

AI for Real-Time Disaster Management

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Abstract: *Purpose: Artificial intelligence (AI) technology is an innovative approach that can be developed to enable rapid and effective action in disaster management activities for disaster-affected countries. This study aimed to reveal the role and application methods of artificial intelligence systems in disaster management processes (pre- and post-disaster). It also discussed the adequacy and effectiveness of these roles and methods, especially in Türkiye Study design/methodology/approach: A systematic literature review on the use of AI systems in disaster management was conducted and an inventory on the use of AI in disaster management was developed. This inventory was prepared by considering earthquakes, floods, fires, tsunamis and hurricanes as data sets. These datasets are categorized, compared and evaluated in terms of their application locations, time and duration of use (pre- or post-disaster), developed AI systems and their purposes, methods, scale and final products. Findings: The study revealed that the use of AI systems will be effective in minimizing logistical challenges in the intervention and management of natural disasters. Additionally, the systematic review has observed a frequent focus on earthquakes in AI applications related to disasters, and it was determined that research on the prevention and process management of other potential disasters is limited. Originality/value: This study is highly effective in revealing the role of AI systems in disaster management and identifying their utilization in Türkiye. It is expected to provide preliminary knowledge for future studies by focusing on artificial intelligence studies in disaster management in a holistic manner.*

Keywords: *Artificial intelligence*

I. INTRODUCTION

Historical disasters have become a significant risk factor for humanity. Destructive consequences caused by both natural processes and human activities are observed on a global scale. Intensive urbanization and nature interventions result in disasters causing devastating damages and significant socioeconomic losses, with a trend of increasing frequency (Hoeppe, 2016). The absence of a universally agreed-upon or standardized definition of disaster highlights the divergent perspectives and contextual variations regarding the subject. Diverse disciplines, policymakers, and practitioners within different regions have offered distinct definitions that are molded to their specific motivations and challenges (Linardos et al., 2022). These definitions may emphasize various aspects of disasters, including their environmental, social, economic, or political dimensions, resulting in a disjointed interpretation environment. According to United Nations Office for Disaster Risk Reduction's (UNISDR) terminology, a disaster is defined as a "serious disruption in the functioning of a community or society, including human, material, economic, or environmental impacts that surpass the affected community or society's ability to cope with their own resources" (UNISDR, 2009). Based on the terminology of The International Disaster Database (EM-DAT), disasters are classified into two main groups: natural disasters and technological disasters. The absence of a single disaster definition emphasizes the complex and evolving nature of this field of study. This situation prompts researchers to adopt an approach specific to understanding, mitigating and responding to complex events due to the nature of disaster definition. The absence of a lucid disaster definition and the escalating destructive effects of disasters keep the issues of disaster management and disaster response relevant. Disaster management aims to effectively manage the processes of communities, institutions and governments to minimise the damage that disasters may cause, to ensure the safety of people by preparing before the disaster, to intervene after the disaster and to improve all damaged situations (Altay and



Green, 2006). The process includes a series of preventive, preparedness, response and recovery steps that are usually implemented in four stages (Khajwal and Noshadravan, 2021; Van Wassenhove, 2006; Altay and Green, 2006). These steps depend on activities such as emergency relief and response, emergency planning, emergency rescue and medical care, shelter opening and management, material distribution and damage assessment (Linardos et al., 2022; UNISDR, 2009). Time is the most important issue while carrying out the activities. Therefore, disaster management processes should focus on not only highly accurate techniques, but also fast-performing and optimized methods. The use of artificial intelligence to analyze big data to quickly obtain useful and reliable information is becoming increasingly popular to support effective decisionmaking in disaster management (Eskandarpour and Khodaei 2017; Velev et al. 2018; Sun et al., 2020)

The adverse impacts of disasters pose challenges to disaster response by managers facing increasingly limited resources and a depleted workforce. Such challenges force local authorities to reassess their disaster management policies (Sun et al., 2020). In an era where the importance of technological developments is increasing day by day, utilizing the power of artificial intelligence (AI) has emerged as a promising development in disaster management. AI, which has the capacity to realize radical changes in pre- and postdisaster processes, offers the potential for rapid and effective intervention to local and regional authorities in disaster-affected areas. AI has become an important tool in disaster management with various techniques used in data analysis, forecasting, decision support systems and emergency response. Among the main application areas of these tools are disasters such as hurricanes, earthquakes, floods, forest fires and landslides. However, in recent years, AI developments have also utilized in the management of events such as the refugee crisis, which is one of the leading disasters caused by human intervention (Drakaki and Tzionas, 2021; Drakaki et al., 2018; Younes et al., 2022; Abikova, 2020; Weber et al., 2023)

II. METHOD

2.1. Setting and participants

When the study flow was examined, the main processes in disaster management were discussed in the first step and the place of artificial intelligence in the disaster management process was defined. In the second step, the background of artificial intelligence systems and their usage areas in disaster management were focused. Then, the existing studies in the literature were reviewed in order to make evaluations on their use in Turkey. The review requires a systematic process to be followed. A systematic literature review is a systematic examination of all studies that can be related to a given topic in order to answer a specific problem (Kraus et al., 2020). This method involves a gradual literature review, filtering the results of the review, critical analysis of the studies, assessing the quality and level of evidence, interpretive analysis of the findings, and reporting for the intended audiences (Syender, 2019; Yıldız, 2022). In this context, a systematic literature review was conducted in the third step of the study. In the fourth step, bibliometric analysis was conducted to reveal the relationships between process monitoring and the studies conducted in the field. Bibliometrics is the numerical analysis of publications produced by individuals or institutions in a specific field, in a specific period and in a specific region, and the relationships between these publications (Donthu et al., 2021). The bibliometric analysis data on disaster management and artificial intelligence were obtained from the Web of Science (WoS) database. VOSviewer program was used to visualize the data. VOSviewer is an open source software developed in recent years to create, visualize and explore maps based on network data (Van Eck & Waltman, 2022; Arslan, 2022). Through this analysis management, the number of related studies was revealed and the connection of these numbers with AI concepts was determined..

2.2. Background of Disaster Management and AI Systems

From the past to the present, there have various disasters that have caused significant losses worldwide, and these disasters are still continuing. Since most disasters occur in a very short period of time, rapid planning, decision-making, and implementation of the right practices are critical for a successful and effective disaster management process. In general, the disaster management process has a complex and dynamic structure..



Artificial intelligence (AI) is defined as the ability of computer systems to learn, infer what it learns, respond to environmental stimuli and perform human-like cognitive functions. The term "artificial intelligence" (AI), introduced by Prof. John McCarthy at a conference held at Dartmouth College in New Hampshire in 1956, gained prominence with Alan Turing's article "Can machines think?". Initially, the primary objective of research in artificial intelligence was to create machines with the ability to learn new things, perceive their environment, and exhibit intelligent behavior, similar to a human being. Herbert Simon, one of the field's founders, expressed great confidence that this objective would be accomplished with ease, asserting that machines would be capable of performing all tasks that humans can do within twenty years (Simon, 1979). Thanks to the developing technology, access to big data and the hardware that enables the processing of big data have opened the door to a new era of artificial intelligence. In this era, the components that were discussed around artificial intelligence were data-based learning, artificial neural networks, deep learning, adaptive learning, program solving and decision making, expert systems, fuzzy logic and genetic algorithms (Pirim, 2006). Through these components, Artificial intelligence (AI) has made great advances in many sectors in recent years and its areas of use are constantly expanding. It is actively used in many fields such as healthcare, training, finance, commerce, energy and transportation.

2.3. Data analysis

Audio recorded interviews were transcribed verbatim; content such as nuances of speech, emotional expressions and nonverbal behaviour were also transcribed (Peräkylä et al., 2008). Transcripts were then translated to English, and cleaned for the analysis.

Two analytical techniques were used. The main technique was thematic analysis (TA), which involved 'identifying, analysing and interpreting patterns of meaning' within the collected data (Braun and Clarke, 2006). The process was completely inductive, as the purpose was to derive an understanding of suicidal behaviour in the Indian context 'without trying to fit the data into a predetermined coding framework or researchers' preconceived notions' (Nowell et al., 2017). English translations of the transcripts were imported into ATLAS-ti (v9.0.15.0) (Atlas.ti, 2020) and used for this analysis. There were three broad stages. In the first stage, two coders (MB and KN) independently and simultaneously coded the first 10 transcripts, making extensive notes as to the meanings of their codes and their relevance to the research questions. They then met to discuss their findings, resolve discrepancies, and develop an initial coding framework which consisted of codes and their definitions, and semantic domains (grouping of similar codes by meaning or relationships). In the second stage, Coder1 (MB) coded the next 20 transcripts using this framework, adding codes to it when necessary. They then randomly selected half the transcripts, removed their codes and sent the coded portions of the transcripts ('quotations') to Coder2 (KN), who independently assigned codes within the framework to these portions. MB then merged the files by the two coders, and calculated inter-coder agreement (ICA) (Krippendorff's c-Alpha-binary) for the transcripts used by both coders (Krippendorff., 2004). The two coders once again resolved any differences through discussions, and made modifications to the framework. At this stage, they also formulated a tentative set of emerging themes and explored their interrelationships. The same process was repeated in the third, and final stage, for the remaining 17 transcripts. The last step in this stage involved finalising, naming, defining and illustrating the identified themes.

TA was supplemented by summative content analysis (SCA), which involved 'identifying and quantifying certain words' in text in order to understand the 'contextual use of the words' and their 'underlying meaning' (Hsieh and Shannon, 2005). The local language transcripts were used for this analysis so as to capture as far as possible, the essence of words and to prevent losses of meaning in translation. This approach was included to examine 'essential' texts, elicit any cultural expressions, and enable some quantification of findings (Rapport, 2010). The analytical process was similar to TA, and was conducted over 5 rounds. In the first round, the first 9 transcripts were selected. Two coders (of three - KM, PK, or AKS) independently examined each transcript, extracting into an excel sheet, words that they thought were relevant to the research questions. The analysis team (MB, KM, KN, AKS, PK) then met to review this list, and cast their vote for what words would form the initial codebook. This process was repeated over the next three



rounds; in each round, the codebook was modified and refined – words were added or removed, and similar words were grouped together into categories. In the fifth and final round, the codebook was finalised, and frequency counts or word clouds were generated for the selected words in ATLAS-ti. SCA was also used to quantify codes identified through TA, to examine frequency of concepts and gender differences, in order to indicate potential trends that could be verified later by quantitative studies. Findings from both approaches were integrated.

Our analysis focused on themes related to the four main research questions. To uncover the key risk factors that led to suicide attempts, we used a comprehensive list of exhaustive codes that focused on capturing a range of phenomena; we also examined key words in text to understand the various forms and manifestations of these phenomena in the Indian context. To understand what factors were related to or influenced one another, we connected and clubbed together codes that co-occurred together in text, both within and across transcripts, and those that had a temporal relationship. To develop the pathway to suicide attempts, we examined the sequence in which the factors occurred in the life of each participant, and then compared and contrasted these sequences across participants; to understand the most common pattern, we calculated the frequency of factors at each point in the pathway. To understand factors common to young women, we calculated the number of times both codes and the quotes involving each factor appeared in male and female participant groups, and examined what factors were more frequent in female participants. Analytical rigor was maintained by having a senior author experienced in qualitative research lead the analysis (MB); using two separate coding teams for the two approaches; having at least two coders for each approach, and the resolving of discrepancies through meticulous discussions or consensus generation; and the testing of the robustness of the coding framework by the calculation of ICA (Rolfé, 2006; O'Connor and Joffe, 2020).

2.4. Ethical considerations

Procedures were approved by the Institutional Review Board of Sangath, the organisation conducting the study. Participants and their families received complete written information, including risks and benefits of participation, confidentiality of data, and freedom to refuse or withdraw without any impact on ongoing medical care. Interviews were conducted by mental health professionals (AKS, KM, PK) who underwent extensive training in the use of the interview guide, and counselling techniques. Participants were interviewed only after they recovered medically. Efforts were made to prevent another attempt by employing the suicide prevention strategies recommended by the WHO (World Health Organization, 2010).

III. RESULTS

3.1. Sample characteristics

There were 200 young people who presented to the Emergency department in the study period, of which 197 survived their suicide attempt. Among those who survived, 106 (54%) were inpatients. Of the inpatients, 83 (78%) met the eligibility criteria. Of the 23 (22%) ineligible inpatients, 13 could not be located, 7 spoke other languages, and 3 were medically incapacitated (had mental retardation, or active psychosis). Of the eligible participants, 54 (65%) consented to the interview; 47 agreed to have their interview audio-recorded and were included for the analysis.

The mean age of the sample was 22 years. There were more females (N = 27, 57%) than males (N = 20, 43%), and unmarried (N = 30, 64%) than married persons (N = 17, 36%). 43% (N = 20) were employed, 36% (N = 17) were students (N = 2 were working and studying), 17% (N = 8) were homemakers, and 9% (N = 4) were not employed. 60% (N = 28) practiced Hinduism, 21% (N = 10), Islam and 19% (N = 9), Buddhism. Ingestion of pesticides (herbicides, insecticides, and fungicides having a high concentration of organophosphate chemicals) was the most common method used (N = 22, 47%), followed by ingestion of household disinfectants (N = 19, 40%), drug overdose (N = 5, 11%), and hanging (N = 1, 2%).



3.2. Reasons for the attempt

There were three main higher-order risk factors: (1) background factors (2) psychological distress and (3) intervening factors. These factors, and their sub-factors are defined and described below, along with the number of participants (N), and illustrating quotes (in italics). Participants are referred to by their ID, gender and age, to preserve anonymity. They are presented in the order in which they occur in the pathway, and the interactions and connections between factors are contained in the description of each factor.

ICA for these factors was high: 0.94, 0.89, 0.69 (stage2) and 0.96, 0.83 and 0.69 (stage3) respectively (<0 indicates no agreement; 0–0.20, slight agreement; 0.21–0.40 fair agreement; 0.41–0.60, moderate agreement; 0.61–0.80, high agreement; and >0.81, nearly perfect agreement (Landis and Koch, 1977)).

3.2.1. Background factors

Background factors included characteristics at the level of the individual and/or their social environment which increased vulnerability to suicide attempts. These were the first factors on the pathway, and one or more of these factors led to 'psychological

IV. CONCLUSION

Disaster management requires a multidisciplinary approach and involves all levels of society (local, regional, national and international). A successful disaster management system aims to ensure that resources are used effectively, people are safe and the damage caused by disasters is minimized. Therefore, disaster management should be a strategy that needs to be continuously updated and improved. With this study, it may be easier for researchers who will work in this field to identify critical research gaps. Furthermore, with this study, the areas and methods that the use of AI in Turkey can be effective in the disaster management process are presented to the users. Disaster management and artificial intelligence (AI) applications research findings and analyses indicate that integrated systems can be improved in future studies to be conducted on local and global scale. These systems can achieve more effective results by integrating artificial intelligence technologies into a comprehensive disaster management system. Integration of systems can automate processes such as early warning, forecasting, damage assessment and aid distribution. The success of artificial intelligence systems to be used for disaster management also depends on the quality and quantity of data collected. Therefore, continuous and high quality data collection methods should be developed. It is necessary to create big data and systematic processing of this data. Moreover, disaster management experts should be specialized in this field and their number should be increased for the effective use of artificial intelligence technologies. Integration of specialized individuals and effective system utilization will ensure qualified disaster management. Otherwise, a process management with a high margin of error that does not reach an effective solution may be possible. The other important aspect of process management is infrastructure assessment.

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