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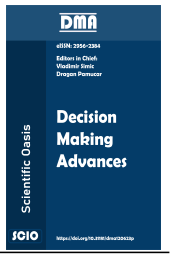

Fuzzy AHP Approach for Multi-Criteria Stress Analysis During COVID-19: A Case Study

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ABSTRACT

The novel coronavirus 2019 (COVID-19) pandemic poses a challenging and stressful situation among people from 2019 to date globally. This study analyzes various factors responsible for the stress intensity among India's urban cities to identify the most affected metropolitan city. The study identified six Indian urban cities and three major stress factors: routine, social, and job, with each factor having sub-criteria. A fuzzy analytic hierarchy process is used to model the situation, and a synthetic extent analysis method (EAM) is employed to solve the model. The modified EAM has been also applied and the two results compared. It has been found that the modified method is more robust than EAM. The concept of the minimum degree of possibility is applied to obtain the weight vector for the main criteria. After identifying the main stress criteria and its sub-criteria and six metropolitan cities, the hierarchy of identifying India's most affected metropolitan cities during COVID-19 is structured. The study found that using EAM, Mumbai is the worst affected city, followed by Bengaluru, Chennai, Delhi-NCR, and Hyderabad. While using the modified method, the most affected areas are found to be Pune, followed by Mumbai, Chennai, Hyderabad, Delhi-NRC, and Bengaluru. It further discovered that routine stress-related is the most critical factor in identifying the most affected metropolitan city, followed by social and job-related stresses.

Keywords:
COVID-19; Stress Analysis; Synthetic Extent Analysis; Fuzzy-AHP; Global Ranking; Degree of Possibility

1. Introduction

There are many articles published about COVID-19, but one thing that might be of interest is what

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we learned from this pandemic and what we can recommend for the future should the world face a similar "pandemic". The novel coronavirus 2019 (COVID-19) outbreak initially identified in December 2019 at Wuhan, China [1] attacks respiratory organ. The COVID-19 transmits from one individual to another through inhalation of respiratory droplets of an infected person or via direct contact with a contaminated object. On 22^{nd} January 2020, 571 cases of COVID-19 infected patients reported in 25 of China's provinces [2, 3]. A week later (30th January 2020), about 7734 cases confirmed in China, with 90 reported cases in 13 other countries, including Canada, France, Germany, United States, and the United Arab Emirates [3, 6]. The trend of deadly infectious disease of COVID-19 increase exponentially and spread globally, reached about 5,656,615 cases by 24th May 2020 with total deaths of around 355,355 persons [7]. The virus became a public health emergency announced by the World Health Organization (WHO) on 30th January 2020 and later declared a pandemic on 11th March 2020.

Presently, there is no known antidote or vaccine unanimously approved for curing the disease. However, several control measures, such as lockdown, social distancing, the prohibition of crowded programs, use of a steam vaporizer, and face mask use in public places, employed by different countries for curtailing the rapid spread of the COVID-19 pandemic.

Recently, different vaccines such as Astherazenica, Covaxin, COVIDshield, etc. are being issued by different countries, despite the unequivocal critics from several medical experts worldwide. The coronavirus pandemic poses unprecedented fears, stress, and psychological trauma similar to the previous pandemic and epidamic [5]. Naturally, recreational activities, outings, social gathering, and interaction with family and friends remove anxieties and worries among the human race. However, the lockdown imposed on people due to the COVID-19 pandemic does not give room for all these social activities. As a result, people are very disturbed and fear contagious diseases, especially elderly persons and those with a history of some deadly diseases such as hypertension, asthma, hepatitis, etc. The stress from the shorting down of businesses, survival for food, and lack of inflow of income give rise to an increased degree of fear and worries of sustainability amongst people globally. In some countries, government and charity organizations play a vital role in addressing these fears by providing the citizenry with some token as food items and daily needs. However, the situation is not the same across the globe because of the high population and level of preparedness by some nations. The developing countries suffer a higher percentage of this setback; India is among them.

Living in the COVID-19 pandemic is like the worst of all life's nightmares. The main objective of this study was to investigate the psychological suffering among the various metropolitan cities of India. Metropolitan cities are regarded as the most popular Indian towns with a considerable population and are responsible for the COVID-19 surge in the region. Some significant threat of virus propagation includes public gathering, religious congregations, and public celebrations during festivals. It can disrupt the appreciable gain of suppressing the chain of COVID-19 spread in metropolitan cities. Three cities – Delhi, Mumbai and Chennai – were the major during the first twelve months of the COVID-19 surge in India. However, during September, a considerable spike in the situation in Bengaluru led the southern town to second place ahead of Mumbai and Chennai. Although only these four metropolitan cities can be traced to one in every seven cases in the country, they have become even worse in terms of death – one in every five deaths in India has occurred in those cities. State governments have implemented various strategies, including lockdown and shooting down their boundaries, to control the pandemic.

The ongoing COVID-19 pandemic has created a situation in which the community suffers from a fear of stress, drug addiction, solitude and domestic violence. Schools and colleges were closed for a year, and the likelihood of a child abuse crisis is possible. In the current time, it is difficult to forecast the results of the current COVID-19 pandemic, but we should benefit from the previous experience of pandemics to find our best ways to take steps in the current times. Most researchers have identified adverse psychic impacts, including post-traumatic perceived stress, frustration and vengeance. Ex-

tended quarantine, fever, disability, irritation, boring, insufficiencies in resources, lack of awareness, economic damage and stigma were all identified as the stressors. Scientists have also documented the long-term psychosocial effects of such pandemics. This wide-ranging reporting on mental health conditions requires an in-depth strategy and initiative on mental health to alleviate mental and emotional problems during the COVID-19 time.

India is the second-largest populated nation with over 1.4 billion people in the world. The country is critical of the coronavirus pandemic—the stresses and fears caused by the corona outbreak in India increase by the day. With the new variant of the virus that is claiming lives exponentially, several fears caught the front line healthcare workers, security personnel, pharmaceutical outlets, elderly and young persons as to who is the next victim. Some of the stress and fears that commonly affect people are: fear of transmission from an infected person who could be a family member; fear of death due to infection of the virus; fear of visiting healthcare centres even at illness; fear of quarantine in an isolation centre for travellers; fear of losing an infected family member(s); and stress due to loneliness and fatigue [8]- [14]. Many factors such as the virus saga, misunderstanding and interpretations of different group leaders, lack of proper and sufficient awareness by government and agencies concern might cause these fears and stress, which is dangerous to people's well-being. It is a fact that stress hurts human vision and IQ and complicate the health condition of those having some mental or psychic problem. Several authors studied these phenomena, as will be highlighted in the literature review section.

The remaining article organized as follows: Section **??** provides the introduction and overview of the study. The related literature on MCDM and stress during COVID-19 reviewed and presented in Section 2. Section 3 discusses the methodology of the study. Section 4 present the application of the methods discussed in the context of Indian metropolitan cities. Section 5 analyses and discusses the results. Finally, the article concludes with recommendation and suggestions for further study scope in Section 6.

2. Literature Review

In human history, a pandemic is inevitable. It occurs from time to time and from one region to the other. For instance, in 1918-1920, there was a Spanish flu and then followed by Asiatic flu in 1956-1957 [15, 16]. The Severe Acute Respiratory Syndrome (SARS), with its variants, occurred in 2003-2003 as documented [17]. The Swine flu and Ebola diseases erupted in 2009 and 2013, respectively, claiming a reasonable number of lives [18, 19]. Another disastrous and deadly outbreak is the COVID-19 that is currently dreading and consuming lives double exponentially globally [20, 21]. THe COVID-19 pandemic affected the world's economy by hitting the bedrock and bachbone of every nation's economy, i.e. the "Micro, Small and Medium Enterprise (MSME)" [13, 23]. The coronavirus crisis brought what Warren Bennis and Burt Nanus called "volatility, uncertainty, complexity, and ambiguity (VUCA)" in many economy contributing sectors such as Agriculture, services, employment, healthcare system, education and manufacturing. [24–28]. Many people face stress psychologically as a result of job loss due to lockdown globally. Any physical or emotional changes due to human consequences can be called stress [29]. Stress varies from one individual to another, as it is known that one man's food is another man's poison. Social media such as Facebook, Twitter, TV, etc., is contributing reasonably to the increasing anxiety and stress among the people in the world. The essence of lockdown is to avoid chances of contaminating the coronavirus, but, on the contrary, it creates much stress among the population [30]. The stigma and finger-pointing at countries having the first coronavirus cases is another stress level on the citizens worldwide. World Health Organization (WHO) has been renaming new corona variants with different Greek names such as Alpha, Beta, Gamma, and Delta to avoid stigmatization and stress. For instance, the UK variant is called *Aplha* and that of India as *Delta*. The

second wave of corona in India led to a severe lockdown which created prolonged stress like the cost of living, staying home, working from home to a mist family, health issues, stretching healthcare facilities, fear of job security, and overall change of social lifestyle.

There is no aorta of doubt that coronavirus has affected and installed fears and stress among the global population. Prominent among the stress are those related to health issues many people are either infected or affected mentally or emotionally [31, 32]. Another stress is related to job scarcity and termination. Even though all working places are under lock and key due to lockdown, the daily expenses continuos; for example, utility bills such as electricity, water supply, internet, phone calls are inevitable. Government agencies and private companies have to cut costs since there is no full-time work during the covid-19 lockdown. A very few personnel required to do some essential duties from home; these poses fears in many workers as to losing their jobs; newly graduated young citizens who expect to get an excellent job before COVID-19 are in a dilemma. All those, as mentioned earlier, are responsible for job-loss stress [32, 33, 35].

The closer of markets added to a different kind of stress. There is a disruption in the supply chain network of goods and services, and the available commodities are becoming scarce by the day during the COVID-19 lockdown in most countries. For instance, India is open for only a short period for specific products such as groceries, and other edible are nowhere to be found. The little available become costly due to its higher demand. Hence, people bear the stress budding of the cost of living [34–37]. Strategically, it affects the well-being of an individual, especially the less-privileged ones or poor citizenries. In some nations, the government tried to assist needy persons with food items during the lockdown period. However, because of population and inadequacy of resources, the masses hardly feel the impacts of assistance. Many people might not get it at all; therefore, this can be regarded as significant stress due to living costs.

Similarly, family stress also exists as a result of working from homes. Coronavirus forces employees to work from homes, and not everyone can cope with the pressures of work and that of the family; Hence combining the two become very hectic and stressful [38]. Therefore, it contributes to social disruption, the concentration at one's work, and overall efficiency. An extended family typically lives together in developing countries like India. It is challenging for such kind of family to observe social distancing while at home. There could be no corona-free in such a setup; hence, it poses traits for contamination.

Another sector that suffers from the menace of the COVID-19 pandemic is entertainment. The social distance slogan and the lockdown have developed social life stress [39]. People are no more allowed to socially interact as before, no gathering, no congregations, meetings with friends and celebrities, no marriage celebrations, etc. Therefore, Social life is endangering, as entertainment is part of the catalyst that boosts an individual's physical and mental well-being. Without social interactions, such a befitting advantage is missing and have repercussions on human health. Several studies relating to COVID-19 in India has been ongoing, the dimension and perspective of the researchers differ from point to the next some are documented in [40–45, 47].

India's urban cities shocked on the 24th of April 2020 and stretched consequences to the announcement of lockdown by the government. It marked the first lockdown experienced by the country. A series of lockdown followed after at several states until the present time, depending on the severity of coronavirus cases. In India, like most of developing nations, urban cities attract people from the rural in search for greener pasture and white-cola jobs. A very significan percentage of coronavirus cases (60-70)% in India are from the densely populated areas [45, 46].

Authors use several MCDM techniques in COVID-19 research. For example, analysis of COVID-19 based on TOPSIS, spherical fuzzy information, least-square regression, Gaussian neuro-fuzzy classifier, fuzzy-rough sets, Delphi-based MCDM, interval-valued Pythagorean fuzzy linguistic TODIM, and Z-number under uncertainty have been documented [48–68]. However, the fuzzy analytic hierarchy

process (FAHP) extent analysis method has not been used to analyze the factors for stress intensity during the COVID-19 pandemic. Hence, this research presents the FAHP method (EAM) in COVID-19 stress analysis to bridge the existing gap.

3. Methodology

This section presents the techniques and methods applied in analyzing various stress due to COVID-19 pandemic. It discusses the preliminaries of a fuzz sets and numbers, FAHP, and the stepwise computational procedure.

3.1 Fuzzy Sets and Fuzzy Numbers

The fuzzy logic introduced by [69], to conclude from unclear, vague or imprecise information. In order to illustrate this knowledge in mathematics, a fuzzy set of goals with continuous membership grades has been developed. A membership function in fuzzy sets assigns each object a grade of membership in [0, 1].

For representing a fuzzy set in mathematics, a tilde "$\sim$" will be placed above a symbol that represents a fuzzy set. A triangular fuzzy number (TFN), $\widetilde{A}$ is shown in Fig. 1. A TFN is denoted simply as $(\alpha,\ \beta,\ \chi)$. The parameters $\alpha,\ \beta$, and χ denote the lowest possible value, the most likely value and the highest possible values that describe a complete fuzzy event [70]. When $\alpha = \beta = \chi$, it is a non-fuzzy number by convention [84].

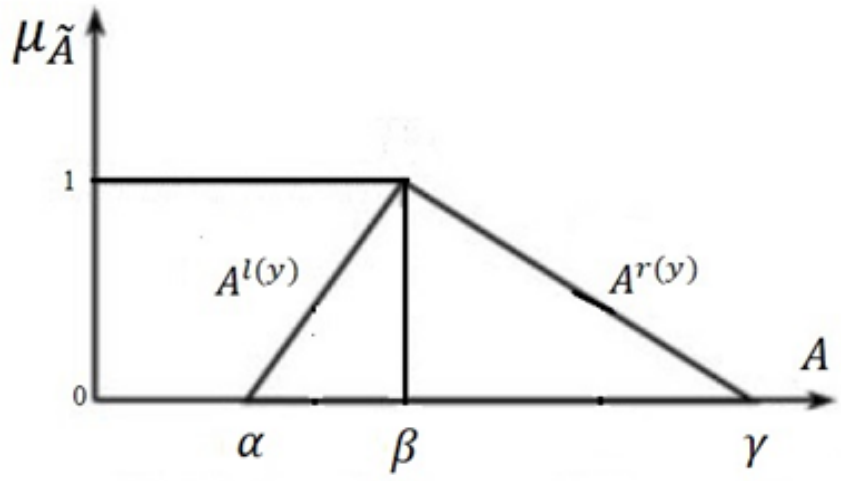

Fig. 1. Triangular fuzzy number

On the left and right-hand side, each TFN has linear representations that can describe its membership function [70], as:

$$\mu_{\tilde{A}} = \begin{cases} 0, & if\ \ x < \alpha \\ \dfrac{x-\alpha}{\beta-\alpha}, & if\ \ \alpha \leq x \leq \beta \\ \dfrac{\chi-x}{\chi-\beta}, & if\ \ \beta \leq x \leq \chi \\ 0, & if\ \ x > \chi \end{cases} \tag{1}$$

Fuzzy numbers are simple to use intuitively to represent the quality decisions of the decision-maker. A fuzzy number can always be given by its corresponding left and right representation of each

degree of membership (Kahraman et al., 2004):

$$\widetilde{A} = \left(A^{l(y)},\ A^{r(y)}\right) = \left[\alpha + (\beta - \alpha)y,\quad \chi + (\beta - \chi)y\right],\ y \in [0,1] \tag{2}$$

where $l(y)$ and $r(y)$ represented the left side and the right side of a fuzzy number $\widetilde{A}$, respectively. In detail, fuzzy numbers algebraic operations can be found in [85].

The primary developmental trend of AHP since its inception up to 2011 have been studied, and documented [71]. The AHP applications have been demonstrated in different sectors by several authors [72]- [81]. Some of its benefits and the associated limitations in expert choice are studied and presented [82]. The AHP does not consider the uncertainty situations, as such, the concept of fuzzy logic added to the AHP by Van Laarhoven and Pedrycz as an extension and called it fuzzy AHP (FAHP) [83].

3.2 FAHP Extent Analysis mMthod

In crisp AHP, the precedence of one decision variable over another is determined by a distinct scale of one to nine, whereas for FAHP, fuzzy numbers or linguistic variables are used. In reality or practical situations, decision-makers tend to represent uncertainty using triangular or trapezoidal fuzzy numbers. The solution approaches distinguish from crisp AHP because of the use of fuzzy numbers in FAHP. The EAM is the most popular method used for solving the FAHP [86]. The extent analysis approach is used to take into account the extent of each fuzzy numbers that is satisfied for the purpose or goal. In this EAM, the "extent" is measured by using a triangular or trapezoidal fuzzy number. On the basis of the fuzzy values for the extended analysis of each object, a fuzzy synthetic degree value can be obtained, which is defined as follows:

For the identification of the most affected metropolitan cities problem, let $X = \{x_1, x_2, \ldots, x_n\}$ represent the elements of the alternatives as an object set and let $U = \{u_1, u_2, \ldots, u_m\}$, represent the elements of the stress identification criteria as a goal set. According to [86] in EAM, each object is taken, and extent analysis for each goal, g_i, is performed respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$$A^1_{g_1}, A^2_{g_2}, \ldots, A^m_{g_i},\ \ i = 1, 2, \ldots, n. \tag{3}$$

Where all the $A^j_{g_i}$ are TFNs. Kahraman et al. [70] used the EAM suggested by Chang [86] in the following ways:

Step 1: The value of fuzzy synthetic extent with respect to i^{th} object is defined as:

$$F_i = \sum_{j=1}^{m} A^j_{g_i} \otimes \left(\sum_{i=1}^{n}\sum_{j=1}^{m} A^j_{g_i}\right) \tag{4}$$

To obtain $\sum_{j-1}^{m} A^m_{g_i}$, perform the fuzzy addition operation of m extent analysis values for a particular matrix such that,

$$A^j_{g_i} = \left(\sum_{j=1}^{m}\alpha_j,\ \sum_{j=1}^{m}\beta_j,\ \sum_{j=1}^{m}\chi_j\right) \tag{5}$$

and to obtain $\left(\sum_{i=1}^{n}\sum_{j=1}^{m} A_{g_i}^{j}\right)^{-1}$, perform the fuzzy addition operation of $A_{g_i}^{j}(j=1,2,\ldots,m)$ values such that

$$\sum_{i=1}^{n}\sum_{j=1}^{m} A_{g_i}^{j} = \left(\sum_{j=1}^{m}\alpha_j, \sum_{j=1}^{m}\beta_j, \sum_{j=1}^{m}\chi_j\right) \tag{6}$$

and then compute the inverse of the vector in Eq. (6) such that,

$$\left(\sum_{i=1}^{n}\sum_{j=1}^{m} A_{g_i}^{j}\right)^{-1} = \left(\frac{1}{\sum_{j=1}^{m}\alpha_j}, \frac{1}{\sum_{j=1}^{m}\beta_j}, \frac{1}{\sum_{j=1}^{m}\chi_j}\right) \tag{7}$$

Step 2: The degree of possibility of $A_2 = (\alpha_2,\ \beta_2,\ \chi_2) \geq A_1 = (\alpha_1,\ \beta_1,\ \chi_1)$ is defined as:

$$V(A_2 \geq A1) = \sup_{y \geq x}\left(\min\left(\mu_{A_{(1)}}(x),\ \mu_{A_{(2)}}(x)\right)\right) \tag{8}$$

and can be equivalently expressed as follows:

$$V(A_2 \geq A1) = hgt\left(A_2 \bigcap A_1\right) = \mu_{A_{(2)}}(d) \tag{9}$$

$$\mu_{A_{(2)}}(d) = \begin{cases} 1, & if\ \ \beta_2 \geq \beta_1, \\ 0, & if\ \ \alpha_1 \geq \chi_2, \\ \dfrac{\alpha_1 - \chi_2}{(\beta_2 - \chi_2) - (\alpha_1 - \beta_1)}, & Otherwise \end{cases} \tag{10}$$

where d is the ordinate of the highest intersection point between μ_{A_1} and μ_{A_2} . In Fig. 2, the intersection between A_1 and A_2 can be seen.

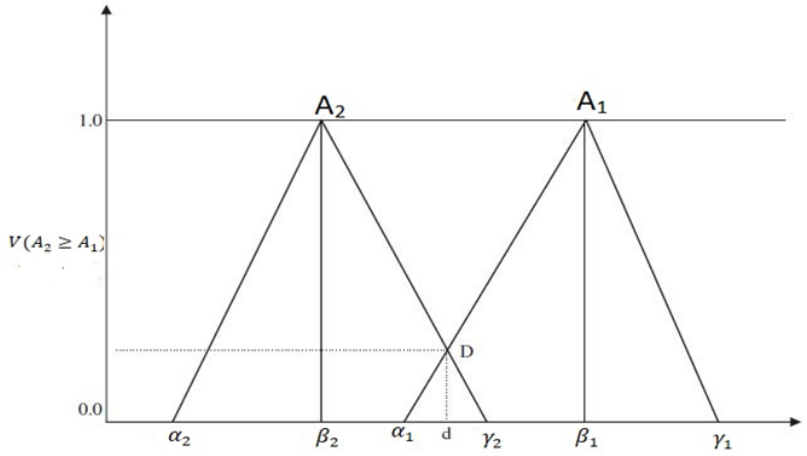

Fig. 2. Intersection between A_1 and A_2

To compare A_1 and A_2, we need both the values of $V(A_2 \geq A1)$ and $V(A_1 \geq A2)$

Step 3: The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers $A_i\ (i = 1, 2, \ldots, k)$ can be defined by

$$V\left(A \geq A1, A_2, \ldots, A_k\right) = V\left[\left(A \geq A_1\right) and\ \left(A \geq A_2\right)\ and \ldots and \left(A \geq A_k\right)\right] = \min V\left(A \geq A_i\right),\ \forall\ i\ 1, 2, \ldots, k \tag{11}$$

Assume that, $d'(A_i) = \min V(S_i \geq S_k),\ \forall k = 1, 2, \ldots, n;\ k \neq i$ Then, the weight vector is given by

$$W' = \left(d'(A_1), d'(A_2), \ldots d'(A_n)\right)^T \tag{12}$$

where $d'A_i\ (i = 1, 2, \ldots, n)$ are n elements.

Step 4: Normalizing Eq. (12), gives the normalized weight vectors as

$$W = \left(d(A_1), d(A_2), \ldots d(A_n)\right)^T \tag{13}$$

Here W is a non-fuzzy number, which gives the priority weights of one alternative over the other.

3.3 Stepwise Computational Procedure

The process to calculate the priority weights of the various decision variables and to decide the most affected metropolitan cities of India during COVID-19 time with the use of FAHP methodology can be summarized as follows:

Step 1: Make the fuzzy matrices of the criteria with the objective goal with the help of the survey method.

Step 2: Determine the fuzzy synthetic extent value of each criterion by using equation no. (4).

Step 3: Determine the degree of possibility of the superiority of each fuzzy synthetic extent value for each other.

Step 4: Decide the least possible extent to which each criterion is superior to the other.

Step 5: Determine the criteria's weight vectors using the minimum least possibility of dominance for each criterion.

Step 6: Normalize the weight vectors obtained using step (5) and determine the final weight of the main criteria's concerning the goal.

Step 7: Repeat Step 2 to 6 to decide the final weight of all the sub-criteria.

Step 8: Similarly, decide the weight and priority of each attributes concerning each sub-criteria.

Step 9: Multiply the priority weights of the attributes with the sub-criteria and determine the priority of the attributes concerning the main criteria. Step 10: Multiply the priority weights of the decision attributes with the priority weight of criteria and decide the absolute priority of the decision attributes concerning the goal.

Step 11: Decide the most affected metropolitan cities with the highest priority weight.

4. COVID-19 Stress Analysis: Application

In this global pandemic, everyone with limited resources spending as much as time with their family, and due to the rapid rise in the COVID-19 cases along with the lockdown situation in most of the Indian metropolitan cities, most of the people's are facing difficulties in their daily day to day life. This study evaluating the potential stresses feel by the people due to COVID-19 and lockdown in the metropolitan cities of India.

COVID-19 has disturbed almost every part of life, causing forced alienation and social dissociation, financial difficulty, fear of a life-threatening disorder and feelings of impudence and hopelessness. Unfortunately, the emerging global pandemic cannot be tackled by a formula or operating manual. COVID-19 hits indiscriminately to all the sections of the society, without preference for the boundaries, sex, gender, colour, ethnic group or social status. People keep themselves inside the house, shelter and live in fear and do not know the challenges and complications the day or next will bring, even whether the virus attack will continue to exist for them or a loved one. The unprecedented pandemic caused many countries to declare it an epidemic of public health by applying far-reaching measures to curtail its expansion, including travel bans, emergency management protocols and even whole country lockdown. In addition to anxiety and fear over the transmission of diseases, people faced other problems that could affect their social and emotional well-being, including restrictions to movements, adjustments to their lifestyles, living and working environments. The sudden abrupt existence of the disease and its viral capacity is likely to lead to distress and other symptoms of mental well-being. People have been specifically instructed to keep a social distance, wear a mask, and regularly sanitize their hands [93]. The concerns that heighten psychological stress are also exacerbated by problems in the medical field, a more extended quarantine, fear of infections, frustration, fatigue, insufficient supply, lack of knowledge, a monetary loss and stigma [94]. In some segments of the population, this pandemic's uncertainty may perhaps lead to mental health issues.

Here, stress that occurred due to the COVID-19 global pandemic has been taken into account to discuss the numerical illustration of the FAHP. The decision-maker wants to consider all the possible essential stresses affecting the people's of the metropolitan cities during the COVID-19. A decision-making group is formed, which consists of experts from academics and businesses. A lengthy discussion on every criterion (stresses), and attribute (metropolitan cities) has been conducted and based on intensive discussion, three prime criteria are identified. The discussion has been further prolonged to decide the thirteen sub-criteria and six potential metropolitan cities of India. The following steps have been considered to form the hierarchy:

1. Define the global pandemic situation.
2. Identify the overall objective. What the people's are facing during COVID-19?
3. Identify the criteria and sub-criteria required to achieve the overall goal of the study.
4. Identify the attributes that satisfy the aim of the study.
5. Construct the hierarchical structure of the problem by putting the goal at the first level, second level criterion, third level sub-criterions and fourth level decision attributes.

Figure 3 shows the complete hierarchical structure for identifying the most affected metropolitan cities of India during COVID-19. After constructing the hierarchical structure, the next task is to obtain the priority weights of each criterion, sub-criterion and attributes by using the FAHP approach. Priorities of one criterion or sub-criterion over another are determined using the questionnaire shown in the Appendix **A**.

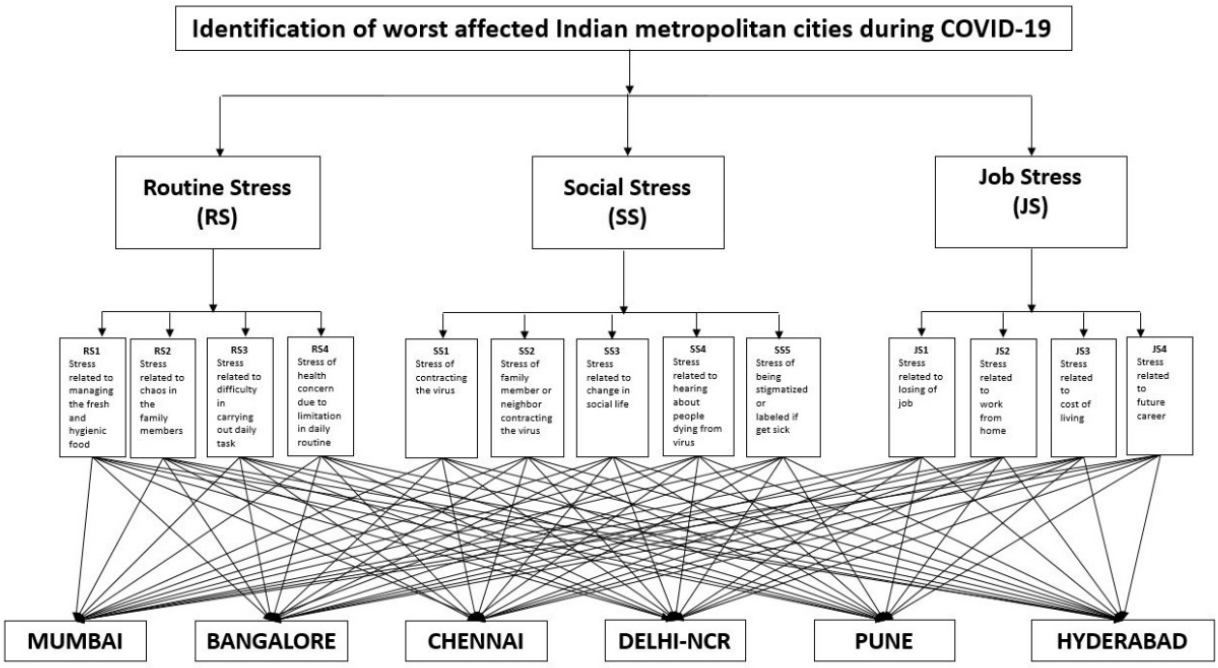

Fig. 3. Hierachial Structure of Stress During COVID-19 in Indian Metropolitant Cities

Firstly the overall objective of the problem has been identified, which is "identification of the most affected metropolitan cities of India during COVID-19". In this study, all those metropolitan cities have been considered which are experiencing a high number of COVID-19 cases. All possible types of stresses that could affect the people during the COVID-19 have been discussed with an expert in academics and other business professionals. Also, other types of stress available in the literature reviewed with the expert. This study's purpose builds by combining the main criteria and sub-criteria determined by the expert and literature.

The first three main criteria have been identified. The main criteria determined by the team of experts and from the literature were routine stress, social stress and job stress. The discussion has been further prolonged to decide the 13 sub-criteria with six potential metropolitan cities. The sub-criteria determined by the team of expert and from the literature review are: the stress of contracting the virus, the stress of family member or neighbour contracting the virus, stress related to loss of job, stress related to work from home, stress related to change in social life, stress related to cost of living, stress related to managing the fresh and hygienic food, stress related to a future career, stress related to chaos in the family members, stress related to difficulty in carrying out the daily task, stress related to hearing about people dying from the virus, the stress of being stigmatized or labelled if get sick, the stress of health concern due to the limitation in daily routine. The primary and sub-criteria have detailed below:

Routine Stress (RS): During the COVID-19 pandemic, people fear being infected with the virus/disease, leading to stress and other negative consequences. Thousands of people affected by the pandemic, with many being sick or dying due to the disease's spread. Because of the change in everyday habits, the pandemic halts sports events, gyms, social gatherings and closes restaurants, hotels, colleges, universities, and businesses, resulting in sleeping sickness among individuals. Some of the identified routine stress during COVID-19 are stress related to managing the fresh and hygienic food (RS1), stress-related to chaos in the family members (RS2), stress-related to difficulty in carrying out the daily task (RS3), and stress of health concern due to limitation in daily routine (RS4).

Social Stress (SS): This pandemic has caused severe economic and social disorders that may have

caused psychiatric impacts. With the lack of preventive treatment approaches and managing the COVID-19 infection and the accelerated pace of the transfer of viruses, all aspects of life are affected.

To restrict the dissemination of the virus, clear guidelines and new rules developed to facilitate self-isolation. The pandemic condition has overall changed the central facets of people's lives differently and dynamically. Some of the identified social stress during COVID-19 are: the stress of contracting the virus (SS1), the stress of family member or neighbour contracting the virus (SS2), stress-related to change in social life (SS3), stress-related to hearing about people dying from the virus (SS4), and stress of being stigmatized or labelled if get sick (SS5).

Job Stress (JS): How we all work has now been altered due to COVID-19. Some of us have worked physically, while others have worked remotely since mid-March or faced termination of service. No matter where we serve in a pandemic, our everyday lives have been stressed. The way you cope with this stress will affect your well-being positively or negatively. Unpredictability and inconvenience from this normal may even threatening every professional's efficacy and mental well-being. Some of the identified job stress during COVID-19 are stress related to loss of job (JS1), stress related to work from home (JS2), stress-related to cost of living (JS3), and stress-related to future career (JS4).

5. Reuslt Analysis and Discussion

After identifying the main stress criteria and its sub-criteria and six metropolitan cities, the hierarchy of identifying India's most affected metropolitan cities during COVID-19 is structured. Fig. 3 shows the structuring of identifying the most affected metropolitan cities during the COVID-19 hierarchy of four levels. The top-level of the hierarchy represents the ultimate goal of the problem: identifying the most affected metropolitan cities during COVID-19 times. The second level of the hierarchy is grouped under three criteria: routine stress, social stress, and job stress. At the third level, these main criteria decomposed into various sub-criteria that show the various types of stress felt by India's people. Finally, the bottom level of the hierarchy represents the six metropolitan cities of India.

After constructing the hierarchical structure, different priority weights of each main criteria, sub-criteria, and attributes have been calculated using the FAHP approach. The help of the questionnaire achieved the comparison of the importance of one main criteria, sub-criteria and attributes over another. The existing research group and the expertise of the decision-maker used to determine the preference for one criterion over another. Then, the decision-maker compared the main criterion; then, the decision-maker compared the sub-criteria about the main criteria. The decision-maker finally compared the metropolitan cities with each subcriterion.

In order to compare the pair's, the decision-maker used the linguistic variables, which have been transformed into the corresponding triangular fuzzy numbers, as given in Table 1. After the pair-wise comparison matrices constructed, the accuracy of the evaluation in pairs for each matrix verified with the consistency index [95]. The consistency ratio found below 0.10 for each matrix of pair-wise comparison. Therefore it can be assumed that pairs of decisions are suitable for all matrices. The priority weights have been determined using the FAHP method for each main criterion, sub-criterion, and attributes. As an example, the priority weights determination of the main criteria is discussed below in detail. The linguistic variables have been transformed to fuzzy triangular numbers with the values of Table 1.

For Table 3, the fuzzy evaluation matrix in Table 2 is used to transformed the linguistic variable to a TFN for evaluating the main purpose.

The fuzzy "synthetic extent" values of the criteria have been first determined by using the Eq. (4) to identify priority weights for the main criteria. The fuzzy 'synthetic extent' value of the three main criteria's is denoted by F_{RS}, F_{SS}, F_{JS}.

Table 1
Linguistic Variable with TFN

Linguistic Variable	Triangular fuzzy number
Equally preferred	(1,1,1)
Weakly preferred	(2/3,1,3/2)
Fairly strongly preferred	(3/2,2,5/2)
Very strongly preferred	(5/2,3,7/2)
Absolutely preferred	(7/2,4,9/2)

Table 2
Comparison matrix for main criteria using linguistic variables

Strees Types	**Routine Stress**	**Social Stress**	**Job Stress**
Routine Stress	EP	1/FSP	VSP
Social Stress	FSP	EP	WP
Job Stress	1/VSP	1/WP	EP

Table 3
Comparison matrix for main criteria using TFN

Strees Types	**Routine Stress**	**Social Stress**	**Job Stress**
Routine Stress	(1,1,1)	(2/5,1/2,2/3)	(5/2,3,7/2)
Social Stress	(3/2,2,5/2)	(1,1,1)	(2/3,1,3/2)
Job Stress	(2/7,1/3,2/5)	(2/3,1,3/2)	(1,1,1)

$$F_{RS} = (3.9, 4.5, 5.16) \otimes \left(\frac{1}{13.16}, \frac{1}{10.83}, \frac{1}{13.16}\right) = (0.29, 0.42, 0.57) \tag{14}$$

$$F_{SS} = (3.16, 4, 5) \otimes \left(\frac{1}{13.16}, \frac{1}{10.83}, \frac{1}{13.16}\right) = (0.24, 0.37, 0.55) \tag{15}$$

$$F_{JS} = (3.16, 4, 5) \otimes \left(\frac{1}{13.16}, \frac{1}{10.83}, \frac{1}{13.16}\right) = (0.15, 0.22, 0.33) \tag{16}$$

The degree of possibility of over $F_i(i \neq j)$ has been determined by using Eqs. (9) & (10), with the help of the fuzzy "synthetic extent" value given in Eqns. (14) - (16).

$$V(F_{RS} \geq F_{SS}) = 1,\ V(F_{RS} \geq F_{JS}) = 1,\ V(F_{SS} \geq F_{RS}) = \frac{(0.29 - 0.55)}{(0.37 - 0.55) - (0.42 - 0.29)} = 0.84$$

$$V(F_{SS} \geq F_{JS}) = 1,\ V(F_{JS} \geq F_{RS}) = \frac{(0.29 - 0.33)}{(0.22 - 0.33) - (0.42 - 0.29)} = 0.16$$

$$V(F_{JS} \geq F_{RS}) = \frac{(0.24 - 0.33)}{(0.22 - 0.33) - (0.37 - 0.24)} = 0.37$$

By using the Eq. (12), the minimum degree of possibility, has been obtained as:

$$d'(RS) = \min(1,1) = 1,\ d'(SS) = \min(0.84,1) = 0.84,\ d'(RS) = \min(0.16,0.375) = 0.16$$

Therefore, using the minimum degree of possibility, the weight vector for the main criteria's Routine Stress, Social Stress, and Job stress was obtained as $W' = (0.16, 0.84, 1)$. After the normalization process, the local weight vector of the three main criteria found to be $W = (0.11, 0.24, 0.65)^T$. Based on the obtained weight, we can conclude that the most critical criteria for identifying the most affected metropolitan cities during COVID-19 are job stress criteria because they have the highest priority weight, followed by social stress and routine stress. The EAM proposed by Chang [86] has some limitations pointed out by Wang et al. [87]. They pointed out that the normalization formula (7) is wrong. The correct normalization formula for a set of triangular fuzzy weights should be as follows:

$$F_i = \frac{RS_i}{\sum_{j=1}^{n} RS_j} = \left(\frac{\sum_{j=1}^{n} \alpha_{ij}}{\sum_{j=1}^{n} \alpha_{ij} + \sum_{k=1,k\neq i}^{n} \sum_{i=1}^{n} \beta_{kj}}, \frac{\sum_{j=1}^{n} \beta_{ij}}{\sum_{k=1}^{n} \sum_{j=1}^{n} m_{kj}}, \frac{\sum_{j=1}^{n} \chi_{ij}}{\sum_{j=1}^{n} \chi_{ij} + \sum_{k=1,k\neq i}^{n} \alpha_{kj}} \right) \tag{17}$$

To verify the score of modified EAM (MEAM), it must satisfied the below three condition of feasibility:

$$w_i^{\alpha} + \sum_{j=1,j\neq i}^{n} w_j^{\chi} \geq 1; \quad i = 1,2,\ldots,n \tag{18}$$

$$\sum_{i=1}^{n} w_i^{\beta} = 1; \tag{19}$$

$$w_i^{\chi} + \sum_{j=1,j\neq i}^{n} w_j^{\alpha} \leq 1; \quad i = 1,2,\ldots,n. \tag{20}$$

After satisfying the condition from eq. (18) to (20), the mathematical programming model has been constructed, which derives the priorities of the triangular fuzzy comparison matrix through the solution of the following constrained nonlinear optimization model:

$$\begin{aligned} &\min\ J = \sum_{j=1,j\neq i}^{n} \left((\ln w_i^{\alpha} - \ln w_j^{\chi} - \ln \alpha_{ij})^2 + (\ln w_i^{\beta} - \ln w_j^{\beta} - \ln \beta_{ij})^2 + (\ln w_i^{\chi} - \ln w_j^{\alpha} - \ln \chi_{ij})^2 \right) \\ &Subject\ to: \\ &w_i^{\alpha} + \sum_{j=1,j\neq i}^{n} w_j^{\chi} \geq 1; \quad i = 1,2,\ldots,n; \\ &\sum_{i=1}^{n} w_i^{\beta} = 1; \\ &w_i^{\chi} + \sum_{j=1,j\neq i}^{n} w_j^{\alpha} \leq 1; \quad i = 1,2,\ldots,n. \\ &\sum_{i=1}^{n} (w_i^{\alpha} + w_i^{\chi}) = 2; \\ &w_i^{\chi} \geq w_i^{\beta} \geq w_i^{\alpha} \end{aligned} \tag{21}$$

The optimum solution to the above model formed the normalized triangular fuzzy weights $\widetilde{w} = (w_i^{\chi},\ w_i^{\beta},\ w_i^{\alpha})\quad i = 1,2,\ldots,n$. After using the above model, the new weight vector for the main criteria- Routine Stress, Social Stress, and Job Stress was found to be $w = (0.19, 0.34, 0.47)^T$. Job

Stress obtained the highest priority weightage, followed by Social Stress and Routine Stress. The same calculations have been applied to the other pairwise comparison matrices, and the priority weights of each main criteria, sub-criteria and attributes have been calculated. The priority weights calculated by using EAM and MEAM for each main criteria, sub-criteria, and features are given in Table 4-6. In Table 4, the weightage obtained by using the EAM, the stress of health concern due to the limitation in daily routine got the highest weightage among the sub-criteria of routine stress followed by the stress related to managing the fresh, hygienic food. Similarly, for MEAM, stress associated with managing the fresh and hygienic food got the highest weightage, followed by stress related to the chaos in the family members and stress of health due to limitation in daily routine.

In Table 5, among the sub-criteria of social stress, solved by EAM and MEAM, the stress of contracting the virus got the highest weightage followed by the stress of family member or neighbour contracting the virus. And among the sub-criteria of job stress, given in Table 6, stress related to work from home got the highest weightage followed by the stress related to future career and stress related to job loss when solved by EAM and MEAM, respectively.

The next task is to determine the overall score of each considered metropolitan city and choose the worst affected metropolitan cities during COVID-19 based on the different types of stresses. Assessing the priority weights of attributes required the priority weights of main criteria and sub-criteria to be combined. Table 7-9, the priority weight at the top of the column has been multiplied in each column of the matrix and added for each row. In Table 7, the priority weights of the sub-criteria concerning metropolitan cities have been calculated by using EAM and MEAM. Based on the different sub-criteria of routine stress and the obtained scores as shown in Table 7, Mumbai is the most affected city during COVID-19 times, followed by Chennai and Pune.

According to population density and the nation's economic output, India's three most significant metropolitan areas are Mumbai, Chennai, and Pune. As of June 2021, Maharashtra was the state with the most number of COVID cases. Even though the illness spreads over the whole state, Mumbai and Pune City account for almost 50% of the COVID-19 verified cases [88]. At that time, there were many more COVID-19 instances than in any other city in the nation. Metropolitan areas are victims of population density, putting residents at risk from close quarters and congested public transportation. High density has also been seen as an issue in cities that have been severely impacted, such as Delhi, Pune, Chennai, Mumbai, Bengaluru, etc. Living in crowded urban areas poses several post-coronavirus dangers, which have become more prevalent due to the epidemic. In these enormous towns, social distance is quite difficult to achieve [89]. To stop the spread of the coronavirus in these slums, narrow alleyways, tiny, cramped dwellings that are tightly connected, more than five people living in a small house, sharing bathrooms, exposed sewers, and long lines to get water make it practically impossible. The COVID-19 report highlights the urgent need to improve towns' capacity for self-governance by highlighting their limited ability to provide infrastructure and services and manage catastrophes [90].

For the majority of humanity, the COVID-19 pandemic is proving to be a significant stressor. It is quite likely that mental health is deteriorating given the massive number of infections in India, the rising death toll, and the harsh measures used by the government to stop the virus' spread, particularly the quarantine. To the best of our understanding, the psychological effect and mental health of the general population residing in India during the COVID-19 pandemic have been poorly impacted.

Individuals reported how much they felt their everyday lives were altered due to the present crisis, including if they had to postpone or cancel plans for major events, make significant changes to work or study or take any trips. Pets have more to give than simply a slobbery hello or a jovial nuzzle during the COVID-19 pandemic. According to Johnson and Volsche [91], pets offer a variety of health benefits, including decreased blood pressure; lowered cholesterol levels; decreased triglycerides. The type of fat in your body; reduced feelings of loneliness; increased opportunities for exercise and outdoor activities; improved opportunities for social connection. Pet owners during COVID are looking to their

animals for much more than simple friendship and better health as they struggle with issues including unemployment, health troubles, and social isolation. It has been found that owning a pet can help alleviate symptoms of sadness and anxiety and even provide a sense of optimism for certain people.

The same calculations have been applied to the other sub-criteria of social stress. Job stress and the priority weights of the attributes concerning metropolitan cities have been calculated. The priority weights for social and job stress sub-criteria are given in Tables 8 and 9. Based on the different sub-criteria of social stress and the scores shown in Table 8, Bengaluru is the most affected city during COVID-19 times, followed by Mumbai and Pune. And based on the different sub-criteria of job stress and the scores as shown in Table 9, Chennai is the most affected city during COVID-19 times, followed by Bengaluru and Hyderabad.

In the end, the priority weights of each of the considered metropolitan cities concerning the main criteria routine, social and job stress have been determined. The priority weights of the metropolitan cities are given in Table 10. To shorten the method for identifying the worst affected metropolitan cities during COVID-19 in India, MS-Excel is utilized in calculating the priority weightage of all the parameters based on the questionnaire formed. After using the FAHP technique, the priority weights obtained using EAM for each attribute are found to be $(0.212, 0.199, 0.184, 0.151, 0.106, 0.148)$. Based on the EAM stress analysis, it can be seen that the worst affected metropolitan cities during COVID-19 times are $Mumbai > Bengaluru > Chennai > Delhi-NCR > Hyderabad > Pune.$ While the priority weights obtained using MEAM for each attributes are $(0.184, 0.116, 0.179, 0.150, 0.193, 0.178)$. Based on the MEAM stress analysis, it can be seen that the worst affected metropolitan cities during COVID-19 times are $Pune > Mumbai > Chennai > Hyderabad > Delhi - NCR > Bengaluru$. Based on the global rankings, Mumbai is relatively the most important place during COVID-19 time. People in these cities experiencing more stress as compared to other cities because of two facets of this pandemic. Everyone's worried about this pandemic; they may be infected with the virus. The other fear is due to lockdown that brings a dramatic break from our normal lifestyle. The routine disorder may cause people to feel anxiety, especially the professional's workers who are constantly working during lockdown may experience fatigue and animosity. Many people fear that they will lose their jobs, other people have wage decreases and are worried and unsure of their prospects in the present situation. The key to combating stress is understanding why the lockdown is important, retaining a positively functioning everyday life, and maintaining a physical distance digitally and emotionally from friends and relatives.

6. Conclusion and Recommendations

Living in the COVID-19 pandemic is like the worst of all life's nightmares. The main objective of this study was to investigate the psychological suffering among the various metropolitan cities of India. Urban cities are regarded as the most popular Indian towns with a vast population and are responsible for the COVID-19 surge in the region. Gathering, congregations, and public celebrations during festivals pose a significant threat of virus propagation and can result in disruption to the appreciable gain of suppressing the chain of COVID-19 spread in metropolitan cities. Three cities – Delhi, Mumbai and Chennai – were the major during India's first twelve months of the COVID-19 surge. But during September, a massive spike in the situation in Bengaluru led the southern town to second place ahead of Mumbai and Chennai. Although only these four metropolitan cities can be traced to one in every seven cases in the country, they have become even worse in terms of death – one in every five deaths in India has occurred in those cities. State governments have implemented various strategies to control the pandemic, including lockdown and shutting down their boundaries.

The ongoing COVID-19 pandemic has created a situation in which the community suffers from a fear of stress, drug addiction, solitude and domestic violence. Schools and colleges were closed for a

year, and the likelihood of a child abuse crisis is very much possible. In the current time, it is difficult to forecast the results of the current COVID-19 pandemic, but we should benefit from the previous experience of pandemics to find our best ways to take steps in the present times. Most researchers have identified adverse psychic impacts, including post-traumatic perceived stress, frustration and vengeance. Extended quarantine, fever, disability, irritation, boring, insufficiencies in resources, lack of awareness, economic damage and stigma were all identified as the stressors. Scientists have also documented the long-term psychosocial effects of such pandemics. This wide-ranging reporting on mental health conditions requires an in-depth strategy and initiative to alleviate mental and emotional problems during the COVID-19 time.

The continuous social news concerning the COVID-19 pandemic causes typical over-reactive psychological behaviour among the public in the current pandemic situation. The news chains are packed with personal incidents and stories from health professionals, victims, suspects and family members who are confronted with community stigma and discrimination. There is an increase in information from all media about the spread of the virus and its effects. We are reminded of the dissemination of viruses by television, smartphone alerts, WhatsApp messages, and other social media updates from morning tonight. The emotions and worries are encompassing into stress due to the situation created by social media. During this period, various stressors were causing stress, such as quarantine, wage cuts, unemployment, insecurity, fear, harassment, assault, etc., among the population. Although quarantine is a vital prevention measure for curbing the spread of infectious diseases, several studies have shown that quarantine negatively affects people [96]. Containment at home is little benefit to many people, especially those in coercive relationships. According to figures released by the National Commission of Women, the lockdown exacerbated the plight of sexual assault.

This study identified and analyzed various factors responsible for these stresses. It uses the FAHP and extent analysis and the modeified extent analysis methods to rank the priorities of each main and sub-criteria. A structural hierarchy of the scenario is designed. A questionnaire is used in comparing major stress factors and the sub-criteria alongside their attributes on the hierarchy structure. The study found that using the extent analysis method, Mumbai is the worst affected city, followed by Bengaluru, Chennai, Delhi-NCR, and Hyderabad. While using the modified method, the most affected area found to be Pune, followed by Mumbai, Chennai, Hyderabad, Delhi-NRC and Bengaluru. It further discovered that routine stress-related is the most critical factor in identifying the most affected metropolitan city, followed by social and job-related stresses.

In addressing the contributory causes of stress, an instant discussion could be needed on preventive factors that help promote healthy mental health within the population. In the current situation, in which physical fitness is the primary concern due to the virus transmission, the subsidiary problems and references must also be monitored and prevented at individual, family and community levels. Following are the recommendation to deal with stress around the pandemic and to hold us in a good spirit:

- A healthy lifestyle will alter thinking and emotions positively. Return to the basics: eating nutritious food, exercising (e.g. walking, stretching, biking or cycling), sleeping, doing activities you want. There are many ways to build and maintain a stable state of life, even though there is self-quarantining or operating from home.

- It is usual for us to worry about all the ordinary things that we cannot do during transition. Make a deliberate change to concentrate on the things we can still enjoy or do better while we are home more often. There could be some suggestions:
  - Continue your studies and learning
  - Read a novel or book

  - Experience a new thing (e.g., try to cook a new dish, learn to play utensils, learn different types of languages, and learn gardening).

- The love and treatment received from others help one to tackle the complexities. Spending time with family and friends will give a feeling of warmth and security. Speaking with others about our worries, feelings, and intentions will also help us find valuable ways to learn about a challenging situation or to cope with it.

- Remember that physical distancing does not have to mean a social breakup. Also, there are different ways we can use social media to stay linked and connected with everyone remotely. For instance, a small call, text or video call with friends and family members, sharing some nippy and easy food recipes, exercising or yoga together over video conferencing, or joining an online discussion forum or group.

- It is imperative to show attention to relatives, families, or disabled persons in our communities at periods like these. It could create a sense of optimism, intent and significance. Some of these could be:
  - Send a note of motivation or support to someone you care about.
  - Deliver a meal to the needy in the neighbourhood.
  - Try to donate something to the needy.

In future work, several multi-criteria decision-making techniques such as Fuzzy-TOPSIS, fuzzy-VIKOR, fuzzy-CoCoSo, among others, could be used to identify and analyze more factors to compare the results and techniques efficiency. This study will help government, policy-makers, philanthropist, humanitarian and relief organizations concentrate in the worst affected metropolitan cities while given aids and donations towards the betterment of people living standards.

Conflict of interest

The authors declare no conflicts of interest.

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Appendix A

The questionnaire form is used to compare criteria, sub-criteria and attributes as given in hierarchical structure. Some of the questions are given below:

1. How significant is routine stress when it is compared with social stress?
2. How significant is routine stress when it is compared with job stress?
3. How significant is social stress when it is compared with job stress?
4. How significant is routine stress when it is compared with social stress?
5. How significant is stress related to managing fresh and hygienic food compared to stress-related chaos in the family members?
6. How significant is stress related to managing fresh and hygienic food compared to stress-related to difficulty carrying out a daily task?
7. How significant is stress related to managing fresh and hygienic food compared to the stress of health concern due to daily routine limitations?

8. How significant is stress related to chaos in the family members compared with stress related to difficulty carrying out a daily task?
9. How significant is stress related to chaos in the family members compared with the stress of health concern due to limitation in daily routine?
10. How significant is stress related to difficulty in carrying out daily tasks compared to the stress of health concern due to daily routine limitations?

Table 4
Priority weights for Routine Stress Hierarchy

	Stage 1 Priority		**Stage 2 Priority**			**Stage 3 Priority**		
Stage 1 Criteria	EAM	MEAM	**Stage 2 Criteria**	EAM	MEAM	**Stage 3 Criteria**	EAM	MEAM
Routine Stress (RS)	0.11	0.19	RS_1	0.32	0.27	Mumbai	0.05	0.05
						Bengaluru	0	0.27
						Chennai	0.20	0.15
						Delhi-NRC	0.29	0.23
						Pune	0.46	0.17
						Hyderabad	0	0.13
			RS_2	0.15	0.25	Mumbai	0.03	0.03
						Bengaluru	0.02	0.14
						Chennai	0.37	0.12
						Delhi-NRC	0	0.29
						Pune	0.24	0.13
						Hyderabad	0.34	0.29
			RS_3	0.20	0.23	Mumbai	1	0.19
						Bengaluru	0	0.10
						Chennai	0	0.21
						Delhi-NRC	0	0.05
						Pune	0	0.20
						Hyderabad	0	0.25
			RS_4	0.33	0.25	Mumbai	0.31	0.21
						Bengaluru	0.26	0.25
						Chennai	0.31	0.12
						Delhi-NRC	0	0.13
						Pune	0.08	0.07
						Hyderabad	0.04	0.22

Table 5
Priority weights for Social Stress Hierarchy

	Stage 1 Priority			**Stage 2 Priority**			**Stage 3 Priority**	
Stage 1 Criteria	EAM	MEAM	**Stage 2 Criteria**	EAM	MEAM	**Stage 3 Criteria**	EAM	MEAM
Social Stress (SS)	0.24	0.34	SS_1	0.12	0.22	Mumbai	0	0.22
						Bengaluru	0.40	0.12
						Chennai	0.25	0.13
						Delhi-NRC	0.07	0.21
						Pune	0.03	0.18
						Hyderabad	0.25	0.14
			SS_2	0.28	0.21	Mumbai	0.14	0.19
						Bengaluru	0.38	0.15
						Chennai	0.15	0.24
						Delhi-NRC	0	0.09
						Pune	0.29	0.06
						Hyderabad	0.04	0.27
			SS_3	0.05	0.19	Mumbai	0.23	0.12
						Bengaluru	0	0.23
						Chennai	0.44	0.18
						Delhi-NRC	0.08	0.16
						Pune	0.06	0.12
						Hyderabad	0.19	0.19
			SS_4	0.20	0.20	Mumbai	0.30	0.21
						Bengaluru	0	0.09
						Chennai	0.26	0.13
						Delhi-NRC	0.11	0.03
						Pune	0	0.39
						Hyderabad	0.33	0.15
			SS_5	0.35	0.18	Mumbai	0.22	0.08
						Bengaluru	0.25	0.28
						Chennai	0	0.23
						Delhi-NRC	0.29	0.21
						Pune	0.24	0.14
						Hyderabad	0	0.06

Table 6
Priority weights for Job Stress Hierarchy

	Stage 1 Priority			Stage 2 Priority			Stage 3 Priority	
Stage 1 Criteria	EAM	MEAM	**Stage 2 Criteria**	EAM	MEAM	**Stage 3 Criteria**	EAM	MEAM
Job Stress (JS)	0.65	0.47	JS_1	0.17	0.23	Mumbai	0.43	0.24
						Bengaluru	0.16	0.08
						Chennai	0	0.27
						Delhi-NRC	0.20	0.05
						Pune	0.21	0.18
						Hyderabad	0	0.18
			JS_2	0.37	0.41	Mumbai	0.19	0.09
						Bengaluru	0.26	0.07
						Chennai	0.30	0.11
						Delhi-NRC	0	0.25
						Pune	0.07	0.22
						Hyderabad	0.18	0.26
			JS_3	0.20	0.18	Mumbai	0.15	0.13
						Bengaluru	0.08	0.01
						Chennai	0.13	0.11
						Delhi-NRC	0.34	0.21
						Pune	0.01	0.22
						Hyderabad	0.29	0.26
			JS_4	0.26	0.18	Mumbai	0.11	0.13
						Bengaluru	0.24	0.16
						Chennai	0.21	0.19
						Delhi-NRC	0.25	0.16
						Pune	0	0.14
						Hyderabad	0.19	0.22

Table 7
Priority Weight Matrix concerning routine stress

Sub-Criteria	RS_1		RS_2		RS_3		RS_4		**Alternative Priority Weight**	
Methods	EAM	MEAM	EAM	MEAM	EAM	MEAM	EAM	MEAM	EAM	MEAM
Weight	0.32	0.27	0.15	0.25	0.20	0.23	0.33	0.25		
Mumbai	0.05	0.05	0.03	0.03	1	0.19	0.31	0.21	0.323	0.117
Bengaluru	0	0.27	0.02	0.14	0	0.10	0.26	0.25	0.089	0.193
Chennai	0.2	0.15	0.37	0.12	0	0.21	0.31	0.12	0.222	0.149
Delhi-NRC	0.29	0.23	0	0.29	0	0.05	0	0.13	0.093	0.179
Pune	0.46	0.17	0.24	0.13	0	0.20	0.08	0.07	0.210	0.142
Hyderabad	0	0.13	0.34	0.29	0	0.25	0.04	0.22	0.064	0.220

Table 8
Priority Weight Matrix concerning social stress

Sub-Criteria	SS_1		SS_2		SS_3		SS_4		SS_5		**Alternative Priority Weight**	
Methods	EAM	MEAM	EAM	MEAM	EAM	MEAM	EAM	MEAM	EAM	MEAM	EAM	MEAM
Weight	0.12	0.22	0.28	0.21	0.05	0.19	0.2	0.20	0.35	0.18		
Mumbai	0	0.22	0.14	0.19	0.23	0.12	0.3	0.21	0.22	0.08	0.188	0.168
Bengaluru	0.4	0.12	0.38	0.15	0	0.23	0	0.09	0.25	0.28	0.242	0.170
Chennai	0.25	0.13	0.15	0.24	0.44	0.18	0.26	0.13	0	0.23	0.146	0.181
Delhi-NRC	0.07	0.21	0	0.09	0.08	0.16	0.11	0.03	0.29	0.21	0.136	0.139
Pune	0.03	0.18	0.29	0.06	0.06	0.12	0	0.39	0.24	0.14	0.172	0.178
Hyderabad	0.25	0.14	0.04	0.27	0.19	0.19	0.33	0.15	0	0.06	0.117	0.164

Table 9
Priority Weight Matrix concerning job stress

Sub-Criteria	JS_1		JS_2		JS_3		JS_4		**Alternative Priority Weight**	
Methods	EAM	MEAM	EAM	MEAM	EAM	MEAM	EAM	MEAM	EAM	MEAM
Weight	0.17	0.23	0.37	0.41	0.20	0.18	0.26	0.18		
Mumbai	0.43	0.24	0.19	0.09	0.15	0.13	0.11	0.13	0.202	0.139
Bengaluru	0.16	0.08	0.26	0.07	0.08	0.07	0.24	0.16	0.202	0.089
Chennai	0	0.27	0.3	0.11	0.13	0.11	0.21	0.19	0.192	0.161
Delhi-NRC	0.2	0.05	0	0.25	0.34	0.21	0.25	0.16	0.167	0.181
Pune	0.21	0.18	0.07	0.22	0.01	0.22	0	0.14	0.064	0.196
Hyderabad	0	0.18	0.18	0.26	0.29	0.26	0.19	0.22	0.174	0.234

Table 10
Main attributes concerning goal

Sub-Criteria	RS		SS		JS		**Alternative Priority Weight**	
Methods	EAM	MEAM	EAM	MEAM	EAM	MEAM	EAM	MEAM
Weight	0.11	0.19	0.24	0.34	0.65	0.47		
Mumbai	0.323	0.117	0.188	0.168	0.202	0.139	0.212	0.184
Bengaluru	0.089	0.193	0.242	0.170	0.202	0.089	0.199	0.116
Chennai	0.222	0.149	0.146	0.181	0.192	0.161	0.184	0.179
Delhi-NRC	0.093	0.179	0.136	0.139	0.167	0.181	0.151	0.150
Pune	0.210	0.142	0.172	0.178	0.064	0.196	0.106	0.193
Hyderabad	0.064	0.220	0.117	0.164	0.174	0.234	0.148	0.178