



Series Review

Antifragility of healthcare systems in Croatia and Bosnia and Herzegovina: Learning from man-made and natural crises

Ružica Tokalić^{a,1}, Marin Viđak^{a,1}, Mersiha Mahmić Kaknjo^{b,1}, Ana Marušić^{a,*}

^a Department of Research in Biomedicine and Health, University of Split School of Medicine, Split, Croatia

^b Department of Clinical Pharmacology, Cantonal Hospital Zenica, Zenica, Bosnia and Herzegovina

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ABSTRACT

Acute crises, such as a war or a pandemic, are the ultimate tests for health care systems' resilience (temporary response to stress with change and adaptation) and antifragility (permanent benefit from change in response to stress). In this Health Policy paper, we analyse and discuss how the healthcare systems of two European countries – Bosnia and Herzegovina and Croatia – adapted to war as a man-made disaster, and how they adapted to COVID-19 pandemic twenty-five years later. These countries experienced full scale wars in recent history, which significantly changed their political and healthcare systems. This experience prepared the countries for the response to the pandemic, which coincided with two earthquakes in Croatia. We argue that healthcare systems in Croatia and Bosnia and Herzegovina are not only resilient but antifragile, and that they benefited from stressors they were exposed to. The antifragility of the two systems were primarily based on human effort – the strength, adaptability and resilience of health care professionals. We will look at lessons from the wars that were applied to the pandemic and discuss newly recognized opportunities and improvements.

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1. Resilience and antifragility as concepts in health care

According to Taleb [1,2], when a complex system is affected by a crisis there are three possibilities: the system will break (fragile), it will endure without change (robust), or it will improve (antifragile).

A fragile system does not do well under stress and responds to change with a breakdown. A robust system responds to stress without breaking, but also without any change, which limits its acceptable exposure to stress factors. If the stress continues, robust systems will break. Resilient systems respond to stress with change and adapt up to a certain point. They are designed with stress response mechanisms in mind, but they do not benefit nor improve from these situations. After a while, when stressors minimize, resilient systems

return to their original form [3]. Antifragility is the capacity of a system to produce a response that leads to more benefit than harm (so-called convex response) [4]. Antifragile systems thrive in stressful conditions and continually benefit from change in response to stress factors.

While Taleb argues that resilience is similar to robustness [2], there is a crucial difference in the ability for change that resilient systems possess and robust do not. Research has shown that healthcare systems which describe themselves as resilient have to have the ability to change [5], adapt and anticipate for unknown and volatile scenarios [6]. Importantly, those processes result in better healthcare systems [6], which makes them antifragile, not resilient [2].

One might argue that healthcare systems are innately designed as resilient and not antifragile, because resilient systems anticipate stressors and include response mechanisms in its design, while antifragile systems respond to unknown stressors. After all, planning for natural disasters, epidemics, or man-made disasters is a part of public health strategy [7,8]. A review of healthcare resilience describes it as planning and preparation for future crises, as well as adapting to chronic stress factors, which leads to permanent change [3]. For that change to happen, healthcare systems need material and human capital, but also good information management and social networks and collaboration, with organizational cultures oriented towards learning opportunities [3] – all characteristics that could be attributed to antifragile systems.

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* Correspondence author at: Prof. Ana Marušić, MD, PhD, Department of Research in Biomedicine and Health, University of Split School of Medicine, Šoltanska 2, 21000 Split, Croatia.

E-mail address: ana.marusic@mefst.hr (A. Marušić).

¹ These authors contributed equally to the manuscript.

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Acute crises, such as a war or a pandemic, are the ultimate tests for systems' resilience and antifragility. Unfortunately, previous research has shown that public health strategies for disasters lack in most countries [9]. Moreover, there is rarely a plan or a strategy for possible overlaps of emergencies, such as natural disasters, e.g. floods or earthquakes, and epidemics [10]. Such overlaps, or "double-hits", are almost impossible to predict, and management strategies for them are rarely a part of a system's design. To successfully overcome such extreme stressors, a system has to be antifragile.

Bosnia and Herzegovina (BH) and Croatia, formerly the parts of the same country, have experienced both a man-made and a natural crisis, and managed to survive and improve in some ways. Croatia is the only member of the European Union (EU) that experienced a full-scale war and occupation of its territory since World War II, and the war in BH was the most devastating conflict in Europe since World War II [11]. In this Health Policy paper, we will analyse the unique situation of both countries and their response to the war and COVID-19 pandemic. We argue that BH and Croatian healthcare systems are not only resilient, but antifragile, and that they managed to benefit from stressors they were exposed to. We argue that the main strength in healthcare systems' response to the stressors were its professionals. We will look at lessons from the war and how they shaped healthcare systems in both countries, their response to the pandemic, and review opportunities and improvements that could provide benefit in the future.

2. Crisis 1: Healthcare system in a war

As BH and Croatia were a part of Yugoslavia, their healthcare systems were functioning in the framework of a centralized, communist system [12]. After gaining independence, both countries experienced difficult transitions from controlled to market economy. At the same time, their newly independent healthcare systems were challenged by war—a man-made crisis.

Croatia declared independence in July 1991, followed by the Croatian War for Independence. The country maintained a universal healthcare system with limited private healthcare initiatives, mostly by concessions in primary healthcare and some secondary healthcare institutions [13]. Shelling of civilian quarters during the first months of the war caused massive damages and a large number of civilian casualties, and indirectly worsening of chronic diseases in the population [14]. Several limited epidemics of infectious diseases were also reported during the war, including typhoid fever, dysentery, and *Hantavirus* haemorrhagic fever [15–17]. The Ministry of Health declared a national emergency, ordered a mobilization of healthcare workers and created special war hospitals with civilian health staff [17]. Croatia also provided shelter for both Croatian and BH refugees, whose numbers reached the maximum in December 1992 (800,000 refugees; about 15% of Croatian population) [18].

BH declared independence in March 1992 and received international recognition in April 1992. However, independence was followed by armed conflict. As the war was not expected, the BH healthcare system entered the war unprepared [12], without medical supplies and other necessities. The BH healthcare system did not manage to adapt to the newly gained independence, let alone to elaborate the organizational strategy and tactics in the newly created chaotic war conditions. Hospitals in Sarajevo ran out of basic supplies within the first three months of the siege, with chronic uncertainty in power, food and water supply during the whole war [12], forcing medical workers to improvise in almost all health services. The war lasted for four years and took nearly a hundred thousand victims, 65% of them being BH Muslims [19]; over 2.2 million people were displaced [20] and 12,000–50,000 women raped [21,22].

BH healthcare system was challenged not only in terms of taking the heavy burden of providing war health services in impossible conditions, but also by a severe lack of physicians—the backbone of the

healthcare system. Some fled the country, some were killed, and the education of future physicians was severely endangered by the long-lasting siege of the capital, leaving a large generation gap [23] — a loss that is irreplaceable and difficult to overcome even in countries with strong economies in more stable circumstances [24,25]. Analyses have shown that the number of physicians, dentists and pharmacists was exceptionally low after the war: there were only 641 of them by the end of 1996, 37.7% of the pre-war number [26].

3. Post-war health burdens

Healthcare systems in both BH and Croatia maintained universal health coverage but diverged organizationally after the war. Following a more complicated political organizational scheme established by the truce in 1995 [27], BH was propelled to a more difficult path. BH is still far away from functional state as it is under the constant supervision from the international community, with a permanent position of the High Representative for Bosnia and Herzegovina, more than 25 years after the war. The country is a potential EU accession candidate, but it has yet to begin its path in terms of EU integration. The complexity of BH politics produced a most complex healthcare system organization for a country of barely 3 million people: the state is divided into 3 different political systems: Republika Srpska, Federation of BH and Brčko District, and all 3 parts are functioning as independent, almost state-like jurisdictions, so the healthcare system is divided in two major structures: Federation of BH, which has a decentralised system of decision making in healthcare, with 10 subordinate cantons, and Republika Srpska, which has a centralized system. In practice, there are 13 official decision makers in the healthcare system: Insurance Fund of Republika Srpska, Insurance Fund of Brčko District (Brčko District is an isolated, standalone unit), Federal Solidarity Fund and 10 Cantonal Insurance Funds in the Federation of BH [28,29].

The situation has significantly improved due to intensive efforts to increase the workforce and opening of several new medical university schools. Currently, key public health problems in BH are the increasing numbers of chronic non-infectious diseases, aging population, and high level of unemployment, leaving around 17% of the population without health insurance [28]. Lately, global migrant crisis that has a serious adverse impact on BH as a border country to the EU, with over 1000 km border shared with Croatia [30].

After the war, Croatia faced challenges similar to other Central and Eastern European countries that moved from controlled to democratic socioeconomic systems [31]. These included balancing the development of different healthcare services while taking into account expenditure and stabilization of effectiveness and quality of care [32] and combatting direct and indirect cost of war [33]. The largest public health challenges in Croatia are cardiovascular disease, smoking, obesity and unrecognized malignancies [34].

BH and Croatia came out of the war with hardened, experienced health systems that not only survived the great challenge of a man-made disaster but changed and continued to function in the newly formed socioeconomic systems. It can be concluded that BH and Croatia health systems had been antifragile during the war: both countries entered it as non-independent units of a centralized healthcare system and emerged with healthcare systems that not only survived the ultimate challenge of war as a man-made disaster but improved with that experience and continued to function as independent systems.

The prolonged recovery from a catastrophic event may have prepared the two systems for the next challenge.

4. Crisis 2: Challenge of a pandemic

Twenty-five years after the war, with their health systems still evolving and still burdened by the consequences of the wars, BH and

Croatia were hit by the COVID-19 pandemic. As in all other countries, the most difficult task was to adapt the healthcare system to prevent the spread of the disease and effective treatment of a large number of patients [35]. This required difficult and prompt decision-making to balance public health and economic welfare.

All healthcare workers faced enormous challenges due to lack of knowledge [36], protective equipment, specialized work force, limited number of ICU beds and personnel [37,38], and diagnostic tests [39]. First case was detected in Croatia on 25th February 2020 [40], and after the initial rise in cases, an epidemic was declared on 11 March 2020 [41], following the closure of schools in Istria, part of Croatia closest to Italy [42] and then in the rest of Croatia [43]. Soon afterwards, social distancing measures were imposed, public gathering banned and non-essential stores were closed [44]. Loitering in public spaces was restricted as was leaving the place of residence without special clearance, which was enforced by police [45-47]. Lockdown stopped short of implementing curfew, but everyone was instructed to stay at home [48]. The government organized the response to pandemic in five phases, with the lockdown in March and April 2020 as the fourth phase [49], but clear description of what constituted each phase was not provided to the public.

To prepare the healthcare system for the pandemic, the Ministry of Health issued a Decision on Mobilization of Healthcare Workers [50]. Emergency health service was reorganized [51], 24/7 fever clinics were opened [52], and Croatian Army was instructed to set expedition camps next to the hospitals for patient triage and care [52]. As the only specialised hospital for infectious diseases, the University Hospital for Infectious Diseases "Fran Mihaljević", was already at full capacity by mid-March 2020, the Ministry of Health established four primary respiratory-intensive centres in major Croatian cities, plus a field hospital with 300 beds set up by the army in the capital of Zagreb – home for almost a quarter of Croatian population. Secondary centres for milder cases were opened in specialized hospitals at a county level throughout Croatia, and tertiary centres were set up as field hospitals in indoor arenas to accommodate COVID-19 patients in large cities [53].

While riding on the first COVID-19 pandemic wave, the capital of Zagreb was struck by another, natural disaster: a damaging earthquake that hit at 06:24 AM on 22 March 2020 [54]. 26,197 buildings were damaged, out of which 1,900 are now marked as inhabitable [55]. The University of Zagreb School of Medicine, largest higher education medical institution in Croatia, was severely damaged, as well as numerous hospital building throughout the city [56], prompting urgent evacuation of patients [57] and further complicating treatment of both regular and COVID-19 patients [56].

Restrictions regarding travel out of place of residency were lifted in May 2020, and reintroduced again in December 2020, at the beginning of the second pandemic wave [53]. This pandemic wave was joined by another earthquake, now near the town of Petrinja, on 29 December 2020. This earthquake was even more damaging than the one in Zagreb, killing 7 people and causing massive damage to the cities of Petrinja and Sisak [58]. The patients from hospitals in Sisak and Petrinja had to be evacuated by Croatian Army helicopters to hospitals in Zagreb. Travel restrictions were lifted for residents of areas hit by the earthquake [59]. Overall, Croatian population adhered to public health measures, including social distancing and masking [60]. Although there is a general lack of trust in the institutions in everyday life, both Croatian military and Civil Protection Headquarters were considered trustworthy several months after the onset of the pandemic [61].

While epidemics can occur in the aftermath of natural disasters and complex emergencies [7], such as the cholera outbreak after an earthquake in Haiti in 2010 [62], overlap of a pandemic with natural disasters is an unfortunate coincidence not witnessed previously in modern society [56]. A typical response to an earthquake involves leaving damaged buildings after the initial shock, providing

assistance and first aid if possible and seeking refuge in organized shelters [63]. This standard procedure is in direct opposition to COVID-19 restriction measures, and Croatian government advised everyone to maintain physical distance after the earthquake [64]. This was in line with current, updated earthquake recommendations by preparedness agencies in other countries [65]. While no definitive official data are available, there seemed to be a small increase in number of local cases of COVID-19 after the earthquake in Zagreb in March 2020 [66], but not after the December earthquake. In Petrinja, rapid COVID-19 antigen tests were used for screening [67], mobile teams began vaccinating first responders and people in shelters [68], and the EU donated additional vaccines [69]. This response, in addition to the already existing mask mandate prevented the increase in COVID-19 cases after the Petrinja earthquake [70]. The concept of "double hit" by two natural disasters [66] is being challenged in Croatia, where three natural disasters – two earthquakes and a pandemic – happened in a short timeframe. The response of the Croatian healthcare system to the earthquake coupled with local response to the pandemic in a challenging situation can be considered as an antifragile response, creating new knowledge about complex responses.

BH had to make more severe decisions on restricting citizens' freedom in order to preserve its weak economy. The extreme decentralization of health care organization in BH resulted in a wide variety of responses, with lower and poorer healthcare institutions responding rapidly to the immediate crisis, perhaps even more successfully than the national response. At the national level, corrupted purchase of inadequate ventilators (currently a subject of an official investigation) [71], as well as very late procurement of vaccines, when neighbouring countries had already come a long way in the immunization process [72], contributed to the mass hysteria and distrust in governmental and health authorities.

Early in the pandemic, BH received support from other European countries, and WHO representatives organised online consultations with experts from Italy [73]. BH took advantage of its brain drain: critical care providers working in healthcare systems all over the world, supported by WHO, implemented a multimodal tele-education intervention to rapidly share critical care knowledge related to COVID-19. Over 2,000 healthcare professionals, mostly physicians, participated in this unique educational activity between March 2020 and May 2020, making use of social media platforms as feasible, low-cost, and effective methods to share knowledge [74]. Similarly to Croatia, enormous misbalance in the needs and supply of PPE ignited valuable cooperation between medical and engineering community to produce PPE for first-line respondents [75].

Before the immunization started in March 2021, when the president of neighbouring Serbia donated 5000 vaccines (these were near expiration data and were used to vaccinate health workers) [76], more than a third of population had developed antibodies [77]. At the moment, BH healthcare system has survived the third, strongest wave, and we dare to say that with more than two hundred thousand officially recovered patients (with actual numbers probably higher), and the same number of officially vaccinated people [78], (and an unknown number vaccinated in neighbouring Croatia and Serbia), BH is rapidly moving towards more favourable epidemiological position and a much more optimistic winter season.

Croatia and BH survived the first three pandemic waves with varying success but did not experience major congestion of their healthcare systems, as witnessed in some other countries, like neighbouring Italy and Slovenia.

5. Moving forward: antifragility lessons

BH and Croatia were not resilient systems in the 90s, according to Taleb's definition [2]. The wars fundamentally broke the region and scarred nations for generations to come. However, the disaster of war

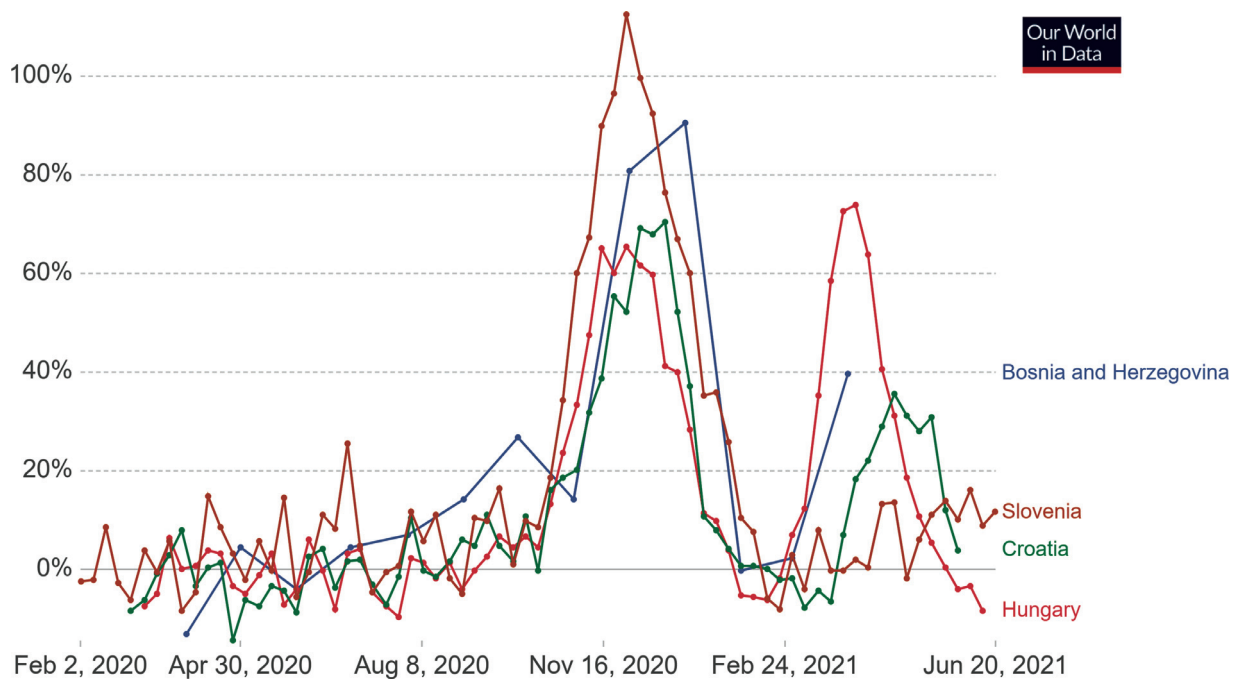


Fig. 1. Excess mortality in Bosnia and Herzegovina, Croatia, Hungary and Slovenia from 2 February 2020 to 20 June 2021. Source: Our World in Data (<https://ourworldindata.org/coronavirus>), reproduced under CC BY license. The data present the number of weekly or monthly deaths in 2020-2021 as a percentage from the average of the number of deaths in the same period in 2015-2019. Sources of data: Human Mortality Database (<https://mortality.org/>; 2021) and World Mortality Dataset (https://github.com/akarlinsky/world_mortality; 2021).

was a challenge that the countries managed to use as an opportunity for change. For some healthcare systems, such as the USA, the pandemic has been the ultimate stressor: more people died from COVID-19 in the US than in World War I, World War II, The Vietnam war and 9/11 terrorist attack combined [79]. For BH and Croatian healthcare systems, the war was far more devastating and made these systems improve and strengthen: the pandemic could have had more victims and more devastating consequences without the experience from the war and preparedness for a crisis (Fig. 1). The past experience helped both countries in their response to a new crisis.

After the war, Croatia maintained an integrative system of homeland security. This approach proved to be effective in post-war crises, such as COVID-19 pandemic [80]. Overall, Croatian response to COVID-19 pandemic was similar to the crisis mitigation response during the war in the 90s, and smallpox epidemic in the 70s. Mobilization order for healthcare workers during this pandemic was the first one since the Homeland war in the 90s [80].

BH paid a price to the catastrophically uncoordinated national reaction, including a delay in procurement of tests and vaccines. It ranks infamously third in the world in deaths per million inhabitants, with almost half of these deaths occurring in the third wave [81]. The late provision of vaccines was not a failure of the healthcare system but the result of dysfunctional state policy that was not sufficiently involved in vaccines procurement at the global level. Prevention of a greater tragedy came as a result of the experiences from the war crisis and the unusually fragmented system of decision-making in healthcare. BH has many lower decision-making levels that can act independently. Such a system may be considered a weakness in a regular, non-emergency situation, but it was more efficient in the pandemic situation as decisions could be taken locally without delay [82,83]. These small islands of excellence and local independence helped BH to survive the pandemic.

When we compare excess mortality as a measure of not only direct impact of the pandemic but of indirect impacts [84], Croatia and Bosnia and Herzegovina did not fare worse than neighbouring countries: Slovenia, the most developed country that emerged after

the dissolution of Yugoslavia without war destruction and losses, and Hungary – a neighbouring country to Croatia with similar (and more successful) post-communist transition (Fig. 1).

The art of improvisation, developed to compensate for the lack of resources in the war, helped both countries' healthcare professionals to function adequately in the pandemic. A third of physician workforce in both countries is older than 55 [85,86], which means that they have lived and worked through the war times, so the war experience was still strong in the healthcare systems, particularly at the senior level. For example, many of the leading experts in response to the pandemic had experience combating outbreaks of infectious diseases or other diseases during the wars in the 90s [87-89].

Healthcare professionals proved to be the most valuable part of both systems, but their vulnerability is often overlooked. Medical staff in BH and Croatia have shown high professional and ethical standards during the war [90]. The antifragility of health workers helped build resilience of the health system to new challenges (and their combinations). In the crisis of a war, the people and the healthcare systems of the two countries survived great harm, but also managed to recognize opportunities to build better systems and to walk out of the crisis as independent, stronger, and aware of their capabilities. Health professionals took the main burden of the pandemic, and proved once again that their readiness to take action in critical conditions is a key determinant of a robust healthcare system [91].

Measuring antifragility in complex systems is difficult [92], and any conclusions we have made should be interpreted in light of that limitation. Croatia and BH have experienced different changes since their independence, and these influenced healthcare systems as well. Political challenges may have prevented systems to grow in answer to a challenge. However, war remains the biggest crisis these countries faced, particularly in healthcare. The scope of this Health Policy paper limits the exploration of a wider political and social context for the pandemic and its consequences, and is thus necessarily a simplified presentation of a complex situation. The real impact of the

COVID-19 pandemic crisis will become visible in the following decades, and future research is needed to see whether the responses of healthcare systems were adequate, how they influenced the society and health in the two countries and whether they were truly anti-fragile as a whole.

Authors' contributions

RT, MV, MMK jointly wrote the first version of the manuscript. AM provided the initial idea and critically revised the manuscript. All authors approved the submitted version and take accountability for the whole manuscript.

Declaration of Interests

We have no competing interests in relation to this manuscript.

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