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Review Article

Reshaping care in the aftermath of the pandemic. Implications for cardiology health systems

Antonio Jordan-Rios [a], Vincenzo Nuzzi [b], Daniel I Bromage [a], Theresa McDonagh [a], Gianfranco Sinagra [b], Antonio Cannata [a,b,*]

[a] Department of Cardiovascular Science, Faculty of Life Science and Medicine, King's College London, 125 Coldharbour lane, London SE5 9RS, UK
[b] Cardiothoracovascular Department, Azienda Sanitaria Universitaria Integrata Giuliano Isontina (ASUGI), University of Trieste, Trieste, Italy

A B S T R A C T

In the last two years, the COVID-19 pandemic has undeniably changed everyday life and significantly reshaped the healthcare systems.

Besides the direct effect on daily care leading to significant excess mortality, several collateral damages have been observed during the pandemic.

The impact of the pandemic led to staff shortages, disrupted education, worse healthcare professional well-being, and a lack of proper clinical training and research.

In this review we highlight the results of these important changes and how can the healthcare systems can adapt to prevent unprecedented events in case of future catastrophes.

1. Introduction

Since the COVID-19 pandemic commenced more than two years ago, it has taken the lives of more than six million people around the globe [1]. In parallel with high mortality rates, health care delivery has been severely disrupted. A pandemic such as this has shown how vulnerable and unequal global health care systems are. It has also been accompanied by significant economic and social consequences [2,3]. Now it is understood that while limiting the rate spread of virus is important, the need to build strong and resilient health structures, that can offer essential services without delay, is also mandatory.

In this review, we highlight the many disrupted areas in cardiovascular medicine and describe their impact on quality of care and mortality. Starting from the excess mortality occurred during the pandemic, the review will focus on the impact on different areas of health system, mainly staff and first contact personnel, the impact of the pandemic on the generation of scientific evidence (clinical trials) and on the effects on patient control and adherence to treatment. Finally, we review the implementation of different technological and logistical strategies to contain a possible future event.

1.1. Excess mortality

Health systems across the globe have seen: (1) a decline in CV hospitalisations (mainly acute presentations), (2) the carrying out of fewer diagnostic and interventional procedures, and (3) fewer outpatient and community consultations [4,5]. Therefore, patients have presented later and sicker. All of these factors have resulted in more than a 5% excess in CV mortality (Fig. 1) [5].

The effect of COVID-19 on patients with cardiac comorbidities and the impact of acute cardiovascular events in patients affected by respiratory failure due to COVID-19 is well established [6–10]. However, another important issue that emerged during the pandemic was the increased cardiovascular mortality due to an unprecedented disruption of health systems [11,12]. For cardiovascular death, an up to 3-fold excess mortality was identified, especially during the first lockdown, which impacted most severely upon patients with existing cardiovascular disease, and this was maintained through 2021 [13]. The impact in Europe has been estimated at 31,000 to 62,000 excess deaths with a relative risk of 1.5 to 2.0[13]. In the United States of America (USA), excess mortality caused by COVID-19 was observed specifically in the subgroup of patients with a history of ischaemic and hypertensive heart disease [14].

During the COVID-19 pandemic, there was a significant decrease in acute admissions for cardiovascular diseases across all European countries. Specifically, hospitalizations decreased by 31% for acute coronary syndromes, 34% for acute heart failure, and 32.3% for arrhythmias [15]. *Only pulmonary embolism admission and out of hospital cardiac arrests were more common during the COVID-19 outbreak* [5,16]. *When compared to 2019,*

* Corresponding author at: Department of Cardiovascular Science, Faculty of Life Science and Medicine, King's College London, 125 Coldharbour lane, London SE5 9RS, UK.
E-mail address: Antonio.cannata@kcl.ac.uk (A. Cannata).

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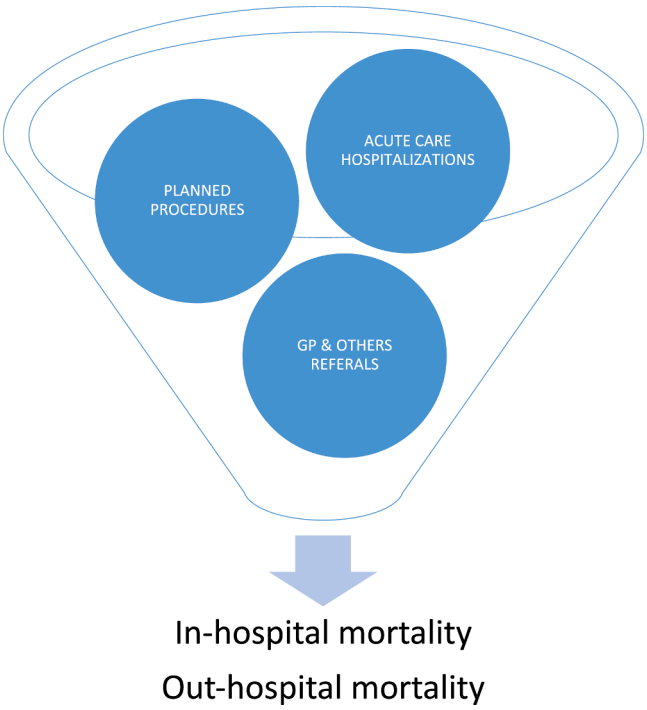

Fig. 1. Factors contributing to the excess mortality during the COVID-19 pandemic.

those admitted to the emergency department had a much higher mortality risk (4 times higher death risk) during the COVID-19 outbreak, which was not directly related to COVID-19 [15].

This generalised increase in cardiovascular mortality is considered to be due to several factors: firstly, a general reluctance on the part of patients to go to hospitals for fear of becoming infected; secondly, a reduction in health care staff availability either because of the high rate of infection or the assignment of staff to attend areas dedicated to COVID and thirdly, the cancellation of follow-up consultations, as well as necessary investigations or procedures [11,17].

Not only excess mortality, but also the incidence of out-of-hospital cardiac arrest was a notable problem. In an analysis of the Lombardia Cardiac Arrest Registry (CARe), Baldi et al. *reported 362 cases of out-of-hospital cardiac arrest during 2020 compared to 229 cases during the same period in 2019 (58% increase)* [16].

The incidence of out-of-hospital cardiac arrest at home, as well as unwitnessed cardiac arrest was also higher (7.3% and 11.3% higher, respectively).

The magnitude of the disruption to health systems was evident as in the same study, the average arrival time for emergency services was 3 min slower compared to 2019, and the proportion of patients receiving cardiopulmonary resuscitation was 15.6% lower than in the year prior to the pandemic [16].

1.2. Staff shortage and mental health

One of the immediate effects of the coronavirus pandemic was the absence of staff and emotional damage within the workforce, with the consequences now being palpable [18]. The absence of staff (either through contagion or emotional stress) and the lack of sufficient supply of personal protective equipment contributed to the increased rate of infection, death and spread of the disease [19]. Elements such as access to personal protective equipment, health and safety protocols, and adequate rest and recovery periods determined how effectively health workers treated patients [20].

Although there are specific protocols to mitigate medical staff shortages [21], the situation in each country was highly variable. In the case of the Italian health system, students in their final years were allowed to join hospitals to help (Calabria decree). In the case of the USA, medical students in advanced stages were permitted to graduate earlier to assist in patient care [22]. In some other hospitals, medical specialities unrelated to critical respiratory management were even requested to provide continuous emergency care [21]. Incorporating diverse specialities into these patients' care helped obtain favourable outcomes, but with the knock-on effect of shortages in other routine services and staff burn-out [20,23,24]. These manifestations indicate that staffing shortages were severe and that there is no perfect solution to resolve them.

Moreover, hospitals across the USA, Singapore and the UK implemented various solutions to staff shortages. For example, staff were divided into different non-contact groups with alternating work weeks, which reduced the risk of exposure and contact with each other and with the patient, while at the same time providing a reasonable interval of time to rest [25–27] as well as reducing the number of screening tests. Today, in the age of vaccination, hospitals around the globe and national health services will need to develop innovative systems that incorporate hybrid models capable of delivering care without depleting their own human and material resources.

Together with staff shortages, the maintenance of strong mental health was crucial. Mental health of staff during the pandemic was critically influenced by the unprecedented scenario. According to a survey conducted by the British health service (NHS), burn-out and staff shortage impacted the mental well-being of health care professionals. Almost 40% of those reported some form of emotional exhaustion [24]. Hence, medical staff shortages and loss of emotional well-being may impact upon the quality of services provided, as the proportion of staff who feel that they provide a quality service is lower compared to 2020 (68% vs 74%) due to some degree of emotional exhaustion from lack of sufficient support in performing routine tasks [28,29]. Furthermore, The high rate of infection among health workers, who witnessed an increased number of deaths and becoming potential carriers of the virus for others helped to perpetuate a sense of anxiety, despair and uncertainty about the future. Understanding how the changes occurred during the pandemic have influenced healthcare professionals' mental health may help in preventing future burnouts and promote a better care.

1.3. Collateral damage to medical education in the pandemic

It is estimated that students from more than 2400 medical schools worldwide were directly or indirectly affected in the initial months of the pandemic [30,31]. Unlike other sciences, the teaching of medicine is delivered, in a hands-on fashion, during tutorials, in direct contact with patients and in a face-to-face manner.

In cardiology, the traditional two-way teaching model (consultant-student, i.e., ward-rounds and clinics) and (patient-student: bedside and clinical appointments) meant that the normal learning flow was halted and required the implementation of technologies such as videoconferencing. Despite this, fellows were forced to temporarily put aside their cardiology studies to learn about microbiology, critical care and palliative medicine, which presented a significant intellectual burden in addition to the already strenuous frontline duty [32].

On average, it is estimated that more than 95% of cardiology fellows were affected by a substantial change in their training programs [31–33] causing a significant impact on their training, mainly regarding clinical activities. A suspension of clinical rotations and face-to-face sessions were paralleled by a decrease in the number of procedures fellows needed to develop a particular skill [33–35].

Those training in subspecialties such as echocardiography, interventional cardiology and electrophysiology [31] had difficulties obtaining the number of cases or procedures considered sufficient to achieve competencies, in part because of an environment without full supervision by senior physicians and by the number of patients reduced to the minimum necessary within the hospital [36,37].

Two different studies conducted among fellows in various

interventional cardiology departments in New York City reported a moderate to severe impact on more than 90% of respondents. It highlights that the damage from the pandemic impacted in the short term, particularly in those areas of expertise that require achieving a competency-based on performance of a specific number of procedures [28,29]. It is estimated that for a 1-year training program, suspension or postponement of procedures by only 1 to 3 months reduces a fellow's volume of experience by 10–25% [37].

As a solution, extensions to the number of days required to obtain these competencies were offered. In some places in the USA, the academic program director was allowed to decide on the competency of the fellow [22]. However, we should note that already proven educational strategies such as medical simulator training was implemented fully due to the face-to-face restrictions that were in operation (23). Tools like telemedicine and home-based work compensated for this collateral damage. In some institutions, fellows contacted patients from home (telemedicine) and remotely interpreted studies such as echocardiograms [17,32].

As is the case with the emergence of new challenges, there were some unique opportunities to review topics not often used in standard practice. Thrombolysis for acute coronary syndromes (dosage, indications, complications) [33] or discussion on concepts of end-of-life ethics and mechanical ventilation strategies.

A particular phenomenon happened within the research field among cardiology fellows. On the one hand, a very low proportion of them expressed the desire to pursue an academic career (<1%) [31] but paradoxically, it was during the first two waves of COVID that research activities became relevant as it was a suitable time for the fellows to write manuscripts, do statistical analyses and to discuss results and hypotheses [17,32].

During the pandemic, the way of spreading knowledge turned to videoconference and webinars platforms that largely replaced face-to-face sessions and scientific meetings. There are two schemes for delivering knowledge remotely: synchronous and asynchronous. In the former, participants are connected live, while the latter allows the recording of academic material and makes it available online for consultation with the flexibility of time and space (OnDemand) [38]. A recent meta-analysis demonstrated higher overall satisfaction with online vs traditional teaching (mean difference 0.60, 95% CI 0.38 to 0.83; $p<0.001$) [39]. However, the population studied consisted of medical students, not cardiology fellows. It is likely that satisfaction would be lower fot the latter because clinical and hands-on interaction plays such a crucial role in cardiology training.

Webinars became one of the leading educational tools [32,33]. Some of their advantages are: accessibility from anywhere in the world, without the need to travel, lower costs compared to a face-to-face meeting, and they can be recorded for later consultation by attendees [35]. It is also possible to obtain a more significant number of attendees, as even those isolated by the virus can attend. Interestingly, e-learning, at least in the experience of 1 centre, allowed fellows to venture into areas other than cardiology (pulmonology, critical care medicine and anaesthesiology) [37].

Not least, the mental health of the fellows was also affected in more than 2/3rds [31], mainly due to the loss of the barrier between work/-study and home. The teaching model shifted to a 100% digital format. With it, the structure of a timetable and a work schedule was lost; it demanded being connected all the time, which brought severe burn-out problems and emotional breakdown [37]. The professional frustration towards performing roles not typically practised by cardiology fellows (elements of critical care medicine, infection control, advanced airway management, disaster medicine) was notorious. In several centres, cardiovascular care units were transformed into COVID wards [37].

The lag in completing the curriculum brought anxiety and uncertainty about the fellows' future (post-graduate offers). Of note, more than half felt this lag could not be made up in the following years of their training [36].

The COVID-19 disruption in medical training highlighted the dissatisfaction of many fellows with the current curricula. They report being insufficiently prepared with the existing programmes [31]; this may provide an opportunity to develop a hybrid curriculum toward a competency-based system [34] where even the fellows participate in the design of the new academic structure.

Research activities should play a central role in the training of cardiologists, as the generation of novel ideas and projects that advance the science of cardiology depends on it. To this end, it is crucial to structure mixed programs that, using digital tools, can create sufficient competence for fellows and relieve them of unnecessary activities so that they can use that time for research. In other words, it is necessary to consider whether aspects such as the duration and structure of the program itself are sufficient.

2. Clinical trials

Cardiology clinical research has gone through radical changes in the last two years [40]. From a clinical point of view, many cardiologists put their efforts into the fight against the pandemic in COVID-19 units, consequently reducing the possibility of devoting time to clinical research. On the other hand, several trials were abandoned in favour of studies assessing specific therapies for patients with COVID-19 respiratory failure [41]. Furthermore, many activities such as patient screening, randomisation, follow-up visits, follow-up blood tests and event adjudications were frequently performed remotely. The missing in-person visits may affect the quality of the evaluation. Indeed, only patient-reported information can be collected on the phone. At the same time, clinical signs of ongoing cardiovascular problems, such as congestion and hypoperfusion, cannot be precisely detected without a focused clinical and instrumental assessment [42].

Moreover, the documented reduction in the admission rates for acute cardiovascular diseases may underpower any trial due to a reduced endpoint rate compared to the planned rate [43]. Stunning evidence emerged from the GUIDE-HF trial's results, which aimed to assess the utility of remote monitoring of pulmonary artery pressure in patients with chronic heart failure. The enrolment was concluded in December 2020. Overall, the trial result was negative, as the incidence of the primary HF outcome was not different between the two groups. However, a dramatic reduction in HF hospitalisations was noted during the pandemic, and a pre-specified analysis including only the pre-pandemic period showed a significantly lower incidence of the primary outcome in the arm treated with the investigational device [44]. These results might be explained both by a global reduction in the admissions for HF and by a change in the behaviour of the patients (reduced causes of acute decompensated HF such as respiratory tract infections, healthier lifestyle, more precise self-adjustment of daily diuretic dose, etc.) [45,46]. The consequences of all these deficiencies in conducting clinical trials in cardiology might dramatically impact the development of new therapies. Indeed, on the one hand, the interruption of ongoing trials, alongside the economic loss, prevents investigational therapies from being adequately studied. On the other hand, negative trials due to COVID-19 effects on the outcomes assessment might lead to incorrect conclusions [47]. Hence, specific solutions were suggested to avoid underpowering of clinical trials in cardiology due to the COVID-19 pandemic:

Firstly, more accurate remote assessment of potential endpoints (home weight, self-reported symptoms, devices for arrhythmias, home blood pressure monitoring) [48].

Secondly, meticulous pursuit of the potential endpoint by the investigators, even though it might involve more work.

Thirdly, statistical adaptation may be useful to face the possible underestimation/underrepresentation of clinical endpoints.

Another study hit by the pandemic was the AFFIRM AHF trial, from the analysis of which we can draw some solutions. In order to analyse the impact that the loss of patients to follow-up could have, a sensitivity analysis had to

be performed prior to COVID-19 [49]. *Other measures, such as electronic data capture and home visits by clinical trial conductors (CROs), help minimise interruptions to follow-up as used in the REVIVED trial* [50].

It is essential to mention that these statistical strategies, along with others such as sub-analysis studies, only partially help to resolve trial problems during pandemics.

Behind GUIDE-HF trial, many other trials were also disrupted such as PARADISE-MI, IAMI and Dal-GenE. Important statements released by EMA, FDA and NIH during the pandemic should serve as a guide to interpret and conduct them. Estimating the decisive impact of the pandemic on the results of a multicentre study is very challenging as the decrease in admission rates observed globally may dilute the ability to observe treatment-specific differences.

COVID-19 also impacted poor-quality research. In a relevant analysis by Glasziou, it is clear that within all the clinical trials registered for COVID-19, there were essential flaws in the design, sample size, presence of a control group and multicentre scope; likewise, the measured relays were not homogeneous. The distribution and reach of the preprints led to misinformation to the public with erroneous conclusions, such as in the case of hydroxychloroquine [51]. *The pandemic also exacerbated unnecessary duplication of studies. For example, a large number of clinical trials were simultaneously registered for hydroxychloroquine that turned out to have no clinical benefit. This highlighted a limited global infrastructure for communication and collaboration in hypothesis generation that, in turn, led to duplication and wasted content, at least during the first year of the pandemic.*

2.1. Risk control in patients

In addition to the excess mortality and its undeniable impact on health systems, the pandemic has also affected human lifestyles, particularly in the most vulnerable patients who, unable to continue receiving the same level of care as before, experience declines in their health and long-term prognosis [52].

Sedentary individuals have twice the relative risk of developing coronary events as physically active individuals [53]. Moderate exercise is recommended on most days of the week for a minimum of 150 min per week for both primary and secondary prevention [54,55]. The globally mandated isolation measures and social distancing contributed to people staying at home and adopting a more sedentary lifestyle than before. Gyms and sports facilities closed their doors.

There is diverse evidence documenting a significant decrease in physical activity during major confinements; on average, from March to April 2020, there was a 45.2% decrease in physical activity reported in papers from the UK, USA, Australia and Poland [56]. This trend appears to be replicated in paediatric and adolescent populations (5 to 13 years of age), with information coming from parental reports [57]. Finally, a global study collected data from 455,404 patients on their step count and found a 27.3% decrease in mean daily steps 30 days after lockdown initiation [58].

The pandemic led to changes in dietary habits [59] and an increase in junk food consumption [60]. These changes are worrying given the risks associated with physical inactivity, unhealthy eating and consequent weight gain. We still don't know the long-term outcomes. However, the excess mortality rate recorded during the second year of the pandemic (2021) may partly be explained by the vulnerability of patients as they increase their cardiovascular risk factors and experience disruption in the provision of services to control them.

It is also important to note that excess mortality may be related to the negative impact of lockdown. It has been shown that there is a substantial psychological impact of confinement on lifestyle-related risk factors. Not only that, highly stressful and demoralising events represent a risk factor for acute coronary syndromes [61].

Therefore, we must consider for future epidemics that lockdown must be carefully managed.

2.2. The importance of continuity

The coronavirus pandemic event demonstrated the need to create more flexible health systems to continue delivering services despite severe disruptions. Detaining or deferring patient care has serious consequences: increased in-hospital mortality and increased mortality at home and in nursing homes, particularly for conditions such as ST-segment elevation myocardial infarction and heart failure [4,11,62,63]. Those patients who did make it to the hospital presented with more severe disease [4,64].

This needs to be countered with confusion-avoidance messages from authorities emphasising that patients should not defer care in case of alarming symptoms. Notable efforts such as the European Society of Cardiology (ESC) campaign "You can't pause a heart" seek to balance staying at home with prompt transfer to a hospital in case of an emergency [65].

The degree of disruption caused by the pandemic on the healthcare system was never anticipated, and its consequences are only beginning to be visible. Deferring interventional procedures and failing to conduct necessary clinical trials leaves patients with significant residual risk and contributes to excess mortality [66,67]. Conversely, strategies such as e-health and the adaptation of new protocols in imaging studies and interventional procedures helped maintain continuity in healthcare systems [4].

This crisis served as a reminder of the value of primary healthcare in order to manage unanticipated spikes in demand and ensure everyone receives continuity of care. A successful response from the health system is facilitated by strong primary health care, organised in multidisciplinary teams with innovative roles for health professionals, integrated with community health services, outfitted with digital technology, and working with well-designed incentives [68].

A robust primary care setting allows patients to receive medical attention without attending busy hospitals and helps maintain continuity of care while reducing pressure on the entire health system [69]. *Part of the strategies included in strengthening the primary care setting is: establishing teams with solid links to the communities, expanding home-based programmes, allowing digital tools to communicate primary with secondary levels and effectively sharing clinical information inside the country* [69].

Making healthcare systems more robust against future public health emergencies, preserving the innovations developed and implemented during the pandemic is necessary.

Indeed, after the crisis' acute phase, there will be a massive wave of common chronic diseases that will cause death and disability, with cardiometabolic disorders riding the peak of the wave [70]. *Primary care should be strengthened to facilitate access to health services during a pandemic, especially for vulnerable patients such as those with chronic diseases* [70]. *Also, primary care needs to be appreciated as the cornerstone of health systems. More novel resources must reach primary care to ensure medical follow-up during rough times.* Remote telemonitoring stands as a novel approach that might help not only in keeping with uninterrupted health access but also in the interplay between primary and secondary settings. Nevertheless, we also need clinical trials to support the evidence that remote appointments are equally beneficial to close in-person follow-up

2.3. Telemedicine and e-health

The digital transformation that has taken place in cardiology has helped to provide a continuum of care in cardiovascular health. Incorporating telemedicine into outpatient settings with a particular focus on risk factor management and implementing rehabilitation activities within the patient's home demonstrated improved patient adherence with outcomes similar to in-person visits [71–73]. In addition, remote cardiac care proved to be convenient for both patients and physicians, offering essential advantages such as reduced travel and waiting times, avoidance of unnecessary transfers, reduced costs, less crowding of physicians and patients at hospital centres and flexible schedules (24/7),

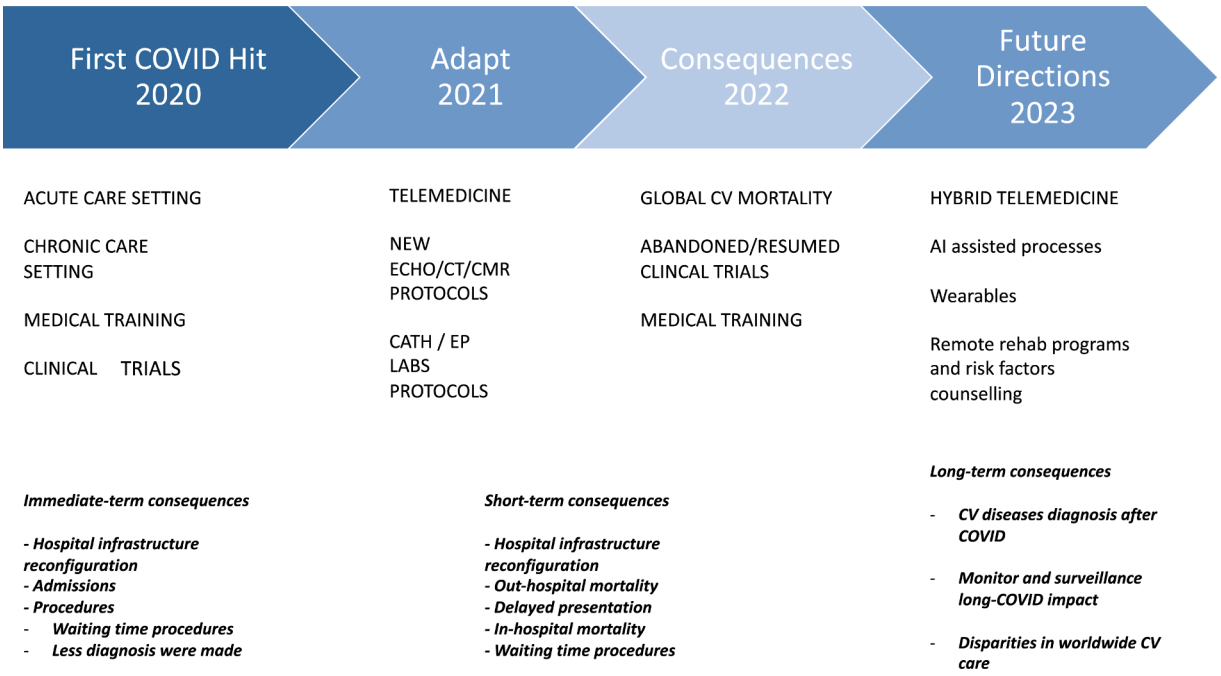

Fig. 2. Healthcare systems adaptations throughout the pandemic and future directions.

as well as allowing for proper medication reconciliation [74].

Paradoxically, the pandemic also revealed a possible overuse of invasive procedures that requires a more thoughtful approach in the future [75,68].

The conditions that were most easily managed and followed up with telemedicine were: heart failure, atrial fibrillation, and ischaemic heart disease [76]. Since 2010, a study has shown that between 36% and 63% of myocardial infarctions could be prevented by reducing risk factors alone [77]. In pandemic terms, risk factor control has never been more critical, as cardiovascular disease and its risk factors are associated with unfavourable outcomes in COVID-19 infection [78]. Moreover, this care modality was as satisfactory and comfortable for the patient and the cardiologist as face-to-face consultations [79].

Concerning heart failure, Xu et al.'s group demonstrated that patients who received either in-person or remote follow-up after hospitalisation had a lower 30-day risk of readmission, giving telemedicine an essential place as a cost-effective and valuable tool, especially in times of crisis in the health system [80]. Telemedicine has been used even before the pandemic in the field of arrhythmias and atrial fibrillation. During the pandemic, wearables and portable electrocardiography devices allowed physicians to detect abnormal rhythms in real-time with the possibility of early intervention and improved prognosis [81,82].

There are significant barriers that need to be considered when implementing an e-health strategy. Access to technology is not equal in all parts of the world, and some demographic groups are more disadvantaged than others. Elderly patients and those living in rural areas with inconsistent internet access [83] would be virtually excluded from receiving care; furthermore, communities with poor health services are also, in many cases, those with limited internet access, which, far from benefiting, would contribute to further widening the inequality gap [84]. Therefore, for telemedicine implementation to grow, new mechanisms must emerge to enable universal and intuitive access for doctors and patients.

2.4. Adapting new protocols

Several protocols were developed around the world that focused on both more judicious selection of which patients would benefit most from the study or procedure and, at the same time, designed rapid acquisition protocols without compromising the quality of the study.

The ORACLE protocol made it possible to obtain haemodynamic and pulmonary information through a rapid ultrasonographic sequence without compromising the quality of the measurements or the integrity of the healthcare personnel performing it in less than 25 min [85]. Appropriate patient selection using stricter criteria allowed for prioritised studies with an impact on clinical management decision [86], making it an effective strategy in periods of shortage of medical staff and protective equipment.

In interventional cardiology, stricter criteria were also applied, based on the hospital occupancy rate during the peak of the pandemic. Only STEMI patients were admitted to the catheterisation laboratory and low-risk NSTEMIs were postponed [87]. On the other hand, the EAPCI gave a prominent role to thrombolysis as the strategy of choice in scenarios where immediate access to the catheterisation suite was not possible, due to lack of staff or bed saturation, and favoured ventriculography to assess ventricular function in all patients without prior echocardiography [88]. Furthermore, an impressive reduction in the number of elective procedures in cardiology departments was observed during the pandemic [89,90].

Similarly, a striking reduction in the number of electrophysiology procedures was observed during the pandemic waves [91]. Priority was given to those patients at higher risk of fatal events e.g. with complete heart block, generator change for pacemaker-dependent patients and recurrent life-threatening arrhythmias requiring ablation, at the expense of a reduced amount of procedures targeting stable patients [92]. Alongside all these features, all the healthcare workers must attempt to reduce the risk of contracting the infection both from the patient and from other colleagues. For this reason, appropriate personal protective equipment should be regularly worn, including eye protection [17].

2.5. Future direction

2.5.1. Prolonged COVID-19 and cardiovascular sequelae

According to the World Health Organisation (WHO), it is recognised that after the acute phase of infection, some subjects experience persistent symptoms not explained by any other reason; in fact, there is a code in the ICD for this new condition (UO9) [93].

There is consensus that patients who persist with cardiovascular

symptoms 12 weeks post-infection may have prolonged COVID without a precise end date. Current studies show that after one year of diagnosis, only 22.9% of patients are symptom-free and that a slow recovery is related to the severity of the disease [94].

The long-term consequences of COVID-19 are not entirely clear. A previous study demonstrated that 42% of the patients had subtle right ventricular dysfunction after clinical recovery from COVID-19 [95]. Furthermore, a 12-month follow-up demonstrated an increased risk for major cardiovascular outcomes: stroke, arrhythmias, coronary heart disease and thromboembolism (HR: 1.52, 1.84, 1.75, 2.93, respectively) regardless of the prior existence of other risk factors [96].

Given the significant number of infected people worldwide (more than 355 million) and based on cardiovascular risk factors prevalence, the potential number of people affected in the long term may be enormous. This highlights that strategies should be designed to monitor long-term cardiovascular outcomes and prepare governments and health systems to cope with increased numbers of patients with cardiovascular disease, increased economic burdens and possibly a change in the life expectancy of the world's population [97,98].

2.5.2. Towards new health systems

The damage to the health systems caused by COVID-19 has been major. Pandemics such as the coronavirus are unlikely to be the last we will face.

During the pandemic, unnecessary or excessive patient follow-up was identified [75] and also, for the first time, visits to emergency departments for non-urgent (non-relevant) conditions reached their lowest level [99], allowing a unique window of opportunity for systematic changes focused on adopting lower-cost strategies with greater reach [100].

For the most part, funding for health systems has been insufficient and keeps them in a perpetual state of vulnerability to future challenges. Although many countries have subsidised COVID-19 testing and treatment, better strategies must be implemented to ensure that people do not fall into poverty due to high out-of-pocket health expenditures [100]. The resilience of a health system lies mainly in ensuring health workers' physical, mental and economic protection [101].

Incorporating technology into the health system with regularity strengthens the healthcare environment, improves major health outcomes, and takes healthcare to another level: precision medicine [102]. The future involves hybrid environments capable of offering e-health under a more holistic concept: telemedicine and remote liaison with patients, continuous remote monitoring through wearables, adding artificial intelligence to routine decision making [103,69] as well as predicting major cardiovascular events with simple tools such as the electrocardiogram or biomarkers as old as the human voice itself (Fig. 2) [104].

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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