Evolution of International Occupational Health and Safety Management Systems

Vyom Saxena
Health, Safety & Environment Group
Bhabha Atomic Research Centre (BARC), Trombay-400085, INDIA
E-mail for Correspondence: vsaxena@barc.gov.in

Introduction

A management system is a set of policies, processes, and procedures that an organization utilizes to manage tasks such as safe operation, product quality, legislative and regulatory conformance, etc. to achieve its objectives. An Occupational Health and Safety Management System (OHSMS) promotes a healthy working environment by providing a framework to identify, control, and manage Occupational Health and Safety (OHS) risks and opportunities [Boyle, 2019]. Gallagher describes Occupational Health and Safety Management Systems (OHSMS) as "an integrated framework comprising planning and review processes, organizational and management structures, consultative mechanisms, and specific program components, all working cohesively to enhance health and safety performance" [Gallagher, 2003]. Implementation of an effective OHSMS aims at bringing down workplace injuries and minimizing the accompanying costs. Many studies have shown that safety management has a positive influence not only on safety performance but also on parameters like competitiveness and economic-financial functioning [Fernández-Muñiz, 2009]. Occupational health and safety management systems (OHSMS) have evolved significantly over time, reflecting advances in industrial practices, societal awareness, technological innovation, and the identification of human factors as an important aspect in relation to OHS [Cohelo, 2005]. This evolution has transitioned from basic reactive measures to sophisticated, proactive, and integrated systems aimed at preventing workplace incidents, illnesses, and fatalities.

Occupational Health and Safety (OHS) practices were rudimentary in the pre-industrial era. Workplaces, primarily agricultural or artisanal, often relied on traditional methods without formal systems for managing risks. Hazards such as accidents or diseases were addressed reactively and informally. The Industrial Revolution (18th-19th Century) marked the beginning of large-scale factory systems, introducing machinery and mass production. These advancements also brought significant hazards such as exposure to harmful substances (e.g., coal dust, lead), dangerous machinery without safeguards, Poor ventilation and lighting, etc. Governments responded with some early legislations, e.g., the UK's Factory Acts (1833, 1844) introduced basic safety regulations, limiting working hours and mandating safeguards for machinery. The U.S. implemented state-level laws addressing workplace safety by the late 19th century [Manuele 2019].

The early 20th Century saw the emergence of Regulations saw development of formal OHS standards (20th century) with the establishment of formal health and safety standards. Workers' compensation laws were first introduced in Germany in the late 19th century and adopted globally in the early 20th century, these laws incentivized employers to reduce workplace hazards. Occupational diseases were recognized with Silicosis and asbestosis cases that highlighted the need for exposure limits and preventive measures. Institutionalization of OHS regulation began to take shape in the Mid-20th Century after World War II and subsequent industrial expansion emphasized workplace safety. The U.S. Occupational Safety and Health Act (1970) created OSHA, setting enforceable standards for workplace hazards, and organizations like the International Labour Organization (ILO) and the World Health Organization (WHO) promoted global OHS standards [ILO 2005].

Systematization of OHSMS started in the late 20th Century with rapid industrialization that gave rise to the

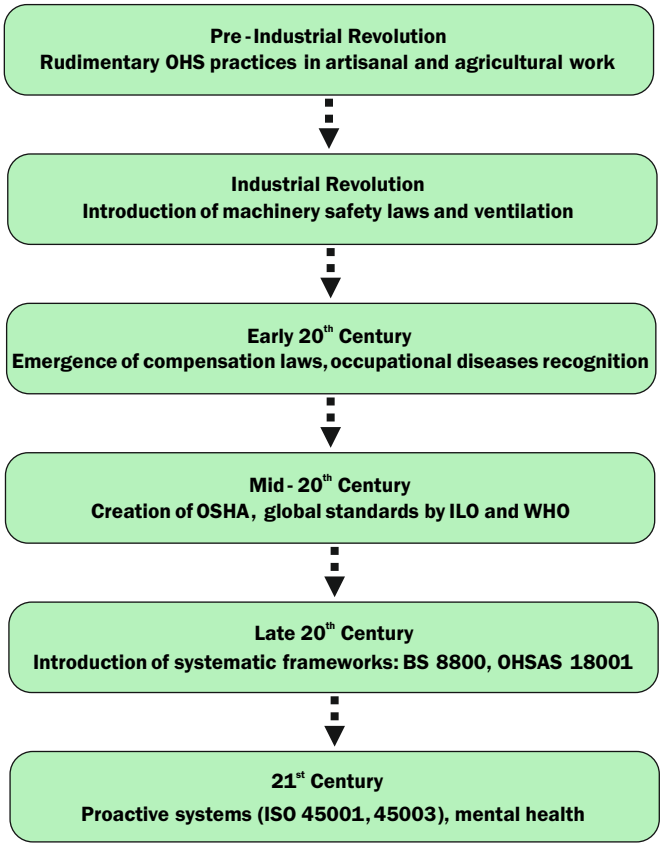

Fig.1: Evolution of systematization in Occupational Health and Safety.

Table 1: A comparison of various OHS management systems.

Aspect	ISO 45001	OHSAS 18001	ILO-OSH 2001	ANSI/ASSP Z10	BS 8800
Origin	International Organization for Standardization (ISO)	British Standards Institution (BSI)	International Labour Organization (ILO)	American Society of Safety Professionals(ASSP)	British Standards Institution (BSI)
Adoption	2018	1999 (withdrawn 2021)	2001	2005 (latest revision 2019)	1996 (superseded by OHSAS 18001)
Focus	Risk-based approach; worker participation	Hazard identification, risk assessment	Continuous improvement in OSH performance	Management systems for improving OSH	Guidance framework for OHSMS
Applicability	Global	Global	International	Primarily US	UK (guidance-level, non-certifiable)
Certifiability	Yes	Yes (until 2021)	No	No	No
Key Principle	PDCA Cycle, leadership commitment, and worker involvement	PDCA Cycle	Tripartite approach (employers, workers, and government)	Risk-based and performance-oriented	Framework and guidance
Structure	Annex SL (10 Clauses)	PDCA Cycle (non-Annex SL)	Flexible	High-level framework	Guidance document
Risk Management	Emphasis on proactive risk management	Reactive focus on hazard control	Proactive and preventive focus	Risk-based thinking and reduction	Hazard and risk guidance
Worker Participation	Strongly emphasized	Limited emphasis	Strongly emphasized	Encouraged	Encouraged
Integration with Other Standards	Easily integrates with ISO 9001, ISO 14001	Limited integration	Not explicitly designed for integration	Can be integrated with other systems	Limited integration
Legislation Alignment	Can be tailored to national regulations	Broadly aligned with existing laws	Focused on ILO standards	Focuses on US regulations and ANSI standards	Aligned with UK regulations
Context	Organization -specific context considered	Limited focus on organizational context	Not explicitly considered	Organizational factors considered	Limited contextual consideration
Migration	Replaces OHSAS 18001	Superseded by ISO 45001	Standalone	Standalone	Precursor to OHSAS 18001
Certification Benefits	Globally recognized; enhances credibility	Previously widely recognized	Not certifiable	Improves safety culture	Non-certifiable
Major Limitation	Requires significant implementation effort	Limited flexibility	Non-certifiable; guideline-based	US-centric	Superseded and outdated

concept of Management System Frameworks [Parvu, 2024]. The rise of total quality management (TQM) influenced OHSMS development. Frameworks emphasized a systematic approach, integrating health and safety into business processes. The earnest efforts towards OHS management systems were first attempted with the release of a guide to OHS in 1996 based on Health and safety at Work Act 1996 of the International Labour Organization. The British Standard BS 8800 (1996) and later the Occupational Health and Safety Assessment Series (OHSAS 18001) in 1999 provided a structured approach to implementing OHSMS globally [McKinnon 2019].

The 21st Century is the era of Modern OHSMS which emphasizes proactive risk management, employee engagement, and integration with other business systems. Modern systems focus on hazard identification, risk assessment, and prevention rather than incident response [Lynda, 2007]. The first international standard for occupational health and safety management systems came into being in 2007 as Occupational Health and Safety Assessment Series 18001 (OHSAS 18001). Over the past three decades, there have been constant efforts to improve the OHSMS and to make it more wide-ranging, realistic and comprehensive [Karanikas, 2019]. Fig. 1 depicts the evolutionary time chart on the systematization and standardization in OHS.

Published in 2018, this international standard replaced OHSAS 18001. It provides a risk-based approach aligned with ISO management system standards (e.g., ISO 9001 for quality management). ISO 45001, designed to drastically improve the levels of workplace safety and productivity is the new standard for management systems of OHS. It was first proposed in 2013 and the final document was published after many deliberations and revisions in March 2018. ISO45001 has now completely replaced the earlier international standard, OHSAS 18001. The OHSAS 18001-certified organizations had time till September 2021 to migrate to ISO 45001. With an emphasis on management commitment, worker involvement, and risk control, ISO 45001 intends to prevent work-related injuries, illnesses, and fatalities by specifying requirements for an OHSMS [Lindholm 2023]. This new standard follows the approach of other management systems such as ISO 14001 and ISO 90001. Although ISO 45001 draws on certain aspects of OHSAS 18001, it is a new and distinct standard, not a revision or update.

ISO 45001 significantly differs from its predecessor OHSAS 18001 which focused more on controlling hazards and provided a framework for the effective management of occupational health and safety including risk management and legal compliance. OHSAS 18001 had a reactive approach that focussed solely on risks and not solutions, whereas ISO 45001 has a proactive and preventive approach requiring hazard risks to be evaluated and remedied before they cause accidents and injuries. ISO 45001 is process-based and dynamic in all clauses whereas OHSAS 18001 is procedure-based and static. Similarly, ISO 45001 considers both risk and opportunities but OHSAS 18001 deals only with risk. Another major difference is that unlike OHSAS 18001, ISO 45001 considers the views of interested parties too. Table 1 Highlights the significant differences between Various international OHS guidelines and management systems.

In the course of continual evolution, ISO 45003, the most recent addition to OHSMS and the first global standard giving in-depth practical guidance on managing psychological health in the workplace was introduced in June 2021. An add-on extension of ISO 45001, it provides guidance on the management of psychosocial risks as part of the occupational

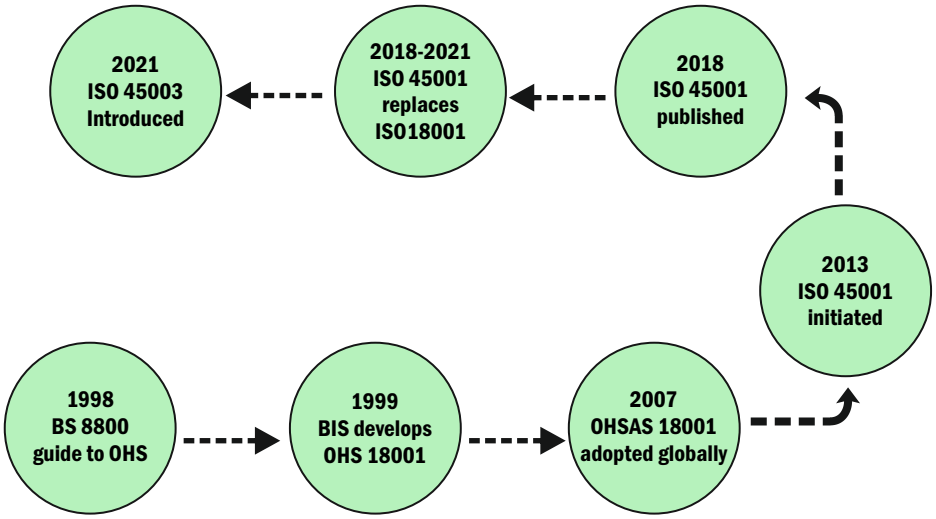

Fig.2: Timeline of the evolution of systematic International OHS guidelines and management systems.

health and safety management system [Leka, 2010]. ISO 45003 is not an accreditation in itself but a proactive attempt to encourage ISO 45001-certified organizations to consider mental health as an integral part of their working lives. Fig. 2 gives the timeline of the integrated standards in OHS culminating into OHS Management Systems (OHSMS).

Factors Influencing the present state of OHSMS Evolution and the Challenges

Technological Advancements of the present times have transformed the industry and workplaces like never before. The rapid strides made in fields like information technology, Automation, Digitalization, Robotics, and drone technology have not only revolutionized the occupational space but also the OHS facet. Real-Time monitoring is possible with IoT devices and sensors that allow continuous monitoring of workplace hazards, such as noise, air quality, and ergonomics. Predictive Analytics and Data-driven approaches can predict potential hazards with great precision and guide preventive actions. Digital Training Tools such as virtual reality (VR) and augmented reality (AR) offer immersive training experiences. However, the most unique feature of the latest OHSMS is its Employee-Centric Approaches. odern OHS management systems emphasize employee well-being and considers stress, burnout, and mental health as workplace concerns [Gallagher, 2001]. It acknowledges diversity and inclusion as important considerations to address unique risks faced by vulnerable groups, including women and older workers.

Government regulations have been a primary driver of OHSMS advancements, mandating compliance and setting minimum standards. Major industrial accidents like the Bhopal gas tragedy (1984) and the Chernobyl disaster (1986) underscored the importance of robust safety systems, leading to stricter regulations and better practices [Hale, 1998]. Globalization and the resultant global integration of supply chains has prompted multinational organizations to adopt consistent OHSMS frameworks across borders. Companies increasingly view OHS as a part of their ethical responsibilities, improving reputation and stakeholder trust. These influencing factors and the concomitant challenges are presented in Fig. 3.

The integration of advanced technologies such as AI, robotics, drones, and automation into workplaces brings numerous occupational hazards that require careful management. AI systems, while enhancing efficiency, can perpetuate biases, create privacy concerns through extensive data collection, and lead to overdependence, which may result in operational failures or errors. Workers interacting with robotics face risks of mechanical injuries, programming errors, and electrical or hydraulic failures. Additionally, drones introduce hazards like physical accidents, airspace interference, noise pollution, and cybersecurity breaches, while automation can lead to skill degradation, job insecurity, system failures, and ergonomic issues from repetitive monitoring tasks. These challenges are not only physical but also psychological, as workers may experience stress over adapting to these technologies or facing potential displacement [Nuhu 2024].

To address these hazards, organizations must adopt proactive safety measures. Training and awareness programs can equip workers with the skills needed to manage and mitigate risks associated with new technologies. Ergonomic design and user-friendly systems can minimize physical strain and errors. Conducting comprehensive risk assessments ensures that potential hazards are identified and mitigated early [Reese 2018]. Cybersecurity measures are crucial for protecting sensitive data, especially in AI-driven and drone-enabled environments. Furthermore, psychological support systems can help workers cope with the stress and anxiety arising from job insecurity and workplace changes. By implementing these strategies, industries can cultivate a safer and more inclusive environment, ensuring the benefits of advanced technologies are harnessed without compromising worker well-being.

Small and medium enterprises (SMEs) often face significant challenges in implementing comprehensive occupational health and safety management systems (OHSMS) due to limited resources [Robson 2007]. Financial constraints make it difficult for SMEs to invest in advanced safety technologies, hire dedicated safety professionals, or conduct regular risk assessments. Additionally, a lack of technical expertise can hinder the development and maintenance of systematic frameworks aligned with standards like ISO 45001. SMEs also struggle with time constraints, as small teams often prioritize operational demands over safety initiatives. Compliance with complex regulations can be overwhelming, especially in industries with stringent safety requirements, leading to a reliance on reactive measures rather than proactive systems. These constraints highlight the need for tailored support, such as simplified guidelines, affordable training programs, and government subsidies to help SMEs enhance workplace safety effectively.

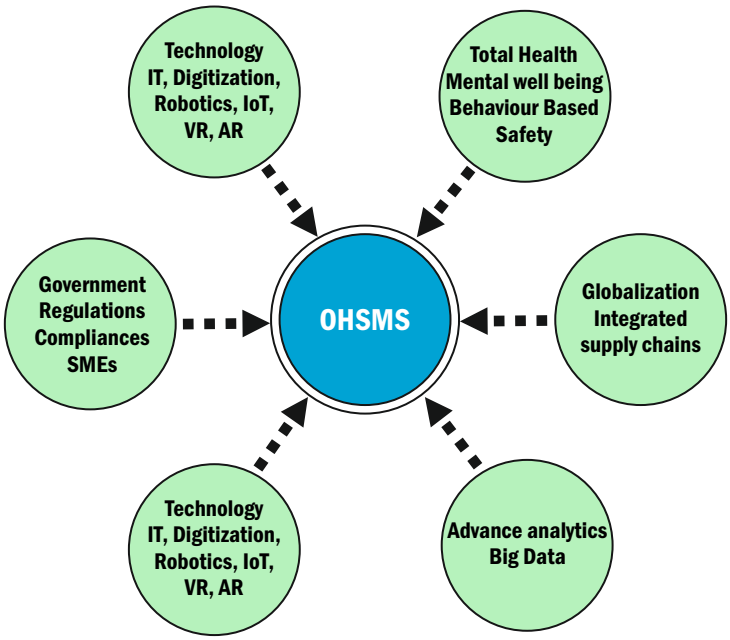

Fig.3: The current Influencing Factors and the associated challenges for OHSMS.

Future Trajectory of OHSMS

Aligning Occupational Health and Safety Management Systems (OHSMS) with Environmental, Social, and Governance (ESG) goals represents a holistic approach to workplace safety and sustainability. By integrating OHSMS with ESG frameworks, organizations can address worker safety while promoting environmental stewardship and social responsibility. This alignment ensures that safety practices consider environmental impacts, such as reducing waste or emissions, and prioritize inclusivity and well-being for all employees [Wang 2020]. Governance principles enhance accountability, encouraging transparent reporting of health and safety metrics alongside ESG performance. Such integration not only boosts compliance and stakeholder trust but also drives sustainable growth by embedding safety and ethical considerations into core business strategies.

Leveraging big data and AI for predictive risk management enables organizations to proactively identify and mitigate potential workplace hazards. By analyzing vast datasets from sensors, equipment logs, and employee feedback, AI algorithms can detect patterns and predict risks before incidents occur. For example, machine learning models can forecast equipment failures or highlight high-risk areas based on historical trends. This data-driven approach enhances decision-making, allowing for timely interventions and resource optimization. Additionally, predictive tools improve compliance with safety regulations by providing actionable insights in real time. Integrating big data and AI into risk management systems not only enhances workplace safety but also fosters a culture of continuous improvement and innovation [Parvu 2024].

Occupational Health and Safety Management Systems (OHSMS) can ensure psychological safety by creating an inclusive, supportive, and mentally healthy work environment. Key strategies include promoting open communication, where employees feel safe to express concerns or ideas without fear of retaliation or judgment. Incorporating mental health initiatives, such as stress management programs, access to counseling, and training managers to recognize and address psychological stressors, helps mitigate burnout and anxiety. OHSMS can also establish policies against workplace bullying, harassment, and discrimination, ensuring fairness and respect for all employees. Regular assessments of workplace culture, combined with feedback mechanisms, allow organizations to identify and address psychosocial risks proactively [Lindholm 2023]. By embedding psychological safety into OHSMS, businesses not only enhance employee well-being but also improve engagement, productivity, and overall organizational resilience.

National Regulatory Frameworks

United States

Occupational Safety and Health Administration (OSHA) primarily governs the United States' regulatory framework. OSHA sets permissible exposure limits (PELs) for various workplace hazards, including airborne contaminants, noise, and exposures from various chemicals. organizations like the American Conference of Governmental Industrial Hygienists (ACGIH) Complement OSHA, and provide Threshold Limit Values (TLVs) that often influence international standards. Additionally, the National Institute for Occupational Safety and Health (NIOSH) conducts research and issues recommendations that guide OSHA's regulations [ILO 2024].

European Union

Occupational Health and safety standards in the European Union (EU) are codified under the European Framework Directive 89/391/EEC. This directive mandates that employers assess and mitigate risks while advancing a culture of preventive safety. The EU's regulatory approach often emphasizes worker participation in safety programs. Additionally, the REACH (Registration, Evaluation, Authorisation, and Restriction of Chemicals) regulation directly impacts industrial hygiene by enforcing stringent controls over chemical use and exposure [ILO 2024].

Japan

Japan's industrial hygiene framework is regulated by the Industrial Safety and Health Act (ISHA) which mandates comprehensive risk assessments, regular health check-ups for workers, and strict adherence to exposure limits for hazardous substances. Japan's emphasis on proactive measures, including education and training, aligns closely with international best practices [ILO 2024].

Australia

Australia's Model Work Health and Safety (WHS) Act and related codes of practice ensure robust industrial hygiene measures. The Safe Work Australia agency supports compliance through guidelines and exposure standards. Australia's system is distinguished by its clear guidelines for industries like mining, agriculture, and construction [Gallagher, 2001].

The Indian Regulatory Picture

India's industrial hygiene regulations are governed by multiple frameworks, including the Factories Act, 1948, and the recently introduced Code on Occupational Safety, Health, and Working Conditions (OSH Code), 2020. These regulations mandate provisions for workplace ventilation, dust control, chemical safety, and occupational health services. However, significant challenges persist, including limited enforcement, fragmented regulatory oversight, and lack of worker awareness. The recent legislative framework, the OSH Code 2020 consolidates and simplifies existing labor laws, offering an opportunity for streamlined implementation. Industries like mining, chemicals, and construction are under stricter scrutiny for compliance. However, Insufficient staffing and resources for inspectorates hinder effective implementation [OSH 2020].

Conclusion

Occupational Health and Safety Management Systems (OHSMS) have progressed from reactive, informal measures to structured, proactive frameworks that prevent workplace hazards. Early efforts, influenced by industrial milestones like the Industrial Revolution, included legislation such as the UK's Factory Acts and U.S. safety laws. The 20th century formalized OHS with global standards, such as BS 8800 and OHSAS 18001, emphasizing systematic integration into business operations. Modern OHSMS, like ISO 45001, focus on proactive risk management, employee engagement, and addressing psychological health (ISO 45003). Technological advancements, including IoT, AI, and predictive analytics, enable real-time monitoring and hazard prediction, while SMEs face challenges due to limited resources. Future trends include aligning OHSMS with Environmental, Social, and Governance (ESG) goals, leveraging big data for predictive safety, and fostering psychological well-being. Global regulations, tailored to regional needs, continue to drive advancements. This evolution highlights a growing commitment to safer, more inclusive, and conducive workplaces.

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