

# PSYCHOSOCIAL EFFECTS OF COVID-19 PANDEMIC AMONG HEALTH CARE WORKERS

Yedu Krishnan SS<sup>1</sup>, Thasneem.S<sup>2</sup>, Roshni P R<sup>3</sup>

<sup>1,2</sup> Student, M Pharm, Department of Pharmacy Practice, Amrita School of Pharmacy, Amrita Vishwa Vidyapeetham, Kochi-682041, Kerala, India.

<sup>3</sup> Assistant Professor, Department of Pharmacy Practice, Amrita School of Pharmacy, Amrita Vishwa Vidyapeetham, Kochi-682041, Kerala, India.

<sup>1</sup>yedu773677@gmail.com, <sup>2</sup>thasni9633@gmail.com, <sup>3</sup>roshnipr@aims.amrita.edu  
Corresponding author: Roshni P R, roshnipr@aims.amrita.edu

Received: 14 March 2020 Revised and Accepted: 8 July 2020

**ABSTRACT:** The rapid spread of corona virus is mounting challenges on both health care professionals and health care systems. To constrain the outbreak of COVID-19 many significant efforts have been made like focusing on mobilization of intensive care beds and ventilators, developing standard treatment protocols for treatment of patients.

Health care teams are working day and night to contain the outbreak and to meet the current challenges. On doing so they fail to attend their self needs and are burdened with thoughts of uncertainty of future and doubts concerning resources and risks at hand; and continuous exposure to physical sufferings, death and threats to their own safety is having a negative psychological stress on them. These conditions can arouse feelings of fear and anxiety in the short term, and continuous exposure to risk can lead to serious posttraumatic stress syndromes, deleterious mental impacts and even professional burnout in the long run.

Taking into consideration the unique mental health impact of current outbreak, protecting medical staff from adverse psychological effects of COVID-19 outbreak is of utmost importance. We hope that our review will make everyone realize the strain and stress the medical workforce are bearing during the COVID-19 outbreak. Accounting to our remarkable adaptability, we hope that, our medical team can come out of the current pandemic in flying colours with new skills, closer relationships and greater confidence in the power of society. Staff support and the provision of facilities and equipment by hospitals and the government are required to retain and encourage medical staff during times as of the current pandemic.

**KEYWORDS:** COVID-19, Healthcare professionals, Isolation, Stress, Post traumatic Stress Disorder.

## I. INTRODUCTION

Frailty Ever since the humans started spreading across the globe there is a spike in incidence of infectious diseases globally. Outbreaks have been occurring frequently; but a few has the inherent potential to reach a global pandemic level. It was on December 31, 2019 the China office of World Health Organization (WHO) started noticing special cases of pneumonia of unknown aetiology in Wuhan city of Hubei province in China. Later on, in February 11, 2020 WHO gave the disease a name “Corona virus disease of 2019” (COVID-19). China being a global hub with increased global integration travel and urbanization has led to the rapid global spread of COVID-19 and was subsequently declared as a pandemic on March 11, 2020; deadliest of all witnessed in our lifetime so far.

COVID-19 pandemic being a new disease; its obvious the rapid spread of the diseases can trigger feelings of fear and threat there by influencing the cognitive well being of the society. The lives of everyone and the well-being of the society are at stake. The current outbreak paved way to an unparalleled situation for every individual; especially the healthcare professionals (HCP), with the current outbreak being mentioned as the worst public health crisis in a generation.

Now a few questions popes out in everyone’s mind.

**“Why COVID-19 is such a stressor and more devastating than a natural disaster or war?”**

It is indeed a huge stressor with devastating effects far greater than any wars or natural disasters we have endured. Natural disasters are often confined to specific locations and that to for a specific time frame; people are quite sure they can escape, if they want to or if they have the possibility to do so and in times of war we have a clear-cut idea

of who our enemy is and he is easily recognizable. But when it comes to a pandemic, we don't have a time frame and the threat is everywhere and can even be carried by the person next to us which builds up the pressure.<sup>1,2</sup>

### **“What have we learned from the past?”**

Other than physical damage, pandemics have an inherent potential to influence mental health of the public. The pandemic and the related containment measures especially quarantine, social distancing and self-isolation can have a detrimental impact on mental health. It is quite evident that a neuropsychiatric link exists between these pandemics and psychological stress disorders from the data acquired from the past outbreaks like influenza and severe acute respiratory syndrome (SARS). In particular feelings of loneliness and reduced social interactions arouse feelings of boredom and anger; which are proven risk factors for serious mental disorders, like schizophrenia and major depression. In pace with current outbreak the symptoms like cough and fever may also results in cognitive distress and anxiety due to the fear of contracting the COVID-19 themselves.<sup>3</sup>

### **“What is the current world scenario with respect to COVID-19?”**

Globally COVID-19 count is nearing the 60 lakh mark; with cases surging to 5,685,938 and a death toll of 3,52,227. United States tops the list with 1,725,275 infected patients and a death toll over 1 lakh. The conditions are somewhat stabilized in Spain, Italy and France. Currently cases are dramatically increasing in Brazil and Russia. India stands 10 in the list with COVID-19 count of 1,51,876 and a death toll nearing 5000 but what is troubling India is the reporting of highest ever spike in COVID-19 cases continuously. Countries all around the globe are giving relaxations to imposed restrictions in an effort to renew their economy which could make the second wave more severe.

## **2. SOCIAL ISOLATION AND MENTAL HEALTH:**

It is often quoted, “If you have seen one disaster, you have seen one,” reflecting the uniqueness of every disaster. The COVID-19 brought a drastic change in the world's population; dramatically changing what is normal, complicating previously basic and uncomplicated elements of daily life. Daily life has changed drastically to most, and the "normal" lifestyles as we know are suspended indefinitely. These changes can make the people anxious and unsafe; feelings of being unsafe coupled along with not knowing the exact cause or progression of the pandemic and fake news can lead to discrimination against people of specific descent.

There is a direct association between quarantine and the mental health outcomes. Longer a person is confined to quarantine, the poorer the mental health outcomes and greater are the chances for symptoms of post-traumatic stress disorder (PTSD). Shortage of essential commodities, foods, medicines and further restrictions of routine daily activities adds up to the stress.

COVID-19 pandemic is presenting a unique set of stressors and psychological trauma-related challenges to all humans but a certain section of society is at a greater risk of physiological harm, the most vulnerable being children, females, elderly people and people belonging to lower socio-economic groups. People who are stranded in the streets pose a greater risk for poorer health outcomes and the risks are likely to be enhanced during a pandemic. This section of our society relies on support programs that may be interrupted due to pandemic. In pace with the pandemic mentally retarded patients experiences more stress and pressure and are likely to experience an exacerbation of their pre-existing conditions and have a greater risk of developing PTSD after such events. A fraction of our society is habituated to alcohol and other related products and is vulnerable to setbacks as a result of imposed travel restrictions. People in treatment of alcoholism and other drug abuse can face difficulties and additional complications as result of social isolation. Patients receiving cancer therapy or who have undergone organ transplantation are at greater risk as they are immuno-compromised and have greater chances of being infected.

A group which requires special mention is HCP who occupies the forefront in our battle against the COVID-19. In the early rapid expansion phase of these pandemics, HCP are continuously exposed to feelings of extreme vulnerabilities, uncertainty and threat to life, coupled up with both physical and cognitive symptoms of moderately high anxiety and subsequent psychological distress.

We cannot assume that the negative mental impacts will cease after the quarantine but is more likely to extend to post quarantine period. Social isolation in the future can pave way to avoidance behaviours like cutting off social contact and tendencies to avoid crowds and public places. As we all know majority of the people are confined in their houses with nothing much to do as a result of it, they may face difficulties while returning to work. There are also high odds for evolution of certain long-term behavioural changes like excessive hand washing.

During this time of difficulty, it is important to step up and help the vulnerable who are experiencing stress, anxiety and existing mental health and social challenges. It is crucial that we work collaboratively and with utmost determination upholding humanitarian feelings to keep people safe within the constraints of the pandemic.<sup>4</sup>

### **3. FRONT LINE HCP:**

From the beginning of the global COVID-19 pandemic outbreak we have been hearing the news about HCP who are working in the frontline of the attempts to quell the outbreak. Globally they are receiving applauds and words of praises and respect from everywhere for their hard work and sheer dedication.

#### **3.1 Who are HCP?**

It is must that we should have a clear-cut idea about our frontline battlers in the fight against the COVID-19 pandemic. HCP are skilled persons who provide health services and advices based on formal training and experience. Frontline HCP include doctors and nurses from departments of infectious disease emergency medicine, intensive care units, fever clinics and technicians mainly from radiology and laboratory medicine and hospital staff from infection control.

HCP occupies the frontline in the battle against COVID-19, which is having a serious psychological toll on them; hence it is our duty to support them. Their willingness to serve the patients has been least affected even in the current pandemic. Even though being under such intense pressure and threat full circumstances they showcase high levels of commitment and professionalism. It is evident that their belief in safety, skills and risk perception are proven facilitators for their willingness to work. The increasing knowledge gained about the spread and transmission of disease and the implementation of scientific procedural techniques and systematic treatment protocols, along with awareness programs, help to boost their morale and will help them to stay more on the positive side.

In light of the increased psychological pressure mounting on them, sufficient methods should be adopted and implemented to ease the stress and strain to which they are continuously prone to; as it is our duty to support them.<sup>5</sup>

#### **3.2 How HCP are paying a heavy price in this battle?**

**“Healthcare is becoming more like factory work, Work faster, patients are sicker, do more with less, deal with it. If you can’t, there is a culture that if you are unable to just roll through while something like this happening and continue to be a fully productive worker, that you are defective”**

After COVID-19 outbreak, fear and panic generated surrounding the novel virus, have paved way to both physical and verbal attacks against the HCP, that too in an alarming rate, which makes it a problem which requires immediate attention. While the HCP are at the forefront in the battle against the current pandemic putting their life at stake and risking everything that they have in the harms way; even then many across the globe grasped under the clutches of fear and uncertainties around them are not valuing their immense efforts and life.

**“HCP are not scared of infections as they are of the abuses and assaults launched against them by the very society they serve and treat to protect”**

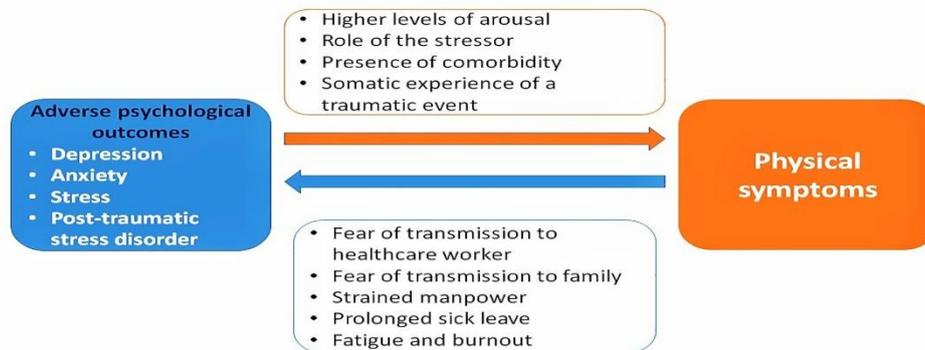
WHO has stated an integrated approach should be actively pursued at all levels of integration based on the combined and balanced consideration of prevention and treatment. Therefore WHO held’s employers accountable for both ensuring the safety of their employees and acting to treat them after an act of violence has occurred.<sup>6</sup>

### **4. PSYCHO SOCIAL STRESS ON HCP:**

Evidence from the past outbreaks like SARS underlines the severity in emotional distress most likely to be faced by HCP. It’s worthwhile to assume that during the early expansion face of such outbreaks, HCP can experience feelings of vulnerabilities and threat to their own life and existence; along with physical and mental symptoms of anxiety. In the current COVID-19 outbreak, HCP are being confronted with mounting challenges like any they have faced before.

Ever since the COVID-19 outbreak our HCP are under immense stress and strain as they are in the frontline efforts to contain the pandemic. In fact, they are paying a heavy price for their efforts as most of them experience various physical symptoms and are also under intense psychological distress. It is indeed challenging that we are not able to draw any true link between physical symptoms and psychological distress. One thing we have learned from the past outbreaks is that physical symptoms are more prevalent during these periods and they may be serving as ways for communicating our deep emotions. Therefore, we can come to a hypothesis that the increase in incidence of self-reported physical symptoms is likely to be result of the psychological impact of the outbreak. Based on our

assumptions we can postulate a bi-directional relationship between psychological distress and physical symptoms.<sup>7,8</sup>



**Fig 1. Bi-directional link between psychological distress and physical symptoms**

**4.1 Moral Injury:**

The driving force of HCP in their battle against COVID-19 pandemic is their social and moral responsibility alongside with their compassion for others. But now concerns have raised as quick decisions has to be made for systematically sorting and isolating patients with symptoms and risk of infection, hard choices needs to be made regarding rationing care, planning ventilator assistance based on the survival chances of the patients and to decide whether to enforce complete or partial shutdown measures when a patient or staff test positive for COVID-19 as a result of contact. Witnessing countless death each day adds up to their grief as they were trained to serve and protect others. They feel helpless and many feels they have failed in their mission. The moral injury is associated with increased risk of psychiatric disorders and suicidal ideation.<sup>9</sup>

**4.2 Situation of Dilemma:**

It is quite clear that the symptoms of the current outbreak are diverse, non-specific and similar to other viral infections. Whenever HCP develop such signs or symptoms, they are confused, that they can't decide whether to opt for leave or to continue working along with their over stressed colleagues. There is also a high chance for symptoms like throat pain, cough, headache and myalgia to be exacerbated at times of these outbreaks, owing to the psychological stress or due to the presence of various other co morbidities. One other thing troubling them is that they don't know how to deal with those patients who are not willing to cooperate with medical measures and those who refuse to be quarantined at hospitals due to panic or lack of knowledge. These dilemma paves way to feelings of fear and anxiety and can have a negative psychological strain on them.<sup>10</sup>

**4.3 Cascade of emotions:**

As HCP serve as the frontline workers, they pose an increased risk of exposure to the virus they fear that they may end up with COVID-19 themselves. The fear of contracting the virus is of high intensity as a result of high asymptomatic transmission rates of COVID-19 amongst HCP. Due to high odds for contracting the virus they fear that they could turn out to be potential carriers of the virus and cause transmission among fellow HCP and to other patients. The most troublesome being that they worry about carrying it home and passing it on to loved ones and family members if they choose to continue to work. They even fail to attend their self needs being burdened with thoughts of uncertainty of future and doubts concerning resources and risks at hand; and continuous exposure to physical sufferings, death and threats to their own safety is having a negative psychological stress on them and often pave way to serious mental health problems.<sup>5,11</sup>

**4.4 Job stress:**

**“The nature of work is changing at a whirlwind speed. Perhaps now more than ever before, job stress poses a threat to the health of workers and in turn the health of organizations”**

It is referred to as the deleterious physical and emotional response which occurs simultaneously when the job requirements do not match the capabilities, resources or needs of the worker. The workplace plays an important part in affecting our mental wellbeing and health. Job stress is mainly as a result of overworking, vague instructions, unrealistic deadlines, job threats, isolated working conditions etc. Job stress can pave way to poor health and thereby increasing the rates of work-related injuries and accidents which can have a negative toll on

HCP who fail to cope with the changes. During the current COVID-19 outbreak we are understaffed by a large margin and therefore the HCP are overworking to cope with the current situation and literally burning themselves out.<sup>12</sup>

#### **4.5 Professional burnout:**

Professional burnout is a condition which develops through the cumulative impact of both empathizing with others suffering and being committed to their recovery. Published articles demonstrates that the burnout involves three stages; emotional exhaustion, depersonalization and reduced personal accomplishment. It exerts a great influence on their quality of life and their personal and professional capacities. Features of burnout are a loss of physical, cognitive and emotional energy; reduction of ability to use effective coping strategies, negative attitudes and disengagement from work. Patients will have to pay a heavy price due to reduced efficiency of HCP and health care services. Tragically, burnout is also linked to higher rates of suicide among HCP across multiple specialties and can also lead to increased mortality rate among patients due to the decreased efficiency of health care programs and services.<sup>13</sup>

#### **4.6 Economic issues:**

It is one of our least concerns in this time of crisis as even HCP are feeling the economic stress; they are putting it at side and are continuously working to serve their patients in all possible ways. They are considering their options to ensure short time stability and long-term growth opportunity.

#### **4.7 Problems at our hand:**

As for HCP the novel nature of the pandemic, shortage of testing kits and essential medical supplies, inadequate testing, limited treatment options, shortage of personal protection equipment (PPE) and difficulties faced while equipping PPE are the emerging concerns causing considerable amount of strain and stress and has inherent potential to overwhelm our health care systems.

**4.7.1 Novel nature of the virus –** The virus is itself quite unique and at the same time possesses inherent ability to expand their genetic diversity by nurturing recombination and mutation at the time of infecting host and even has the ability to overcome species barrier during the spread of the outbreak. The variations of incubation period based on the potential of the virus and the host defence mechanism adds up more pressure .<sup>14</sup>

**4.7.2 Testing kits –** The global shortage of these kits due to scarcity of supplies, slow approval processes and their sky rocketing demand outstripping production capacities is slowing down our fight against the virus. Adding to the headache is in the doubt in the accuracy of the test results.

**4.7.3 PPE –** It is a type of equipment or clothing worn to protect oneself from a specific hazard but it requires special training for wearing it. It won't serve its purpose unless one knows to use it correctly. HCP across the country are facing shortage of PPE. Putting on and taking off these PPE is quite time consuming and difficult work. The use of PPE for long periods causes difficulties in breathing and limited access to toilet and water, results in subsequent physical and mental fatigue.<sup>15</sup>

#### **4.8 Stigma and social discrimination against HCP:**

**“People fail to get along because they fear each other; they fear each other because they don't know each other; they don't each other because they have not communicated with each other”**

These are the words of Martin Luther King. It is true indeed.

An aspect of prime importance is the fight against the social stigma and discrimination toward those treating and caring COVID-19 patients. It is most hurtful as HCP have to bear a lot of pain just for performing their duties and responsibilities. They are tiring themselves in serving us in adverse conditions even risking their lives but it is quite shocking to realize that they are being assaulted and abused by the same whom they serve to protect. All this can cause immense strain on them and can lead to the development of anxiety, depression and detrimental effects on mental health which could lead to negative psychological pressure. This in turn can cause immense stress on health care services there by reducing the quality of health services and programs.<sup>16</sup>

**"But it is okay. This is a global crisis, and we can't think only of our families. We are happy to serve the people"** In spite of all the troubles we cause them these are the unified words of our HCP.

#### **4.9 Impact of fake news:**

Threat is so immense that Guy Berger; an United Nations Educational, Scientific and Cultural Organization (UNESCO) executive quoted;

**“In times of high fears, uncertainties and unknowns, there is fertile ground for fabrications to flourish and grow. The big risk is that any single falsehood that gains traction can negate the significance of a body of true facts”**

Fake news spreads around the globe with such great intensity; that a few are referring to the new tide of false information following the COVID-19 pandemic as “disinfodemic”. Internet is spreading a large amount of fake news which outruns the virus itself, triggering panics and uncertainties to a great extent. Fears are rising in the mind of every individual to such an extent that some with symptoms are putting life at risk, trying unproven remedies in the hope of curing themselves. Misinformation can also arouse feelings of doubt, threat and uncertainty about the future which can generate or exacerbate fear, depression, and anxiety.<sup>17</sup>

### **5. Concerns for future:**

**5.1** Posttraumatic stress disorders (PTSD) – PTSD and depression could be the second wave of the current COVID-19 outbreak. Odds are quite high for the occurrence of PTSD after the outbreak among the frontline workers. As per the recent reports released by the WHO, approximately 25% - 30% of the HCP globally are at the verge of burnout. Therefore, chances are quite high that between 15% -20% of HCP to contract PTSD after the outbreak. Ever since the current COVID-19 outbreak they are under overwhelming threat of safety along with the fear of infecting their loved ones. The uncertainty of the future makes the situation much worse. Their continuous exposure to physical sufferings, severely ill patients and death induces sleep disturbances, grief, depression and anxiety to level greater than our imaginations. While trying to cope with current challenges, HCP fail to attend their self needs and their psychological stress which makes it more evident that these PTSD could arise as a second wave after the COVID-19 outbreak.<sup>18</sup>

**5.2** Shortage in HCP – During the current COVID-19 outbreak HCP is working 24/7; to contain the pandemic. Most of them are burned out as they are overworking to cope with our current needs. Being the frontline workers, they possess the higher risk of being infected. Hence there is a higher chance that once the pandemic gets over, we may face a shortage of HCP like never before mainly due to PTSD, burnout and mental exhaustion.

**5.3** Resurgence of diseases - Immunization is an essential health service which may be affected by the current COVID-19 outbreak. The delays in children’s immunization programs in the worst scenario may pave way to potential epidemic in coming months. The magnitude of problem depends on how long these services are interrupted and whether the children who have missed doses can make up for it before returning to school. We can opt telemedicine for development, but vaccines are the shield, that protects them.<sup>19</sup>

**“Disruption of immunization services, even for brief periods, will result in increased number of susceptible individuals and raise the outbreak-prone vaccine preventable diseases (VPDs)”**

### **6. CONCLUSION:**

COVID-19 is the most serious global crisis of our generation in many ways similar to the Spanish flu endured by the previous generation. The two pandemics have a lot in common; like the quarantine and social distancing measures. Back then people felt so bad that when these restrictions were lifted, the people rushed into the streets and rejoiced. In the coming weeks, the second wave occurred, with tens of millions of dead. Let’s not repeat history in the time of COVID -19.

The pandemic will be over, but its effects on mental health and well-being will remain for a long time. We are hopeful that our efforts will help to reduce the stigma and social discrimination against HCP and also hope that it aids in efforts to promote their psychological well-being. Staff support and the provision of facilities and equipment by hospitals and the government are most essential to motivate medical staff during the pandemic. Human beings are remarkably adaptable, and it is our belief that the vast majority of us can emerge stronger and wiser with many new relationships and skills to chain down COVID-19.

### **REFERENCES:**

1. Chew NWS, Lee GKH, Tan BYQ, et al. A multinational, multicentre study on the psychological outcomes and associated physical symptoms amongst healthcare workers during COVID- 19 outbreak. *Brain, Behavior and Immunity*. 2020;(April):0-1.
2. Fiorillo A, Gorwood P. The consequences of the COVID-19 pandemic on mental health and implications for clinical practice. *European Psychiatry*. 2020; 63(1): 1–2.

3. Shah K, Kamrai D, Mekala H, Mann B, Desai K. Focus on Mental Health During the Coronavirus ( COVID-19 ) Pandemic : Applying Learnings from the Past Outbreaks. *Cureus*. 2020;12(3):1-8.
4. Usher K, Jackson D, Bhullar N. Life in the pandemic : Social isolation and mental health. *Journal of Clinical Nursing*. 2020;00:1-2.
5. Tsamakidis K, Rizos E, Manolis AJ, Chaidou S, Kypmpouropoulos S, Spartalis E et al. COVID-19 pandemic and its impact on mental health of healthcare professionals. *Experimental and Therapeutic Medicine*. 2020;19:3451-3453.
6. Indulekha Aravind. Covid-19 : How healthcare workers are paying a heavy price in this battle. *The Economic Times of India*. 11 April 2020.
7. Chen Q, Liang M, Li Y, Guo J, Fei D, Wang L et.al. Mental health care for medical staff in China during the COVID-19. *Lancet Psychiatry*. 2020;(20):1-2.
8. Depierro J, Lowe S, Katz C. Lessons learned from 9 / 11 : Mental health perspectives on the COVID-19 pandemic. *Psychiatry Research*. 2020;288(April):1-3.
9. Chen L, Cai H, Zhuang Q, Ma J, Fu L, Jiang Y. Psychological Impact and Coping Strategies of Frontline Medical Staff in Hunan Between January and March 2020 During the Outbreak of Coronavirus Disease 2019 (COVID-19) in Hubei, China. *Medical Science Monitor*. 2020;26:1-16.
10. Williamson V, Murphy D, Greenberg N. COVID-19 and experiences of moral injury in front- line key workers. *Occupational Medicine*. 2020;(May):1-3.
11. Huang Y, Zhao N. Generalized anxiety disorder, depressive symptoms and sleep quality during COVID-19 epidemic in China: a web-based cross-sectional survey. 2020;( Feb):1-18.
12. Harnois G, Gabriel P. Mental health and work : Impact , issues and good practices. *World Health Organization*. 2000; 20 Avenue Appia, 1211 Geneva 27, Switzerland.
13. Albott CS, Wozniak JR, Brian P, Wall MH, Gold BS, Vinogradov S. Battle Buddies: Rapid Deployment of a Psychological Resilience Intervention for Health Care Workers During the Corona virus Disease 2019 Pandemic. *Anaesthesia & Analgesia*. 2020;(Special Article):1-12.
14. Priyadarsini SL, Suresh M. Factors influencing the epidemiological characteristics of pandemic COVID-19 : A TISM approach Factors in fl uencing the epidemiological characteristics of pandemic COVID-19 : *International Journal Healthcare Management*. 2020;0(0):1-10.
15. Pfefferbaum B and North CS. Mental Health and the Covid-19 Pandemic. *The New England Journal of Medicine*. 2020;(May):1-3.
16. Erickson S. Discrimination Against Healthcare Providers : Through Training and Practice. *University Honors Theses*. 2018;(Feb):1-19.
17. Casero-ripollés A. Impact of Covid-19 on the media system. Communicative and democratic consequences of news consumption during the outbreak. *El profesional de la informacion* 2020;(29):1-11.
18. Duteil F, Mondillon L, Navel V. PTSD as the second tsunami of the SARS-Cov2 pandemic. *Psychological Medicine*. 2020;(April):1-6.
19. Kurup VM, Thomas J. Edible Vaccines: Promises and Challenges. *Molecular Biotechnology*. 2020;62(2):79-90.