Hospital admissions	0	0	10	
	4	Mortality rate	4	0	0	

Table 2 **Continued**

Disease group	Number of studies	Outcomes assessed	Number of studies finding ↑compared to pre-COVID-19	Number of studies finding = compared to pre-COVID-19	Number of studies that found ↓ compared to pre-COVID-19	Overview
	2	Symptom severity at admission	2	0	0	
Cardiac arrests (CA)	6	Hospital admissions	4	2	0	
	3	Mortality rate	3	0	0	
Others						
Other CVD	12	Hospital admissions	5	1	6	
Other cardiac procedures	2	Hospital admission	0	0	2	

↑: increase; ↓: decrease; = : equal to.
AP: angina pectoris; CAD: coronary artery; ICH: intracranial haemorrhage; MI: myocardial infarction; and TIA: transient ischaemic attack.

Delays in treatment initiation

Six studies found a significant longer median DTB time, ranging from 41 to 66 min during the COVID-19 period compared to a time ranging between 34 and 40 min during pre-COVID-19 times[16,21,57,66–68] and four studies did not find a significant difference in DTB times during the COVID-19 pandemic compared to pre-COVID-19 times.[28,31,60,69] Moreover, one study observed a significant shorter DTB time during the COVID-19 period compared to pre-COVID-19 times.[67]

Treatment procedures

Six studies reported a significant reduction in the number of PCI procedures for STEMI patients ranging from 15 to 66%.[19,35,57,59,68,70]

Additionally, three studies observed a significant decrease in the number of catheterization procedures, with reductions ranging from 25 to 45%.[26,71,72]

Mortality rate

Fifteen studies found a higher mortality rate for patients with IHD during the COVID-19 pandemic ranging between 1 and 25%.[15,17,21,28–30,32,35,39,42,47,56,59,71,73] A French study analysing the period from before the 1st lockdown until after the 2nd lockdown found a decrease in hospitalizations for AMI, without observing any increase in mortality, acute cardiac complications or 3-month mortality among AMI patients.[20]

Cerebrovascular accident

Fifty-one studies examined the impact of the COVID-19 pandemic on CVA.[44,46,48–50,53,54,74–117] All of them investigated the impact on both ischaemic stroke (IS) and haemorrhagic strokes (HS). Transient ischaemic attacks (TIA) were analysed in 17 studies, while four studies examined intracranial haemorrhage (ICH).[86,103,107,117]

Stroke hospital admissions

Thirty-eight studies reported a significant decrease in stroke hospital admissions, ranging between 9 and 40%.[44,46,48–50,54,74,75,80–88,90–96,99–103,105–107,110–112,115–117] A German study showed a significant decrease in the number of daily stroke admissions during the first and second waves of the pandemic compared to pre-COVID-19 times, but observed a return to normal during the third and the fourth waves.[82] Similarly, a Danish study found consistent with pre-pandemic levels stroke admission rates during various stages of lockdown and reopening.[108] In contrast, a Bulgarian study found a significant 17% increase in the number of stroke cases during the first wave of the pandemic compared to the same period in 2019.[109]

Transient ischaemic attack hospital admissions

Twelve studies found a significant decrease in hospital admissions ranging from 15 to 25% during the pandemic compared to pre-COVID-19 times.[49,50,53,75,80,86,88,91,103,107,114,118] Five studies found no significant difference in hospital admissions.[78,87,90,108,117]

Intracranial haemorrhage hospital admissions

Four studies found that ICH admissions significantly decreased by 16–22% during the pandemic period compared to the pre-COVID-19 period.[59,60,61,62]

Delays in seeking help after symptom onset

Six studies found significant increases in symptom-to-door times during the pandemic, with mean or median times ranging from 66 to 230 min compared to 34 to 120 min in pre-COVID times.[79,95,97,104,116,117] In contrast, eight studies did not find any significant time differences in seeking medical help after symptom onset.[74,76,78,81,94,98,106,115]

Delays in treatment initiation

Two studies reported a significant longer median DTN time, with 30–55 min during the pandemic[84,90] compared to 27–51 min in pre-COVID times,[76,111] while five did not find any delay.[79,110,115–117] Four studies also found a significant longer DTG, ranging from 62 to 185 min during the pandemic compared to 50–185 min during pre-COVID times,[87] but seven studies did not find a delay.[77,81,101,106,115–117] Moreover, a British study found significantly reduced internal delays (i.e. DTG times) during the first wave of the pandemic compared to pre-COVID times.[92]

Treatment procedures

Fourteen studies demonstrated a decrease in the number of reperfusion therapies during the pandemic compared the pre-pandemic period ranging from 4 to 42%.[74,76–78,80,88,89,98,100,106,107,109,111,113] Fifteen studies however observed no change in the number of reperfusion therapies.[83,86,87,92,96,99,101,103,110,112,114–118]

Level of severity at hospital admission (NIHSS) and level of disability (mRS) post stroke

Seventeen studies indicated no significant changes in stroke severity upon hospital admission,[74,77,79,87,90–92,96–98,100,104,106,109,110,115,116] while three studies did not find any differences in post-stroke disability levels.[81,101,109] Two studies revealed significantly higher NIHSS scores[76,94] and one study reported a significantly higher mRS score[109] during the COVID-19 pandemic compared to pre-pandemic times. Conversely, a Swiss study demonstrated a significant improvement in NIHSS score during the first lockdown.[81]

Mortality rate

Eight studies[49,82,84,85,103,108,109,112] found that mortality rates were significantly higher during the pandemic, with increases ranging from 8 to 70% for different outcomes. In contrast, three studies[79,94,119] did not find a significant increase in in-hospital deaths during the pandemic. One study also reported a 17% increase in 30-day mortality risk rate.[108] Notably, 30-day out-of-hospital case fatality rates after hospital admission were particularly high during the pandemic, reaching 70% in some cases.[85]

Heart failure

Ten studies assessed the impact of the COVID-19 pandemic on HF[43,45,54,118,120—125] and all of them reported a significant reduction in hospital admissions, with a relative decrease ranging from 9 to 66%. However, four studies indicated an increase in mortality rates, with in-hospital mortality rates ranging between 6 and 7% during the pandemic compared to mortality rates ranging between 5 and 6% in the pre-COVID-19 era.[122—125] Furthermore, two studies identified a significant increase in patients with more severe symptoms at the time of admission.[123,126]

Cardiac arrests

Two studies evaluated IHCA, while four studies focused on out-of-hospital cardiac arrest (OHCA).[47,71,127—130] Four studies[127—130] reported a significant rise in CA rates, with a relative increase ranging from 11 to 56%. However, two German studies did not find a significant change in OHCA admissions during the first wave of the pandemic.[71,131] Additionally, two studies reported a decreased survival rate after resuscitation,[127,128] while one study observed a significant increase in in-hospital mortality rate during the COVID-19 pandemic compared to pre-COVID times.[129]

Others

Other cardiovascular diseases

Seventeen studies examined the broader cardiovascular disease groups.[42,45,47,49,52,58,71,85,118,119,132–138] Two German studies investigated arrhythmic heart disease hospitalizations. One study found a significant increase (IRR = 2.4), while the other did not observe any difference compared to the pre-COVID-19 period.[47,58] An Italian study reported a 27% relative decrease in acute myocarditis hospital admissions during the pandemic compared to pre-COVID times. However, the incidence of pericarditis and myopericarditis/perimyocarditis remained stable. Four studies found a significant decrease in pulmonary embolism hospital admissions, with reductions ranging from 40 to 83% during the pandemic compared to pre-pandemic times.[42,45,85,136] One of these studies also reported a threefold increase in related in-patient mortality rate. Studies found significant decreases in hospital admissions for venous thrombolysis,[139] chest pain,[133] aortic ruptures,[49] and new-onset atrial fibrillations[134] but a study found a significant increase in aneurysmal subarachnoid haemorrhage[119] during the COVID-19 pandemic compared to pre-COVID-19 times.

Other cardiac procedures

One British study found a significant reduction in both surgical aortic valve replacement (AVR) and transcatheter AVR during the first and second waves of the pandemic. Additionally, the study reported a significant increase in 30-day mortality rate for both AVR and coronary artery bypass grafting procedures (135). A German study found decreased proportions of chronic coronary syndromes catheterization procedures during the pandemic compared to pre-COVID times.[71]

Quality assessment

There was a good inter-rater agreement between both reviewers for the quality assessment with a weighted kappa statistic of 85%. Studies with lower quality scores may still provide valuable information and/contribute to the understanding of the research question, therefore we did not reject studies based on quality assessment. Only one study had a quality score <50.[75] The latter focused on the impact of the pandemic on CVA hospital admissions in Italy and found that there was a drop in admissions for TIA but not for strokes. Details of the quality assessment of each study included in the review are in Supplementary material 3.

Discussion

The COVID-19 pandemic has disrupted healthcare systems worldwide, causing delays in the delivery of essential medical services, including CVD care. A survey performed by the European Society of Cardiology (ESC) in April 2020, among 3000 healthcare professionals worldwide showed a decrease in AMI admission and an increase in delayed presentations at cardiology wards.[140,141] With time, high-level evidence with more robust study designs estimating the indirect impact of the COVID-19 pandemic on delayed CVD care and confirming the results of the ESC survey was added to the literature.[120,142,143] For example, a systematic review examining the effects of the pandemic on the care and management of patients with acute cardiovascular disease revealed a decrease in hospital admissions for acute coronary syndrome (ACS) by 40–50% and for stroke emergencies by 12–40%.[144] This study aimed to provide a systematic review of the available evidence on the impact of the COVID-19 pandemic on delayed CVD care in Europe. This information is crucial to understand the indirect impact of the pandemic on CVD care and to develop strategies to minimize the burden of delayed CVD care in the future. Almost 90% of the studies included in our review reported on the first wave of the pandemic (generally including the post-lockdown period), those majorly showed that hospital admissions for acute CVD such as AMI, stroke, and HF decreased during the pandemic, while mortality rates for CVD patients increased. Delay in seeking medical help after symptom onset was also observed. In contrast, there was an increase in CAs and lower survival rates. Additionally, there were reductions in urgent and elective cardiac procedures. Our results are in line with a systematic review on the impact of the pandemic on the care of patients with acute CVD, which found a reduction in ACS hospital admissions of 40–50% and 12–40% for stroke emergencies.[144] Another recent review on pandemic's impact on CVD health in 2020 found reduced CVD facility admissions and lower CVD mortality, though some studies showed the opposite.[145] We have included a few studies (mainly focusing on CVA) that also reported on the second, third, and fourth waves of the pandemic. Those generally showed a decrease in hospital admissions and an increase in mortality rates[43,108] during the first wave of the pandemic followed by an increase in hospital admissions, almost hitting pre-COVID-19 levels,[53,82,83,95] and improved time to treatment initiation,[95,97] which may reflect a learning curve within healthcare systems in providing CVD care during the pandemic, changing patient attitudes during the pandemic, and the success of public health campaigns to reassure patients about the safety of seeking emergency care when needed.[82,95]

The decrease in hospital admissions for CVD during the pandemic can be attributed to various factors.[120] Government lockdowns and movement restrictions, fear of contracting COVID-19, and confusion about seeking medical care likely dissuaded patients from visiting hospitals. Additionally, healthcare systems were overwhelmed with COVID-19 patients, resulting in reduced capacity to treat non-COVID-19 related conditions such as CVD.[148] Social restrictions and confinement may have limited the number of witnessed acute cardiovascular events and patients sharing their symptoms with others.[146,147] Moreover, lifestyle changes, such as increased physical activity, reduced alcohol consumption, healthier eating habits, and decreased exposure to environmental triggers, due to reduced air pollution and changes in ambient temperature during the first lockdown, may have also played a role in reducing hospital admissions for CVD.[16]

Delays in seeking treatment for CVD during the pandemic may again be explained by the fear of the virus, pushing patients away from seeking medical attention, even when experiencing CVD symptoms.[148] In addition, with COVID-19 dominating news coverage and reduced public health campaigns promoting CVD awareness, some individuals may have attributed their CVD symptoms to the virus and be less aware of CVD symptoms, which could also partly explain delays in seeking medical help.[67,149] The pandemic caused delays in CVD treatment due to changes in healthcare provision, including strained availability of healthcare professionals, hospital resource allocation, and ICU bed availability.[150] Insufficient personal protective equipment and COVID-19 tests at the start of the pandemic also caused delays in emergency procedures and CVD treatment.[151,152]

Increased CVD mortality rates during the pandemic could be attributed to delays in diagnosis and treatment initiation leading to more severe cases and increased risk of death. For instance, delays in treatment for STEMI patients are associated with negative outcomes such as myocardial salvage, maintenance of left ventricular function, and survival.[153] Moreover, the decrease in AMI admissions may have increased the risk of OHCA and CVD mortality.[129] Increased stress, anxiety, and depression due to fear of the virus, social isolation, economic uncertainty, disruption to daily life, and ever-changing information and guidelines related to the pandemic may have also contributed to increased CVD mortality rates.[154,155] Increases in stroke mortality rates may be due to delays in thrombolytic therapy.[156] While most studies did not show a difference in the level of stroke severity at admission (NIHSS score) compared to pre-COVID-19, two studies found higher NIHSS scores, which are associated with a higher risk of mortality.[157] Increases in OHCA mortality may be explained by the reluctance of witnesses and emergency personnel to perform cardiopulmonary resuscitation on potentially contaminated patients, given that it is a process that generates aerosols and carries a significant risk of COVID-19 transmission.[158]

Reductions in hospital admissions and delays in seeking medical help for patients with IHD and CVA could lead to a potential increase in the number of undiagnosed and untreated cases, which may result in more severe cases and worse long-term outcomes, including a higher risk of MI, HF, and death for IHD, and increased disability and mortality for CVA.[159] Delayed treatment for IHD, such as decreases in PCI and catheterization procedures, could also lead to further damage to the heart muscle and increase the risk of complications, such as HF or arrhythmias.[68] Similarly, decreased hospitalizations for stroke could lead to missed opportunities for secondary prevention (i.e. identifying and managing risk factors that increase the likelihood of stroke recurrence) and potentially result in worse outcomes, as stroke is a time-sensitive condition that requires timely treatment.[160] Even minor delays in stroke treatment can have negative effects on clinical outcomes.[161] For HF, decreases in hospital admissions could potentially lead to disease progression, hospitalization, and even death, as patients may not have received timely and appropriate treatment.[162] Additionally, those patients have higher risks of complications from COVID-19.[163] Declines in HF hospitalizations can also lead to missed opportunities for healthcare professionals to assess the patient's condition, adjust medications, and provide self-management education, potentially resulting in more severe cases and worse long-term outcomes.[164] The significant increase in CA cases, and lower survival rates could potentially result in a higher burden of disease in the long term. Survivors of CA may have a lower quality of life and require ongoing medical management, which could increase demands for healthcare resources and services and potentially strain healthcare systems.[128] Furthermore, the pandemic has led to a reduction in cardiac procedures, which could have long-term implications such as a backlog of cases and increased demand for healthcare resources. This could result in delays in patient care, longer waiting times, poorer health outcomes for patients who require timely and appropriate care, and increased costs for patients and insurers.[165]

Additionally, it is important to acknowledge that the long-term consequences of COVID-19, such as long COVID, may also have an impact on the prognosis and treatment of CVD patients. This can be attributed to direct myocardial injury (i.e. COVID-19 leading to myocarditis, pericarditis, cardiomyopathy, and other cardiac abnormalities),[166] indirect cardiovascular effects (i.e. systemic inflammatory response caused by COVID-19 leading to prothrombotic state, endothelial dysfunction, and vascular inflammation, which could contribute to developing or exacerbating CVDs)[167] and the impact on CV risk factors (i.e. persistent symptoms, physical deconditioning and medication side effects contributing to worsening hypertension, diabetes, dyslipidaemia, and obesity potentially leading to poorer CV outcomes).[168] Healthcare providers should remain vigilant in assessing and managing CV risks in individuals with long COVID, including regular monitoring, lifestyle modifications, and pharmacological interventions. Further research is needed to fully understand the long-term impact of long COVID on CVD patients, necessitating multidisciplinary collaboration for comprehensive management strategies.

Our review offers a comprehensive and synthesized overview of available evidence on CVD and cardiac procedures in Europe, providing insights that can guide future research efforts in this area. Furthermore, by including studies on the impact of the second until the fourth waves of the pandemic, our review sheds light on the potential long-term effects of delayed CVD care. Lastly, the quality assessment of our review suggests that the overall quality of the studies included is relatively high as only one study[75] is found to be of low quality (score <50). Removing the study does not influence our findings differently since all of the studies reporting on TIA hospital admissions observed a drop during the pandemic. Although multiple studies on our topic were conducted in the USA and Asia, our review is limited to European countries due to differing containing and tracing measures that may have affected the care trajectories of CVD patients during the pandemic.[169] Additionally, there are limitations related to the included studies. Firstly, the 132 studies we reviewed did not always report consistent outcomes, with some using relative changes while others describe IRRs. Secondly, most studies analysed the pandemic's impact during or after the first wave, leaving a gap in our understanding of its long-term effects.

Policy-makers and healthcare systems should collaborate to prepare for future pandemics, ensuring adequate resources and capacity to manage both COVID-19 and non-COVID-19 health conditions, including CVD. To address public concerns and reduce delays in seeking medical attention for CVDs during a pandemic, clear guidelines and accessible healthcare services should be provided. Measures such as telemedicine services could help. Promoting healthy lifestyles could also reduce the burden of CVD during a pandemic. A future review covering all pandemic waves would help assess the longer-term impact on delayed CVD care in Europe. Also, the use of decision-analytic modelling for instance, could be used to estimate the potential long-term consequences of delayed CVD treatment during the pandemic. This involves identifying relevant care pathways, gathering data inputs (including parameters from literature and national data providers such as insurers, sentinel general practitioner networks, and hospitals), and conducting simulations of various scenarios to compare outcomes (i.e. healthcare costs and health-related quality-of-life losses). By providing decision-makers with evidence-based estimates of the potential impact of different decisions and interventions, decision-analytic modelling can help inform policies and strategies that optimize patient outcomes and healthcare resource utilization. The impact of our study's findings should be considered in light of country-specific restrictions and climate variations that influenced the delivery of CVD care during the pandemic. Varying containment measures, healthcare resources, and climate conditions across countries likely contributed to the results observed.[170] Thus, when devising future measures to mitigate the negative effects on CVD care, it is vital to account for the local context and customize interventions accordingly. Understanding the unique challenges faced by each country can guide the development of targeted strategies to minimize disruptions in CVD care and improve patient outcomes.

Our results demonstrate a negative impact of the COVID-19 pandemic on CVD care. A remaining question includes the long-term consequences of delayed CVD treatment during the pandemic. Evaluating the long-term health and economic impact of the pandemic on CVD care now could help policymakers develop appropriate responses to prevent or minimize the consequences.

Supplementary material

Supplementary material is available at *European Heart Journal—Quality of Care and Clinical Outcomes* online.

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Data availability

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