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IMPACT OF HUMAN DISASTERS AND COVID-19 PANDEMIC ON MENTAL HEALTH: POTENTIAL OF DIGITAL PSYCHIATRY

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SUMMARY

Deep emotional traumas in societies overwhelmed by large-scale human disasters, like, global pandemic diseases, natural disasters, man-made tragedies, war conflicts, social crises, etc., can cause massive stress-related disorders. Motivated by the ongoing global coronavirus pandemic, the article provides an overview of scientific evidence regarding adverse impact of diverse human disasters on mental health in afflicted groups and societies. Following this broader context, psychosocial impact of COVID-19 as a specific global human disaster is presented, with an emphasis on disturbing mental health aspects of the ongoing pandemic. Limited resources of mental health services in a number of countries around the world are illustrated, which will be further stretched by the forthcoming increase in demand for mental health services due to the global COVID-19 pandemic. Mental health challenges are particularly important for the Republic of Croatia in the current situation, due to disturbing stress of the 2020 Zagreb earthquake and the high pre-pandemic prevalence of chronic Homeland-War-related posttraumatic stress disorders. Comprehensive approach based on digital psychiatry is proposed to address the lack of access to psychiatric services, which includes artificial intelligence, telepsychiatry and an array of new technologies, like internet-based computer-aided mental health tools and services. These tools and means should be utilized as an important part of the whole package of measures to mitigate negative mental health effects of the global coronavirus pandemic. Our scientific and engineering experiences in the design and development of digital tools and means in mitigation of stress-related disorders and assessment of stress resilience are presented. Croatian initiative on enhancement of interdisciplinary research of psychiatrists, psychologists and computer scientists on the national and EU level is important in addressing pressing mental health concerns related to the ongoing pandemic and similar human disasters.

Key words: *human disasters - COVID-19 - mental health - digital psychiatry - artificial intelligence*

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INTRODUCTION

COVID-19 presents a serious threat to mental health around the globe by elevating rates of anxiety, depression, posttraumatic stress disorder (PTSD) and negative societal behaviors (Shigemura et al. 2020). Therefore, recent Lancet Psychiatry paper (Xiang et al. 2020) calls for urgent advancement of mental health care due to coronavirus pandemic, including crucial and pressing goals of mental health assessment, support, treatment, and services, based on experiences from past serious virus pandemics. However, more than 200 affected countries have very limited resources of mental health professionals in comparison to the forthcoming growth of demand. The increasing demand for psychiatric services in the overburdened mental health care system presents a risk of creating a global public mental health crisis throughout the world, what would be harmful and frustrating for patients, their families and other mental health providers. Digital psychiatry with its tools and means, like artificial intelligence, telepsychiatry, internet-based computer-aided mental health tools and services, as well as an array of other new technologies, can help globally and urgently during the coronavirus pandemic. Croatian and EU-supported initiative based on public-private partnership of developers, computer scientists, psychologists and psychiatrists, working together on translation of state-of-the-art computer tools and methods related to multimodal signal processing, virtual reality, machine learning, cognitive computing, and artificial intelligence, may lead to more efficient mitigation of stress-related disorders in a variety of uncertain and unpredictable human disasters, like the ongoing COVID-19 pandemic and recent Zagreb earthquake.

HUMAN DISASTERS AND MENTAL HEALTH DISORDERS

Deep emotional traumas in societies overwhelmed by large-scale human disasters, like, global pandemic diseases, natural disasters, man-made tragedies, war conflicts, social crises, etc., can cause massive stress-related disorders (Badkhen 2012). Around 16% of the global population is affected by mental health disorders (Rehm & Shield 2019) with lifetime prevalence estimates in the range of 12.0-47.4% (Kessler et al. 2007). There are diverse barriers to mental health treatment (Andrade et al. 2014), and the consequences of untreated or inadequately treated societal stress-related disorders are far-reaching, affecting individuals and their families, as well as society in general, in the form of lost work productivity, unemployment, homelessness, marital and parenting problems, domestic violence, drug and alcohol abuse, suicides and others (Tanielian & Jaycox 2008, Weehuizen 2008). Moreover, before COVID-19 pandemic, the global economic loss due to mental health

disorders has been projected to 16.3 trillion U.S. dollars worldwide for the period 2010-2030 making mental health the most expensive part of healthcare system (Trautmann et al. 2016). Stress-related mental health disorders are mainly associated with large-scale human disasters (Ćosić et al. 2012a, 2017): 25% of PTSD cases after 1999 earthquake in Turkey (Tural et al. 2004); 13.5% of PTSD cases among population within 20 km from the epicenter of 1988 earthquake in China (Cao et al. 2003); 29.1% of PTSD cases and 25.5% of depression cases among evacuees from 2016 wildfires in Alberta, Canada (Belleville et al. 2019); 30.6% of PTSD cases in children and adolescents after cyclone in India (Kar et al. 2007); increased rates of PTSD, depression and anxiety after 2004 tsunami in Indian Ocean among adults in Sri Lanka (Hollifield et al. 2008) and Thailand (Van Griensven et al. 2006); increased impact of downsizing on employees' mental health (Kivimäki et al. 2007); impact of massive unemployment in recessions on mental health (Brand et al. 2008); increased percentages of suicides in economic crises (Granados & Roux 2009, Stuckler et al. 2009, Reeves et al. 2014), and so on. Still we are waiting for statistical reports on impact of the 2019-20 wildfires on the prevalence of mental health disorders in Australia, due to severe direct damages to the land, property and human lives as well as smoke-related health hazards (Borchers Arriagada et al. 2020, Newnham et al. 2020, Vardoulakis et al. 2020, Yu et al. 2020). A research report on the situation in Afghanistan (MacDonald et al. 2010) notes that in some provinces, "when asked about their emotional state, more than half of the interviewees spoke of feelings of anger, and almost a third felt depression and frustration." Furthermore, according to Afghanistan's health minister Dr. Suraya Dalil, 60% of the Afghan population suffers from mental health problems (Moreau 2010). Generally, in Europe, the WHO estimated that 44.3 million people suffer with depression and 37.3 million suffer with anxiety (WHO 2017, 2018). Therefore, seeking for more effective ways of coping with large-scale emotional traumas, negative emotions and the associated mental health disorders is being brought back into spotlight due to global coronavirus pandemic.

PSYCHOSOCIAL IMPACT OF COVID-19 AS A GLOBAL HUMAN DISASTER

Confirmed COVID-19 pandemic's figures demonstrate to the global scale severity of the current public health challenges facing more than 200 countries and territories worldwide (Statista). The full extent of social and economic consequences currently cannot be foreseen but can be intuitively understood from the fact that various countries have implemented full or partial lockdowns (Reguly 2020). The negative economic impact of COVID-19 is being analyzed by the leading business magazines (Carlsson-Szlezak et al. 2020, O'Sullivan 2020, Weller 2020, The Economist 2020). Among the issues discussed by these articles are numerous closures and near bankruptcies of businesses despite monetary and fiscal support, as well as the rise of unemployment, evidenced by an unprecedented number of over 3 million unemployment claims in the U.S. in a single week, which happened during the last week of March 2020. Likewise, analyses of the global negative economic impact are being published in scientific journals, e.g. (Ayittey et al. 2020), which gives estimates of global GDP decline of roughly 0.42% in the Q1 of 2020 due to COVID-19 outbreak.

While the critically urgent issues of virus containment, treating of patients and vaccine development are being addressed, it is also mandatory to start addressing as soon as possible the long-term effects of destabilized mental health of global societies. Due to public health and outlined economic reasons, it is well recognized that COVID-19 presents a serious threat for mental health around the globe; for example, a WHO technical guidance note (WHO 2020), stated that "the main psychological impact to date is elevated rates of stress or anxiety", with a warning that "as new measures and impacts are introduced – especially quarantine and its effects on many people's usual activities, routines or livelihoods – levels of loneliness, depression, harmful alcohol and drug use, and self-harm or suicidal behavior are also expected to rise". Similar concerns are raised elsewhere as well (Shigemura et al. 2020), i.e. that the expected mental/physical health consequences of coronavirus pandemic can be more or less predicted and will likely include: extreme fear and uncertainty; lowered perceived health; negative societal behaviors driven by fear and distorted perceptions of risk, including distress reactions (insomnia, anger, extreme fear of illness even in those not exposed) and health risk behaviors (increased use of alcohol and tobacco, social isolation); as well as mental health disorders (PTSD, anxiety disorders, depression). For illustration of an ongoing impact of COVID-19 on mental health, in a poll of 5,000 Chinese citizens, 21.5% registered PTSD symptoms (Kirton 2020), which resembles percentages of PTSD (28.9%) and depression (31.2%) symptoms experienced by polled quarantined citizens during SARS outbreak in 2003 (Hawryluck et al. 2004). Also, in a poll of 2,091 Chinese inhabitants, the prevalence of PTSD symptoms among the public in mainland China 1 month after the COVID-19 outbreak was 4.6%, while the prevalence in high-risk public, e.g. in Chinese provinces with higher number of COVID-19 cases, was 18.4% (Sun et al. 2020). In the U.S., coronavirus poll in March 2020 (Hamel et al. 2020) showed about a third of adults overall (32%) feeling that worry and stress related to coronavirus had a negative impact on their mental health, including 14% who said it had a "major" impact. A range of scientific papers analyzing impact of past virus pandemics on mental health, as well as recently published articles specifically on the topic of mental health and COVID-19 outbreak, indicate that timely actions need to be undertaken to minimize mental health damage to the world population by coronavirus pandemic.

Recent Lancet Psychiatry paper (Xiang et al. 2020) calls for urgent advancement of mental health care due to coronavirus pandemic, including crucial and pressing goals of mental health assessment, support, treatment, and services, based on experiences from past serious virus pandemics. The outlined approaches include: delivery of mental health support to patients and health workers by multidisciplinary mental health teams established by health authorities at regional and national levels; authorities' clear communication with regular and accurate updates about the outbreak in order to address the public sense of uncertainty and fear; setting up of secure services for psychological counselling and bridging the social isolation, by mobile internet based devices and applications for affected patients, their families and members of the public; and regular clinical screening for depression, anxiety, and suicidality in suspected and diagnosed COVID-19 pneumonia patients and health professionals. In addition to obviously vulnerable populations for adverse mental health outcomes due to COVID-19 outbreak, i.e. the infected and ill patients and their close persons, particular mental health support should also be directed toward individuals with pre-existing mental/physical conditions, and, health-care and aid workers, especially nurses and physicians working directly with ill or quarantined persons (Shigemura et al. 2020). Additional research, related to coronavirus pandemic (Huang & Zhao 2020, Lai et al. 2020) and 2015 MERS outbreak (Lee et al. 2018), similarly recognize that healthcare workers are at high risk for mental illness and suggest prompt and continuous monitoring of the psychological consequences as well as early targeted mental health interventions toward this vulnerable population. The paper on quarantined Toronto health care workers during 2003 SARS outbreak emphasizes that the acute stress of working with highly infectious patients needs to be acknowledged and timely referral paths developed for health care workers in need of mental health services (Robertson et al. 2004). A broader review paper on mental health consequences for first responders generally, including public health workers, highlights evidence of quarantine being a predictor of acute stress disorder diagnosis in public health workers, and calls for research on preventive strategies and treatments for specific mental health disorders at individual level, as well as empirical evaluation of population-based preventive approaches in populations of public health workers responding to human disasters (Benedek et al. 2007). The local government of Wuhan has even implemented policies that focus specifically on mental health support to their medical workers caring for COVID-19 patients (Kang et al. 2020). The COVID-19 pandemic has brought serious social psychological impact to the Chinese people, especially those quarantined, leading to proposals of new technology-assisted psychological crisis intervention models based on remote psychological intervention facilitated by internet based technologies, particularly widespread application of 4G or 5G networks and smartphones (Zhang et al. 2020). The seriousness of the psychological impact of quarantine has been recognized in a literature review that presents synthesis of relevant evidence from prior virus outbreaks in order to offer guidance for the public and policy makers during coronavirus pandemic (Brooks et al. 2020). Beyond being quarantined, national survey of over 4,600 citizens across 31 regions in China showed that some people are more vulnerable to mental health deterioration due to COVID-19 outbreak than others, like individuals with low trait of self-control, who are therefore more in need of psychological aids to maintain mental health in the encounter of this pandemic (Li et al. 2020).

LIMITED RESOURCES OF MENTAL HEALTH SERVICES

The coronavirus pandemic has seriously affected almost the entire world, but affected countries have very limited resources of mental health professionals in comparison to the forthcoming growth of demand. For illustration, the number of psychiatrists per 100.000 inhabitants is 2.2 in China and 11 in the U.S. (Kirton 2020), while the most recently available Eurostat data, from 2017, give corresponding numbers for European countries (Eurostat), e.g.: 51.7 in Switzerland, which is the highest number in Europe, 27.4 in Germany, 22.9 in France, 17.4 in Italy, 16.1 in Croatia, 10.5 in Spain, 9.2 in Poland, 7.8 in Bulgaria etc. While it has been recognized that mental health service availability, accessibility and financing represent particular challenges in developing countries (Andrade et al. 2014), even in the U.S. nearly 40% of population lives where there is a shortage of mental health professionals and 60% of counties are without a psychiatrist (Marr 2019). Accordingly, critical shortfalls of psychiatrists and other mental health specialists to provide treatment in a range of countries represents an additional challenge for mental healthcare in times of the ongoing pandemic. The increasing demand from overburdened mental health care system and psychiatric services presents a risk of creating a global public mental health crisis throughout the world what would be harmful and frustrating for patients, their families and other mental health providers. The shortage of psychiatrists and potential increasing the number of psychiatrists - by itself - will not be sufficient to improve access and the quality of mental health care. The solutions cannot rely only on recruiting more psychiatrists or raising payment and reimbursement rates. It should be a combination of interrelated efforts that will require support from a range of stakeholders. In the context of comprehensive strategies and solutions to address the lack of access to psychiatric services, artificial intelligence, telepsychiatry and an array of new technologies, like internet-based computer-aided mental health tools and services should help globally and urgently during the coronavirus pandemic. Trend toward increasing the availability of telepsychiatric services using smartphones, not only in China, but a

range of other countries as well, that have shortage of psychiatrists in comparison to the anticipated acceleration of demand for mental health services is very promising way forward. There are even estimates that 45% of the world has less than 1 psychiatrist to every 100,000 people, while over 50% of the world population owns a smartphone (Lovejoy 2019). Increasing the supply side of mental health services to match the demand can be facilitated by broader use of state-of-the-art tools and means of digital psychiatry, particularly for high-risk groups like: confirmed coronavirus patients, health workers directly caring for these patients, as well as quarantined people and those exhibiting vulnerable psychological traits.

POTENTIAL OF DIGITAL PSYCHIATRY

The application of digital technologies in PTSD mitigation has been the main topic of our research in the Laboratory for Interactive Simulation Systems, Faculty of Electrical Engineering and Computing, University of Zagreb over the last 15 years. This approach is based on translation of relevant findings from psychophysiology and neuroscience using state-of-the-art computer tools and methods related to multimodal signal processing, virtual reality, machine learning, cognitive computing, and artificial intelligence (Popovic et al. 2006, Ćosić et al. 2010, 2012b, 2013, 2019b, Kukolja et al. 2014, Šarlija et al. 2017, Dropuljić et al. 2018). Design and development of such digital systems requires more joint interdisciplinary research and efforts of computer scientists and developers, as well as psychologists and psychiatrists. These goals and objectives are pressing in the face of the ongoing COVID-19 pandemic due to lack of psychiatric resources and services. Applied research and development, particularly in artificial intelligence and machine learning (Chandler et al. 2020, Graham et al. 2019, Shatte et al. 2019, Lovejoy 2019), have become a highly promising and attractive topics of digital psychiatry (Eberhard 2018, Hariman et al. 2019). Our engineering, scientific and research experience so far was related to the development of computer tools and methods for emotion elicitation (Horvat et al. 2014), emotion estimation (Kukolja et al. 2014), emotion regulation and cognitive-behavioral therapy (Popovic et al. 2006, Ćosić et al. 2013), stress inoculation/resilience training (Popović et al. 2009, Ćosić et al. 2010), prevention of stress-related disorders and strengthening the soldiers' ability to cope with highly stressful situations (Ćosić et al. 2010, 2012b), as well as assessments of individual and group stress resilience features (Ćosić et al. 2012a, 2016, 2017, 2019a, 2019b). Recent relevant international project experience is related to the NATO research and development project "Multidisciplinary Metrics for Soldier Resilience Prediction and Training" (Ćosić et al. 2019c), completed in cooperation with Hadassah Hebrew University Hospital, Jerusalem, Israel and the Emory University School of Medicine, Atlanta, Georgia, USA during 2016-2019. In 2005, we organized one of the first international NATO conferences "Novel Approaches to the Diagnosis and Treatment of Posttraumatic Stress Disorder" (Roy 2006). In collaboration with the Interactive Media Institute in Brussels and Virtual Reality Medical Center in San Diego, we organized a series of international conferences and seminars in Croatia, Austria and Turkey on the topic of digital technologies in mitigation of psychological disorders caused by stress, suicide, pain and traumatic brain injury to soldiers and war veterans, which were supported by NATO Science for Peace and Security Program (Wiederhold 2008, 2010, 2011, 2012, 2013). Due to ongoing explosion of mental health disorders during COVID-19 outbreak (Sun et al. 2020, Wang et al. 2020), former Croatian initiative on NATO Center of Excellence for Resilience and Mental Health might deserve more attention again. In 2013, NATO's Allied Transformation Command, Norfolk, Virginia, USA has included this Croatian initiative on its list of potential future NATO centers of excellence, based on the presentation of this initiative at the annual NATO Military Mental Health Expert Panel meeting in Brussels, Belgium. Based on Croatian multidisciplinary research and experience in coping with invisible wounds of Homeland War (Jakovljević et al. 2006, Kozarić-Kovačić et al. 2005; Kozarić-Kovačić & Borovečki 2005, Marinić et al. 2007, Jovanovic et al. 2009, Pivac et al. 2004), we do believe that joint Croatian public-private partnership under the leadership of Croatian Government may successfully compete for dedicated European funds regarding COVID-19 public health consequences. Such Croatian public-private partnership would also assume the establishment of an interdisciplinary national data mobility framework that would guide future concepts, models, algorithms, data sharing, as well as improvements in access to computing power. Being directly relevant in the context of COVID-19 pandemic, the purpose of this joint initiative of psychologists and psychiatrists working together with computer scientists and developers may also lead to more efficient European mitigation of stress-related disorders in a variety of uncertain and unpredictable human disasters, like earthquakes, wildfires, floods, global economic crises, migrations and terrorism.

CONCLUSION

While coronavirus pandemic is unquestionably in the focus of worldwide attention, specific influences on the magnitude of negative psycho-socio-economic fallout of COVID-19, which depends on a constellation of pre-pandemic, peri-pandemic and post-pandemic factors in each country and region, deserve particular attention. For illustration, the Zagreb earthquake in Croatia in March 2020 during the ongoing pandemic represents an additional risk factor that might increase the post-pandemic prevalence of mental health disorders in Zagreb beyond coronavirus outbreak alone. Since Croatia already has a high number of pre-pandemic cases of

chronic PTSD due to the 1990s' Homeland War, it is imperative from the national perspective to recognize high-risk persons for mental health disorders in order to provide them timely and efficient support and prevent a new buildup of PTSD in Croatian population caused by coronavirus pandemic 2020.

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Krešimir Ćosić: idea, concept and design of the article, continuous reviewing and approval of the final version.

Siniša Popović: literature search, writing manuscript, continuous reviewing and approval of the final version.

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