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Social Media and the Internet of Things for Emergency and Disaster Medicine Management

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Abstract. Social Media and the Internet of Things are nowadays full and strong components of day-to-day life worldwide. Both allow communicating with others 24 hours a day, 7 days a week without distance limitations. During the last decade, on-site citizens have shared disaster-related first reports on social media. Official institutions are using the same framework for delivering up-to-date and follow-up directives. Moreover, monitoring health risks, patients, and systems behavior in real-time over the Internet-of-Things allows detecting different levels of anomalies that might lead to critical events that need to be managed as an emergency. Emergency and disaster medicines deal with broad and complex medical, surgical, mental health, epidemiological, managerial, and communicational issues. Social Media platforms and the Internet of Things are technologies that increase cyber-physical interactions between individuals, machines, and their environment. The generated data over time are massive and are supporting the emergency or disaster mitigation process. This chapter deals with, in the first section, the social media platforms, and the Internet of Things. Then, at a second one, the concepts of emergency, disaster medicine and management are discussed. In the following two sections, we discuss applications and usages of social media and IoT technologies for improving the management (preparedness, response, recovery, mitigation) of emergencies and disasters as fundamental keys and pillars for efficiently handling the managerial information flow in emergency and disaster contexts.

Keywords. social media; Internet-of-Things; online social networking; community networks; disasters; emergencies; risk management; hazard management

1. Introduction

Social Media (SM) and the Internet-of-Things (IoT) are full and strong components of day-to-day life worldwide. Both allow communicating with others people and systems 24 hours a day and 7 days a week without strongly feeling distance limitations.

During the last decade, with the increase emergence of, on-site citizens have shared disaster-related first reports on SM. Official institutions are using the same framework for delivering up-to-date and follow-up directives in case of disruptive events. Moreover, monitoring health risks, patients, and systems behavior in real-time over the IoT allows

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detecting different levels of anomalies that might lead to critical events that need to be managed as a crisis. This must involve generally emergency and disaster medicines practitioners. These specialties are dealing at the same time and at different scales, with medical, surgical, psychological, psychiatric, public health, epidemiological, managerial, and communicational issues. In this context, social media platforms (SMPs) and the IoT are technologies that increase the cyber-physical interactions between individuals, machines, and their environment. The generated data over time are massive and are supporting the emergency or disaster mitigation process.

In this chapter, we define the SMPs and the IoT in the first section. In the second section, we introduce the concept of disaster. In the last part, we highlight the nowadays relationships between Social Media and the Internet and how they are vital and new fundamental pillars for efficiently handling emergency and disaster information-flow management.

2. Social Media Platforms and the Internet-of-Things

Social Media platforms and the Internet-of-Things are technology-based domains connecting the real and the virtual worlds and taking the interactions between individuals (e.g., humans, animals), machines (e.g., computers, smartphones, transportation vectors, home appliances), and their environments (e.g., living spaces, roads, working places) to the cyber-physical dimension [1,2].

2.1. Social Media Platforms

Today, Social Media platforms macrocosm is driven by high levels of interactivity, dynamicity, and ubiquitously. SMPs are at the crossroad of instant messengers, multimedia sharing systems, and "open-air public speaking" [3]. The individual or collective "shares" (e.g., text messages, pictures, photos, sound records, videos, documents, hyperlinks) can publish and read 24 hours a day, 7 days a week, 365 days a year, all around the world in an abundance of languages supported by the SMPs.

The users of the SMPs can be individuals acting for themselves and organizations represented by one or more than one individual. Signing-up is free and then allows each user to connect with others known or unknown in the real world.

The social media ecosystem comprises:

- News websites (e.g., "BBC News" [4], "CNN World" [5], "Der Spiegel" [6]),
- Collaborative encyclopedias (e.g., Wikipedia [7]), and
- Social networking services (SNS) provide different functionalities and services. For example:
    - Facebook as a polyvalent and grand public focused platform [8];
    - Flickr [9], Instagram [10], or Pinterest [11] as video and picture sharing platforms);
    - Twitter [12] or Tumblr [13] as blogging services; LinkedIn focusing on professional networking and services [14];
    - Reddit [15] as a mix of the previously highlighted platforms and which enable news aggregation, web content rating, and blogging/discussion website;

- Telegram [16], as an instant messaging and a video-telephony platform, also allows creating or joining groups and channels supporting broadcasting to an unlimited number of subscribers).

2.2. The Internet-of-Things

Even though the Internet is a cyber-physical system, most communication is human-to-human based (a.k.a, the Internet-of-People or IoP). Nonetheless, the constant increase of the connectability of machines, devices, and components (a.k.a. objects), each one with its unique identifier, is taking the IoP to the IoT wherein humans are a minority [17].

The Internet-of-Things is a global space-expanding platform itself each time a newly identified object joins the whole. Moreover, IoT continuously integrates more automated data processing and generates new information and knowledge support for decision-making.

The main aim of an IoT-centric society is to have an integrated architecture allowing moving from the well-established Human-to-Human (H2H) or Human-to-Machine, (a.k.a. H2M or Human-to-Thing) paradigms to a Machine-to-Machine (a.k.a. M2M). Therefore, humans move the tails of the overall communications and decision-making processes. To do such a thing, the IoT must solve real-life problems by establishing, developing, implementing, and deploying robust architectures. This evolutionary and integrative process is based on the collaboration between the academia and the industry by defining translational and interoperability standards that are usable in a wide range of application fields, such as health, medicine, transportation, manufacturing, homeland security, and infrastructure safety, and more [17–19]. This revolution brings humanity to a ubiquitous computing and communication-centered era. The crucial part of the IoT as an M2M environment is changing populations' way of life by morphing them to a kind of abstraction of themselves giving inputs to machines, to "things". This is inducing huge ethical issues which are out of scope in the current chapter [20,21]

Nonetheless, the Internet-of-Things is more than a Machine-to-Machine assembly. The IoT is a whole integrating at different levels of complex hardware and software technologies [22], such as:

- Wired and wireless networks of sensors and actuators [23],
- Identification and tracking technologies, e.g., Radio Frequency Identification techniques (RFID) [24];
- Communication protocols [23,25,26];
- Distributed intelligence enhancing small devices' capabilities [27–29].

2.3. Social Media and the Internet-of-Things as a Whole

Social Media and the Internet-of-Things are a whole, a System-of-Systems.

SMPs interact with their users mainly by using mobile and ubiquitous systems (i.e., smartphones, tablets, computers, home appliances such as televisions) to run their applications and collect data.

If we focus on smartphones, they are all-in-one tools. A smartphone acts as a phone, but also as a small computer (e.g., for browsing the web), a telemonitoring system comprising different sensors (e.g., cameras, accelerometer, barometer, gyroscope; magnetometer; Global Positioning System (GPS) units, proximity sensors, light sensors, Light Detection and Ranging (LIDAR) sensors, biometric sensors, for fingerprint sensor

or facial recognition and using optical, capacitive and ultrasonic technologies; and more in the next future).

Besides, the current cellular communication technologies (4G and 5G networks) [30] are crucial for allowing to get and share updates on social media in near real-time and comprising environmental data collected by the plenty of sensors available on the IoT ultimate tool known as smartphone [31].

To sum up, Social Media and the Internet-of-Things are now deeply integrated from the perspective of the day-to-day users, looking at them as the Internet.

Looking at this Social Internet-of-Things is challenging when we consider it as pervasive, fully connected, and having autonomous intelligence. This extensive integration and penetration in people's life can offer some kind of safety feeling (having systems taking care of our well-being). Still, because of their openness, they are targets for cyber-attacks [32]. Both are central points to explore when social media and IoT tools and systems are used for emergency and disaster management (EDM).

3. Emergency and Disaster Medicine and Management

In the following section, we define some concepts related to emergency and disaster medicine and management. We focus then on integrating social media and the internet-of-Things in these fields.

Emergency medicine and disaster medicine are both multidisciplinary specialties. Their common challenge is to look simultaneously and handle medical, surgical, psychological, psychiatrically, public health, and epidemiological, managerial, and communicational issues. Disasters are disruptive, sudden, and complex emergencies. Let us consider nano-disasters with impacts at the individual level. This kind of event is defined from our perspective as an emergency (for emergency medicine) affecting directly one or a few individuals. Disaster Medicine relates to mega-disasters with consequences at different population levels, with at least a few thousand people involved [33]. The COVID-19 pandemic involves both [34,35].

Uncertainty in action induces risk and hazard, engendering disruptive and unusual events such as an emergency and a disaster. These events induce losses of human life, damages to infrastructures and economic activities, and may negatively affect the environment. Several scales were defined and implemented over time for quantifying and categorizing the severity, the complexity, and the impacts of disasters [36,37].

The fundamental differences between an emergency and a disaster reside in scales and capacities to handle it efficiently.

Emergencies and disasters have variable and heterogeneous impacts and consequences on human activities, depending on the event scales. It is possible to classify them according to the number of directions or collateral casualties. On one hand, an accident impacting a small number of individuals (from one to ten) in a small area (less than a square kilometer) must be considered as a nano-disaster or minor disaster and can be handled as an emergency. On the other hand, a significant national or global event affecting a large population, such as at least a few tens to hundreds of thousands of people must be qualified as a large-scale disaster, mega-disaster [33,38]. Table 1 shows some examples of natural, man-made, and the combination of both kinds of disasters (at different scales).

Table 1: Examples of natural, man-made, and the combination of both kinds of disasters (at different scales)

Nature forces	**Combinations of disasters caused by natural forces and man-made**	**Man-Made (anthropogenic)** [39]
Climat phenomenons (hurricanes, floods [40], extreme heats)	Natech disasters for "Natural Hazard Triggering Technological Disasters" [41,42]	Residential or industrial casualties (fires, explosions, "Nuclear, Radiological, Biological or Chemical" hazards) [43]
Seismological events (earthquakes, landslides, volcanic eruptions) [44]	Technological Hazard triggering Natural disaster [43]	Transport accidents and calamities (Air, Maritime, Road, Railway) [45]
Epidemics and Pandemics (Influenza [46], Plague, Smallpox, Coronaviruses [47])		Cyber-attacks of any kind of (healthcare) infrastructures such as Hostech disasters ("Hostile Hazard Triggering Technological Disasters") [48,49]
		Societal events such as conflicts or acts of terrorism [50]

However, the main difference between an emergency and a disaster is related to how the resources allow efficient managing this event. In that way, the understanding of risks of small and large scales enables the development of preparedness plans. These one must be suitable for managing the event in short delays and taking in charge of casualties from the event area to a well-fitted infrastructure (e.g. field or permanent hospital for medical and surgical cases, emergency accommodation, or socio-psychological support, in other cases). The large-scale events usually exceed the involved community's abilities and capabilities (local resources).

The emergency preparedness plan (EPP) or the disaster preparation plan (DPP) are based on the continuous mitigation of previous disruptive events. Nowadays, the EPPs and the DPPs give technologies a critical position, like the Emergency and Disaster Response/Recovery Plans (e.g., ERPs and DRPs). In social media, the IoT, and more globally in the ubiquitous and mobile health technologies era, technologies support EDM from end to end. These vectors facilitate the event report, the dispatch of first responders and on-field medical teams, search-and-rescue, evacuation, hospitalization, discharge, and follow-up.

4. Social Media as Emergency and Disaster Management Platforms

Through search engines and social networks, the Internet is used to monitor, predict, and survey changes in populations (a.k.a. infoveillance [51,52]). This is used to get early disease outbreak warnings and follow its dissemination and resilience [53]. Social Media and Social Networks Services are powerful tools, allowing the mass to connect, interact,

and collaborate. We have used them worldwide for the last two decades in different forms (e.g., blogs, chat rooms, discussion forums, wikis, YouTube Channels, LinkedIn, Facebook, and Twitter) [54].

Social Media as an ecosystem is a well-known vector for communicating and sharing evidence-based healthcare information and recommendations [55]. Nevertheless, efficient and effective health-related communication must be monitored and controlled for the "quality and reliability" of published and disseminated information [56]. Considering the fundamental human rights of communication over the social networks, and more globally over social media, between healthcare information customers and providers [57] must encourage the community to be active in developing relevant and constantly up-to-date policies for protecting confidentiality and privacy [58–60].

Reported data and information flowing from a disaster scene at its first instants are disorganized, where the event effects the perceptions and witnesses on-scene such as victims, witnesses, first responders, and off-scene with the emergency services dispatchers getting preliminary reports, media and more particularly social media arena players publishing breaking news. Additionally, concerning the number of people involved, the event generates massive data, information, and knowledge.

Because of this "chaos", data and information management and retrieval processes are challenged, raising the need to develop knowledge management infrastructure, allowing collecting, storing, and screening social media data in near real-time.

As an example, a social media historian helps to deal with the preparedness and mitigation of EDM [61]. A Historian is a software environment that allows recording, storing, retrieving, and analyzing events, sequences of events, and processes by time and domain in a factual database. Accordingly, the primary sources of the current historian-based disaster management systems are based on online social media, particularly online social networks [62–64].

Social media-based historians can support emergency and disaster research to better understand individual and collective behaviors during these unusual events; this must improve their mitigations and enhance preparedness for future similar events.

As one illustration of the potential of these kinds of applied historians for previous disaster mitigation and future one preparedness, earthquakes are natural and relatively frequently occurring disasters, having many types of impacts and consequences from an extensive range of societal perspectives.

The availability of disaster-related data is essential, at any time resolution and update, more particularly near real-time events, both for the public and all regional and extra-regional emergency organizations. Social Media comprises news-based television and radio channels having a website and social network pages. These last ones are also resources of data and information related to emergencies and disasters of any kind. In earthquakes, in-depth details are delivered with a relatively long delay compared with governmental and scientific websites. Nevertheless, the population is more confident when these sources publish warnings and reports [65].

A disaster ontology was developed as a first step and evaluated by domain experts reviewing March 11, 2011, Fukushima disaster [66]. This disaster is the umbrella title of a series of events following an earthquake in northern Japan and a tsunami. One of the associated events is a major nuclear accident, the world's most serious accident since the Chernobyl disaster of 1986 [67], and the medical impacts were and are still consequent [66,67]. A central issue identified from the "Fukushima disaster" is the number of sequential events and combined effects. From the "disasters" ontology perspective, the different types of disasters and their subtypes can influence one another. In "Fukushima",

a natural disaster such as a geophysical event (i.e., an earthquake) induced another natural disaster, a hydrological one (i.e., a tsunami) resulting in a set of technological and industrial disasters (i.e., a nuclear plant accident, explosions, and fires of infrastructures). We can link this overall case to medical ontologies for reporting health conditions (such as physical and psychological trauma, epidemic disease) of individuals and populations.

This disaster ontology was evaluated on 37,144 messages extracted from social media and specifically from Twitter for ten days in April 2018. These tweets comprised the keyword "earthquake" (with and without hashtag -#earthquake-). The hashtag-keyword "#earthquake" was present in 74.64% of the tweets, having a median length of 140. 53.91% are re-tweets (not original messages), and 1.19% replied to another tweet. The geolocation coordinates were attached to 11.57% of the tweets of the sample. The density and the volume of the messages published on Twitter related to the earthquakes changed over time, and spikes indicated unusual events. They were associated with reports of earthquakes of various intensities on governmental and scientific websites. Common occurrences of different kinds of disasters have been noticed, such as "earthquake" and "tsunami" appearing together in 0.92% of messages, "earthquake" and "nuclear" in 0.52%. Furthermore, emergency and disaster medicine-related terms such as "injuries", "injured", "dead", "death", "suffer", "healthcare", "medical", "emergency" "survival kit", "emergency kit", "first aid" appear in average 0.04% [61].

Using Social Media as a whole for reporting hazardous events can support the mitigation of these events and improve the preparedness for future potential ones. Analyzing, in near real-time, the contents of a massive volume of messages published over social media may allow us to understand the needs of the event field/scene and the assistance that can be provided. However, a key issue of using social media data and information is the difference in the quality of the different kinds of sources affecting their reliability. However, social media can self-regulate misinformation through the masses during these disruptive events [68].

In other terms, social media has changed the information dissemination pathways in case of emergencies and disasters. They transformed how emergencies and disasters are tracked and managed. For example, smartphone applications are used during disruptive events (e.g., hearth attack, car accident, terrorist attack) for alerting, asking for assistance, and reporting quickly, simply and efficiently to emergency services.

For example, Facebook [69] and Twitter [70], provide crisis communication tools and information sources. These tools are activated in case of terror attacks such as the attacks in Paris on November 13, 2015 [71] or during the typhoon Mangkhut, which struck Hong Kong in September 2018 [72]. This feature of the social media platforms allows users in an area affected by a crisis to mark themselves or others as safe.

Nowadays, SMPs integrate more than interpersonal communication services. They are storing data that can be investigated for (1) mitigating particular events, (2) surveilling changes in population behaviors, and (3) helping, for example, decision-makers to adapt their communication strategies to enhance population compliance and resilience to recommendations and directives in case of an emergency or a disaster. Moreover, most of the SMPs are used over mobile applications installed on smartphones and tablets with embedded sensors and receivers that make them connected objects of the Internet-of-Things and their users as members of the Internet-of-People (another kind of things).

5. The Internet of Things for Hazardous Events Detection

The Internet-of-Things is the whole of all the devices connected and controlled by and over the Internet. The "IoT power" resides in the product of the interactions between communicating devices and complex systems (Cyber-Physical Systems). This ecosystem affects the global level, systems design and engineering [73], economic [74], and resources management [75].

In the context of EDM, the whole IoT is a game-changer. IoT generates large volumes of data that must be collected, stored, extracted, and processed by analytics technologies. The results of this analyses support decision support systems (DSS) for improving, for example, emergency response operations [76,77]. As one example, smart cities are designed in such a way the same can contribute to enhance emergency and disaster resilience. Indeed, smart cities are integrating to their management platforms, IoT systems located in different places such as smart buildings [78-79] or roads for safety and traffic management [80,81].

In a smart building, IoT-based systems are able, for example, to detect and to generate alerts about

- Fire or floods in a building,
- Air pollution beyond the threshold level in the specific areas,
- Earthquakes and tsunamis.

In smart healthcare and focusing on emergency and disaster medicine and management, IoT-based systems are able, for example,

- To support distant monitoring and diagnostic [82-84]; particularly in an era like the current COVID-19 pandemic one [85–88];
- To deal with vehicle accident detection, reporting [80];
- To collect road loads for computing a continuously updated (medical) emergency evacuation path [80,83,89];

The Internet-of-Things in Emergency Medical Care and Services (used too in disaster medicine and management) is a part of the new healthcare information systems.

In emergency and disaster medicine, time, availability, and accuracy of contextual information are critical for increasing the chances of successfully providing the most adapted care in the shortest delay. Nonetheless, this is dependent on completeness, consistency, conformity, accuracy, integrity and the timeliness of the data and the information received and collected from the emergency call by dispatch to the emergency department admission. The Internet-of-Medical Things (IoMT) allows collecting and real-time data preprocessing from the patient and its environment for on-field monitoring and diagnosis support. In other terms, the IoMT platforms provide a telemedicine emergency management framework and patient-centric-information-based care services [90].

Accordingly, developing new and improving existing IoT systems and services for enhancing the emergency and disaster medicine and management practice must be based on telemedicine (as the main component of smart healthcare). The IoT-based telemedicine allows providing the on-scene healthcare practitioners (EMTs, paramedics, nurses, and physicians) with distant added-value expertise [91]. Firstly, the patient's historical data is accessible online (e.g., on a smartphone or a tablet) for supporting efficient initial diagnosis and treatment. Secondly, all the IoMT such as biological and physiological sensors (comprising imaging such as ultrasound) measurements can be used [85–87]:

- Immediately by decision-support systems, and
- Uploaded into the patient's electronic health record (EHR) for or later follow-up.

In such a way, many benefits are expected from the IoT and the IoMT in emergency medicine and management to move to a proactive practice. The COVID-19 pandemic is an essential trigger for developing policies facilitating the implementation of these new technologies for ensuring continuous, efficient, and effective delivery of care in a social distancing context (less physical contact between patients and healthcare practitioners, and fewer visits to medical clinics). Also, in parallel, it is critical to consider using the IoT and specifically IoMT in daily usage. Over and above that for handling emergencies and disasters, we require looking at architectures, security aspects of the health-data generated and exchanged.

6. Conclusions

One key challenge in using Social Media and the Internet-of-(Medical) Things in Emergency Medicine and Management relies primarily on data and information quality. Reports about hazardous events are produced by and on various channels, such as the traditional media (e.g., newspapers, radio, and television), social media, social networks (e.g., Twitter, Facebook, Snapchat, and Instagram), and IoT sensors.

- Traditional media and Social Media are allowing institutions and the mass to **broadcast disruptive event reports**.
- The **IoT/IoMT are social media components** by being integrated in the mobile devices hosting their applications and so permitting sharing the collected data collected.
- **Decision-making can be affected by the quality of data**, information, and knowledge collected and generated by healthcare professionals, journalists and by the population.
- **The "Social Internet-of-Things" is pervasive, fully connected, and has an autonomous and collective intelligence.**
    - This extensive integration and penetration in people's lives can offer **safety and security feelings** (having systems taking care of our well-being).
    - But, the openness of Social Media, IoT, and so Social IoT are good **candidates for cyber-attacks** [32]. Accordingly, using these technologies in emergency and disaster medical practice and management must consider developing additional layers dealing with the security of the systems from end to end (cyber-defense against attacks and network management for handling real-time communication failures).
- An additional new pillar of delivering emergency care and disaster management relies on the technological "**Quality of Service**" provided currently by Social Media and IoT devices and systems as a part of the alert, operation, and management processing [92].

The opportunities and the prospects of Social Media and IoT/IoMT in the practice of emergency and disaster medicine and management are numberless and still not fully defined and are still open research issues [93].

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