METHODOLOGY FOR PREVENTION THROUGH DESIGN IN OCCUPATIONAL SAFETY

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Abstract. *Prevention by Design (PtD) is a concept of methodologies that can be applied during the design phase of work processes and products, ensuring the reduction of risks to the safety and health of individuals exposed to the design in all its forms. The purpose of this master's thesis is to assess the current methods of identifying and preventing work injuries among companies with the potential to implement Prevention through Design. Additionally, it aims to gauge the interest of designers, planners, and technical-engineering staff in its application. The analysis is conducted through literature research and a survey questionnaire distributed to companies directly or indirectly involved in design processes and products. This article provides an initial research analysis and sets the stage for further research on the methods and practices of implementing this ideology in the Republic of North Macedonia. The paper concludes with a summary of the data analysis and offers recommendations for future research.*

Keywords: Prevention through design, occupational safety and health, design for safety.

1. INTRODUCTION

Prevention through Design (PtD) is regularly practiced in various industry sectors worldwide, indicating a clear interest in implementing this methodology throughout the industry. However, until its benefits are recognized and enabled, inhibitors of PtD implementation restrict its widespread diffusion across the industry. Efforts are being made, through various tools, to promote its use, overcome barriers, and educate industrial professionals/designers on this subject.
In the analysis of the occupational injuries in the Republic of North Macedonia, according to the Institute of Public Health, a total of 1,121 work-related injuries were recorded in 2019, and 599 work-related injuries in 2020. The rate of work-related injuries in 2019 in the Republic of North Macedonia was 141.0/100,000. This means that for every 100,000 workers, 141 workers were injured throughout the year. In 2020, the rate of work-related injuries was 75.3/100,000, indicating that for every 100,000 workers, 75 workers were injured. These statistical indicators demonstrate the relevance and the need for a comprehensive preventive approach that can contribute to reducing the number of work-related injuries and identifying workplace hazards and risks.

Table 1. Rate of work injuries per 100,000 employees in the period from 2019-2020 in the Republic of North Macedonia; Source - Work Injury Information 2019-2020, Institute of Public Health of the Republic of North Macedonia.

Injury Rate	*2019*	*2020*
Total work-related injuries	*1.121*	*599*
Number of employees	*797.651*	*794.909*
Injury rate per 100.000 employees	*141*	*75,3*

These alarming figures provide clear evidence that work-related accidents are a serious global problem and highlight the need for additional measures to enhance worker safety. This study primarily focuses on the implementation of the Prevention through Design (PtD) methodology and its impact on improving the safety of employees directly involved in carrying out work tasks. It addresses practical implementation and answers questions such as "Does design-based prevention increase worker safety?" and "What methods are available for incorporating PtD in the design phases?"
The introduction provides an overview of PtD, a brief historical review of its development, its merits, and general implementation-related issues. The subsequent sections review existing literature and research to confirm the influence of design-based prevention on employee safety and the reduction of work-related injuries. This chapter

includes a hypothesis, research methodology, and expected outcomes. Based on research from existing scientific literature, the elements and principles of design are defined, along with practical examples of successful PtD implementation that have contributed to risk reduction in the workplace. The obtained results from the study, along with the analysis of existing literature and research, supplemented by empirical research, will demonstrate the significance of PtD in reducing losses during work execution in the context of occupational safety and health. The information and findings from this study will contribute scientifically and provide practical insights relevant to organizations from a design/engineering perspective on their occupational safety and health systems.

2. LITERATURE REVIEW

In the field of mechanical engineering, design decisions have a significant impact on safety outcomes in various industrial settings. To prioritize safety, laws and regulations have been implemented in many countries, requiring mechanical engineering companies to integrate safety measures during the design phase. Despite these efforts, there is a need to increase awareness among mechanical engineers about the importance of incorporating safety into design. Existing literature suggests that Prevention through Design (PtD) principles can effectively enhance safety in mechanical engineering. Handbooks and recommendations developed for mechanical installations offer valuable insights applicable across industries. Overall, integrating safety into the design phase is crucial for protecting workers and preventing accidents in mechanical engineering, and ongoing awareness and education efforts are essential for optimal results.

3. METHODOLOGY

This methodology focuses on incorporating safety and preventive measures during the design phase of projects, products, and processes. It aims to identify and mitigate potential risks and hazards to ensure a safer working environment and improve the overall safety and health of employees. The survey results indicate that there is a need for greater awareness and education among professionals regarding the implementation and benefits of this methodology.

Table 2. Description of different levels of hierarchy, from most effective to least effective.

Phase	Activity
Conceptual Design	Setting goals for safety and health at work and identifying occupational hazards
Preliminary Design	Eliminating hazards, if possible; replacing them with less hazardous agents/processes; establishing goals to minimize the risk for remaining hazards; risk assessment; developing alternative control options. Writing project specifications.
Detailed Design	Selection of controls; conducting a process hazard review.
Procurement	Developing equipment specifications and incorporating them into procurement; developing "checks and tests" for factory acceptance, testing, and commissioning.
Execution	Ensuring safety on the construction site and safety for the contractor.
Commissioning	Performing "checks and tests"; safety reviews before startup; development of standard operating procedures; risk/exposure assessment; and management of residual risks.
Start-up and Management Education	Change management; modification of standard operating procedures.

The Key phases for implementing Design for Prevention:

- Hazard Identification: Identifying all hazards associated with the project, considering the full range of intended uses as well as foreseeable misuse.
- Risk Assessment: Assessing the risk of harm occurring and evaluating existing controls.
- Design Review: Eliminating hazards and controlling risks (If identified risks cannot be eliminated through feasible design modifications, the focus of the designer shifts to reducing the risk to the extent reasonably practicable. The designer must consider what is known or should reasonably be known about the risk and all possible means of reducing it).
- Implementation: Addressing residual risks and hazards.
- Learning: Monitoring and reviewing the risk assessment throughout the project, including key design phases.

Each phase involves a set of tasks to be performed by one or more of the following stakeholders: Architect; Civil engineer; Mechanical engineer; Design engineer (safety specialist/supervisor); General contractor; Investor/Maintenance personnel.
It should be noted that the Design for Prevention process is a sequential and cyclical process. After the implementation of design for prevention, the mechanical installation contractor documents the lessons learned within their company and shares them with other stakeholders in future projects. Through the conducted research and questionnaire, a modified form adapted to the existing methodology will be proposed, resulting in recommendations and checklists for the design process to reduce risks in later stages of execution.

4. CONCLUSION

The study revealed challenges and opportunities in implementing Design for Safety among designers and workers. Awareness and practical application of safety considerations during the design phase were lacking. However, participants expressed interest in learning and integrating Design for Safety. Accessible educational resources and standardized practices are needed. Early integration of safety measures is crucial, and regulatory requirements and industry-specific standards are necessary for consistent implementation. Clear guidance and a safety-focused culture are essential. Comprehensive initiatives should raise awareness, provide education and training, and establish standardized practices. Collaboration among stakeholders is vital for developing industry-specific standards. By enhancing awareness, education, and standardization, Design for Safety can improve safety outcomes and project efficiency. The research objectives include a comprehensive understanding of this methodology and its specific characteristics represented in existing scientific research literature, as well as recommendations for implementing the methodology in companies involved in designing mechanical installations and products.
Demographics: The majority of respondents (64.8%) were in the age group of 25-34 years, indicating a dominance of this age bracket in the survey. Furthermore, 49.6% of the participants had completed postgraduate studies, and the years of work experience varied. The industries and job positions represented in the survey were predominantly focused on designers, project managers, technical personnel, engineers, and professors from the Faculty of Mechanical Engineering in Skopje.
Training in Safety and Health: Only 8.4% of respondents were trained specifically in safety and security, while 70.7% had attended training related to safety and health in the workplace. This suggests a significant proportion of participants were educated and aware of the importance of worker safety. However, the frequency of training varied, with some individuals attending training only once and others undergoing multiple training sessions at specific intervals.
Familiarity with Design for Prevention Methodology: When asked about their familiarity with the Design for Prevention methodology, the survey revealed that only 10.3% of participants were familiar with the methodology, 24.1% had partial knowledge, and the remaining respondents had never heard of it. Notably, 65.5% of participants indicated no knowledge of the methodology, highlighting the need for greater education and awareness about its significance and advantages.

Importance of Designing for Safety: A positive response was received from 96.6% of respondents when asked about the potential improvement of working conditions and employee safety by incorporating preventive safety measures during the design phase of processes and products. This demonstrates a strong interest in implementing the methodology across various industries and job positions. Additionally, 54.4% of participants stated that their company identifies and considers all risks related to worker safety during the design of projects, processes, and products.
Overall, the survey results emphasize the importance of promoting education and awareness about the Design for Prevention methodology among professionals. It also highlights the potential for implementing preventive safety measures during the design phase to create a safer working environment and improve the overall well-being of employees.

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