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Review

International Management System Standards Related to Occupational Safety and Health: An Updated Literature Survey

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Abstract: The implementation of an international management system (IMS) in any organization (or part thereof) creates an efficient framework regarding the sustainable development and the review of processes required to manage occupational safety and health (OSH) efficaciously. Moreover, Occupational Safety and Health Management System (OSHMS) standards identify requirements regarding OSH management systems, with the aim of enabling an organization to adopt dynamic policy and objectives that take into consideration lawful requirements relating to OSH risks (e.g., safe and healthy workplaces, prevention of work-related injuries, etc.). This article extends the research and the results of a previous study of ours and comparatively presents (a) the main IMS standards concerning OSHMS and (b) the statistical results and new findings of an updated literature survey for additional time intervals (i.e., the years 1995–2005 and 2018–2020), ultimately covering the entire period of the years 1995–2020. Thus, the main targets of the study were (i) the implementation and comparative presentation of OSHMS standards, (ii) the reinforcement of their application at the worksites of any organization, and (iii) the development of a new ameliorated OSH management system model based on the knowledge from the literature review. On the other hand, some dominant results and findings are the following: (a) The industrial sector and construction sector demonstrate the highest percentage of OSHMS utilization. (b) The OHSAS 18001 standard remains the most frequent OSHMS standard even though, despite the fact that the ISO 45001:2018 is a recently developed OSHMS, it presents a considerable percentage distribution with reference to the total OSHMS articles despite its brief lifespan. (c) An effectual IMS OSHMS must merge various management systems, such as OSH (safety and health), QMS (quality), and EMS (environmental). (d) Organizations and businesses of any kind and any size can certainly develop and implement OSHMS standards. (e) Some substantial barriers to the implementation of an OSHMS standard are the high cost vis à vis implementation and management, the difficulty for the employees to realize its significance in OSH, and the complicatedness of combining different standards. (f) Occupational epidemiology must be one of the main features of an OSHMS standard. (g) Governments, employers, and employees admit day after day that the effectiveness of applying OSHMS standards at the organization level is considerable for decreasing the occupational hazards and risks and also for raising productivity.

Keywords: international standards; international management systems (IMS); occupational safety and health (OSH); safety management system (SMS); occupational safety and health management system (OSHMS)

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1. Introduction

1.1. Introductory Elements

Occupational accidents present a momentous effect on human well-being and, in addition, create large costs in any country's social health/insurance system. Moreover, the topic of "safety and health" (OSH, OS&H) or "health and safety" (OHS, OH&S) concerning labor (or occupational work) is one of the most significant issues in any corporation. For example, an industrial accident or an occupational disease can affect both the worker and the company. These malfunctions, which are usually expressed by the missing working hours and the delay times in production and also by the cost of their replacement, can impinge on the company's quality product [1,2]. Consequently, the adoption of an OSHMS system and its certification can be beneficial to enterprises.

Organizations of all kinds (such as companies, corporations, operations, firms, enterprises, institutions, and associations or parts thereof) are progressively more concerned with attaining high OSH performance results via the limitation of their OSH risks in accordance with their objectives and OSH policy. They do so in the framework of increasingly strict legislation, the growth of financial policies, and additional measures that reinforce good-quality OSH practices and the amplified concerns expressed by stakeholders about OSH topics. Numerous organizations have undergone OSH audits in order to have their OSH performance assessed. Nevertheless, by themselves, these audits and reviews may not be adequate enough to afford an organization the commitment that its performance not only meets, but that it will keep on meeting, the law and policy necessities. Thus, the implementation of a structured management system incorporated by the organization, for example the OHSAS 18001:2007 [3], is necessary.

Furthermore, OSHMS systems were developed as a consequence of a plethora of several and severe industrial accidents throughout the decades of the 1970s and 1980s (for example, the Flixborough accident in 1974, the Seveso incident in 1976, and the Piper Alpha disaster in 1987). Thorough examinations of these events revealed insufficiencies in the dominant techniques for the regulation and the management of OSH and determined the necessity to use approaches that methodically address both engineering and educational action [4]. The proliferation of OSH management systems, which have been used worldwide since the 1990s [5], has dramatically increased the concentration of performance measurement methods, tools, and techniques [6].

Generally, "danger" can be determined as a feature of any process or substance that might possibly cause damage [7]. Moreover, "risk" has been defined as the chance that something or someone would be negatively affected by peril [8], while "hazard" is determined as any insecure condition or possible source of an adverse event that includes a noteworthy "potential" (i.e., an ability that might be developed and lead to future consequences, such as specifying the quantity of charge energy in an electric field or of mass in a gravitational field) of damage or harm [9]. Additionally, "risk" has been interpreted as a measure (under uncertainness) of the severity of a danger (or a hazard) [7] or a measure of the likelihood and seriousness of bad effects [10].

The public interest in the subject of risk management has extended by leaps and bounds over the past three decades, whereas risk analysis and assessment (RAA) has emerged as an efficient and comprehensive process that complements the whole management of nearly all aspects of our lives. Directors, managers, advisors, consultants, and anyone who is responsible for health care, physical and technical infrastructure systems, the environment, etc., all include risk management in their decision-making procedure. Furthermore, the universal adjustments of risk analysis by various disciplines in conjunction with its growth by government agencies and industry in decision making, have led to a remarkable progress in theory/methodology/handy tools [10].

In addition, RAA is an essential course of action for any organization's safety policy, having the elimination of every "potential" of damage in a productive process as a key goal, whilst quantified risk evaluation (QRE) is the most vital part of the entire process of assessing the perils, hazards, undesirable situations, and unsafe conditions in the work. It is considered that risk constitutes a "quantity", which, on the one hand, can be measured, and, on the other hand, can be expressed by a mathematical equation in association with the utilization of recorded accident data. Furthermore, RAA is an fundamental and systematic method of appreciating the occurrence, the impact, and the consequences of human beings' actions on technical systems with perilous features and constitutes an indispensable means for accomplishing the safety policies of each organization [11,12].

The usage of SMS systems creates an efficacious framework in the workplaces as far as OSH management is concerned (e.g., developing, implementing, and reviewing the required plans and procedures). Since the 1970s, substantial development actions regarding methodologies have occurred, driven by the identification the following facts: (i) OSH is influenced by all of the aspects of an organization's design and operation; (ii) the design, implementation, and management of OSHMSs must incorporate the environment, quality, humans, and technical systems proportionally with an organization's unique features; (iii) OSH constitutes a management function and needs widespread management commitment and participation; (iv) amalgamating elements generate a set of specified accountabilities and responsibilities for the activities at all levels of the organization; (v) incidents, illnesses, and harm unveil the existence of a problem in a specified system and are not simply associated with human errors; and(vi) performance aims should reverberate management objectives [4].

The IMS standards, which cover the subject of OSH at worksites, are aimed at providing enterprises, organizations, and any law body with elements of an efficient OSHMS system that can be joined with additional management characteristics and at helping enterprises and organizations to achieve their OSH and financial objectives. The OSHMS standards identify specific requirements as far as an OSHMS system is concerned in order to facilitate an organization in the development and implementation of the policy and the objectives that take legitimate requirements and information concerning OSH risks into consideration. These are intended to be applied to all kinds and sizes of organisms and to comprise various geographical, social, and cultural conditions. The accomplishment of an OSHMS system depends on the commitment of every level and function of the organization and particularly on the uppermost management. A system of this type enables an organism to grow an OSH policy, settle aims and processes to attain policy commitments, take actions that are needed to improve performance, and demonstrate the compliance of the system to the requisitions of the OSHMS standard. Moreover, the main goal of OSHMS standards is the support and promotion of capable OSH practices in equilibrium with socio-economic necessities [3].

The British Safety Council (BSC) and the International Labour Organization (ILO) carried out a study in which they assessed the benefits of accident and illness prevention in businesses over a 2-year period. The study reveals that an enterprise that adopts an SMS system achieves the subsequent results [13]: (a) improved productivity, (b) considerable reductions in the frequency of absenteeism, (c) noteworthy decreases in compensation claims and insurance costs, (d) improved work psychology in association with increased concentration at work and morale, and (e) improved organizational image to suppliers and customers.

There is no perfect definition of safety, which means that a "quantity" of risk always remains in the work, which is determined as residual risk. Hence, any process, product, and/or service can be moderately (or relatively) safe. More explicitly, "safety" is accomplished by confining risks down to tolerable levels, known as "tolerable risk", which constitutes an optimal balance between absolute (ideal) safety and fulfilling requirements using a process, product, and service. A framework of risk management that includes risk assessment (analysis and evaluation) and risk reduction is used to achieve a tolerable risk level [14]. Risk management is separated into three single subphases. The first subphase is associated with the attainment of the risk analysis of the specified systems (and subsystems) and the calculation of hazards, while the second one is associated with the evaluation of risk. These two subphases constitute the "risk assessment" phase, whereas the ultimate subphase is completed by taking proper measures in order to control and reduce the risk [15,16].

Normally, four stages are designated in the scientific literature as far as quantitative risk assessment is concerned [11,12,17]: (a) qualitative analysis, which comprises the circumscription of the system and its purpose, hazard identification and explanation, and failure scenarios and modes; (b) quantitative analysis, which involves the specification of the consequences and likelihoods of the prescribed events and also risk quantification by a value (or number) and/or a diagram as a function of likelihoods and consequences; (c) risk evaluation, which includes the risk evaluation results in accordance with the outcomes of the earlier analyses; and (d) risk control and reduction measures, which are dependent on the risk evaluation outcomes.

According to CCPS [18], risk is determined as a measure of financial loss or human harm in terms of the probability and the magnitude of the perdition and/or harm. Furthermore, IEC specifies risk by the amalgamation outcome of the frequency of occurrence (or probability) and the consequence of a specific harmful event [15].

It should be kept in mind that limited systematic (for instance, the works by Robson et al. (2007) [19], Frick (2011) [20], Marhavilas et al. (2018) [1], and da Silva and Amaral (2019) [21] and recitative or narrative (for example the works by Frick and Wren, 2000 [22]; Gallagher et al., 2003 [23]; Saksvik and Quinlan, 2003 [24]; Walters, 2002 [25]; Swuste et al., 2020 [26]) literature surveys about the issue of OSHMS standards exist.

Robson et al. (2007) [19] developed a conceptual model for the factors that affect the reliability and validity of seventeen OSHMS audits.

Recently, da Silva and Amaral (2019) [21] published a systematic literature review, wherein they emphasized occupational safety issues compared to employee health issues, and additionally, their analysis pointed to weaknesses in use of epidemiological indicators in the management of OHS, which allow companies to proactively manage events with their employees.

Recently, Swuste et al. (2020) [26] conducted a review of safety literature via scientific sources in English and Dutch and presented the situation of occupational safety and safety management between the years 1988 and 2010. Their study revealed that the quality of safety management systems research is poor, and moreover, that organizational learning has not yet entered the field of occupational safety.

In the work of Marhavilas et al. (2018) [1], the main IMS standards of promoting OSH were depicted, as were the statistical results (via descriptive statistics) of an investigation associated with the review of several scientific/technological articles (published in appropriate journals by Elsevier B.V.) relating to OSHMS standards and covering the years 2006–2017. Through this paper, we extend the results of our previous study (by Marhavilas et al., 2018) [1] by comparatively presenting (i) the main IMS standards concerning OSHMS and (ii) the statistical results of an updated literature survey for additional intervals (more specifically the years 1995–2005 and 2018–2020); consequently, we eventually cover (using these two articles) the period spanning the years 1995–2020.

1.2. Structure

As far as this article's structure is concerned, it consists of six sections: (a) the introduction, (b) an outline of the OSHMS standards, (c) the methodology used for searching the scientific literature, (d) results and findings, (e) the discussion, and (f) the conclusions.

2. Outline of OSHMS Standards

An SMS system constitutes a methodology through which each organization or business (either public or private and commercial or industrial) directs its inner processes in order to attain its goals, which are related to a plethora of miscellaneous issues (involving service and/or product quality, environmental performance, operational capability, OSH in the workplace, etc.). The intensity of the system's intricacy in any organization will depend on its particular context. In small organizations, there is not any requisite for wide-ranging documentation due to the fact that the employees know plainly how to contribute to the accomplishment of the organization's overall goals. Furthermore, the operation of more complicated enterprises may necessitate analytical documentation in order to perform their organizational aims. Furthermore, IMS standards facilitate organizations to improve their performance by determining repeatable actions that organizations consciously put into action in order to achieve their goals (objectives) and to create a fixed organizational culture that automatically engages in a continual cycle of self-evaluation, modification, improvement, and adjustment of processes and operations via sharp employee consciousness and management commitment, guidance, and leadership [1].

An OSHMS system constitutes a mingling of the planning and review, managerial regulations, consultative adjustments, and the essentials of a specific program, which collaborate together in a consolidated way to ameliorate the performance of OSH [27].

Below, we present an outline of the most significant international OSHMS standards based on specific information from various sources.

2.1. BS 8800

This system was developed in 1996 by the British Standards Institution (BSI) and called BS 8800:1996, while in 2004 and 2008, there were two revisions, the BS 8800:2004 and BS 18004:2008, respectively. It provides directions for OSHMS systems to support conformity with the denoted OSH policies and aims and discusses how OSH could be incorporated within an organization's whole management system [28]. Additionally, it was updated to take into consideration new law-making alterations as well as the latest Health and Safety Commission (HSC) and Health and Safety Executive (HSE) actions and to give noteworthy guidance on critical areas such as risk management and assessment. In addition, the revision of BS:8800 mirrors national and international OSH topics that have emerged since its publication in 1996, a fact that directed the publication of OHSAS18001, OHSAS18002, and the ILO-OSH 2001-Guidelines, which are related to OSHMS systems [29].

What is more, the BS18004:2008 SMS examines the OSH requisitions in a working environment and gives practical advice for accomplishing correct safety measures. Moreover, it helps management to reveal commitment and fine practice and also ensures certain compliance by all parties via technical documents. This SMS standard also supports organizations in achieving correct requirements whenever they try to implement an OSHMS with an exterior party. The implementation of BS18004 SMS is appropriate for any organization (as far as its type and size is concerned), and on the other hand, it is principally handy for personnel dealing with the OSH on both operational and strategic levels [30].

2.2. HSG 65

This standard was produced (in 1991) by the Health and Safety Executive (HSE), constituting a handy guide for managers, OSH health professionals, directors, and employee representatives who aim to improve the situation of OSH in their organizations [31]. Later on, it was revised in 1997 and 2013. It is worth noting that the HSE moved away from applying the POPMAR (Policy, Organizing, Planning, Measuring performance, Auditing, and Review) methodology (or model) concerning the management of safety and health, moving to a new approach with the name PDCA (Plan–Do–Check–Act). The PDCA approach (or framework) attains a specific stability between the system and its behavioral features of management. It also commonly utilizes the management of safety and health as an undivided part of good management rather than as a separate system [32].

2.3. OHSAS 18001

This concrete standard (and its companion, OHSAS 18002, with the appellation "Guidelines for the implementation of OHSAS 18001") was developed with the assistance of forty-four (44) cooperating organizations (constituting the Project Group of Occupational Health and Safety Assessment Series (OHSAS)) in response to customer mandates for a distinguishable OSHMS standard in association with their management systems that could be assessed and certified. The first edition (i.e., OHSAS 18001:1999) was technically revised and replaced by the second edition (i.e., OHSAS 18001:2007) in 2007. Its second edition was generated due to the providences of the standards ISO 9001:2000 (quality standard), ISO14001:2004 (environmental standard), ILO-OSH (safety and health standard), and miscellaneous OSHMS standards (or publications) to intensify the compatibility of these in order to (a) enlarge the benefits for the users and (b) to ease the assimilation of several attributes in OSHMS systems regarding the quality, environmental features, and OSH by organizations that wished to do so. Furthermore, this standard is also based on the PDCA methodology, which could be concisely outlined with the subsequent: (i) "Plan": establish the objectives and procedures required to achieve the results in conformity with the organization's OSH policy; (ii) "Do": properly implement the processes; (iii) "Check": monitor and measure the processes in the frame of OSH-policy, goals, laws, and other requirements and also report the results; and (iv) "Act": take action to persistently make OSH's performance better [3].

2.4. ILO-OSH 2001

Since its foundation in 1919, the ILO (International Labour Organization) has utilized and adopted numerous international work (labor) conventions and treaties (along with supplementary recommendations) concerning OSH aspects, and, additionally, various technical publications and codes of practice for a variety of OSH issues. These ILO-OSH Guidelines (the first edition was produced in 2001, and the second one was published in 2009) were derived by the actions of a broad base that included the ILO (with its triple composition of "governments–employers–workers") and additional stakeholders. In addition, they are modulated by internationally established principles of OSH as set out in many international labor standards. Thus, they offer an outstanding and dominant tool for the growth of a sustainable safety culture inside businesses. The practical recommendations of the above-referred guidelines are proposed for usage by all those who are responsible for OSHMS. They are not officially or lawfully obligatory and are not aimed to be a substitute for national regulations and/or laws or alternative conventional standards. Of course, OSH protocols conforming with ILO-OSH's requisitions compatible with national legislation, regulations, and rules are the liability and obligation of the employer. The employer must show forceful leadership and dedication to OSH actions within the organization and make proper adjustments for establishing an efficient OSHMS system, which ought to enclose the key fundamentals of (a) organizing, planning, implementing, and evaluating the actions for improvement and (b) of the OSH policy [33].

2.5. AS/NZS 4801–2001

This standard is a united "Australian & New Zealand Std" and was derived by the "Joint Technical Committee SF-001" (in November 2001) in order to supersede or amalgamate the previously existing standards: (i) AS 4801:2000 "*Occupational health and safety management systems—Specification with guidance for use*" and (ii) NZS 4801(Int):1999 "*Occupational health and safety management systems—Specification with guidance for use*". Its aim is to establish auditable criteria for an OSHMS system, and, on the other hand, aims to comprise the most excellent elements of such SMS that are already broadly used in New Zealand and Australia. It involves proper guidance for the way that those criteria could be realized. Moreover, it should not be depended upon to guarantee conformity with all lawful and other commitments; for instance, the fulfillment of this standard might inevitably not meet legitimate OSH obligations. Regarding the organizations that desire to develop, implement, improve, and audit an OSHMS system, a couple of combined and supplementary standards are accessible to provide essential guidance. Furthermore, the version of AS/NZS 4804:2001 with the title "*Occupational health and safety management systems—General guidelines on principles, systems and supporting techniques*" is the principal standard that is pertinent to every organization and offers broad guidance on how to develop, implement, improve, and audit an OSHMS system. The version AS/NZS 4801 creates an audit structure mainly for use by third party organizations that have been asked by a body to conduct an irrespective audit on its OSHMS. Furthermore, the framework could be used as a basis (or standard) for evaluation, assessment, or comparison throughout internal auditing processes. The AS/NZS 4804 standard provides broad guidance (i) on how to establish (or set up) an OSHMS system; (ii) on how to accomplish continual improvement in an OSHMS system; and (iii) about the resources needed to establish and perpetually improve an OSHMS. The instructions included in AS/NZS 4804 depict a methodical management approach that can aid in fulfilling legitimate requisitions and can lead to persistent improvement in OSH performance.

The overall aim of these linked frameworks (i.e., AS/NZS 4801 and AS/NZS 4804) is to assist in the accomplishment of the greatest OSH performance via methodical reduction and/or the abolishment of risks. Furthermore, the AS/NZS 4801 and AS/NZS 4804 guidelines are aimed to reserve the essential fundamentals of an efficient OSHMS for organization that can be combined with various management requirements in order to help organizations to attain a high-level OSH as well as other financial and social objectives. These standards are not intended to be utilized for generating trade barriers, nor for modifying the legal commitments of an organization. They are noncompulsory (voluntary) and valuable tools for businesses, whereas governments can use them as little as (or as much as) they wish [34].

2.6. ANSI/AIHA Z10–2005

This standard was developed in 2005 (and revised in 2012) by the "American National Standardization Institute" (ANSI) in collaboration with the "American Industrial Hygiene Association" (AIHA). It is a voluntary and non-mandatory standard that was generated and is used in the USA [35]. It has the goal of assisting organizations to diminish the risk of occupational harm, damage, illness, and death as a major focal point. Some of the foremost features that determine Z10 comprise focus on effectual employee participation, management leadership roles, and design examination and alteration. It constitutes a helpful tool for organizations to improve OSH performance. The implementation of Z10 concentrates on organizations (i) fulfilling their OSHMS policies, (ii) assisting in benchmark safety processes and practices, and (iii) specifying areas where hazard prevention and control are required.

Z10 is grounded in the P–D–C–A SMS model and can be included in businesses with other previously existing standards, such as ISO 9001, OHSAS 18001, and/or ISO 14001. All of these standards are well-matched and effortlessly joined with one another, which allows for audits to be realized concurrently in most occasions [36].

2.7. SS 506

This Singapore Standard for OSH was developed in 2004 (as SS 506:2004) by the Singapore Standards Council (SSC) and was revised in 2009 (as SS 506:2009). It consists of three separate parts: (a) general requirements, (b) implementation guidelines, and (c) specific requirements for the chemical industry. The first component is the adoption of OHSAS 18001:2007, whereas the second one consists of the adoption of OHSAS 18002:2009. This standard is attuned with ISO 9001:2000 (quality standard) and ISO 14001:2004 (environmental standard) SMS systems, a fact that could make the combination (or amalgamation) of QMS, EMS, and OSH SMS systems by organizations easier, and it was indeed decided that they should be combined. In addition, it is compatible with the ILO-OSH:2001 standard of the International Labour Organization (ILO). This standard determines requisites for an OSHMS system to facilitate any organization to build up and put into action policy and objectives that take into consideration legitimate requisitions and information related to OSH risks. Additionally, it can be applied to all categories and magnitudes of organizations and to contain various cultural, geographical, and social conditions. The achievement of this SMS depends on dedication from all levels and functions of the business, and particularly from the uppermost management. The overall goal of SS 506 (Part I and II) is to maintain and endorse fine OSH practices in equilibrium with socio-economic necessities [37,38].

2.8. Une 81900:1996 EX

Shortly after the publication of the BS 8800 Guide, the "Asociación Española de Normalización y Certificación" (AENOR), i.e., the Spanish Association for Standardization and Certification, published the standard UNE 81900: 1996 EX, with the designation "*Prevention of Occupational Risks—General rules for implementation of an Occupational Safety* *and Health Management System (OSHMS)*", in June 1996 (withdrawn in 2002), which emerged on a trial basis for a period of three years in order to know the point of view of organizations when applying management principles that were new and delicate. As such, AENOR chose several organizations in the chemical, construction, and metal–mechanic sectors and was able to verify the favorable reception that this initiative had. The standard was proposed by AENOR in order to be adopted as a European standard (CEN), but it was discarded by the EU countries, principally because it is a standard that is for only certification purposes.

The UNE 81900 family was constituted by the following standards: (i) UNE 81900–1996 EX, with the title "*Prevention of Occupational Hazards. Rules for the implementation of an SGPRL (AENOR:1996)*", (ii) UNE 81901–1996 EX, with the designation "*Prevention of Occupational Hazards. General Rules for the Evaluation of SGPRLs*", (iii) UNE 81902-1996 EX, with the title "*Prevention of Occupational Hazards. Vocabulary (AENOR:1996)*", (iv) BUNE 81903-1997 EX, with the title "*Prevention of Occupational Hazards. General Rules for the Evaluation of an SGPRL. Criteria for the qualification of the Auditors of Prevention (AENOR:1997)*", (v) UNE 81904-1997 EX, with the designation "*Prevention of Occupational Hazards. General Rules for the Evaluation of SGPRLs. Management of audit programs (AENOR:1997)*", and (vi) UNE 81905-1997 EX, with the title "*Prevention of Occupational Hazards. Guide for the implementation of an SGPRL (AENOR:1997)*".

In view of the above, several reasons justify the possible choice of UNE 81900: 1996 EX by an organization, especially of Spanish scope: (a) It is an effective tool to prevent occupational hazards and to consequently reduce accidents in the workplace. (b) Its implementation facilitates the identification of regulatory requirements and compliance with obligations established in the Law on the Prevention of Occupational Risks and its regulatory development. It therefore covered in its day the vacancy that existed at the time of its publication regarding specific Spanish norms in the management for the prevention of occupational hazards. (c) It is a useful tool for integrating management systems thanks to clear relationships with quality management and environmental management.

The rule is mainly characterized by its imperative nature, using the expression "should", which makes it especially auditable [1,39].

2.9. Uni 10616

This standard, which has the designation "Major Hazard process plants—Safety management for the operation—Fundamental criteria for the implementation", and its supplement Uni 10617, which also has the title "Major Hazard process plants—Safety management for the systems—Essential requirements", were developed in 1997 (and withdrawn in 2012) by the Italian Standardization Authority UNI for relevant accident prevention. Some of the major qualifying points of the new UNI 10616-2012 are those described below: (a) The adoption of intrinsic safety principles, such as the substitution of hazardous substances with other, less dangerous substances; the reduction of the quantities present; and modifications of the equipment, of the materials, or of the process conditions; (b) the adoption of risk matrices or charts for evaluating risk acceptability (or tolerability); (c) circumscription of inspection actions and periodical checks of critical lines and equipment based on risk analysis based on RBI (Risk-Based Inspection); (d) the consideration of the external domino upshot between adjacent plants due to explosions, fires, projections of fragments of containers, and the release of flammable and/or toxic substances in order to define the essential prevention and shielding measures; (e) the adoption of a work permission system in order to reduce and to minimize the risks associated with verification, inspection, maintenance, construction, and/or activities of assembling/dismantling parts/components within a plant in operation; (f) the selection of providers of services and goods such as enterprises, builders, and consortia based on consolidated and documented special experience; and (g) affiliating processes for periodical internal auditing with inner or external auditors with specific requirements of competence, impartiality, and objectivity; knowledge of applicable procedures; and confidentiality [1,40].

2.10. GOST 12.0.230-2007

This Russian standard with the title "*Occupational safety standards system—Occupational safety and health management systems—General requirements*" (name in English: GOST 12.0.230-2007, name in Russian: ГОСТ 12.0.230-2007) is based on the ILO—OSH 2001 guidelines, and its purpose is to support and safeguard workers from vulnerability to harmful, dangerous, and injurious production factors and the eradication of accidents involving fatalities, casualties, and occupational illnesses. At the national level, this SMS is used (i) to set up the national fundamentals and essentials of the protection of an OSHMS system assisted by national rules, conventions, and other regulative legitimate actions; (ii) guidance about the application of non-mandatory (voluntary or volitional) OSH protection actions in organizations focusing on conformity with patterns (or norms) and several regulatory lawful activities leading to the consecutive improvement of OSH protection actions; and (iii) guidance about the growth of national and specific commercial standards on OSHMS systems to guarantee the high quality of the workable requirements of organizations in line with the features of activities and their extent.

At the organism or business level, GOST 12.0.230-2007 is aimed at (i) yielding guidelines regarding the essentials of integration in an OSHMS concerning any enterprise as an undivided part of an ordinary policy and SMS system and (ii) boosting the resuscitation of all employees in the organization, involving owners, employers, employees, management personnel, and also their representatives in order to use contemporary (or modern) concepts and methodologies of OSH protection management intended for the continual improvement of OSH protection actions (see Russian Gost, 2007, https://www.russiangost.com/p-20799-gost-120230-2007.aspx (accessed on 25 September 2022).

2.11. ISO 14000 Family—Environmental Management

As referred to above, the IMS standards concerning OSH on worksites are aimed to make the fundamentals of a successful OSHMS in an organization available that could then be combined with supplementary management requirements (for example quality and/or environmental). Hence, the majority of OSHMSs were created to be pursuant QMS and EMS SMS standards in order to help the merging of those QMS, EMS, and OSH management systems in each organization. The ISO 14000 group of standards was created by the ISO Technical Committee (i.e., ISO/TC) and its miscellaneous subcommittees and provides useful tools for businesses and organizations of all types, with the intention to manage their environmental accountabilities. In particular, ISO 14001:2015 and its several supplementary standards (such as ISO 14006:2011) focus on environmental systems to attain these accountabilities [41]. The rest of the standards in the family are focused on explicit activities, such as communications, life cycle analysis, audits, labeling, and environmental challenges (for instance, climate change). Furthermore, ISO 14001:2015 establishes appropriate criteria for an efficient EMS as well as its certification. It illustrates an outline that an enterprise (or organization) can follow to develop an efficient EMS system, and it can be utilized by every organization independent of its activity or occupational sector ([42]; source: https://www.iso.org/the -iso-survey.html (accessed on 25 September 2022).

2.12. ISO 45001

In 2018, the ISO body developed a new standard, ISO 45001, with the title "*Occupational health and safety management systems—Requirements*", which supports organizations to diminish the impact of occupational injuries and diseases by creating a well-organized framework to ameliorate employees' OSH, lessen worksite risks, and create safer and healthier working conditions everywhere in the world. This SMS standard was evolved by a committee and synthesized by various OSH experts and follows a variety of broad SMS principles (for example, ISO 14001 and ISO 9001). It takes into consideration additional SMS standards such as OHSAS 18001, the ILO-OSH guidelines, a variety of national standards and conventions, etc.

ISO 45001 is intended to be applied by any enterprise or organization regardless of its size and/or the category of its occupational sector and can be combined with miscellaneous OSH programs (for instance, worker well-being and wellness). It can help each organization to realize its legitimate necessities and requisitions ([43]; https://www.iso.org/iso-45001-occupational-health-and-safety.html (accessed on 25 September 2022).

Throughout the last four decades, the usage of OSHMS has become a significant and common feature of the worksites of enterprises in the economies of the developed countries. The primary elements of an OSHMS are depicted in Table 1 according to the study by Gallagher (2000) [27]. It is worth mentioning that numerous IMS standards have a comparable configuration, comprising a plethora of equivalent definitions and terms. These features are valuable for organizations that apply an "integrated" SMS that combines the requisitions of two or additional IMS standards concurrently (for instance, an OSH with EMS and/or QMS standard).

Table 1. Primary elements of an OSHMS.

Nr	Elements	Specific Elements
1	Organization, Responsibility, Accountability	• Senior director (manager/executive)—participation (involvement) • Line director (manager/executive) —supervisor responsibilities (duties) • Management liability (accountability/responsibility)—performance quantification (or measurement) • Organization (company/business) OS&H policy
2	Advisory (Deliberative) Arrangements	• OS&H representatives—a systemic resource (or asset) • Issue (or subject) resolution (analysis)—representatives (or deputies) of employees and employers • Concerted (or joint) OS&H committees • Wide employee involvement (contribution/participation)
3	Specific Program Elements	• OS&H rules and processes • Training and education program (plan) • Workplace (worksite) inspections (surveys) • Incident (or event) reporting and examination (investigation) • Declaration of principles and concepts about hazard and risk prolepsis and control • Collection (or assortment) of data and analysis—safekeeping and protection of records • OS&H promotion and furtherance—information anticipation and provision • Purchasing, acquiring, and design • Urgent situations/emergency processes • Medical, health, sanitation, and first aid • Monitoring, assessment, and evaluation • Dealing with particular hazards or risks and work organization aspects

3. Search Methodology

The current literature survey, concerning a period of fourteen years (1995–2005, 2018–2020), was accomplished by choosing papers from significant journals that provide noteworthy visions to scientists and safety managers as far as OSH is concerned. It is worth noting that we utilized a particular research method (PRM), which is well-suited with the PRISMA protocol (acronym of "Preferred Reporting Items for Systematic Reviews and Meta-Analyses"), that constitutes the smallest set of items for systematic review and meta-analysis results (see: http://prisma-statement.org/ (accessed on 9 September 2022)). The applied PRM is displayed in Figure 1 and is shaped into three stages in accordance with the PRISMA-2020 flowchart. Hence, the PRM 1st, PRM 2nd, and PRM 3rd phases (of Figure 1) are correlated with the PRISMA-2020_IDENTIFICATION module, the PRISMA-2020_SCREENING module, and the PRISMA-2020_INCLUSION module, respectively.

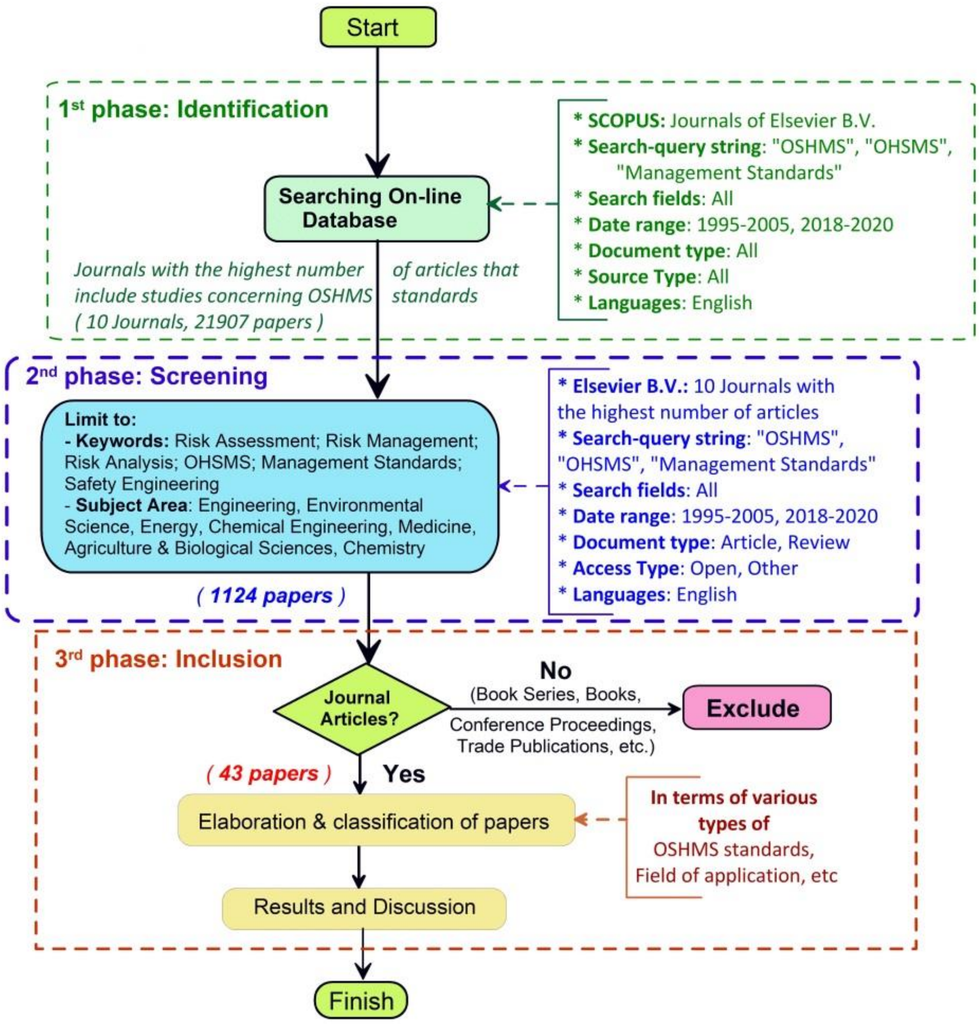


Figure 1. The flowchart of the utilized search methodology is illustrated and is in agreement with the process in the PRISMA-2020 flow diagram for new systematic reviews.

To accomplish the survey, firstly, the research questions (a), the databases to search for the papers (b), and the research terms (c) were determined according to the review goals. The current review was achieved independently by two researchers with knowledge in the subject area of this study.

More explicitly, the three sequential steps of the research technique are as follows: (i) exploration of the scientific literature, initially via the Scopus database and afterwards through Elsevier (first phase: identification); (ii) screening the journals with the maximum number of articles that include important studies on OSH (second phase: screening); and (iii) the selection of relevant studies, elaboration and classification of the articles, and consideration of the quality of the research evidence in the studies (third phase: inclusion). The keywords we used in the search were "Occupational Health and Safety", "OHSMS", "OSHMS", and "Management Standards". In other words, the first step is related to the choice of the proper journals, the second one comprises the suitable keywords for establishing appropriate research questions, and the final one shows the coding technique.

Table 2 lists the exclusion and inclusion criteria that were utilized in the search process.

Table 2. Exclusion and inclusion criteria utilized in the searching process.

Inclusion Criteria	Exclusion Criteria
• Database to search for the papers: Scopus. • Academic publishing company: Elsevier B.V. • Source type: Journals. • Document type: Articles, reviews. • Access type: All (open, gold, hybrid gold, bronze, green, other, etc.). • Publication stage: Final, article in press. • Language: English. • Date range: Years 1995–2005, 2018–2020. • Keywords (Search-query string): "Occupational Health and Safety", "OHSMS", "OSHMS" "Management Standards". • Subject areas: Engineering, environmental science, construction, industry, energy, chemical engineering, medicine, agriculture and biological sciences, and chemistry.	• Source type: Short letters, conference proceedings, reports, books, book series, patents. • Document type: book chapters, conference papers, trade publications, etc. • Language: Languages other than English.

In order to determine the OSHMSs that exist and are used as well as aspects associated with their implementation, four research questions were constructed: (i) What are the existing OSHMSs? (ii) What are the fields of application (or occupational sectors) used for the OSHMSs? (iii) What are the various types of the article material (or data) and the methodologies utilized for implementing an OSHMSs? (iv) What are the sources (or journals) used to define articles with OSHMS standards?

The survey of the scientific literature was achieved by investigating only ten significant scientific journals published by Elsevier (shown in Table 3), which, however, (i) present the highest number of studies concerning OSH (during the period of years spanning 1995–2005, 2018–2020) and (ii) focus on safety and health issues. These journals were also investigated in order to be compatible with the search technique of a previous study by Marhavilas et al. (2018) [1]. The choice of these journals was grounded in the next two criteria: (i) the concentration on safety and health aspects and (ii) the existence of a grand effect among scholars (Q1, IF).

Table 3. The ten investigated scientific journals (published by Elsevier) with the highest number of articles and studies concerning OSHMS standards throughout the period of years spanning 1995–2005 and 2018–2020.

Nr	Source (Journal)/Acronym
1	*Journal of Loss Prevention in the Process Industries/(JLPPI)*
2	*Journal of Safety Research/(JSR)*
3	*International Journal of Industrial Ergonomics/(IJIE)*
4	*Safety Science/(JSS)*
5	*Reliability Engineering &System Safety/(JRESS)*
6	*Accident Analysis & Prevention/(JAAP)*
7	*Structural Safety/(JSS2)*

Table 3. *Cont.*

Nr	Source (Journal)/Acronym
8	*Journal of Hazardous Materials/(JHM)*
9	*Applied Ergonomics/(JAE)*
10	*Engineering Application &Artificial Intelligence/(JEAAI)*

In addition, taking into consideration that rudimentary methodical (such as the studies by Robson et al. (2007) [19], Marhavilas et al. (2018) [1], and da Silva and Amaral (2019) [21] or narrative (such as the articles by Frick and Wren, 2000 [22]; Gallagher et al., 2003 [23]; Saksvik and Quinlan, 2003 [24]; and Walters, 2002 [25]) literature reviews exist on OSHMS standards, we examined and studied published documents from the previously referenced journals (in Table 1), gathering a huge number of approximately N = 21,907 articles published during the periods 1995–2005 and 2018–2020.

4. Results and Findings

4.1. Statistical Results

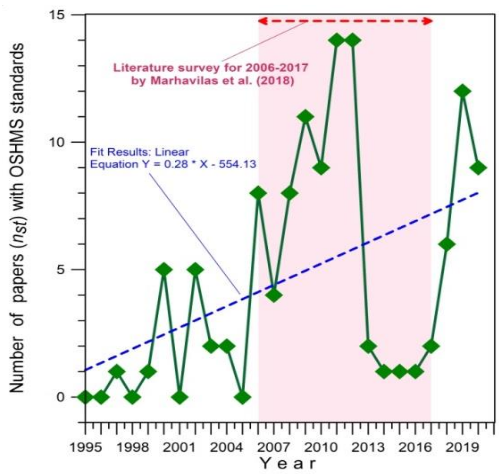
The process of surveying the scientific studies (published during 1995–2005 and 2018–2020) revealed only a small number of published articles concerning OSHMS standards, referred to miscellaneous fields (for instance, industry, engineering, construction, transportation, chemistry, oil and refinery, food sector, etc.) These articles address ideas and notions, concepts and perceptions, methodologies, and tools that have been developed and implemented in sectors such as design, development, implementation, maintenance, and quality control in relation with occupational RAA.

More specifically, all of the scientific papers published in the above journals throughout the periods of 1995–2005 and 2018–2020 were investigated, gathering a total number of N = 21,907 documents. This investigation resulted in M = 1124 papers regarding the subject of OSH, wherein S = 43 articles include, use, or mention OSH management standards pertaining to the worksites and concern many different fields (such as industry, construction, engineering, transportation, high technology, chemistry, medicine, computer science, biology, and so on).

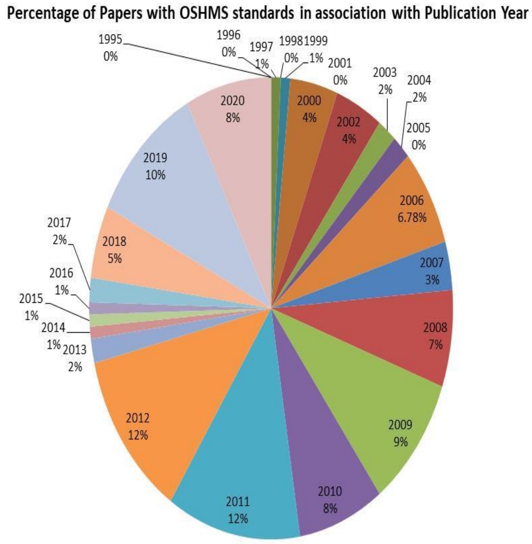
In Table A1 in Appendix A, we depict the categorization results of the S = 43 papers regarding OSHMS standards that were determined by the examination of N = 21,907 documents from 10 sources covering the intervals of 1995–2005 and 2018–2020. More explicitly, this table presents in eight columns the numerical code of each article (column A), the paper's citations (columns B, C, and D), the name of the OSHMS standard (column E), the type of data or material in the paper (column F), the application field (column G), and the source's acronym name (column H).

In Figure 2, we display the yearly variation in the number (n_{ST}) of articles with OSHMS standards published by the previously referred to ten journals throughout the interval of 1995–2020 (graph "a") and the equivalent percentage distribution of articles in association with the publication year (pie chart "b"). We clarify that for the intermediate interval of 2006–2017, we used the data of the study by Marhavilas at al. (2018) [1].

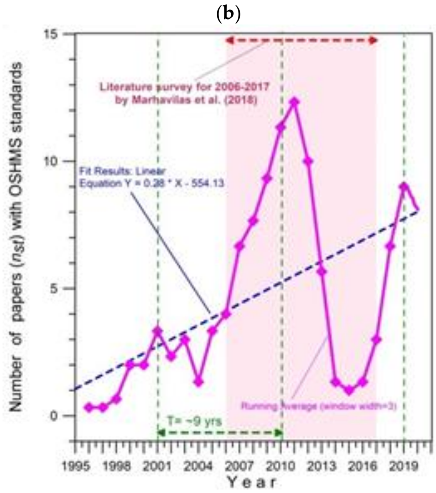
The curve of the graph of Figure 2a shows the existence of a long-term trend (linear) factor with positive inclination throughout the period of 1995–2020 with the following statistical fit-results: (i) fitting equation $Y = 0.278 * X - 554.130$; (ii) number of data points used NDP = 26; (iii) and (iv) average X = 2007.5, average Y = 4.538; (v) residual sum of squares RSS = 421.197, (vi) regression sum of squares RSS′ = 113.264, (vii) coefficient of determination R-squared = 0.212, and (viii) residual mean square RMS = 17.550. In particular, there is a gradual increase during the period 1995–2012 (with local maximums in years 2000, 2002, 2006, and 2020 and overall maximums in 2011 and 2012), while for the years 2013–2016, an abrupt decrease with an intensive negative slope is observed, and an abrupt increase with a positive inclination is observed in the period of 2017–2019.



(**a**)



(**b**)



(**c**)

Figure 2. (**a**) Depiction of the yearly variation of the number of articles (about OSHMS standards) published in ten representative journals by Elsevier B.V. during the period of years spanning 1995–2020 (green curve). (**b**) Distribution of articles with OSHMS standards in relation to the publication year. (**c**) The same drawing in comparison with curve "a" after smoothing the initial curve by the "running average" process (violet curve).

The pie chart of the second graph in Figure 2b shows that the years 2011, 2012, and 2019 are the ones with the highest percentage of papers with OSHMS. The curve in panel "c" depicts the smoothing results by the "running average" process (with a window width equal to 3.0) of the variation in line "2a", which also reveals the existence of a quasi-periodic feature with a period of ~9 years as far as the variation in the number of articles detailing OSHMS standards is concerned.

Continuing on, Table A2 (in Appendix B) displays the statistical results (via descriptive statistics) from the investigation of the above-referred journals (columns A and B), comprising the following information:

- The absolute frequency (N_i) (i = 1,2,3, ... ,10): the quantity of the total examined papers per journal (column C);
- The relative frequency ($F_i = N_i/N$) concerning the 10 used scientific journals regarding the whole quantity (N = 21,907) of the published articles during the intervals 1995–2005 and 2018–2020 (column D);
- The number of papers ($n_{SS(i)}$) concerning OSH science (column E), wherein the whole quantity of papers regarding OSH is M = 1124;
- The relative occurrence frequency ($f_{SS(i)} = n_{SS(i)}/N$) of articles (with reference to N) related to OSH science (column F);
- The number of papers ($n_{ST(i)}$) concerning the OSH field that include/use/refer to OSHMS standards (column G), wherein the total number of the determined papers regarding OSHMS is S = 43;
- The relative occurrence frequency ($f_{ST(i)} = n_{ST(i)}/N$) of articles (with reference to N) concerning the OSH field that include/use/refer to OSHMS standards (column H);
- The normalized (per journal) occurrence frequency ($f_i{}^* = n_{SS(i)}/N_i$) of papers concerning the OSH field (column I);
- The normalized (per journal) frequency of occurrence ($f_i{}^{**} = n_{ST(i)}/N_i$) of papers concerning OSH that include OSHMS standards (column J);
- The relative (with reference to M) occurrence frequency($f^M{}_{SS(i)} = n_{SS(i)}/M$) for papers concerning OSH science (see column K);
- The relative (with reference to S) occurrence frequency of papers ($f^S{}_{ST(i)} = n_{ST(i)}/S$) concerning OSH that include OSHMS standards (column L).

The data presented in Table A2 revealed that the articles concerning the subject of OSH are very few (i.e., M = 1124 or 5.13%) in relation to the quantity of the total examined papers (N = 21,907), and, in addition, the articles that refer to OSHMS standards are extremely few (i.e., S = 43 or 0.2%). We note that although JHM is the journal with the highest number of published articles (N_i = 7388, F_i = 33.72%), JSS is the journal with the highest number of published articles (S_i = 19, $f^M{}_i$ = 43.50%, $f^S{}_i$ = 44.18%) comprising OSHMS standards, according to Table A2 (columns C, D, K, and L) and the bar graph in Figure 3a, which depicts the relative occurrence frequency of papers concerning OSHMS standards during the intervals of the years 1995–2005 and 2018–2020.

Moreover, in the pie charts in Figure 3 illustrated for the period of 1995–2020 show (i) the relative occurrence frequency of miscellaneous OSHMS standards, which are included in the previously referred to S = 43 documents (panel "b"); (ii) the percentage distribution of the articles with OSHMS standards in association with various kinds of data (or material) (panel "c"); and (iii) the distribution of documents with OSHMS standards in association with several application fields (panel "d"). The graphs in Figure 3b unveil that the OHSAS 18001 standard has the highest relative occurrence frequency (32.99%) in comparison with the other OSHMS standards, or, in other words, OHSAS 18001 is the most frequent OSHMS standard according to a survey of the scientific literature from the period 1995–2020. This finding may be due to the fact that the OHSAS 18001 standard was the result of collaboration between thirteen international organizations that make up 80% of the certification organizations. It is worth mentioning that the standard ISO 45001:2018, although it is a new OSHMS standard, presents a significant percentage (3.55%).

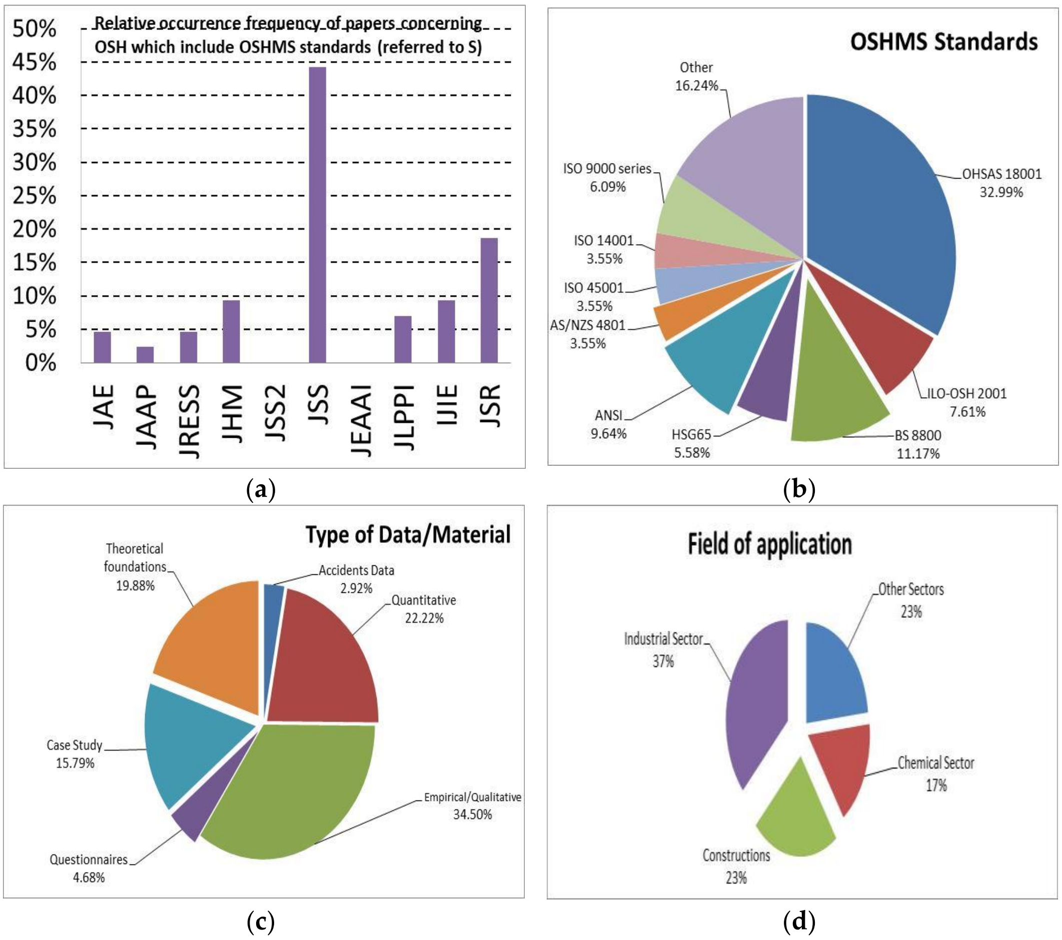


Figure 3. Depiction of (i) the relative occurrence frequency of papers concerning OSH that include OSHMS standards during the intervals of the years 1995–2005 and 2018–2020 (**a**) and (ii) for the period of 1995–2020, the relative occurrence frequency of miscellaneous OSHMS standards (**b**), the percentage distribution of the articles with OSHMS standards in association with various kinds of data or material (**c**), and the distribution of documents with OSHMS standards in association with several application fields (**d**).

Figure 3c reveals that "Empirical/Qualitative" is the most frequent type of data (or material) compared to other types. In addition, two discernible features of Figure 3 are as follows: the industrial sector presents the greatest percentage of articles with OSHMS standards (i.e., 37%), while the second significant field is construction (with 23%).

4.2. Findings

Ultimately, the current review reveals the subsequent findings:

- The documents regarding the issue of OSH are very few (5.13%) in relation to the quantity of all of the examined papers, and additionally, the papers that concern OSHMS standards are exceedingly few (0.2%) (Table A2; columns F and H).
- Even though JHM is the journal with the paramount quantity of published articles (N_i = 7388, F_i = 33.72%), JSS is the journal with the greatest number of articles (S_i = 19, f_{Mi} = 43.50%, f_{Si} = 44.18%) involving OSHMS standards (Table A2, columns C, D, K, and L).
- The curve that depicts the variation in the quantity of articles (about OSHMS standards) discloses a discernible long-term tendency (linear factor) with a positive inclination throughout the period of 1995–2020. More particularly, there is a persistent increase in the period of 1995–2012, while for the period of 2013–2016, a sudden decrease (with

strong negative slope) is observed, and on the other hand, a fast increase (with an intensive positive slope) is observed over the course of 2017–2019 (Figure 2a,c).

- The discernible long-term tendency (concerning OSHMS) reveals that there is a growing scientific interest in the implementation and utilization of OSHMS standards at worksites during the period of 1995–2020 (Figure 2a,c).
- The years 2011, 2012, and 2019 are the ones with the highest percentage of papers with OSHMS standards (according to the pie chart in Figure 2b).
- The variation in the number of articles with OSHMS standards presents a quasi-periodic feature over a period of ~9 years during the period of 1995–2020 (Figure 2c).
- It is worth underscoring that the OHSAS 18001 standard has the highest relative occurrence frequency (32.99%) in comparison with the other OSHMS standards. Additionally, although the new ISO 45001:2018 standard was developed in order to replace the OHSAS 18001 standard, the original one has remained the most frequent OSHMS standard according to the present literature survey throughout the entire period of 1995–2020 because the main aim of OHSAS 18001, from the beginning of its development and publication, the creation and maintenance of a safe work environment as far as workers' safety and health are concerned.
- Furthermore, though standard ISO 45001:2018 is a recent OSHMS standard, it presents, despite its short (brief) lifetime (in terms of its publication and usage) a significant percentage distribution (3.55%) throughout the years 2018–2020 with reference to the OSHMS articles that have been identified by the current review, which may be due to the fact that it was developed to gradually replace the OHSAS 18001 standard.
- The "Empirical/Qualitative" constitutes the most frequent type of data (or material) compared to other types, i.e., quantitative, theoretical foundations, case studies (Figure 3c).
- The industrial sector occupies the uppermost percentage of articles with OSHMS standards (37%), while the second most important occupational field is "construction" (23%).
- OSHMS principles are either voluntary or mandatory (for examples, see the study by Robson et al. (2007) [19]). Mandatory OSHMSs appear due to government legislation, while voluntary OSHMSs appear in private enterprises (or organizations), and they are not directly associated with regulatory requirements.
- Some significant barriers to the implementation of an OSHMS standard in any organization were (i) the high cost as far as its implementation and management is concerned, (ii) the difficulty for the workers to realize the significance of management in OSH, and (iii) the complexity of combining different standards [21,44].
- An OSHMS standard should incorporate two dimensions, the management component (first dimension) and the technical component (second dimension) [45].
- An effectual IMS OSHMS must merge various management systems, such as OSH (safety and health), QMS (quality), and EMS (environmental) [1]. The benefits that can be gained by the usage of integrated management systems are (a) improvement of the internal coordination and of the external appearance of the enterprise, (b) cost reduction, and (c) better compliance with legislation [46].
- Government agencies, employers, directors, managers, safety and health officers, employees, etc., admit day by day, that the effectiveness of applying OSHMS standards at the organizational level of any enterprise is substantial for reducing occupational hazards and risks on the one hand and for increasing productivity on the other [1].
- Businesses of any kind (e.g., industrial, commercial, etc.) and of any size (e.g., small/medium/large businesses) can surely develop/implement and use OSHMS standards.
- Occupational epidemiology must be one of the foremost characteristics of an OSHMS standard, but in the current scientific literature, methods, techniques, and tools do not incorporate comprehensive aspects of epidemiological management [21].

5. Discussion

5.1. Detailed Discussion

The development of management systems in any company affords a noteworthy framework for the implementation (and review) of the processes needed to efficiently manage occupational safety and health (OSH) [1]. Hence, management systems for safety and environment and audits for assessing them have been a foremost research topic throughout the last four decades [47]. Furthermore, an OSHMS is determined as an amalgamation of (i) planning and reviewing, (ii) the organizational arrangement of management, (iii) advisory arrangement, and (iv) the elements of a specific program, which collaborate with one another in an integrated framework to improve safety and health at work [27]. Moreover, according to ILO (2006) [13], an OSHMS standard constitutes the assets of interacting and relative elements to regulate and standardize OSH policy and its objectives as well as to achieve these goals.

Consistent with the study of Kale et al. (2013) [45], the IMS should not only encompass management components but also technical ones. Furthermore, the IMS standards, with reference to OSH at worksites, aim to supply organizations (industrial and commercial) with the essentials of an efficient OSHMS that is integrated with other management systems, both QMS (quality) and EMS (environmental) [1]. It is worth noting that an OSHMS system must be able to shift the organization's attention and activity to the risks that have potentially disastrous consequences as well as to adequately confront day-to-day concerns.

Given that confined systematic or narrative literature surveys exist ([1,19,21–25]) vis à vis the subject of OSHMS standards, we accomplished a thorough literature examination of IMS OSHMS standards by investigating and studying articles by published scientific journals, gathering an enormous number of documents (N ≅ 21,907) during the time spaces of 1995–2005 and 2018–2020. More specifically, this study expands and enriches the results of a previous work by Marhavilas at al. (2018) [1] by comparatively presenting the essential OSHMS standards and the statistical results of a literature review for later time periods (i.e., 1995–2005 and 2018–2020), and, finally, it covers (in association with the article by Marhavilas at al. (2018) [1] the complete period of 1995–2020. Through this review, appropriate scientific papers (vis à vis OSHMS standards) that were published by important scientific journals in the OSH field were investigated. Thus, the main goals of this study were the illustration of the current state of the art and the comparative presentation of the features of OSHMS standards as well as the reinforcement and amplification of their application at the occupational worksites of any organization. The examination of the scientific literature was achieved by considering ten remarkable journals of Elsevier B.V. that have thus far published the highest number of studies focusing on OSH issues (during the intervals of 1995–2005 and 2018–2020) in a framework compatible with the exploration technique of the study by Marhavilas et al. (2018) [1], in order to cover the entire period of 1995–2020.

The OHSAS 18001 standard continues to exist as the one of most significant OSHMS standards because its main scope from the beginning of its development and application was the creation and maintenance of a safe work environment as far as the OSH is concerned. Moreover, although the standard ISO 45001:2018 is a new one, it discloses through its brief lifetime (the years 2018–2020) a remarkable existence, possibly due to the fact, that it was derived to progressively substitute the OHSAS 18001 standard.

The industrial sector occupies the topmost percentage of articles on OSHMS standards. Seemingly, one cause is that industrial enterprises incur more unsafe working conditions at their worksites in comparison with other occupational fields (for instance, because of the usage of heavy machines in the production processes). Furthermore, what follows is the construction field owing to the supreme number of accidents [1].

It is worth noting that OSHMS's philosophy is either voluntary or mandatory, wherein mandatory OSHMSs emerge due to government legislation, whereas voluntary OSHMSs emerge in private organizations and are not straightforwardly associated with regulatory requisitions. Several considerable obstructions to the development of OSHMS standards in organizations, such the great cost as far as their implementation and management are concerned, the arduousness for the employees to comprehend the importance of management in OSH, and the complexity of merging different standards. An OSHMS standard should include two dimensions: a management dimension and a technical one dimension while an effective IMS OSHMS ought to join several management systems, such as OSH, QMS, and EMS (environmental). Thus, the profits that can be derived by the utilization of integrated management systems are the amelioration of the internal coordination and the fine external apparition of any organization, lower costs, and enhanced compliance with legislation. A business from any category (commercial, industrial, etc.) and any size (small, medium, or large) can definitely implement and apply an OSHMS standard.

Government agencies, organizations, businesses, employers, managers, safety/health officers, employees, etc., concede day after day that the effectiveness of implementing an OSHMS standard at the organizational level of each business is substantive for both confining its occupational hazards and for growing its productivity.

Furthermore, occupational epidemiology should be one of the prime characteristics of an OSHMS standard, or, in other words, an OSHMS standard must incorporate comprehensive aspects of epidemiological management. It is remarkable to note that the primary aim of occupational epidemiology is to characterize workplace-related diseases and to recognize their basic causes in order to protect workers from the harmful effects of the work by using work-related primary and secondary prevention measures [48].

5.2. A New-Fangled Suggested OSHMS Model

Taking into account the knowledge from the current survey of the examined scientific studies, we display in Figure 4 a newly proposed OSHMS model based on the principles of the Plan–Do–Check–Act (PDCA) cycle, which could improve the OHSAS 18001 and ISO 45001:2018 standards by concentrating on OSH management and, more particularly, on hazard control at worksites (the reader could focus on the central circular module). The framework of this generic safety management system (SMS) or the OSHMS model is reliant on the principles of prevention, participation, and responsibility. More specifically, this drawing constitutes a four-step model, and just as a circle has no end, the PDCA cycle should be repeated all over again for continual improvement and is considered as a project planning tool, while its heart includes a subsystem for OSH management and for the controlling of the hazards at worksites.

5.3. Limitations and Future Research Directions

It is noteworthy to emphasize that the current study was achieved by utilizing only ten noteworthy scientific journals published by Elsevier in the field of OSH due to the huge amount of articles published by these journals and in order to be compatible with the search technique of a previous study by Marhavilas et al. (2018) [1], covering, eventually, the whole period of 1995–2020. Of course, this feature of the research methodology constitutes an appreciable limitation of our survey. However, for future research, the scientific database of Scopus could be used extensively for elaborating papers covering the subject of OSHMS. Scopus is one of the two giant bibliographic/commercial databases that cover the academic literature concerning practically any scientific field. Nonetheless, there are several other documents (with open or restricted access) from other indexing databases, such as Google Scholar, Science Direct, Web of Science (WoS), Directory of Open Access Journals (DOAJ), Academia, IEEE Xplore, INSPEC, ERIC, JSTOR, PubMed, etc., which might be used to expand the results of this survey.

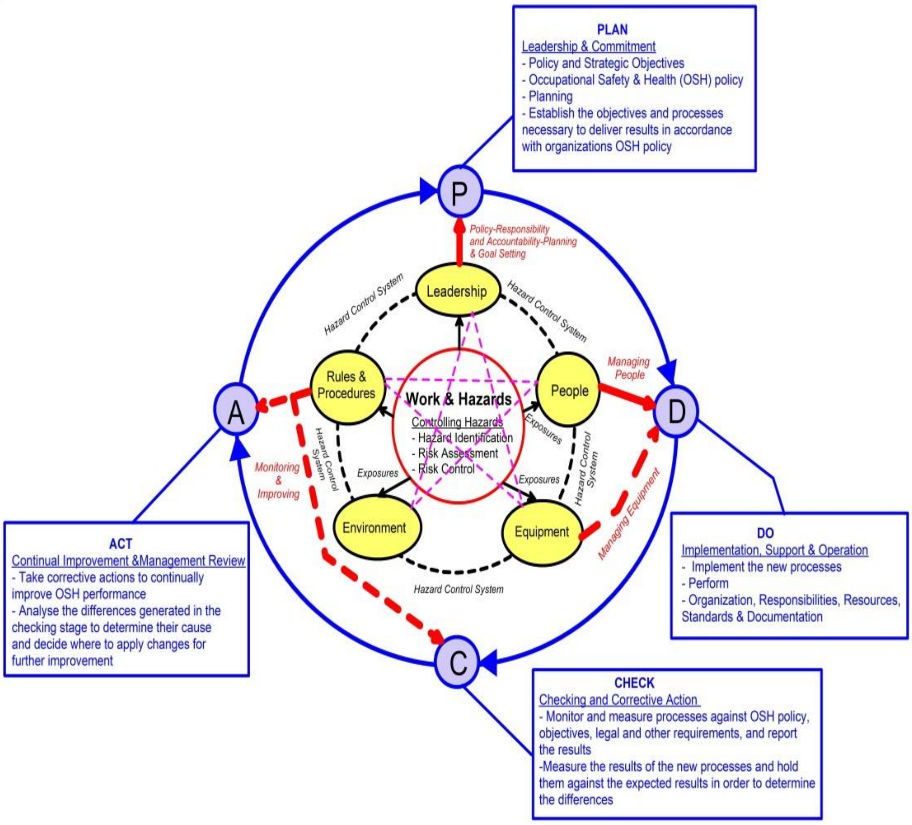


Figure 4. A flowchart for the newly proposed OSH management system model.

Several other restrictions regarding the results of the present work are related to the fact that our survey, via Elsevier's database, was limited to only include (i) reviews and articles and not other (internationally published) document types (for example, book chapters, conference papers, conference reviews, notes, scientific letters, books, etc.) and (ii) published articles, and we excluded articles in press and papers not written in English. We also did not include papers written in other widely spoken languages (such as Chinese, Spanish, German, French, Russian, etc.).

Furthermore, there is another limitation concerning the scope of the literature review, which does not adequately take into account the complexity of the operational environment as well as the influence of biases in decision making (motivational and cognitive), leading to accidents. More specifically there are new hazards and risks related to the complexity of operational environment and organizational and human performance, which are not elaborated by the current OSHMS standards. Such an approach often leads to putting the blame on frontline workers for deficiencies that are at the organizational level enabling and tolerating conditions creating unsafe workplaces (leading to the "drift to failure/accident"). This practice shows that these influences are "soft factors" that are hard to be resolved. Recent research works, such as the ones by Dekker at al. (2011) [49], Leveson (2011) [50], Kahneman (2012) [51], Mosey (2014) [52], Ken Ellis (2014a, 2014b) [53,54], Montibeller and von Winterfeldt (2015) [55], Leveson (2016) [56], Komljenovic et al. (2017) [57], Brocal et al. (2019) [58], and common experience show that organizational performance plays a key role in creating conditions for accidents. Organizational performance also includes less studied motivational biases in the decision-making process, and it is not considered (cognitive biases are relatively well-studied and understood). It is worth mentioning the article of Komljenovic et al. (2017) [57], which discusses that the subsequent level of safety performance will have to examine a transition from coping solely with workplace dangers to a further systemic model taking organizational risks into account. Hence, the experience from the nuclear industry might be valuable, as organizational learning procedures are believed to be more widespread than the technologies in which they are used. With the prominent exception of major accidents, organizational performance has not received appropriate attention. Furthermore, systems thinking has appeared as a crucial approach to efficient management and involves OSH. Thus, bearing in mind the latest ISO45001:2018 standard, a thorough study assessing the extent to which an OHSMS standard incorporates systems thinking aspects derived from the literature would be important (such as the one by Karanikas et al. (2022) [59]). We have the opinion that the newfangled OSHMS model suggested here could assist the reader to sufficiently capture the true image of the analyzed topic, including the aspects discussed above.

6. Conclusions

The advantages of efficacious OSHMS standards for any industrial and commercial organization include (a) more efficient utilization of resources, (b) enhanced financial performance, (c) enhanced risk management, and (d) amplified ability to provide consistent and upgraded products and services. Of course, OSHMS standards do not aim to substitute national laws or regulations and established standards, but, on the other hand, their main goal is to stimulate effectual OHS practices in equilibrium with socio-economic requirements.

Additionally, the finest SMS system is imperfect if it is not appropriately developed and implemented. The SMS system should be sufficiently understood by the people anticipated to implement and apply it. However, the utilization of an OSHMS can cover OSH problems, cheat an organization into perceiving it is successfully managing OSH, and disconcert effort and resources away from OSH towards the SMS system itself.

As a general conclusion, the current study reveals that (a) only an insignificant quantity of published papers concentrating on OSHMS standards (and regarding various occupational sectors) are available for the interval of years spanning 1995–2020, and (b) the scientific community is dilating its interest in the utilization of OSHMS standards day after day.

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Appendix A

This appendix presents the classification results of S = 43 articles determined by the investigation of ten scientific journals (published by Elsevier) concerning OSHMS standards throughout the periods of 1995–2005 and 2018–2020.

Table A1. The classification results of articles including OSHMS standards.

Nr	Paper Citation	Authors	Year of Publication	OSHMS Standard	Type of Paper Data or Material	Field of Application	Source
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
1	[47]	Hale et al.	1997	ISO 9000	Theoretical Foundations/Case Study	All Sectors	JSS
2	[60]	Cuny and Lejeune	1999	OHSAS 18001, EN 1050	Theoretical Foundations/Case Study/Quantitative	All Sectors	JSS

Table A1. *Cont.*

Nr	Paper Citation	Authors	Year of Publication	OSHMS Standard	Type of Paper Data or Material	Field of Application	Source
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
3	[61]	Nanthavanij	2000	ISO/TC 159, ISO/TC 159/SC 3, ISO/TC 159/SC 5, ISO/TC 159/SC 4	Empirical/Quantitative	Industry	IJIE
4	[62]	Harms-Ringdahl et al.	2000	ISO 9000	Empirical/Quantitative	Chemical Sector	JSR
5	[63]	Vassie et al.	2000	BS (BSI) 5750	Case Study/Quantitative and Qualitative	Industry	JSR
6	[64]	Pasman	2000	IEC 61508, ANSI Ž.rISA S84.0	Theoretical Foundations/Empirical/ Qualitative/Quantitative	Industry	JHM
7	[65]	Stavrianidis and Bhimavarapu	2000	ANSI/ISA S84.01, IEC d61508	Theoretical Foundations/Qualitative	All Sectors	JHM
8	[66]	Santos-Reyes and Beard	2002	ISO 14001, HSG 65, BS 8800	Theoretical Foundations/Qualitative	Industry	JLPPI
9	[67]	Kim et al.	2002	ISO 9000, ISO 9001, ISO 14001	Theoretical Foundations/Qualitative	Chemical Sector	JLPPI
10	[68]	Biddle and Marsh	2002	ANSI Z16.2	Case Study/Quantitative and Qualitative	Industry	JSR
11	[69]	García Herrero et al.	2002	ISO 9000, HSG 65	Theoretical Foundations/Qualitative	All Sectors	JSR
12	[70]	Knight	2002	AS/NZS 4360	Theoretical Foundations/Case Study/Quantitative	All Sectors	JSS
13	[71]	Holdsworth	2003	OSHA CFR 29 1910.119, EPA CFR 40, ISO 9000, ISO 14000	Theoretical Foundations/Qualitative	Industry	JHM
14	[72]	DeWolf	2003	OSHA PSM, EPA RMP, OPS IMP	Theoretical Foundations/ Case Study/ Quantitative/Qualitative	Industry	JHM
15	[73]	Tam et al.	2004	ISO 9000	Theoretical Foundations/ Empirical/Qualitative	Construction Sector/Industry	JSS
16	[74]	Yassin and Martonik	2004	OHSAS 29 CFR 1926.451	Theoretical Foundations/ Empirical/Quantitative	Construction Sector/Industry	JSS
17	[75]	Malka et al.	2018	ISO39001	Empirical/Quantitative	Industry	JAAP
18	[76]	Micheli and Marzorati	2018	ISO 11228—3	Case Study/Quantitative and Qualitative	Industry	IJIE
19	[77]	Hohnen and Hasle	2018	OHSAS 18001, ISO/IEC 17021	Theoretical Foundations/Case Study/Qualitative	All Sectors	JSS
20	[78]	Manu et al.	2018	BS OHSAS 18001, HSG 65	Theoretical Foundations/Case Study/Quantitative	Industry	JSS
21	[79]	Álvarez-Santos et al.	2018	OHSAS 18000, ISO 9000	Theoretical Foundations/ Empirical/Quantitative	All Sectors	JSS
22	[80]	Yazdani and Wells	2018	OHSAS 18001	Theoretical Foundations/ Quantitative/Qualitative	All Sectors	JAE
23	[81]	Santos and de Oliveira	2019	ISO 31000, ISO 31010	Empirical/Quantitative and Qualitative	Industry	IJIE

Table A1. *Cont.*

Nr	Paper Citation	Authors	Year of Publication	OSHMS Standard	Type of Paper Data or Material	Field of Application	Source
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
24	[82]	Bolbot et al.	2019	SAE ARP 4761, ISO 14971, IEC 61508, IEC 62508, MIL—STD—882E, ISO 31000	Theoretical Foundations/Quantitative	All Sectors	JRESS
25	[83]	Kruse et al.	2019	OSHA VPP, CA—IIPP, ISO 14001, OHSAS 18001	Case Study/Quantitative and Qualitative	All Sectors	JSR
26	[84]	Winge et al.	2019	ISO 45001	Theoretical Foundations/Qualitative	Construction Sector	JSR
27	[85]	Heras-Saizarbitoria et al.	2019	OHSAS 18001, ISO 14001, ISO 9001	Theoretical Foundations/ Empirical/Quantitative	All Sectors	JSR
28	[86]	Yiu et al.	2019	BS OHSAS 18001, BS EN ISO 9001	Theoretical Foundations/Case Study/Quantitative	Construction Sector/Industry	JSS
29	[21]	da Silva and Amaral	2019	ISO 45001, OHSAS 18001, ISO 14001	Theoretical Foundations	All Sectors	JSS
30	[87]	Skład	2019	ISO 45001	Theoretical Foundations	All Sectors	JSS
31	[88]	N. K. Kim et al.	2019	BS 8800, HSG 65, OHSAS 18001/18002, ILO—OHS 2001, andISO45001	Theoretical Foundations/ Empirical/Qualitative	Construction Sector	JSS
32	[89]	Ruiz-Frutos et al.	2019	ISO 26000:2010	Theoretical Foundations/ Case Study/Quantitative	All Sectors	JSS
33	[90]	Hudson and Ramsay	2019	ANSI/ISO/IEC 17024	Theoretical Foundations/Qualitative	All Sectors	JSS
34	[91]	Ladewski and Al-Bayati	2019	ISO 45001	Theoretical Foundations	All Sectors	JSR
35	[92]	Iftime et al.	2020	ISO 2631—1, ISO 7243, ISO 7726	Empirical/Quantitative	Industry	IJIE
36	[93]	Reniers et al.	2020	ISO 31000	Theoretical Foundations/Qualitative	Chemical Sector	JLPPI
37	[94]	Yang et al.	2020	NS 9415, ISO 14001	Theoretical Foundations/ Empirical/Quantitative	Industry	JRESS
38	[95]	Ji et al.	2020	AS/NZS 4801	Theoretical Foundations	Industry	JSS
39	[96]	Karanikas et al.	2020	AS/NZS 4801, ISO 45001	Theoretical Foundations	All Sectors	JSS
40	[97]	Salguero-Caparrós et al.	2020	ISO 45001	Theoretical Foundations	Industry	JSS
41	[26]	Swuste et al.	2020	ISO9000series, HSG 65	Theoretical Foundations	Industry	JSS
42	[98]	Rose et al.	2020	ISO 31000	Empirical/ Quantitative/Qualitative	All Sectors	JAE
43	[99]	Uhrenholdt Madsen et al.	2020	OHSAS 18001	Theoretical Foundations	All Sectors	JSS

Appendix B

This appendix presents the classification results of S = 43 articles determined by the investigation of ten scientific journals (published by Elsevier) concerning OSHMS standards throughout the periods of 1995–2005 and 2018–2020.

Table A2. The classification results of articles including OSHMS standards.

Nr	Journal	Acronym	Number of Investigated Papers (Absolute Frequency Ni) (N = 21,907)	Relative Frequency (Fi = Ni/N) [%]	Number of Papers Concerning OSH Science ($n_{ss(i)}$) (M = 1124)	Relative frequency of Occurrence for Papers Concerning OSH (with Reference to N) (fss(i) = nss(i)/N)[%]	Number of papers Concerning OSH which Include or Use OSHMS Standards ($n_{ST(i)}$) (S = 43)	Relative Frequency of Occurrence for Papers That Include OSHMS (with Reference to N) ($f_{ST(i)} = n_{ST(i)}/N$) [%]	Normalized (per Journal) Frequency of Occurrence for Papers Concerning OSH Science ($f_i^* = n_{SS(i)}/N_i$) [%]	Normalized (per Journal) Frequency of Occurrence for Papers Concerning OSH Which Include OSHMS Standards ($f_i^{**} = n_{ST(i)}/N_i$) [%]	Relative Occurrence Frequency for Papers Concerning OSH Science (with Reference to M) ($f^M_{SS(i)} = n_{SS(i)}/M$) [%]	Relative Occurrence Frequency for Papers Concerning OSH Which Include OSHMS (with Reference to S) ($f^S_{ST(i)} = n_{ST(i)}/S$) [%]
	(A)	(B)	(C)	(D) = (C)/N	(E)	(F) = (E)/N	(G)	(H) = (G)/N	(I) = (E)/(C)	(J) = (G)/(C)	(K) = (E)/M	(L) = (G)/S
1	Accident Analysis and Prevention	JAAP	2277	10.39%	60	0.27%	1	0.004%	2.63%	0.04%	5.33%	2.32%
2	International Journal of Industrial Ergonomic	IJIE	1541	7.03%	129	0.59%	4	0.018%	8.37%	0.26%	11.47%	9.30%
3	Journal of Loss Prevention in the Process Industries	JLPPI	1407	6.42%	78	0.35%	3	0.013%	5.54%	0.21%	6.93%	6.97%
4	Journal of Safety Research	JSR	989	4.51%	155	0.71%	8	0.036%	15.67%	0.81%	13.79%	18.60%
5	Reliability Engineering and System Safety	JRESS	2629	12%	40	0.18%	2	0.009%	1.52%	0.07%	3.55%	4.65%
6	Safety Science	JSS	2005	9.15%	489	2.23%	19	0.086%	24.39%	0.95%	43.50%	44.18%
7	Journal of Hazardous Materials	JHM	7388	33.72%	53	0.24%	4	0.018%	0.71%	0.05%	4.71%	9.30%

Table A2. *Cont.*

Nr	Journal	Acronym	Number of Investigated Papers (Absolute Frequency Ni) (N = 21,907)	Relative Frequency (Fi = Ni/N) [%]	Number of Papers Concerning OSH Science ($n_{ss(i)}$) (M = 1124)	Relative frequency of Occurrence for Papers Concerning OSH (with Reference to N) (fss(i) = nss(i)/N)[%]	Number of papers Concerning OSH which Include or Use OSHMS Standards ($n_{ST(i)}$) (S = 43)	Relative Frequency of Occurrence for Papers That Include OSHMS (with Reference to N) ($f_{ST(i)} = n_{ST(i)}/N$) [%]	Normalized (per Journal) Frequency of Occurrence for Papers Concerning OSH Science ($f_i{}^* = n_{SS(i)}/N_i$) [%]	Normalized (per Journal) Frequency of Occurrence for Papers Concerning OSH Which Include OSHMS Standards ($f_i{}^{**} = n_{ST(i)}/N_i$) [%]	Relative Occurrence Frequency for Papers Concerning OSH Science (with Reference to M) ($f^M{}_{SS(i)} = n_{SS(i)}/M$) [%]	Relative Occurrence Frequency for Papers Concerning OSH Which Include OSHMS (with Reference to S) ($f^S{}_{ST(i)} = n_{ST(i)}/S$) [%]
	(A)	**(B)**	**(C)**	**(D) = (C)/N**	**(E)**	**(F) = (E)/N**	**(G)**	**(H) = (G)/N**	**(I) = (E)/(C)**	**(J) = (G)/(C)**	**(K) = (E)/M**	**(L) = (G)/S**
8	Applied Ergonomics	JAE	1489	6.80%	117	0.53%	2	0.009%	7.85%	0.13%	10.40%	4.65%
9	Structural Safety	JSS2	525	2.4%	1	0.004%	0	0%	0.19%	0%	0.09%	0%
10	Engineering Application of Artificial Intelligence	JEAAI	1657	7.56%	2	0.009%	0	0%	0.12%	0%	0.17%	0%
	Total		**21,907**	**100%**	**1124**	**5.13%**	**43**	**0.2%**			**100%**	**100%**

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