

Systematic Literature Review on Human Reliability Assessment in Industry

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Abstract. Human reliability is much in question when things happen that are not desirable, such as accidents or other losses in various systems. Studies on human reliability, especially industry 4.0, are widely carried out globally. This study aims to identify trends in human reliability assessment (HRA) approaches. The inclusion criteria used were the subject, year of publication, method/approach, research object, and results. The dataset was taken from Science Direct using the keyword "human reliability assessment" to conduct a systematic literature review. Some of the impacts of problems caused by human reliability issues and the qualitative or quantitative approach used in HRA can be mapped. This literature research can benefit human reliability researchers in industry and industrial practice by providing a practical and up-to-date mapping of human reliability assessment problems.

Keywords: human reliability assessment, human reliability, human errors, systematic literature review.

17. Introduction

To err is humans; it is natural to make mistakes. Human error is always possible, even though various preclusion efforts remain. Human Reliability Assessment (HRA) provides procedures and tools for foreknowing human errors in a human-machine system qualitatively and quantitatively. Reliability engineering is the beginning of HRA, from which it derives its central ideas and methods [1]. Studies on human reliability assessment show a snowballing trend from 2012 to 2021. More issues of human reliability are being investigated in various subject areas nowadays. A literature study on human reliability was conducted to map the problems surrounding human reliability within the scope of the engineering subject and map what engineering researchers used methods and approaches to evaluate and measure human reliability. The data for this study was mined from Science Direct in December 2021.

Humans play an essential role in all systems in the industry, specifically industries that have a high risk of accidents, such as industries related to nuclear, aerospace, and others. Human error is evidence of human unreliability. Human unreliability can have severe consequences for safety and quality. Various approaches and efforts have been made to minimize human unreliability. In a human-machine system, the role of humans is very strategic, so human failure is the primary hazard to safety [2]. This study aims to identify trends in the HRA approach used in industries related to the industry. Various approaches to Human Reliability Assessment are found in this literature study. Human Reliability assessment is a method or approach used to predict the occurrence of human error [3].

18. Methods

The dataset was taken from Science Direct using the keyword "human reliability assessment" to conduct a systematic literature review. The database source used is science direct because the number of published articles on HRA is found chiefly there. Thus, the reviewed papers are from the same publisher, Elsevier. The types of articles reviewed were research papers. The reviewed articles were published in 2012-2022, using the inclusion criteria of engineering as the subject area and open-access articles. Open-access articles are prioritized to be selected for easy access to references. The quality of journals from Science Direct is considered decent, so the citation index, quartile, and impact factor are not the main criteria in this literature research.

Five hundred forty-five articles in the Science Direct database were identified using "human reliability assessment" and "manufacturing." Before the screening began, 445 articles were discarded because they did not write down the common keywords in the 2012-2021 period. Further screening was carried out from the remaining 100 articles to research articles and open access. Forty-nine articles were excluded from the study because the research was not in the engineering subject area. In the end, this stage leaves twenty-one articles for review. The data collection team is 25 students who take a work health and safety class at a private university in Indonesia. Each student collects five paper titles and reviews them according to the inclusion criteria set, using the keywords "human reliability assessment" and "industry." The expected results of the review by the student team is a meta-analysis table recording research objects, problems, and methods used in HRA studies in the literature. Figure 1 shows a diagram of this study's systematic literature review methodology.

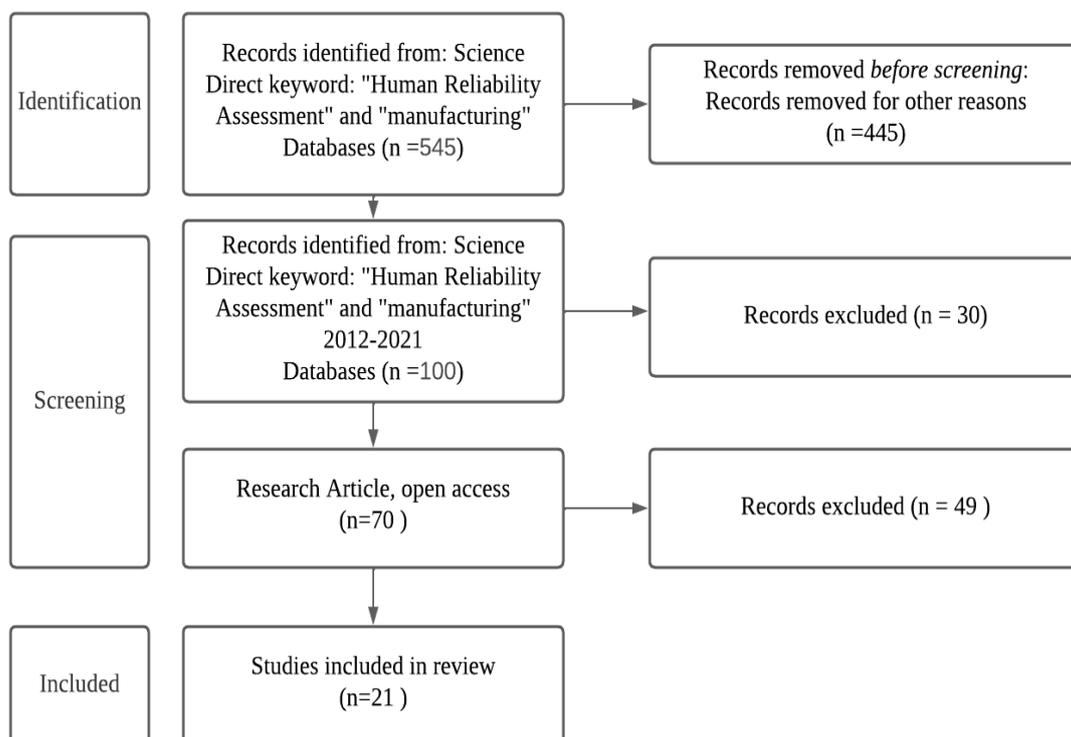


Figure 1. Systematic Literature Review Methodology

19. Result and Discussion

Several issues regarding Human Reliability in Industry

There is an accusation in the revolution of Industry 4.0. The human factor is not considered much by the industry [1]. Based on these allegations, attentiveness is raised that abandoning humans in a complex system such as industry 4.0 will affect the system's performance and ability to function securely. Various challenges were faced by several industries related to human reliability. Academic publications have mainly focused on simulation-based training to improve the safety of the oil and gas industry [2]. There was a lack of specific studies on applying cognitive simulation-based training, such as Augmented Reality-enabled tools or Intelligent Fault Detection and Alarm Management solutions. The issue of human reliability is also related to worker behavior. One example is the object of civil construction research which is full of uncertainty, the availability of data on human/or team behavior is minimal to diagnose the impact of human unreliability [3]. Amid industry 4.0 issues, manual assembly operation is still being conversed a lot [4]. In this era, there is a phenomenon of high expectations for human-centric engineered digital solutions to increase human reliability [2]. There is a challenge that industry practitioners and system designers must answer. Considering that, in all the industrial eras that have passed, various efforts to increase human reliability and minimize human error continue to develop even though this problem will not disappear.

The development of science is indeed a long journey. Based on this fact, there is an awareness that human unreliability is something that a human being must accept. Efforts to increase human reliability that have been carried out are certainly not in vain, considering that each milestone in the HRA study is precious. In this literature study, it is identified which industries have human reliability problems. The potential for problems regarding human reliability occurs in all types of industries where humans have a role in their activities, as charted in Table 1. The following industry classifications can be plotted.

Table 1 Industry Mapping in HRA Literature

Industry	Reference	Object
Transportation	[5]	Train control systems
	[6]	Rail transport
	[7]	Railway turnout systems
	[8]	Onboard Ships
	[9]	Man-Machine System
Manufacture	[10]	Manual assembly operation
	[11]	Maintenance Work
	[12]	Cellular Manufacturing
	[13]	Ship design
Service	[14]	Marine Industry
	[15]	Metrology test
Construction	[3]	Civil construction
Energy	[16] [17]	Petroleum industry
	[18]	Nuclear industry
	[19]	Biopharmaceutical Industry
Health and pharmacy	[20]	Surgery
	[21]	Health care- radiation oncology
	[22]	Medical: brachytherapy
Food and beverage	[23]	Butchery

HRA is a reasonably general and global issue, while the approach used has a very high variation and is very flexible to use for industrial objects anywhere. HRA is multidisciplinary [9]. The disciplines involved in this study are mainly determined by the object and type of industry in which the study is

conducted. HRA research can be in the form of general research regarding method development, so HRA literature does not mention the object of the industry specifically. Understanding every detail of the system operation dramatically affects the HRA's quality of analysis. HRA requires a very accurate situation analysis to identify the potential for human error.

Human Reliability Problem in Industry

Humans are one of the most critical system elements. However, by nature, humans are created with weaknesses in the form of unreliability [24]–[27]. Several problems related to human reliability can be identified in this study. The following table 2 shows the Impacts of the Human Reliability Problem.

Table 2. Human Reliability Problem Impacts

Human Reliability Problem Impacts	Reference
Transportation accident	[5] [6]
System malfunction	[3] [1] [7] [28]
Industrial accident	[9] [11]
Errors in production or service	[10] [19] [8]
Medical malfunction	[21] [20]
Monetary losses	[23]
Quality problems	[12] [29]

Everything ends in monetary losses. The impact of the human reliability problem is not only in the event of accidents but can also be in the form of other losses such as system malfunctions, errors in production or service, and quality problems. Table 2 shows that system malfunction is the most common impact in the literature. Humans are essential system elements, so their unreliability can cause system failures. Next are production or service errors, which relate to the quality of products and services in an industrial system. Quality, reliability, and safety are again an inseparable triangle [30]. Some systems in industrial operations are said to have a high dependence on humans, even though they are supported by automation [5]. Such systems are usually very demanding on human reliability.

The regulation of air traffic and railroads has unique characteristics that require human coordination. An obvious example is the operation of air traffic controllers at airports and train control systems. Research on HRA becomes crucial, considering that the safety of many lives depends on the reliability of officers in this system.

Development of Human Reliability Assessment Method

Measuring and analyzing human reliability are divided into two categories, namely qualitative and quantitative. Table 3 maps out HRA approaches and methods in the literature reviewed.

Table 3 Methods of Human Reliability Assessment

Approach	Methods	Reference
Quantitative	Technique for human error-rate prediction (THERP)	[9] [19]
	Human error Probability- Excel-based tools	[10]
	Adapted Standardized Plant Analysis Risk-Human Reliability Analysis (SPAR-H)	[16]
	Dynamic probabilistic risk assessment	[14]
	Failure Mode and Effect Analysis (FMEA),	[21]
	Fault Tree Analysis (FTA)	[21]
	Performance Influencing Factors (PSF)	[31]
	Data Analytics	[18]
Human Error Probability (HEP)	[12]	

Approach	Methods	Reference
	Failure Mode, Effects, and Criticality Analysis (FMECA)	[32]
	Simulation; System dynamics	[1] [15]
	Performance Influencing Factors (PSF)	[33]
Qualitative	Performance Shaping Factors	[6] [20]
	Design of a working system, equipment, environment, and tasks	[5]
	Modeling/human error probability modeling/ Human Reliability Analysis Models	[7] [13] [21] [11]
	Human Error Assessment and Reduction Technique (HEART)	[23] [22] [8] [28]
	Human failure events (Hess)	[17]

The approach used in HRA consists of a quantitative approach and a qualitative approach. These two approaches involve different disciplines. The quantitative approach is filled chiefly with statistical methods because the discussion about human reliability calculates and identifies the possibility of human error. The science of modeling, mathematics and systems simulation has played a significant role in developing a quantitative approach to HRA. The qualitative approach to HRA is widely used to mitigate human reliability issues, starting from hazard identification, risk assessment, and design of control measures. This study shows that the Human Error Assessment and Reduction Technique (HEART) method is still widely used in human reliability assessment. HEART is a method that can be applied to any object, so its usability is relatively high.

Most HRA methods are "ready to use" and "ready to build" methods. The ready-to-use HRA method provides standard analytical tools that can be used to analyze any system. HEART is one such example. In comparison, the HRA method that is ready to build is a method that is used for specific objects but can be adapted for other research objects that are similar or even completely different. The characteristic of this ready-to-build method is that it has specific analytical indicators but is easy to adapt. Adaptation of one analytical tool from one object to another requires expert involvement. The role of experts, in this case, is essential because the adaptation of tools requires an excellent understanding of system operations.

Of all the literature reviewed, the most important in any HRA review is what recommendations the research can support. The recommendations generated by the research are practical implications to be carried out on the object of study. HRA studies become more strategic and valuable when the recommendations for improvement can overcome the problems faced. Increasing human reliability is one of the efforts to meet human needs in the industrial world. Human needs in activities and work consist of three things: comfort, productivity, and well-being. There is limitations on the use of HRA. It is obvious that not all of these approaches provide decision-makers in these systems enough data to recognize the likelihood of a human mistake, evaluate what more risk it would pose to the public, and minimize that possibility to a manageable level.

20. Conclusion

Humans in the system are significant because the human element in the system has multiple roles. Human failure and error are the indicators of human reliability. Human error results in system failure, impacting other problems such as production errors, product or service defects, work accidents in industry, transportation activities, and financial losses. The problem of human reliability will always exist and occur as long as the role of humans is still present in all activities. HRA studies continue to be developed with various adaptations of their analytical methods, both quantitatively and qualitatively. Of all the HRA studies, the most important thing is that each review can provide recommendations for system improvement for stakeholders. The Industrial Era 4.0 raises higher expectations on HRA issues, where the digitalization approach is expected to overcome the various impacts of human reliability issues

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