Digital Emergency Management for a Complex One Health Landscape: the Need for Standardization, Integration, and Interoperability

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Summary

Objective: Planning reliable long-term planning actions to handle disruptive events requires a timely development of technological infrastructures, as well as the set-up of focused strategies for emergency management. The paper aims to highlight the needs for standardization, integration, and interoperability between Accident & Emergency Informatics (A&EI) and One Digital Health (ODH), as fields capable of dealing with peculiar dynamics for a technology-boosted management of emergencies under an overarching One Health panorama.

Methods: An integrative analysis of the literature was conducted to draw attention to specific foci on the correlation between ODH and A&EI, in particular: (i) the management of disruptive events from private smart spaces to diseases spreading, and (ii) the concepts of (health-related) quality of life and well-being.

Results: A digitally-focused management of emergency events that tackles the inextricable interconnectedness between humans, animals, and surrounding environment, demands standardization, integration, and systems interoperability. A consistent and finalized process of adoption and implementation of methods and tools from the International Standard Accident Number (ISAN), via findability, accessibility, interoperability, and reusability (FAIR) data principles, to Medical Informatics and Digital Health Multilingual Ontology (MIMO) - capable of looking at different approaches to encourage the integration between the ODH framework and the A&EI vision, provides a first answer to these needs.

Conclusions: ODH and A&EI look at different scales but with similar goals for converging health and environmental-related data management standards to enable multi-sources, interdisciplinary, and real-time data integration and interoperability. This allows holistic digital health both in routine and emergency events.

Keywords

One Digital Health; accident and emergency; standardization; interoperability; International Medical Informatics Association

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1 Introduction and Background

Risks arise as a consequence of uncertainty, actions, or behaviors that could lead to wasteful outcomes of disruptive events such as accidents and disasters. The latters are inducing a state of emergency. Depending on the location (*i.e.*, environment) and the scale of the events, their impacts can vary from insignificant to large and complex, thus affecting and carrying consequences on human activities.

An accident is reported as: (i) "nano-disaster" at the individual level, such as a medical emergency, and as (i) "mega-disaster" (large scale and sudden disaster, LSSD) when it concerns a regional, national, or trans-national event affecting a large population [1]. Disasters are also classified in two main categories: (i) "natural disasters" (*e.g.*, flows, earthquakes, tsunamis, climate changes, epidemics, pandemics); and (ii) "man-made disasters" (*e.g.*, climate warning, misinformation, and infodemics [2], terrorist attacks [3], cybercriminality [4]) impacting anyone and particularly the healthcare systems. Both can impact individuals (humans, animals) and populations, as well as the environment.

The set-up of the accident and disaster management cycle (DMC), through its "prevention and preparedness", response, recovery, and mitigation steps, makes it clear that the concept itself of disaster as an entity, paired with its management, is not a series of events which start and stop with the occurrence of the issue, but rather a continuum of interlinked activities, on different scales, which involve different competencies [5, 6].

Planning reliable long-term actions requires, therefore, to enhance the resilience of communities by means of a timely development of technological infrastructures [7] and focused strategies of emergency management, which also include animals [8, 9]. In this complex scenario, multidisciplinary fields arise, which are capable of dealing with the ever-changing, standardization-driven, integration-focused, and interoperability-related dynamics for a technology-boosted management of emergencies under an overarching One Health vision: it is the case of Accident & Emergency Informatics (A&EI) [10] and One Digital Health (ODH) [11].

A&EI focuses on the systematic collection, management, integration, and analysis of health-related data that is generated and recorded on-site mainly during the response step of the DMC, as well as during the daily life by the healthcare practitioners. The aim of A&EI is herein to minimize the impact of the hazardous event and to optimize its management.

ODH proposes a unified top-level framework of One Health [12] and Digital Health [13] and focuses then on five specific dimensions (*i.e.*, citizens' engagement, education, environment, human and veterinary health care, and the healthcare industry 4.0) along with all their possible combinations in terms of health and well-being, under three progressively expanding perspectives (*i.e.*, individual, population and society, environment). Seen from the ODH viewpoint, all future health ecosystems are meant to be digital, so ODH aims at implementing systemic health and life science strategies to manage the One Health components (*i.e.*, human health, animal health, surrounding environment) as a whole. Climate changes, pandemics such as COVID-19 [14–16], wars, economic crises, and so on are impacting humans, animals, and the environmental health in the short-, mid-, and long-term. Each one of the mentioned events are disasters at the large scale, inducing accidents [1]. Related data and information enhance the overall preparedness, response, recovery, and mitigation process. Therefore, A&EI and ODH look through different prisms to the individual and population health to prevent and manage disruptive events [17].

The International Medical Informatics Association (IMIA) Working Groups "One Digital Health" and "Accident & Emergency Informatics" share a leading research question: "how can we digitally improve accident, disaster, and (healthcare) emergency management?". In this paper, we aim to highlight the needs of standardization, integration, and interoperability between the different One Digital Health components from the emergency management point of view, and the Accident & Emergency Informatics overall vision.

2 Looking at the Individual to Serve the Whole

2.1 Individual and Small-scale Event-based Management

2.1.1 Preventive and Predictive Smart Private Environments

In 1957, the World Health Organization (WHO) defined an accident as "an event, independent of the will of man, caused by a quickly acting extraneous force, and manifesting itself by an injury to body or mind" [18]. In addition, WHO reported annually over 1.3 million deaths from road traffic injuries and 650,000 due to falls, which are the first and second causes of death, respectively [19, 20].

Furthermore, road traffic is the leading cause of mortality among young people (aged 15–29 years). The traffic injuries cost countries 1%–3% of their gross domestic product (GDP) [21]. In an emergency, every second counts for delivering rescue and first aid. Failing to detect accidents and promptly notify an emergency department costs lives [22].

However, many adverse health events are not detected in time. Whether an event occurs inside a car or at home, we need monitoring in private spaces. Any rescue operation loops from measuring and event detecting via alerting and dispatching the rescue team towards timely delivering the medical help. Therefore, triggering this loop needs physiological and non-physiological monitoring by sensors and sensing devices [23].

The recent trends in turning smart private spaces into diagnostics spaces [24] support early detection of adverse events long before their occurrence. This is in line with the paradigm shifts in medicine:

1. Subject-to-device in a hospital → device-to-subject in a point of perception (for humans: smartwatch electrocardiogram [18]; for animals: vital signs continuous monitoring [26]);
2. Diagnosis of symptoms → preventive medicine (for humans); in veterinary medicine, a timely assessment of the health benefits from this kind of practice remains unclear [27, 28].

From the viewpoint of human medicine sensory systems measure vital and environmental parameters and detect an accident, automatically report it, and enhance long-term follow-up to continuously analyze health-related influencing factors. This would, consequently, assist in individual (*e.g.*, a fall detection at home) and small-scale (several people involved in a car accident) emergency management.

2.1.2 Communicable and Non-communicable Diseases

Communicable diseases are illnesses caused by viruses or bacteria that people spread to one another through contact with contaminated surfaces, bodily fluids, blood products, insect bites, or through the air [29]. Among others, the recent COVID-19 pandemic highlighted the role of diseases spread over the air between humans and animals. If timely diagnosed, emergency management can prevent an individual event from becoming a global disaster or pandemic. As for the recent pandemic, the initial symptoms, such as physiological arousal (*e.g.*, cardiorespiratory symptoms and increased body temperature) take place a couple of days before the disease onset [30]. Particularly in private spaces such as smart medical homes and cars, this can be measured accurately. Infrared, thermal, capacitive, and mechanical sensors measure the electrocardiogram (ECG), respiratory rate, and ballistocardiogram. Therefore, isolation and low-scale emergency management can prevent a global man-made disaster [31].

2.1.3 Disease-based Emergency Monitoring and Measurement

Statistics from the WHO indicate that three out of ten leading causes of (disease-based) death are cardiac (*i.e.*, ischemia, stroke, hypertension); three are respiratory (*i.e.*, chronic obstructive pulmonary disease, lung cancer, lower respiratory infection); and one concerns physical-related activities (*i.e.*, Alzheimer's and other dementia) [32]. All three categories feature parameters measurable using medical and non-medical sensors and devices. For instance, we can gather information about cardiorespiratory diseases directly by physiological sensors, capable of performing exams such as ECG. We monitor physical activity-related diseases using ambient assisted living (AAL), non-contact (depth and lidar) cameras, and wearable technologies. Even though the direct measurement of the cardiorespiratory parameters through monitoring heart and respiratory rates reflect the health status of the subject, often parameters from other domains such as environmental (*e.g.*, air pollutants) and psychological (*e.g.*, stress) progress the health status. Therefore, an emergency detection is subject to comprehensive measurements in all influencing domains in order to predict, prevent, or take action in a timely manner, for example, generating an appropriate alert [28].

2.1.4 Alerting System Integration into Healthcare Management Systems

The short- and long-term applications of disease prevention and automated event alerts are categorized into (i) health prognostics, (ii) emergency detection, and (iii) assistance and response. An alert generation system can be as simple as a gas or fire detector, or as complex as a cardiac pacemaker with defibrillation and instantaneous data transmission, requiring data fusion from several sensors [28]. However, the alerting system is the gateway and intermediate hub to bridge the user to the first aid. In a simple event, an individual sensor can detect the issue, generate the alert, and request the rescue team. In a complex phenomenon, this requires several parameters measured synchronously and data fusion on different levels of abstraction, data processing and analyzing, and decision making. Therefore, we need to integrate (i) synchronized and smart alerting systems in private spaces and (ii) ambient sensors for measurement activities (for example, during sleep) [33].

2.2 Health, Well-being, Quality of Life, and New Live Standards

During the transition from the industrial world via the information world [34] towards the digital revolution [35], human life expectations have shifted from a mere survival via a basic standard of life towards enhanced quality of life (QoL). In the same manner, health and healthcare systems, as essential parts of health and well-being, have also evolved from the traditional symptom-based methods of diagnostics toward personalized, precise, predictive, preventive, and participatory (P5) medicine. P5 is conceptualized on technological advancement and subject participatory in order to detect the occurrence of abnormalities long before they even occur [36–38].

2.2.1 WHO's Definition of QoL

WHO defines QoL as: "An individual's perceptions of their position in life, in the context of the culture and value systems in which they live, and in relation to their goals, expectations, standards, and concerns" [39]. During the last two decades, many efforts have been made to quantify the QoL through its impact, which encompasses technological methods and tools for objective and quantitative assessment [40, 41].

2.2.2 Domains of Well-being and QoL

Despite the definition provided by WHO, the definition or assessment of QoL lacks universal agreement. Overall, QoL is a broad-ranging concept incorporating people's physical health, psychological state, level of independence, social relationships, personal beliefs, and their relationships to salient features of the environment. Further, it entails a subjective evaluation, which is embedded in a cultural, social, and environmental context. Thus, it cannot be narrowed down to the sole-although wide-concepts of "health status", "lifestyle", "life satisfaction", "mental state" or "well-being".

Currently QoL is evaluated using six domains and 28 specific facets, as follows [42]:

1. Domain I: Physical capacity, such as pain and discomfort, energy, and fatigue;
2. Domain II: Psychological, such as positive feelings, thinking, learning, and concentration;
3. Domain III: Level of independence, such as mobility, activity of daily living, work capacity;
4. Domain IV: Social relationships, such as personal relationships, social support;
5. Domain V: Environment, such as physical safety and security, health and social care;
6. Domain VI: Spirituality, religion, personal beliefs.

Automatic detection and reporting of adverse events is subject to objective sensoric measurements in all these domains. However, there is evidence that a four-sized domain solution is sufficient for individual, small-scale, and health status evaluation. These domains are [43]:

1. Environmental, such as air pollutants, sound noise, and ultraviolet (UV) index [44];
2. Behavioural, such as gait analysis and human activity recognition [45];
3. Physiological, such as heart and respiratory measurements [46];
4. Psychological, such as emotional and facial remote monitoring [47].

2.2.3 Health-related Quality of Life

Health-related quality of life (HRQoL) is a comprehensive and multidimensional concept that comprises aspects relating to physical, mental, emotional, and social functioning. It has been demonstrated that the broad measure of HRQoL can predict morbidity and mortality [48, 49]. As a health and well-being indicator for youth, HRQoL contains data on everyday functioning, physical activity, self-perceptions, and interpersonal connection participation. HRQoL is categorized into four general domains (physical, mental, emotional, and social) which is in line with WHO's influencing factors on well-being and QoL.

The United Nations' (UN) 2030 agenda for sustainable development goal (SDG) and the WHO 13th general programme of work set their aims to ensure healthy lives and promote well-being for all people of all ages. They set three interconnected strategic priorities to: (i) achieving universal health coverage, (ii) addressing health emergencies, and (iii) promoting healthier populations. Thus, the young and the elderly, the healthy and the disease-affected, should benefit [50].

Quality of life for community-dwelling older people

There is more to QoL than health for elderly individuals who remain in their homes. In fact, having a good QoL includes factors like family ties, friends, and activities just as much as overall wellness, health, and functional status. Elderly who live in semi-rural areas more likely review their QoL as excellent than people who live in the inner cities [51]. To some extent, social communications and activities depend on health status, which can be considered as a potent factor in QoL. This supports the focus on smart medical homes and AAL technology on the elderly.

Quality of life for healthy youth

Despite the focus on measuring QoL, there are currently certain challenges in comparing QoL between nations and demographic groups due to their large range of indices. This issue is particularly important for the young age group since considerable differences exist between their life values and perceptions of QoL, when compared to their parents [52–54]. The indicators cover elements from four groups that affect people's subjective happiness with life's quality: environmental, social, economical and socio-political environments. The social environment, particularly family ties and health, is most crucial for a positive perception of QoL. Environmental and economical issues similarly influence the younger people social and political variables have the least impact [55, 56].

Quality of life for patients

QoL is generally rated and measured differently for patients and healthy subjects [57]. The patients' symptoms, diseases' severity and progress, and all the related side effects considerably lower the patient's QoL. As an example, patients diagnosed with lung cancer rate the intensity of their symptoms, their financial difficulties, and their general QoL according to their functioning in physical, psychological, cognitive, social, and life roles [58]. A&EI can contribute to some aspects of the QoL, from an individual point of view, as well as by means of the conceptualized health-related status and measures in smart environments, such as progress assessment and costs of healthcare. The primary aim is achieved through the continuous monitoring of parameters from the main four influencing domains, and the latter via low-cost medical and non-medical devices deployed at home and in the car.

Quality of life, animals, and the ecosystem

Human-animal interaction (HAI) may provide many benefits to people. Close contact to companion animals (pets) improves QoL. Therefore, the medical world increasingly accepts animal-assisted activities and therapy (AAA/T). Pets help youngsters to build their self-esteem and sense of self, encourage communication between family members, kids, persons with disabilities, and solitary people, and improve physical well-being of all humans. The QoL advantages of pet companionship are particularly noticeable in specific conditions and situations [59].

However, animals occasionally host dangerous pathogens that can infect humans and cause sickness; these conditions are referred to as zoonotic illnesses or zoonoses. Zoonotic disorders are brought on by pathogenic microorganisms such as bacteria, fungi, parasites, and viruses. These microorganisms can cause a wide range of ailments in humans and animals, from minor to severe illnesses and even death. Depending on the zoonotic disease, animals can occasionally seem healthy even if they are harboring pathogens that can make people sick [60–62].

Furthermore, with the rapid urbanization and industrialization, the mutual effects between humans and the ecosystem become challenging. Air pollution and climate changes reflect this impact. Yamazaki et al. assessed the adverse relations between air pollution and HRQoL by ecological studies [63]. Other authors draw their attention to animal health and physiological measurement in order to avoid the spreading of human-animal communicable diseases [64]. Furthermore, Whitford et al. considered the ecosystem and climate changes to assess human QoL as well as HRQoL [65].

3 ODH in a Changing World with A&EI Managing Disruptive Events

One Digital Health aims to give a global and integrative view of both the One Health and the Digital Health domains. The five ODH dimensions [11] generate large amounts of data, each either alone or in combination with each other as they relate via events, actors, and places.

For improved support and curation, A&EI specifically aims at integrating data recorded at the accident sites with health records of subjects being involved in such accidents. The health data are recorded in smart spaces using unobtrusive sensors or wearable devices, since continuous data recording improves QoL and HRQoL.

3.1 ISAN and Smart Spaces Integration

In previous work, we proposed the International Standard Accident Number (ISAN) to facilitate the data flow between health data recording spaces (*i.e.*, alerting systems such as smart homes and cars) and healthcare delivery data consumers (*i.e.*, responding and curing systems such as rescue teams and hospitals). The ISAN is a unique token to integrate information and establish secure communication. It combines information and communication technology (ICT), sensing devices, and artificial intelligence (AI) to an entire digital emergency management system. It provides embedded data concerning time, location, and identifier of an emergency event [66]. We have derived technological, syntactical, and semantical requirements for the ISAN based on the features of processes and ICT systems in an emergency and examined the current standards and data formats for the ISAN specification. According to the Health Level Seven (HL7) syntax, ISAN follows the fix-ordered paradigm (*i.e.*, time, location, identifier) but covers a variety of time and location formats. For instance, it supports Unix time and the International Organization for Standardization (ISO) standard 8601, and requests for comments (RFC) 3399, 5322, 2822, and 822. The location is precisely defined by latitude, longitude, and altitude, which can be represented by ISO 6709. In addition, the human-readable format ISO 19160 provides a hierarchical structure of postal address components worldwide.

Nowadays, every ICT device is identified by a media access control (MAC) number. The ISAN supports MAC addresses, but embedded systems can also generate a 10-digit unique identifier (UID).

The ISAN components for time and location further define their uncertainty of measurement (Figure 1).

3.2 Linking Between Events, People, Places, and Factors

The ISAN, as a core element of A&EI, targets the concatenation of distributed health data sources (people) in various silos (places) by implementing a dynamic point of perception (temporal-spatial measurement) in case of an emergency (event). In other words, A&EI interconnects embedded and distributed temporal-spatial data using ICT by developing the sensory in private spaces within a dynamic point of perception. The concept is further enriched by detecting an emergency, reporting the event to healthcare authorities (responding system: rescue service, and curing system: hospital), and linking this data using ICT to improve common knowledge on emergencies. The mechanism is triggered by the systems involved in a rescue operation, which share the ISAN token. Transferred data includes real-time streaming of videos and biomedical measurements, historical vital data (anamnesis), but also non-medical data such as floor plans and rescue sheets [67, 68].

Data analytics in complex emergencies requires intra-system data concatenation and time synchronization in an emergency.

Sensors are the link between human health, HRQoL influencing factors, individuals, spaces, and events. The most frequently used sensors, devices, and approaches in private spaces are: temperature, humidity, sound, fire, volatile organic compound (VOC), and light (environmental); electrodermal activity, ballistocardiogram, electrocardiogram, body temperature, photoplethysmogram, and urine analysis (physiological); camera (psychological); and home automation (behavioral). The sensor network is meant to measure (i) vital signs (e.g., heart rate, respiratory rate, blood pressure, body temperature, and blood oxygen saturation) (ii) non-vital signs such as gait analysis; and (iii) physical- and behaviorally-related parameters (e.g., for dementia and events such as fall).

3.3 Expanding ISAN to Animal and Ecosystem Compatibility

The human-animal ecosystem is intensively interwoven. ODH assesses the human QoL, HRQoL, and the mutual effects between these areas. A&EI approaches address individual health monitoring and simultaneous measurements to manage events along the spatial-temporal perspective.

From a larger perspective, all isolated data regarding the private spaces of individuals and their contacts (with companion pets as well as with other humans) should be fused. Therefore, personalized health of an individual is not only based on physiological measures from private spaces but also connected to any hazard within a dynamic point of perception.

This means we need smart data, rather than “only” big data, which is efficient and informative as to either the onset of individual health issues to large-scale disaster triggers. Smart data comprises human health-related parameters (environmental, behavioral, physiological, and psychological) in private spaces, the outdoor ecosystem and its climate change-related parameters (such as air pollutants and quality), as well as humans’ animal companions (such as general health status and physiological measures).

4 Discussion

4.1 Overview

A digitally-focused management of emergency events that considers the inextricable interconnectedness between humans, animals, and their surrounding environment demands standardization, integration, and systems interoperability. We have provided different ways to answer these needs by looking at existing and futuristic approaches of the ODH and the A&EI frameworks together and integrate a kind of good practice guideline. We have achieved a systemic understanding of and the capacity to handle a wide range of events as a whole: (i) the global climate change (impacting humans, animals, and the ecological system); (ii) the current near-massive extinction wave [69], (iii) the (re)-emergence of trans-species

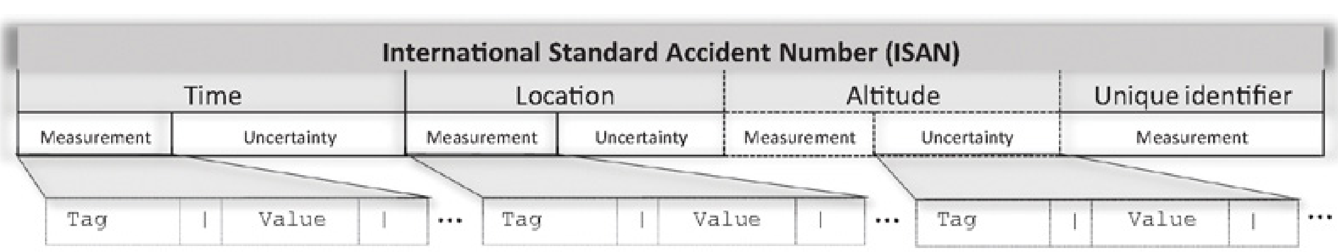

Fig. 1 Structure and components of the International Standard Accident Number [66]

and treatment-resistant diseases [70]; (iv) the challenging and continuous changes in interindividual behaviors and communication like the emergence of infodemic (*i.e.*, spreading of non-accurate or fake news and information) [16, 71]; and (v) disruptive digital technologies supporting the emergency management of any kind of human-related, animal-related, or environmental activities [71]. It is crucial for ODH and A&EI to ramp up, to spread, to rely on findable, accessible, interoperable, and reusable (FAIR) data [72–74], as well as to develop and enhance existing controlled multilingual vocabularies [10, 75].

4.2 FAIRness as the Data Pillar of the ODH/A&EI Empowerment

Nowadays, FAIRness ensures the lawfulness of health- and environmental-related data. In the short-term, the implementation of the FAIR principles can help to solve the demands of data interoperability, which is of utter importance to effectively handle heterogeneous and diverse information in the disaster management domain [76] from end to end, from preparedness to mitigation via response and recovery (*i.e.*, A&EI). In the mid- and long-term, FAIR compliance allows the same bit in a wider and more systemic viewpoint, to redesign processes of interdependence between different kinds of actors (*i.e.*, ODH).

4.2.1 A&EI Short Term

Accident-related data (*e.g.*, generated by detecting abnormality in electronic systems, calling and dispatching emergency services, monitoring social media, reporting first responders' actions, discharging from the emergency department) are similar to health records (*e.g.*, diagnostic, therapeutic, lab test measurement, imaging). Thus, including data from accidents is challenging from a technical viewpoint. Therefore, accident and health record data must be combined in such a way that all the data of the end-to-end accident, emergency, and recovery flow is FAIR to allow an efficient clinical (*i.e.*, primary use) and research (*i.e.*, secondary use) follow-up (*e.g.*, analysis) for all this kind of events. We see the ISAN as a game changer to assure accident-related data FAIRness [68, 77].

4.2.2 ODH Mid- and Long Term

ODH-ness, introduced as the way to evaluate the effectiveness of an ODH intervention [11], reasonably implies the evaluation of the entire set of FAIR principles for each of the three areas-digital humanities, digital animalities, and digital environmentalities-identified and included within the ODH Technology Ring [11, 74]. More particularly, from an ontological perspective, these domains must be understood as the projections of the upper-class "ODH Intervention" idea onto their interdependent classes of digitalities. Accordingly, an effective ODH-ness cannot be considered other than as a sort of FAIR "meta-metric" [74].

4.3 Controlled Multilingual Vocabularies Support ODH and Digital Emergency Management

The MIMO (Medical Informatics and Digital Health Multilingual Ontology) [78] as a controlled multilingual thesaurus and ontology for medical informatics and digital health was successfully initiated and is continuously implemented to provide up-to-date controlled vocabulary references in the various fields of the complex One Health panorama.

Nowadays, based on the same methodology and objective, a controlled multilingual thesaurus focused on ODH (so-called ODHÒN, Greek for "path") is being developed. This thesaurus will be an "upper terminology" focusing on the first step in major items, which will be detailed with several hierarchies and narrower concepts in a second step.

To disseminate both MIMO & ODHON, Health Terminologies and Ontologies Portal (HeTOP[1]) was chosen, which is a cross-lingual multi-terminology server [75]. HeTOP contains more than 2 million concepts in English, 100 health terminologies and ontologies, 55 languages, including non-European languages (*e.g.*, Arabic, Hebrew, Japanese, Korean, Mandarin). The terms currently included in MIMO, to which those from ODHON will be added, are and will be translated by using medical informatics and digital health community existing translations, automated translation based in existing repositories built by multilingual communities (such as Wikipedia [79]), and domain experts' validation.

The generic model of HeTOP is compatible with the ISO 25964 standard and allows interoperability with other vocabularies platforms [80, 81]. The proof-of-concept of the MIMO was integrated, in mid-2019, into the HeTOP terminology server and was in restricted access to identified users. Since the beginning of 2022, MIMO is freely available via HeTOP[2] [78].

Moreover, HeTOP is also hosting thesauri dealing with emergency medicine such as the SFMUt, the thesaurus of the French Society of Emergency Medicine[3] [75]. These controlled vocabularies are a facilitator to expand MIMO and ODHON with A&EI-related concepts and terms.

All in all, MIMO, ODHON and an A&EI-focused terminology will potentially enable and enhance the information and knowledge collection, storage, extraction, analysis and reporting of ODH and A&EI-related resources. The practical applications would rely on detecting and monitoring topical trends to notify disruptive events (accident, disaster, emergency) or innovation.

5 Conclusion

The overlapping challenges and complementary contributions of ODH and A&EI are numerous. While ODH designs a holistic-oriented framework, A&EI introduces an event-focused research field, and both are systems-oriented. Preserving the event focus of A&EI along with the holistic ODH serves QoL as well as HRQoL through the ultimate aim, *i.e.*, emergency and disaster management.

[1] https://www.hetop.eu/hetop/en

[2] https://www.hetop.eu/hetop/rep/en/EFMIMIMO/

[3] https://www.hetop.eu/hetop/rep/fr/SFMU/

The duality of ODH and A&EI regards integration, interoperability, and data FAIRness as keys for personalized and effective public health management.

Thus, the huge volumes of data generated by monitoring, alerting, responding, and curing systems related to human as well as animal health and the environment are shared and processed more efficiently when they will be :

- Designed as highly standardized data ("smart data"), infrastructures, and global management systems to act and react in (near) real-time in regular and disruptive processes;
- Managed as an inclusive working environment taking into account their international dimensions. Thus, controlled multilingual vocabularies must be implemented to enhance the understanding and the development of end-to-end responses to "One Health" events (*e.g.*, human and animal healthcare procedures, detection of environmental hazard) and actions (*e.g.*, education, standard development, citizen's engagement).

Health informatics and Digital Health are at a crossroad. Dealing with human patient and population data is no more the panacea to improve care and wellness. ODH and A&EI are looking at different scales, with similar goals, for converging health and environmental-related data management standards to enable multi-sources (*i.e.*, biological species, technologies, geolocations), interdisciplinary (*e.g.*, human and veterinary medicine, engineering, education, communication, behavioral and social sciences), and real-time data integration and interoperability to allow a holistic Digital Health both in routine and emergency.

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