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Research article

Smart occupational health and safety for a digital era and its place in smart and sustainable cities

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Abstract: As innovative technologies emerge, there is a need to evolve the environments in which these technologies are used. The trend has shifted from considering technology as a support service towards making it the means for transforming all complex systems. Smart cities focus their development on the use of technology to transform every aspect of society and embrace the complexity of these transformations towards something leading to the well-being and safety of people inhabiting these cities. Occupational Health and Safety (OHS) is an essential aspect to be considered in the design of a smart city and its digital ecosystems, however, it remains unconsidered in most smart city's frameworks, despite the need for a specific space for smart OHS. This paper summarizes a 9-month process of generation of a value proposition for evolving the sector of OHS based on a value-map in whose creation several stakeholders have participated. They focused on identifying the products, the methods, the organizational structures and the technologies required to develop an updated, dynamic and robust prevention model focused on workers in smart and complex contexts, and to improve the organizations' capability to guarantee safety even in the most changing, digital and disruptive settings. To assess the relevance and validity of this value-map, a study was carried out to match the set of its elements and its specific and conceptual products discovered, considering also the definition of the past needs and future trends of the sector that a set of renowned stakeholders and key opinion leaders

(with mastery in OHS from several companies and industries) have recently defined for the decade of 2020. A prospective analysis of this match is presented, revealing that there is still an existing gap to be covered in the context of smart cities design: the explicit guarantee of safety for workers.

Keywords: digital transformation; safety at work in smart cities; organizational safety management; safety governance; occupational health and safety

1. Introduction

This paper has the goal of representing the landscape of occupational health and safety in the context of current times, that is, times in which technology has penetrated every aspect of people's lives, resulting in many examples of modern and chaotic cities. The place where humans organize, live and work, the cities, must accomplish with the minimal requirements for guaranteeing their wellbeing and the quality of their lives towards a sustainable developed place, aligned with the "*humanity's aspirations of a better life within the limitations imposed by nature*" [1,2], and in accordance with the United Nations Development Programme and its eleventh goal "Sustainable cities and communities" [3,4], which is something that for workers has been overseen and regulated by traditional occupational health and safety models.

As many cultures exist in the world and considering that there are many governance and regulatory institutions, there have been many emerging institutions overseeing and establishing the management regarding worker's safety. Convergence towards common models and standards has occurred to the point that there is a global community of professionals specialized in the field, and learning from each other.

The recent accelerated advances in information technologies have made cities also evolve towards city models that better adapt and integrate technologies, the smart cities. First, as idealized designs, smart cities started to become real as development through technology became a policy in many cities of the world. In the context of these modern and "smart" cities, occupational health and safety must be carefully driven so that its integration in any aspect of both public and private sectors is guaranteed. For doing so, we believe it is important to listen to the opinion of the experts in OHS about their future views on the field and how they think that occupational health and safety must evolve. From a scientific view, we want to analyze their opinion, the history of occupational health and safety in the context of cities, and we want to try to identify gaps that remain uncovered, so that, by showing our analysis, the future design of smart cities count on a reference for trying to systemically care for workers.

A smart sustainable city is "*an innovative city that uses information and communications technology (ICT) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects*" [5]. Regarding this, all economic, social and environmental aspects of smart cities involve people doing tasks, whose safety must be not only a benefit but a guarantee. Related to this idea, AENOR [6] points that a smart city is "*a fair and equitable city*" which is centered on citizens, and is continuously improving "*sustainability and resilience*", taking advantage of the available knowledge and resources, especially the Information and Communication Technologies (ICT), to improve "*life, the efficiency of urban services, innovation and competitiveness*". Since centered on citizens, safety in smart cities must be addressed from a

governance perspective, for which some specific approaches directly emphasize the role of smartness as an essential feature of governance in modern times [7].

All previously mentioned aspects of viable smart cities are related to the specific dimension of improving people's safety at work, that is, the formally known as Occupational Health and Safety (OHS), but no explicit mention to it is usually given. One of the most detailed descriptions of a smart city available [8] mentions safety but in the context of "*public safety*", not in its relation to an occupational context. However, as Gil-Garcia and colleagues argue, regarding the importance of new technologies "*New and emergent technologies, over the last three decades, have continuously disrupted the administrative landscape of bureaucracies and the public sector around the world*" [9], revealing that the safety of workers as a responsibility of modern governments must be addressed also as an important issue, and considering the most recent technologies available to develop smart cities.

OHS in smart cities goes beyond providing an appropriate chair or a robust helmet, but it comprehends systematically all surrounding risks of workers at work (be this at home or at an office or industry) and also the risks derived to organizational dynamics and culture, which affect people's emotional stability and peacefulness. In order to allow smart cities to embrace efficiently OHS at all levels, it is important to identify the needs of digital transformation and its related dimensions in such a sector, which is the motivation driving this research work.

Until 2019, safety at work had been driven by Occupational Risk Prevention services of companies. However, the COVID-19 global situation made all humankind stop, think, and fast move to the next level in order to adapt. In the occupational health and safety sector, many have been the discussions on how prepared the industries, companies and general organizations were, from both the public and private sector, to globally and systemically protect people at the moment of asking all workers to go home and start working in a "remote setting" that potentially came to stay. Smart cities are the leaders in adopting technologies and driving people, processes and organizations, in general, to adapt and adopt as well, however, no concrete methodologies or strategies on how to drive OHS in the emergent smart cities have been presented before.

Although Occupational Health and Safety (OHS) is not a new topic to talk about, it is the most relevant one from the perspective of people being the most important asset of organizations, considering that the responsibility of guaranteeing the safe return of workers from home after the lockdown relies on it. It is then necessary to ask: are the systems related to OHS ready to provide all the guarantees of a safe return to work or to keep workers working from home as part of a smart organizational strategy? Are these systems ready to manage any emerging situation related to a health crisis? Are these systems ready to support the physical and psychological stability required to improve people's health during and after the workers' return?

All these questions have brought to the discussion a topic that has never been a priority: the need to make OHS systems in modern contexts resilient, active, the main point of reference for the health and safety of workers, and, beyond a simple set of rules, an intrinsic element of the organizational practice that drives a safety-oriented culture.

The current model of implementation of health and safety at work is not sufficiently effective: the proper integration of occupational risk prevention at all levels of companies is not being achieved. An important part of the prevention activity developed is not connected to the supposedly effective implemented Prevention of Risks at Work (PRL/OHS) as described in the regulatory documents, and there is no connection with the environment that facilitates preventive management.

Furthermore, the execution of prevention activities requires a significant dedication of qualified

human resources to bureaucratic and routine activities, which means a reduction in prevention efficiency, as well as an increase in management costs. Moreover, the current model of implementation of Occupational Health and Safety does not facilitate full compliance with Occupational Risk Prevention (ORP) regulations ("Compliance"), and this issue is even more important considering the fact that emergent smart cities do not have an explicit model of Occupational Risk Prevention (ORP) adapted to the dominant IT-driven context of modern livable places with unknown risks and models of safety governance.

It is a problem already perceivable. The preventive information available in the current model of implementation of Occupational Safety and Health is not sufficient to implement modern preventive management: preventive information aimed at workers and those responsible for implementing and monitoring preventive actions is not reaching the recipients quickly and each recipient receives more information than is his or her responsibility. This excess of information received blurs the preventive message.

With this "*diagnosed state of OHS*" in mind, it is then important to appropriately approach the complexity of this problem, aiming to recognize all the perspectives and expectations of the several and so varied set of actors involved in the prevention. It is necessary not only to identify the actors and stakeholders but also to interact with them and understand what are their priorities, what is their action range, and how the relations among them are constraining or facilitating the implementation of an effective prevention system.

This work presents a 9-month experience in which a cross-disciplinary team analyzed the situation of the prevention at the current times and designed a value map that considering the real needs and priorities of relevant stakeholders, proposes a system of interconnected solutions that as a whole constitutes an efficient idealized system to make the prevention required in the 2020 decade a viable goal.

Part of the validation of this work was to review what the trends of digital transformation onto such smart system are, according to key opinion leaders in the sector of OHS, and what should the lines of action be to pursue such digital transformation, considering that it must be sustainable, resilient, responsible with the environment, dynamic, open to changes, and finally, driven by the complexity that the current society is adding to any problem: more people, more perspectives, more human factors, more interconnections, more counterintuitive effects, and so on.

To cover these goals, we present and discuss (Figure 1):

- In Section 2 a landscape combining the advances of the last decade in OHS digitalization through the generation of a summarized state of the art.
- In Section 3 we use the Osterwalder and colleagues' methodology [10] to discuss the current needs of OHS, at the Spanish level, by interacting with and obtaining information from the gathered real agents involved in the Spanish system of OHS.
- Section 4 presents the future trends in the sector, defined by international experts envisioning the OHS future.

After separately developing these three analyses, we did the exercise of combining these three perspectives to visualize what we have reached from the desires of the past, and what should be done in the OHS digitalization field to embrace the future trends for the present decade, the decade of the smart and sustainable cities.

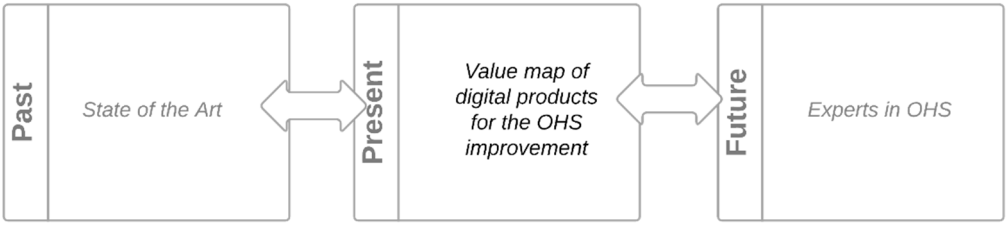

Figure 1. The place of this research in the OHS historic landscape.

2. State of the art

For understanding the context of this research, we explored the existent research conjoining smart cities and occupational health and safety, as well as the state of digitalization in the field of occupational health and safety under a sustainable lens. Next, we summarized the main findings and state how these findings are relevant for the proper understanding of this research paper.

For this research, we searched for works with the different combinations of keywords relevant to this research (sustainable, occupational health and safety, digitalization, smart cities, digital era) in the databases that we have access to (Scopus, WoS, IEEE), and filtered by selecting works considering recency (within the last 12 years), relevance, the publication source, and the consideration of recent trends.

2.1. Sustainable smart cities and OHS

In this subsection, the goal is to explore how OHS has been conceived in existing standards for the development of smart cities. For doing so, the main contents of each standard are reviewed from a critical perspective, aiming to identify whether there is a direct inclusion of OHS and risk prevention aspects or not.

According to [11], there are several aspects in the standards specifically referring to the dimensions of security, including security in infrastructure, security of information systems, security in access to services, security of personal data and sensitive information. However, a few examples of mentions of the dimension of security as the care of people are "*Existing standards can also be applied to improving the resilience of smart cities, considering the safety and security of citizens*", with no specific mention to the duties of people as workers inserted in a smart ecosystem; and regarding transformative processes within sustainable cities that "*The explosive growth of urban data, coupled with their analytical power, opens up for new opportunities for innovation in sustainable cities. This in turn means finding and applying more effective ways of translating sustainability into the physical, spatial, environmental, economic, and social forms of the city*" [12], suggesting dimensions in which workers are daily involved and in which their safety must be considered.

In the "Guideline On Smart Sustainable Cities Standardisation Framework In Relations To Information And Communication Technologies (ICT) Aspects" [5], the main contribution of the frameworks "Management & Assessment Standards", "Services standards", "ICT standards", and "Physical Infrastructure Standards" are mentioned as a key sector of the smart cities [13], however, none of these makes explicit mention of the dimension of safety regarding the workers' activities. It

is possible to see that all of the mentioned sectors of the smart cities included in these standards (around 26 specific sectors) involve people doing tasks, and by definition, all activities may involve risks to be considered, prevented and avoided, so it is possible to think of OHS not as a specific sector to be included in one of these standards, but as a transversal sector correlated to all the specific sectors of the smart city.

In [6], similarly, some general key sectors of smart cities are mentioned. In general, in this work the authors propose a set of areas of attributes of the smart cities that must be cared for: smart economy, smart governance, smart environment, smart mobility, smart society and smart living. The Smart Economy domain groups attributes related to the city's capacity to develop in terms of employment, economic and financial growth. The Smart Governance area groups attributes related to the capacity to efficiently manage resources, execute policies and adequately combine the interests of citizens, social organizations, companies and administrations. The Smart Environment area groups attributes related to the natural environment, the physical structures of energy, water and urban planning, as well as the capacity to be sustainable in its operation in the present and in the future. The Smart mobility domain groups attributes related to transportation and logistics. The Smart Society domain groups attributes related to the city's human capital, education, social inclusion and citizen collaboration. The Smart Living area groups attributes related to improving the quality of life of citizens and their lifestyle in physical and material aspects (health, safety, housing, income) and in social aspects (culture, family, associations, personal development) to promote innovation, education, social cohesion and citizen collaboration. The Smart Environment area groups attributes related to the natural environment, the physical structures of energy, water and urban planning, as well as the capacity to be sustainable in its operation in the present and in the future [6].

Regarding the sustainable sphere, there are specific contributions exploring behavioral intelligence as a means to improve the integration of technology as a driver of smart cities [14], specific guidelines for developing smart sustainable cities [15] in the context of developing countries, frameworks approaching how to measure sustainability in smart cities [16], or the relevance of OHS in the specific context of the Industry 4.0 [17].

A few works explicitly explore Occupational Health and Safety and its role towards a more sustainable society, such as the work of Marhavilas and colleagues [18], who present a study focusing on Sustainable Occupational Safety And Health Management Systems (S_OSHMS), or the main standards, and the added value of considering sustainability as a key aspect for effective occupational health and safety management. Another contribution [19] presents a critical view of the usefulness of the renowned ISO 18001 standard (evolved to ISO 45001) and how it really contributes to the field, focusing more on the results and outcomes instead of the procedures. The authors present specific CMO configurations (Context-mechanisms-outcomes) to properly reach success using OHS management systems.

Despite the definition of areas and the clear mention of the need for health and safety in the area of Smart Living, the reference to health and safety is quite general, leaving decision-makers to create their own interpretations of such terms and designing the strategies they want to achieve such fuzzy goals about health and safety. From a critical perspective, and without diminishing the whole contribution of this work, it is important to mention that no clear distinction as a priority of the aspects related to health and safety of workers is given, so, an extension to the standards in its current form or a complementary definition of guidelines or strategies leading to design “the smart prevention of risks in future cities” is required.

As could have seen, after a review on the most known general standards guiding the design and creation of smart cities, there is no direct consideration of the importance of caring for workers from a governance perspective, so making explicit, in formal areas, the need to cover this aspect from a systemic view. It is in this sense that this paper is extremely relevant. The following subsection will summarize the state of digitalization in the area of OHS, and Section 3 will present the value map with the proposal for systemically guide the integration of OHS as a key factor in the process of digital transformation of prevention required by smart cities.

2.2. State of the digitalization in the OHS field

Regarding Occupational Health and Safety Management Systems, one of the most recent standards is the evolution of the OHSAS 18001, the ISO 45001 [20]. Although not focused on digitalization, by focusing on the improvement of management systems in OHS in the 21st century, the digital dimension is impossible to be ignored, so the standard clearly states some clauses helpful for best digitalization. In detail, the standard "*aligns health and safety in a form that integrates with other management systems used in more than one million organizations. This convergence can provide significant cost savings through improved health and safety performance and the elimination of waste and duplication through standardization and cooperation between departments*" [20].

Bradbrook and colleagues [21] justified the need to adopt technologies to move towards risk reduction in working environments in different industries. And this has largely been the case, covering fields as expected as the development of applications, to unexpected fields such as the use of nanotechnologies in OHS [22]. More recently, according to [23], trying to identify trend technologies in the field of OHS, the following can be mentioned as top trends in the technological and digital field:

- Software programs and applications help to organize the management of safety at work.
- New technologies have improved health, safety and environmental protection.
- The latest technologies have not yet clearly demonstrated their benefits and also pose additional safety risks.
- And all this is related to very specific benefits and risks:
- The most advanced technologies reduce risks and improve working conditions.
- In particular, augmented reality and virtual reality will have a significant impact on teaching and higher education.
- New technologies pose new threats to security.
- People continue to be the focus of attention, regardless of new technologies.
- The unexpected coronavirus crisis will have a major impact on the way we work and will accelerate the digitization of the world of work. Safety at work, and in particular EHS (Environmental Health and Safety) training, will also benefit from this development.

The work of Stacey and colleagues [24] is critical in identifying the key issues that should drive workplace digitization. One of the main challenges relates to the constitution of a more diverse and less defined workforce and the changes that introduce more flexible working patterns, which are expected to be brought about by the increasing prevalence and diffusion of ICT-enabled technologies. This is because ICTs make it possible to work virtually anywhere at any time, and are expected to fundamentally change traditional employer-employee relationships.

Although the dissemination and prevalence of ICT currently vary across sectors, ICT is now generally considered to be an integrated part of many sectors rather than having its own sector, and is

expected to continue to grow in all sectors, although not necessarily uniformly.

The spread and prevalence of ICT application vary across Europe and socio-economic groups. There is evidence that the next decade is likely to see significant and accelerating changes concerning ICTs, which will significantly change the nature of work across Europe and affect most people in some way [24]. This will have the potential to create business opportunities, inter alia by stimulating productivity growth and employment in Europe, with the potential for inequalities in the benefits and disadvantages experienced by different workers. These changes are difficult to predict, so the scenarios will be a valuable tool to help inform EU decision-makers, member state governments, trade unions and employers, and to enable them to take due account of changes in ICTs when making decisions to shape the future of OHS towards safer and healthier workplaces.

According to [24] the main trends and drivers, taken together, imply that the pace of change in ICTs and how they are exploited in the workplace is likely to depend on how the demand for and acceptance of ICTs by the public and workers occurs. Governance and investment-related decisions support ICT innovations (in particular robotics, autonomy and artificial intelligence (AI)), which drive changes in the nature of work and business structures (in particular rapid job changes and staff turnover).

In view of the emergence of new technologies that affect the working environment, Brocal and colleagues [25] propose a method to identify and characterize the emerging risks as a consequence of automation and the adoption of new technologies, specifically in the manufacturing industry. An interesting aspect of this work is that it introduces the concept of "complex problem" as a descriptor of technology adoption in OHS, which in turn leaves the suggestion of using complex approaches to address such problems as well.

Moving closer to the leading technologies, in the Industry 4.0 era, Badri and colleagues [17] present an analysis of the importance of risks in the OHS industry. The authors are mainly dedicated to answering the following questions, in order to justify that Industry 4.0 must also take care of the OHS:

- Are we giving due consideration to changes in Occupational Risks Prevention (ORP) imperatives?
- Are the occupational health consequences of Industry 4.0 being adequately assessed?
- Will we lose any of the gains made through proactive approaches?
- Are there important rational reasons for concern?

Beyond the transition to I4.0 is the fact that there are growing, fragmented, distributed but interconnected networks of collaboration. And this distributed network is increasing the possibilities of accidents and occupational risks by increasing jobs, decreasing corporate monitoring of OHS and/or policy-based regulations. According to this, it is necessary to take care of the OHS in this new and changing environment if we want to avoid playing the game of failure, for which it is necessary then to think of alternatives of organization, of technological integration, of worker's scope and/or to approach systemically and considering its complexity the integrated system of an organization that wants to take care of its OHS.

There are specific works exploring how to care for quality in the era of Industry 4.0 considering the European Foundation for Quality Management (EFQM) 2020. The authors [26] suggest considering the interrelations and linkages between the EFQM and the Industry 4.0 sector, "*can support successful digital transformation by combining quality and excellence with Industry 4.0*" and highlight the relevance of the fact that "managing knowledge, skills, and capabilities is critical for the successful adoption of Industry 4.0" [26].

An expert report [27] presents a clear vision of what could be the way forward in terms of digitalization in OHS. It specifically mentions that digitization offers the potential for innovative and

exciting developments in the workplace, but this is accompanied by new challenges. A clear benefit is that, by anticipating potential challenges to occupational safety and health (OSH), we can maximize the benefits of these new technologies, while ensuring safe working environments. If managed well, digitization can reduce occupational risks and create new opportunities to improve working conditions. This is what the European Agency for Safety and Health at Work (EU-OSHA) is committed to supporting. Some of the specific technologies mentioned in this report, and, where appropriate, some related work, are:

- The development of collaborative intelligent robots.
- Research and development of exoskeletons for the protection of workers [28].
- Research and development of Big Data, Artificial Intelligence and Algorithms [29].
- The development of intelligent protective equipment.
- Applications with augmented and virtual reality.
- Additive manufacturing (related to 3D printing).
- The development of online platforms.

On the other hand, there are quite clear attempts to advance research by making use of Big Data and Machine Learning to improve the identification of inspection objects (companies, institutions, etc.) with high risks of occupational accidents [29]. This report reports that there are some important difficulties related to the selection of high-risk inspection objects using Big Data and Machine Learning, however, the usefulness of these techniques within a risk-based approach is not in any way diminished. These difficulties may be related to the emergence of new risks that "green" tools may bring when incorporated into the Labour Risk Prevention (LRP) ecosystem [30].

In addition, according to [31], the digitization of companies dedicated to ORP must consider the following key aspects:

- Wearables and connected worker technologies.
- Data science and analysis platforms.
- Augmented or virtual reality and simulations for digital training.
- Stress control and reduction technologies and employee well-being.

The management of occupational risk prevention is affected by a wide range of factors. The following are some of the approaches that may be relevant to understanding how prevention implementation, planning, follow-up and monitoring have been managed so far.

Arocena and Nuñez [32] analyze for a group of 193 Spanish SMEs, what prevention strategies they have implemented, how they have managed these strategies, how effective they have been and what factors affect the adoption of these strategies. The authors have been able to identify which factors, such as dedicated effort and the maturity of procedures aimed at supporting prevention, are crucial in the number of accidents that companies have. Based on the evidence from the companies they studied, they found that other factors, such as company size, also tend to have a significant effect, and that small companies are less likely to have an advanced accident management and prevention system that they can take advantage of. Factors that affect whether a company adopts an effective system include the quality of industrial relations, the rate of unionization, the intensity of price-based competition, access to public aid and training provided by public occupational health and safety agencies, the intensity of technology and the manual nature of workers' tasks. Of special relevance in this work is the proposal of dimensions to be observed in risk management: Planning, Control, Integration, Documentation, Emergency, Training, Information, Participation, Ergonomics, Health and Equipment. And from these dimensions the definition of the state of management in the different companies, being

able to be cataloged as Advanced, Technical, Basic or Absent; which can also be measured from stochastic studies and regressions, from the dimensions observed.

More recent works [18,19] study the international standards of management systems in the field of OHS, supporting the idea of sustainability as a key aspect to drive organizational transformation. The authors of [18] highlight the need to consider OHS management systems standards in a wider set of industries, since according to their findings, restricted sectors concentrated the consideration of OHS, while the need of it is general and homogeneous to all types of organizations. Uhrenholdt and colleagues [19] identify specific configurations of management systems according to the ISO 18001 standard, suggesting what would be effective management systems in OHS.

On the other hand, also related to management, the work of Jilcha and Kitaw [33] focuses on identifying the fundamental pillars that must be guaranteed to achieve sustainable development from the perspective of OHS. Specifically, the authors suggest that the pillars to be looked after are: the economy, society, the environment, cultural factors, political factors, technological factors, and as proposed by the authors: innovation in occupational health and safety at work in all entities involved in the work activity. According to the authors, considering all the pillars in the organization reduces accidents and occupational diseases, but they go a little further and propose pillars and areas of work that must be taken care of in occupational health and safety to properly support sustainable development. Among the effects of the improvement that the authors propose they identified: better health of workers, healthier jobs, reduced costs of occupational accidents, the environment is controlled, occupational accidents are managed, and knowledge regarding safety at work is superior.

According to [34], prevention management should be guided by the need to understand the factors that contribute to changes in security and to examine the process of organizational transformation towards better ORP, both at the micro and macro levels. The questions to be asked should be, according to this:

- What factors lead organizations to adopt society's values in order to build lasting institutions, people and society?
- How can organizations be encouraged to take a preventive approach to create healthy workplaces rather than just reacting to accidents and injuries?
- How can senior management be consistent with established and promulgated priorities (what it says it does and what it does) and be strategic in aligning safety priorities with production priorities?

All these questions lead to a complex reflection with no true answer, but depending on the perspective assumed can lead to different expectations and points of reference of what the problem to be solved is and its possible solutions.

On the other hand, in a more general way, Rubio Romero [35] in his book lists integrated management approaches to ORP, distinguishing between several options, the total quality and total safety approaches. These models are old and were designed for management at an organizational level, in a generic way, not specifically for the problem of ORP, nor focusing on technological transformation. Moreover, Uhrenholdt Madsen and colleagues state that no previous works have explored in deep how an effective management system "*has an impact on health and safety performance, and the understanding of the organizational context and mechanisms related to achieving desired OHS outcomes*"[19].

The work of [36] aims to *"provide employers and workers with the basic management elements that will enable them to carry out the different preventive activities in the simplest and clearest way*

possible, providing the necessary criteria so that these are adapted to the legal requirements and the characteristics of each company", this without taking care of the technological aspect of an effective implementation of the companies' prevention strategy.

In a local (Spanish) practical context, the public administration has made available a "procedures manual" that is supposed to guide the adaptation of procedures to a higher strategy of implementation of ORP systems [37]. The assumption of a generic management system with four major phases, to which the procedures supported by this manual are transversal, stands out:

- Preventive action planning.
- Execution of the set of planned actions.
- Measurement and control of what has been done, evaluating its results as well as the quality of the actions carried out.
- Adoption of the corresponding actions to improve the system.

We have seen that management pillars, phases, specific approaches, management maturity levels, etc. are defined. What has not been identified, however, is a comprehensive, holistic approach that relies on technology to not only support but also direct the management of prevention in modern organizations as these being conceived in smart cities, on the assumption that technology is no longer a support factor for operational tasks but rather the driving force behind the effective execution of operations. This is the governance vision that this project aims to address.

Table 1. Summary of the working groups' participation in the Value Maps creation.

Working group created	Mission	Number of people by gender	Affiliation	Experience
1	Value map creation representative of the OHS technicians needs and wishes	3 women/2 men	IRSST	10 years of experience in the OHS field
2	Value map creation representative of the OHS in house prevention services needs and wishes	1 woman/ 3 men	ELECNOR	10 years of experience in the OHS field as directors, managers and technicians
3	Value map creation representative of the OHS external prevention services needs and wishes	1 man	QUIRON PREVENCION	20 years of experience in the OHS field, as Director, manager and technician.

3. Materials and methods-Value map: a sense-making set of digital products to transform OHS

Understanding the needs of the customers and stakeholders in the sector of OHS is a crucial aspect of the value map to be created, so this plays an important role at the beginning of this value proposition design. In order to advance with this identification of needs, a working group was created with representatives and stakeholders from several institutions: including a set of experts in OHS from the Regional Institute for Occupational Safety and Health of the Community of Madrid (IRSST), a group of researchers from the Computer Science Department of the Carlos III University of Madrid, some participants from the company Quirónprevención (External Prevention Service) and the company

Elecnor (In-house Prevention Service). These participants volunteered to participate in this activity attending a call for participation announcing the non-profit purpose of the study and a calendar of meetings. The participants of prevention companies who attended the call are professionals in the field of OHS with professional activities undergoing with the Regional Institute for Occupational Safety and Health of the Community of Madrid (IRSST). The members of the Regional Institute for Occupational Safety and Health of the Community of Madrid (IRSST) and Universidad Carlos III de Madrid are leaders in the field of digitalization of OHS, and agreed to lead this research as part of a specific research chair. As a summary of the working groups participating, Table 1 summarizes the information, considering mission, number of people, affiliation and experience of the involved.

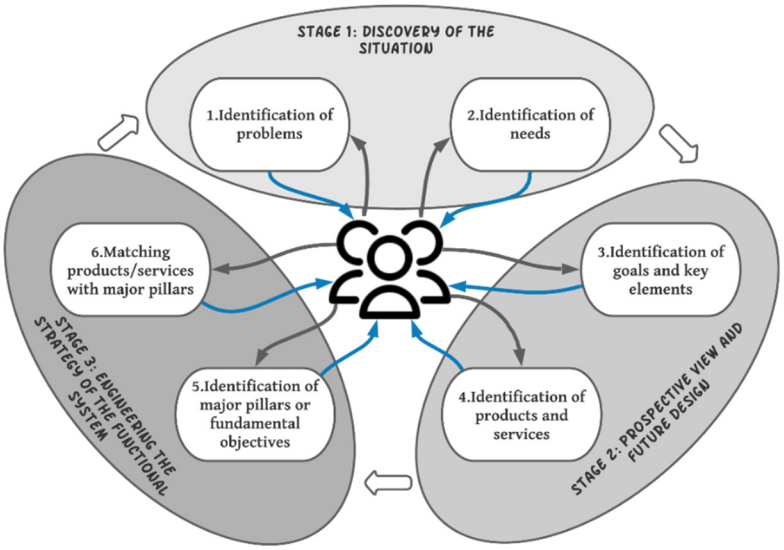

Figure 2. The place of this research in the OHS historic landscape.

Within these working groups, some of the ideas of the Value Proposition Design method from Osterwalder were applied [10]. The description of this process is illustrated as follows.

Stage 1: Discovery of the situation

- Step 1: Identification of problems.
- Step 2: Identification of needs.

Stage 2: Prospective view and future design

- Step 3: Identification of goals and key elements.
- Step 4: Identification of products and services.

Stage 3: Engineering the strategy of the functional system

- Step 5: Identification of major pillars or fundamental objectives.
- Step 6: Matching products/services with major pillars.

4. Results-Step by step: results obtained in a real case

Following, the results and the information obtained in each of the steps are presented.

4.1. Stage 1: Discovery of the situation

For steps 1 and 2, meetings and discussions were held, generating very valuable information that was collected using a specific spreadsheet formatted with the objective of collecting opinions, relevant facts, early findings and conclusions that the participants agreed upon. There were regular face-to-face monthly meetings that after March 2020, with the COVID-19 situation, became virtual permanently.

4.1.1. STEP 1: The problems identified have been summarized below

1) There is a clear lack of preventive culture among workers.
2) Overload due to Authorized Enterprises Registry REA (Registro de empresas autorizadas).
3) The motivation for training is very weak.
4) Excessive administrative work by Enterprise Activities Coordination CAE (Coordinación de actividades empresariales).
5) There is a lack of preventive company culture.
6) Enterprise Activities Coordination CAE (Coordinación de actividades empresariales).
7) Working time is low.
8) The Health and Safety Plan cannot be used on construction sites.
9) There is a general lack of control tools.
10) There is a general lack of support for the integration of prevention.
11) General malpractice among competitors.
12) Lack of tools for the detection of needs.
13) Lack of integration of prevention within companies.
14) Lack of integration of prevention in the CM (*Comunidad Autónoma de Madrid*) among different institutions.

4.1.2. STEP 2: The following needs have been explicitly identified

a. Prevention needs to be integrated into the person.
b. The training required and its extent must be precisely defined.
c. The rules of the prevention service must be improved.
d. The minimum CAE indicators must be clearly specified.
e. Visibility of prevention must be visualized.
f. The risks must be known on a practical level.
g. Prevention activities should be promoted.
h. The tasks of the prevention delegate must be clearly defined.
i. To effectively recommend preventive and protective measures
j. Create the conditions for a responsible person culture.
k. Evidence of prevention activities should be recorded.
l. There must be a support to solve daily issues easily

4.2. Stage 2: Prospective view and future design

An elicitation and validation cycling process was integrated as part of the agenda for the monthly meetings held. The idea was to show to the relevant stakeholders the proposal of goals and key

elements (Step 3), until an improved and refined model was accepted.

Considering the previously identified problems, and the goals to pursue, the technological members of the team followed a process of design of a digital strategy consisting of identifying the products and services required to fulfill all the identified goals and needs.

4.2.1. STEP 3: Identification of goals and key elements

From the problems and needs identified, the participating agents have identified those key elements that they would include in the new model of risk prevention and health. These are listed in the following: "wishes" that we name as goals:

A. Improve the quality of prevention: by involving all the agents related to the process.
B. Encourage the integration of prevention: Through the use of agile approval procedures and a personalized information distribution system.
C. Facilitate the management of preventive planning: Through easy-to-use tools.
D. Improve Quality measurement: Through concrete preventive parameters and metrics.
E. Support prevention services: By using shared criteria.
F. Improve preventive worker training: through training, profile and recognition.
G. Preventive culture: Through continuous recognition of people at all levels of the company.
H. Improve visibility of prevention management and the impact of improvements.
I. Visibility and recognition of the quality levels of prevention services.
J. Create an observatory for R&D in risk and health prevention.

4.2.2. STEP 4: Identification of products and services

The proposed set of tools, strategies and specific developments to tackle these needs are the following:

(1) IT infrastructure and logical architecture for prevention integration: this infrastructure is aimed at supporting the effective integration of the prevention in the company by implementing a Prevention System that covers all the organizational hierarchy levels and all the activities of the company.

(2) App-structure of the company's organization: this application aims to facilitate the integration of prevention in companies, and therefore the compliance with OHS regulations.

(3) LOGICAL PATTERN-risk assessment. App-Risk Assessment: to strengthen the management of Risk Assessment in companies, providing a means to facilitate the unification of criteria in each prevention system, thereby reducing repetitive work by prevention technicians, and opening up a way to make information available for the evaluation of preventive quality.

(4) App-Management of individual and collective protection equipment: to make available to workers the personal protective equipment specified in the risk assessment, and to ensure that it is used in accordance with the specifications (expiry date, maintenance), and also to indicate the availability of the collective protections indicated in the risk assessment.

(5) App-Training element: It consists of an Information System for the registration of the Community of Madrid preventive officer's CV (training received, responsibilities carried out, more evaluations received) and the activity carried out in the different companies in which they have provided their services.

(6) App-Approvals Management: to ensure the commitment of companies' managers to the preventive information generated by the prevention service, by means of an agile system of approvals.

(7) App-Notifications: to encourage participation in the preventive activity, at all levels and related to all company activities, through: company managers, middle management, workers, workers' representatives.

(8) LOGICAL PATTERN-Preventive Management Quality Metrics. App-intelligent evaluation of preventive quality: The aim is to have indicators of the quality of preventive management (some of which are precursors of the accident rate) in companies and prevention services, which will allow advanced statistical analyses to be carried out to evaluate the quality of preventive management and make the management of preventive policy more effective.

(9) Dashboard: it would aim to provide relevant consolidated data, in real time, useful for preventive policy decisions by companies, prevention services and administrations.

(10) Dynamic and living knowledge repository, to provide accessible and secure enterprise OHS information: The aim of this repository is to make available in an organized manner all the preventive information on companies (current and historical), as well as preventive recommendations and criteria for the application of good practices by companies, Prevention Services and public administrations.

(11) Traceable OHS/EHS Chat: it is a system to improve communication and its traceability between the different people involved in the phases of the preventive activity.

(12) Digital Work Environment: This is a gateway to a digital environment that facilitates the digitization of activities not strictly preventive that the company develops.

(13) Preventive Information API: to provide access to the Apps related to the companies' preventive information, which are necessary for the companies to advice and control, and to support the establishment of quality standards and recognitions.

(14) Recognition Model: design of rules. App-Recognition System: To establish incentive and recognition systems (to Prevention Services, prevention technicians, companies, company managers, workers' representatives, workers) and intelligent algorithms for evaluating such systems, which allow for strengthening the commitment of the actors involved in the preventive action and an improvement in their performance in the preventive activity.

(15) Training portal: It is an agile, accessible training portal based on the intelligent management of the contents that are necessary for each worker or agent involved in the training activity or training management.

(16) APP STORE-occupational health and safety: Creation of a category of APPs related to health and safety at work, where applications oriented to the prevention of occupational risks are framed. On a personal level, it should be a social movement that leads to improving the lives not only of the collective of people who work in a company but should also encompass the rest of the people in their society and on the planet.

(17) PLACE TO WORK 4.0: With this, the aim is to promote and create the conditions to advance towards the birth of a holistic culture of safety and health at work, resilient and aware of complex concepts such as collective welfare, with the aspects of OSH intrinsically anchored in this organizational culture.

(18) OHS Observatory 4.0: The aim of this observatory of technological innovation in the field of occupational risk prevention is to guarantee the continuous, critical and up-to-date evaluation of the innovative technological solutions available, analyzing how they fit into the VENTURA model and the changes that may arise in the future.

(19) APP Agile Delphi-Permanent creation of prevention criteria: Permanent observatory for

the creation of criteria agreed upon by experts for the improvement of occupational risk prevention practice.

(20) Standardization of the requirements for digital platforms to support OHS: UNE (Spanish) standard, with future projection to a certifiable ISO standard, on the criteria that must be met by platforms supporting the intelligent and sustainable digitalization of OHS. As well as an evaluation model of the standard, so that companies can know the level of adequacy of their management systems and execution of OHS to the regulatory and certifiable model in the future.

4.3. Stage 3: Prospective view and future design

Matching the products with the goals was a process followed to discover the relevance of the product in light of the goals. The aim is to visualize the goals that are being met and mostly whether there are goals that are not being met, in which case it would be necessary the proposal of alternative products.

4.3.1. STEP 5: Identification of major pillars or fundamental objectives

The key elements of the project should be grouped by major objectives or fundamental pillars of the project. Five fundamental pillars or general objectives have been identified:

- ID → Intelligent Digitalization of OHS management: to facilitate prevention through friendly tools.
- IA → Impact assessment of preventive management: to measure the effect of the action criteria of certain preventive measures.
- PC → Potentiating preventive culture: assessment of the training background. Recognition of all the actors involved.
- VQ → Make visible the preventive quality of the prevention services: promote the valuation of the quality in the preventive activity of the prevention services.
- CI → Continuous innovation in risk and health prevention: maintain an observatory that helps to identify potential innovations that can be applied in serving risk and health prevention to make it evolve.

4.3.2. STEP 6: Matching products/services with major pillars

The products/services grouped by the general objective that they leverage are grouped in the 5 fundamental pillars or general objectives of the project as shown in the following Table 2. This is the product of a mapping performed considering essential variables related to:

- The goal that every product is supporting, through the corresponding acronym.
- The identified emerging pillars, through the color and the corresponding acronym. PC → Green, ID → Yellow, IA → Orange, VQ → Pink, CI → Violet.

The main goal is to identify aspects related to the following questions:

- Which product is supporting more goals?
- What goals are weakly being supported?
- What are the stronger pillars, according to the goals and products supporting them.
- Which pillars need to be better supported?

The next table summarizes our mapping, and represents the main findings of our critical analysis.

Table 2. Products mapped with supporting goals and pillars.

		PRODUCTS/SERVICES																			
PILLAR	**GOAL**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
PC	**A**	X						X			X	X		X	X		X	X			
ID	**B**	X	X		X			X						X							
ID	**C**	X		X			X						X								
IA	**D**	X							X												
IA	**E**	X		X						X										X	X
ID	**F**	X				X								X		X					
PC	**F**	X				X								X		X					
PC	**G**	X				X								X	X	X	X	X			
IA	**H**	X								X	X			X	X						
VQ	**H**	X								X	X			X	X						
PC	**I**	X							X		X			X			X	X			
CI	**J**	X																	X	X	X

5. Future trends and prospective view analysis

A more recent study allows identifying the following list of items with the trends related to the digitalization of OHS according to [23]. This work has been selected as a reference since it is founded on the fact that a specialized and experienced company performed a careful selection process to identify leaders in the sector of OHS/ORP who can based on their experience give opinions and provide a critical view on trending currents regarding the future of OHS. The list is divided into four sections, specifying: the trends in the 2020 decade, the improvement areas, the effect of digital in safety systems, and the application of new technologies in OHS. The trends have been numbered from 1 to 15 for future mention ahead in the paper.

5.1. Trends in occupational safety

- Trend 1: In occupational safety, people are the most relevant and human attributes count the most.
- Trend 2: Digitalization and technology improve most occupational safety strategies. However, we must ensure that the working environment they create is positive.
- Trend 3: A commitment to continuous improvement of existing concepts and ideas, rather than pursuing the creation of new trends.
- Trend 4: Management systems are crucial in occupational safety.
- Trend 5: The diversification of EHS tasks is increasing every day, so it is necessary to review the competencies and responsibilities assigned to each job.

5.2. Improvements in occupational safety

- Trend 6: Safety training, experiential learning and knowledge sharing need to be improved so that employees become more involved in occupational safety.
- Trend 7: Only through better internal communication can the safety culture be strengthened. Communication and cooperation are the main instruments for involving employees in a common

understanding of the culture of safety at work.

- Trend 8: Occupational safety should take a holistic approach.

5.3. Safety management in the digital world

- Trend 9: Software and applications help to organize the management of safety at work.
- Trend 10: New technologies have improved health, safety and environmental protection.
- Trend 11: The latest technologies have not yet clearly demonstrated their benefits and also pose additional safety risks.

5.4. New technologies and their application in occupational safety

- Trend 12: The most advanced technologies reduce risks and improve working conditions.
- Trend 13: In particular, augmented reality and virtual reality will have a significant impact on teaching and higher education.
- Trend 14: New technologies pose new security threats.
- Trend 15: People remain in the spotlight, regardless of new technologies.

With the trends of OHS and its digitalization identified, it is then possible to think about whether the structure of a framework to address such digitalization is appropriate or not. Following is an approach to match the trends previously presented with the proposed digital product identified in our proposal in section 4, in order to assess its relevance and prominence under the light of the present situation for OHS, comparing it with the future prospective.

6. Discussion: Mapping the relevance of the proposal-coping with the digitalization of OHS in the context of smart cities

By having both an insightful analysis on the needs of digitalization of Occupational Health and Safety (OHS), a prospective view of the trends and needs regarding its future, and having also the set of digital products and services identified following the procedure described before, in Section 4, it is possible to ask then about the relevance of the products and services in regard to the past and the future needs. Following, in Figure 3, we present a matrix connecting the proposed products and services with:

1) The past, considering the needs for attention in the area of OHS that were expressed by the works reviewed in the state of the art.

2) The future, considering the trends in the area of OHS that experts in the field have expressed.

PAST																				
[37] (INSHT, 2002)			x					x	x					x					x	5
[36] (Betsraten et al., 2020)		x												x					x	3
[35] (Rubio Romero, 2002)			x					x											x	3
[34] (Chen et al., 2014)		x																x	x	3
[33] (Jilcha and Kitaw, 2017)	x	x							x	x							x	x	x	7
[32] (Arocena and Nuñez, 2010)	x	x			x										x				x	5
[31] (CORITY, 2020)	x		x	x				x	x		x	x	x	x	x		x	x		12
[29] (EASHW, 2019)			x			x	x					x		x					x	6
[28] (EASHW, 2020)	x	x	x	x				x			x	x		x		x	x	x	x	12
[17] (Badri at al., 2018)	x		x					x	x		x	x	x				x	x		9
[25] (Brocal et al., 2018)			x	x												x			x	4
[24] (Stacey et al., 2017)	x		x	x	x	x	x		x	x	x	x	x		x	x	x	x			15
[21] (Bradbrook et al., 2013).	x		x	x								x	x						x	x	7
Count	7	5	9	5	2	2	2	5	5	2	4	6	4	5	3	3	5	6	3	8	
PRESENT																					
Digital product ID	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
FUTURE																					
New technologies and their application in occupational safety	***Trend 15***			x	x	x			x			x		x				x	x	x	x	10
	Trend 14			x															x		x	3
	Trend 13					x									x	x						3
	Trend 12	x		x	x									x								4
Safety management in the digital world	***Trend 11***													x					x			2
	Trend 10			x					x									x				3
	Trend 9	x	x	x	x	x	x	x	x	x			x		x		x	x		x		14
Improvements in occupational safety 2020	***Trend 8***												x					x	x		x	4
	Trend 7	x	x				x					x							x	x		6
	Trend 6					x					x					x	x			x		5
2020 trends in occupational safety	***Trend 5***						x		x		x	x			x	x					x	7
	Trend 4	x	x		x		x		x	x	x					x			x	x		10
	Trend 3					x					x	x	x			x				x	x	7
	Trend 2				x						x	x			x			x	x	x		7
	Trend 1			x		x												x		x		4
Count	4	3	6	5	6	4	1	5	2	5	5	3	3	4	5	2	6	7	8	5	
Product relevance in time	7>4	5>3	9>6	5=5	2<6	2<4	2>1	5=5	5>2	2<5	4<5	6>3	4>3	5>4	3<5	3>2	5<6	6<7	3<8	8>5	
Considering the past and the future, how relevant may the digital products be?	H-M	M-L	H-M	M-M	L-M	L-M	L-L	M-M	M-L	L-M	L-M	M-L	L-L	M-L	L-M	L-L	M-M	M-M	L-M	H-M	

Legend - Color code	L-L PR=Low PFR=Low	L-M PR=Low PFR=Medium	M-L PR=Medium PFR=Low	M-M PR=Medium PFR=Medium	H-L PR=High PFR=Low

Figure 3. Matching: Ventura Assets vs. 2020 Digital Transformation Trends and revealed needs.

From the above table, a qualitative analysis can be made to contrast the relevance of the products that make up this strategy with respect to the two different temporal dimensions mentioned before.

Figure 3 is divided into three main parts. The first part (PAST) contains the match of the studied documents describing the state of the art with the ecosystem of digital products presented in this proposal. The second part (PRESENT) contains the list of the numbered digital products whose description is given in Section 4. The third part (FUTURE) matches the products with the future trends identified by the experts, whose description is given in Section 5. Additionally, there is a legend summarizing the type of cases of relevance of the digital products presented in this research work.

To comprehend the information shown in Figure 3, we have decided to use a Low-Medium-High scale of relevance for the needs expressed in the "past" dimension, and the trends identified within the "future" dimension. This allows us to match such subjective relevancies with the digital products for the digitation of the prevention, letting us conclude on the importance of both each product and the whole ecosystem that they together conform as well.

As can be seen, the relevance of the products varies. In general, and with the aim of simplifying the explanation, 5 categories of products have been identified, which are explained below.

a) Products whose relevance in the past was not connected with many of the reviewed works, and also whose relevance with respect to future trends of the digitization of prevention in smart cities is limited. This is the case of products 7, 13 and 16.

b) Products whose relevance in the past was limited but which connect in a better way with the identified future trends, demonstrating that they are innovative products capable of meeting the emerging needs of digitization of prevention in smart cities. This is the case of products 5, 6, 10, 11, 15 and 19.

c) Products for which the need was considerable in the past but which in the future have not been largely connected to prevention digitization trends. This is the case for products 2, 9, 12 and 14.

d) Products that connect both to the needs for care identified in the past and to future trends in digitization of prevention. This is the case for products 4, 8, 17 and 18.

e) Products that connect strongly with past needs that are addressed and in a not so significant but still important way with future trends of digitization of prevention. This is the case of products 1, 3 and 20.

6.1. Analysis on the fitness of this proposal with the trends of the future of OHS

Also, a more detailed analysis of the relevance of the products can be done by studying how the future trends are being supported. This matching provides a sort of validation on the relevance and completeness of the whole strategy followed to identify the set of digital products/services proposed in this work.

The proposed set of digital products/services has been thought to cover in an amplified way all the needs and requirements related to the expert's opinions of trends and the improvements areas.

As it may be seen, for example, trend number 1, related to *the importance of people and human factors in the field of OH*S is covered mainly by the asset related to the identification of the logical pattern for risks assessment (3), the related training App (5), the definition of the place to work 4.0 (17), and also a tool for the democratization of criteria generation in the field of OHS (19). These are the main products affecting the human factor in the generic ecosystem of OHS, since the risk is the most important aspect to consider to guarantee the prevention.

Trend number 2 affirms that "*Digitalization and technology improve most occupational safety strategies. However, we must ensure that the working environment they create is positive*". This trend is supported by the asset covering the individual equipment for protection management (4), the dynamic proposal of a knowledge repository (10), which clearly represent the digital tendency, the traceable chat (11), the recognition system (14) and models of place to work 4.0 (17) the continuous monitoring and learning (18), and the tool for collective criteria generation through technologies (19).

The third trend "*A commitment to continuous improvement of existing concepts and ideas, rather than pursuing the creation of new trends*" is supported by the proposed App for training (5), since it is the means to execute training to guarantee continuous improvement, by the knowledge repository as a source of knowledge for improvement, the chat enabling practical information retrieval (11), the training portal (15) constituting the platform to execute the improvement plan and finally the digital work environment (12) leveraging the culture shift onto a continuous improvement philosophy.

Trend number 4, "*Management systems are crucial in occupational safety*", is directly supported by most of the assets that were proposed, since the majority of them have been designed under a strategic management light.

Regarding trend 5, "*The diversification of EHS tasks is increasing every day, so it is necessary to review the competencies and responsibilities assigned to each job*", is supported mainly by a need for standardization that product (20) is attending and also some of the apps for monitoring and control, such as the product (16) and (13).

Trend 6 is "*Safety training, experiential learning and knowledge sharing need to be improved so that employees become more involved in occupational safety*", will be supported by the technological platforms (1, 15, 10 and 12) enabling future organizations to share, store and reuse knowledge in an agile and effective way.

Trend number 7, "*Only through better internal communication can the safety culture be strengthened. Communication and cooperation are the main instruments for involving employees in a common understanding of the culture of safety at work*" is directly supported by the set of assets related to communication activities, such as the architectural elements, the application supporting organizational structure (2), the App for management of approval, enabling a direct communication channel (6), the easy chat tool (11) and the OHS observatory (18), allowing the continuous incorporation of relevant information.

The eighth trend, "*Occupational safety should take a holistic approach*" is supported by those elements that directly enable the conditions for an interconnected world in which a wide view of the situation is given and considering the several views and interpretations of the problems that might be identified. The explicit products supporting this are the Digital Work Environment model (12), the Place to Work 4.0 (17), and the OHS Observatory 4.0 (18).

One of the trends better supported is related to management issues. Trend number 9, "*Software and applications help to organize the management of safety at work*" constitutes a bridge between management and technology aimed at guaranteeing safety at the workplace and within the work environment. As so, only the knowledge repository (10), the traceable chat (11), the training portal (15) and the Observatory (18) were not initially linked to this trend, but there is not an absolute fact or declaration denying the possibility of these assets to be affecting this trend in the near future as a consequence of the evolution that it may have or the incorporation of more features bridging with management.

The tenth trend, "*New technologies have improved health, safety and environmental protection*",

is related to the previously mentioned. However, aiming to be more concrete, we have identified of the proposed assets those that were more innovative and may have a significant impact, such as the risk assessment tool (3), the quality of prevention assessment tool (8), and the Place to work 4.0 (17), as it redesigns the future of the organizational prevention strategy at all levels of future cities.

Trend 11, regarding the statement that "*The latest technologies have not yet clearly demonstrated their benefits and also pose additional safety risks*" opens a different debate since it considers the threatens regarding safety-oriented implementations. To address such an issue, we have considered mainly the preventive App (13) and the Observatory (18) that will allow us to identify risk in an inception phase.

Trend 12: "*The most advanced technologies reduce risks and improve working conditions*" Is very related to the previous trends since it considers in general risk reduction (3, 8, 14, 20) and advances in technologies applied to the future cities (1, 9, 12, 17, 18).

Regarding Trend 13, it refers to "*In particular, augmented reality and virtual reality will have a significant impact on teaching and higher education*". This might be supported by these tools enabling formation (15) and knowledge sharing (10), from an innovative and evolving perspective.

Trend 14 affirms that "*New technologies pose new security threats*", which is an issue easily drivable by the proposed technological products enabling to have preventive information (3, 6, 13, 18) notifications (7) and standards (19, 20) to be able to operate in a preventive instead of reactive environment.

Finally, Trend 15 "*People remain in the spotlight, regardless of new technologies*" refers to the need of caring for people appropriately. To do this, some products focus on providing appropriate means of physical protection support (4), some on training people (5), some on approaching people easily and fast (6, 7), and some on training and transforming people towards a more prevention-oriented culture (15, 17, 20).

The latter presented is a brief analysis on the relevance of this proposal for appropriately integrating the prevention culture to the design of sustainable and smart cities. Specifically, this proposal has deployed a method to identify the strategy of integration of the prevention strategy into the explicit fields to be considered by the ideal smart city.

7. Limitations and future research

This research paper contains a summary of an enriching experience in which an interdisciplinary team worked together focusing on promoting the emergence of unknown information about the state of the prevention ecosystem in current times.

The goodwill of the professionals participating for giving objective and useful information seems to be critical since no personal advantages for any parties were possible. All of the participants let the researchers take much of their time and made an effort to provide useful feedback and improvement suggestions, mainly while trying to model the state of the practice in prevention and representing it as the structured information of stages 1 and 2 of this research.

The participants are all immersed in the Spanish context, so being scientifically strict, the validity of this proposal is restricted to the Spanish context. However, the presented "trends" of prevention identified by a third party come from an international study. In future studies, it would be interesting to involve in the process of validation and feedback professionals in OHS from worldwide, so that explicit world relevance becomes notable.

For future studies, the research team is developing a formal contribution to the existent standards for modern occupational health and safety. The team will make good efforts to present the partial advances in conferences and publish the most relevant information so that any regulatory document and the formal institutions start counting on the digital sphere as a lever of change towards better management of OHS in smart cities.

8. Conclusions

Throughout the previous proposal and the needs specified from the experts' opinions, a set of dimensions of effectiveness may be defined, so it is possible now to talk about the potential beneficiaries and specific benefits of the value map presented in this paper.

The sector of Occupational Health and Safety represents a very important dimension in the endeavor of conceiving smart and sustainable cities. The workers' safety must be occupying a very important place in any digital transformation leading process such as the creation of smart cities.

Occupational Health and Safety is critical. It demands consideration from decision makers as it has an important impact in all sectors. After a deep analysis on the areas being considered by the Smart city standardization framework [5], it is remarkable that the traditional concept of Occupational Health and Safety is not explicitly considered, revealing an existing gap with increasing importance, as it was demonstrated for the COVID-19 situation.

In this work, the importance and relevance of Occupational Health and Safety is studied, and as it affects all workers performing jobs in smart cities, an emerging finding is the fact that it must be explicitly included as a key aspect of smart cities standards, such as [5,6]. This gap must be explicitly covered by the description of what we called Smart OHS, and this new aspect of the smart city must be incorporated into existing and future standards in order to effectively consider the digital side of the OHS in the landscape of smart cities.

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Conflict of interest

The authors declare no conflict of interest.

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