International Journal of Transportation Engineering and Technology
2026, Vol. 12, No. 2, pp. 76–83
https://doi.org/10.11648/j.ijtet.20261202.12

Review Article

Casual Factors Influencing Human Errors in Automotive Maintenance: A Review

Edward Julius Mwambage*, Mazuri Erasto Lutema, Christian S. Nabora

Department of Automotive and Mechanical Engineering, National Institute of Transport, Dar es Salaam, Tanzania

Abstract

Maintenance error is cited as one among the major factors in most automotive accidents, including those involves human error in maintenance activities. However, in may system failures caused by human errors in automotive maintenance affects availability, reliability and safety of automotive. Maintenance errors that are resulted from human errors have impact in different ways such as organizational operations target loss, high operating cost, low safety and loss of life or body parts. Human error has not been taken into consideration in managing them unless the incidence or accident occurs. The use of incidence or accident then looking and solving problem is the outdated method, in current world of engineering forecasting, controlling and management should be on place as a part of organization management. The study on the causal factors influencing human errors in automotive maintenance have been carried out for the purpose of identifying the factors and then grouping the factors according to the sources of origin. The methodology used to attain the study objectives was literature and analysis of identified factors. The employed method to analyze and formulate the relationship of factors was the Ishikawa`s fish bone diagram. The identified factors were 24 in number then grouped into four according to their sources of origin as follows: personal factors, organizational factors, environmental factors and vehicle system factor.

Keywords

Human Errors, Automotive, Maintenance, Maintenance Errors, Ishikawa Diagram

1. Introduction

1.1. Background Information

The vehicular transportation industry is the backbone and it grows rapidly in many developing countries. This growth of vehicular transportation goes hand on hand with the increase of importation and assembling motor vehicles for different uses. Motor vehicles as other machines requires regular maintenance so as to remain performing the intended functions at the pre-set standards.

In the current advanced technology where many automotive systems are more sophisticated than before with increased number of computerized systems such as the use of electronic controls in many systems human error become a threat during maintenance specifically in developing countries where the level of technology used in maintenance and maintenance technicians are still far from the real speed of development.

There had been frequently occurrence of human errors in maintenance of automotive with immediate effect or dormant in character which have negative impact on the performance

*Correspondence: Edward Julius Mwambage (eddoojully@gmail.com)

Received: 27 January 2026; **Accepted:** 9 February 2026; **Published:** 18 June 2026

of automotive hence leading to vehicle accidents, on road breakdowns, prolonged down time, increased running costs in terms of fuel and spare parts. The impacts of human errors in maintenance affects both organizations and individual vehicle users in number of ways staring from increase of running costs to the loss of organization performance targets.

According to the study by Mkilania [22] found that every time when the vehicle comes out from workshop or garage for maintenance, comes with a new problem apart from those recorded for that maintenance. This gives the rise for the need of identifying and grouping causal factors responsible for the occurrence of the human errors in automotive maintenance. In view of the above, it is the intension of this study to identify the causal factors influencing human errors in automotive maintenance and grouping the factors into their sources of origin.

1.2. Objectives

The main objective of this study is to investigate the casual factors influencing human errors in automotive maintenance and grouping factors according to their sources. The specific objectives for attaining the main objective are as follows:

1) To identify casual factors influencing human errors in automotive maintenance.
2) Grouping causal factors influencing human errors in automotive maintenance according to their sources.

2. Literature Review

2.1 Maintenance

Maintenance can be defined as all technical and managerial actions needed to keep a facility in as-built condition and therefore proceed to perform its original intended function within a pre-set standard [30].

According to [6, 7] depending on the nature maintenance can be categorized into three main types as follows:

Preventive maintenance – The collection of all activities done on planned, periodic, and specific schedule intended to keep a facility or system in desired working condition through the process of checking and reconditioning.

Breakdown (Corrective) maintenance – This is unplanned activities intended to restore a facility or system to a preset standard, after the deficiencies or failures while the facility or system is in use.

Predictive maintenance – this is the use of advanced tools, equipment and signal-processing technologies for accurately diagnose facility or system real time condition while in operation and then plan for the repair before the system or item breakdown.

2.2. Maintenance Error

Errors that occur due to incorrect inspection, wrong repair or wrong calibration performed during maintenance task.

Maintenance error can be defined as the failure to carry out a maintenance task according to the standard, chain of procedures and principles of good maintenance practice [31].

Common maintenance errors include wrong re-assembly, incorrect specification of replaced parts, skipping of a task step, re-commissioning errors, safety features wrong connection, wrong calibration, or leaving parts and items out or inside the system [23].

2.3. Human Error in Maintenance

Human error is defined as a failure to perform a stipulated task or the fulfilment of an unacceptable activity that could cause the disruption of the planned function and resulting to system and equipment damages [26]. According to [35] human error is defined as an inadvertent error in the performance of a task which can result to instant system failures or can be latent or inactive in character with possibility of harming the technical system's worthiness.

2.4. Causal Factors Influencing Human Errors in Automotive Maintenance

Many studies and researches came up with a number of causal factors influencing human errors in maintenance of engineering systems and machines in which automotive being one of these machines.

The study done by [1, 35] the findings show that the condition of working environment, time pressure, design and fabrication of system or equipment, the complexity of maintenance task, communication, knowledge and skills, working condition of an organization, task planning and scheduling, tiredness, few number of maintenance personnel for the task, induvial problems, distraction while doing maintenance task as well as maintenance manuals and procedures were identified as key factors of human errors in maintenance. The tabled main causal factors of human errors in maintenance according to [21] found to be time pressure, difficult working environment and inadequate communication.

In a study made by [5] found that sources of human error are poorly documented operating and maintenance procedures, insufficient skills, poor equipment design, lack or insufficient training, poor working place layout, poor maintenance tools and equipment, limited amount of light and high-level noise at working place. Also, number of causal factors obtained from the study of [8, 12] include the poor working environment, maintenance task complexity, outdated maintenance manuals and lack of properly written maintenance procedures, poorly designed work layout, maintenance personnel fatigue, poorly designed equipment, inadequate training and lack of experience, unsuitable tools and equipment for specified task. According to the literature and experience put forward by [18] showed that errors in diagnosis and troubleshooting highly contributed to human errors during maintenance activities.

The study of [2, 3] revealed that maintenance team cultures, organizational structure and culture, mental health issues, procedural factors, awkward situations, complicated working environments, exposure to high stress and a tendency to remain rigid to changes are key causal factors of human errors in maintenance. Findings by study of [19] inadequate tools and equipment for troubleshooting and diagnosis, non-compliance with technical instructions, poorly coordinated and organized trainings, and being unfamiliar to the subtask activities were explained as the key factors for the influencing human error in maintenance.

According to the study by [34] the management commitment, organizational structure and traditions, and the organization's local context facilitates the growth of human error in maintenance by hindering the implementation of prevention strategies against human error in maintenance. In the analysis of human factors as a component of the management system's holistic performance, the key human factors that impact the maintenance performance such as competence and motivation of maintenance personnel, in contrast with management, number of tasks, and performance feedback were derived [27, 28]. The non-fulfilment of the established procedures and competence of maintenance personnel were the main causal factors of human error as per research findings of [4]. The study of [29, 32, 33] revealed the following are core human error causal factors: maintenance manuals and procedures, organizational process, trainings to maintenance personnel, equipment design and fabrication, maintenance task supervision, maintenance materials and resources. It was revealed that the major error causal factors are time pressure, poor communication, complacence to instructions and procedures, lack of knowledge, disturbances, fatigue, poor teamwork, scarcity of resources, the inadequacy of awareness, insufficiency of assertiveness, stress [10, 24]. The study of [15] discovered that the manifestation of human errors is related with environmental factors, lack of communication and coordination, time pressure, documentation of maintenance procedures, lack of integration in teamwork, change of shifts and handover, organizational and team norms, fatigue, stress, lack of system knowledge, poorly equipment design and fabrication, insufficient design for maintainability, and absent-minded of maintenance personnel. The study of [9] established a number of factors responsible for human error such as, stress, emotional decision making and poor judgement emotional, work instructions and procedures, concentration, the decrement attentiveness, work task repeatation, fatigue, time pressure, physical factors, social factors, work pace and personal factors, troubleshooting and diagnosis, motivation, morale of employees, skills, knowledge and experience of maintenance team, availability of maintenance tools, availability of parts.

The literature by [11, 16] revealed that diagnostic errors do not have a direct contribution to system failures, yet these can lead to inappropriate maintenance decisions the leads to human errors. The research findings of [13] showed that the procedures is the double edged factor as it stand for both the source of human errors also stands as the defense of human error. The study of [20, 36] came up with the factors such as the following: ambient condition of working area, inadequate supervision, memory and attention issues, poor judgment and decision making, poorly designed equipment, inflexibility and inadaptability were revealed as the major causes of human error.

Poor inspection and diagnosis, failures in isolation and localization, failure in detecting the symptoms, the incorrect assessment of the condition of the considered part or unit during maintenance task were main causes of human errors by the study of [18].

By observing all these causal factors of human errors as they have explained by different scholars, it is observed the sources causal factors of human errors are double edged in natures such that the causes can used as defenses against human error in maintenance. It is very important to identify the causal factors of human error in order to come up with sufficient strategies and initiatives for mitigating human errors in the maintenance of automotive systems.

3. Methodology

The methodology used to attain the study objectives was through literature review whereby the identified factors are further subjected to causal and effects methods which included the Ishikawa's fishbone diagram where a relationship among factors were obtained.

Ishikawa Diagram for Causal Factors Influencing Human Errors in Automotive Maintenance

Ishikawa Diagram is also known as fishbone diagram or the Cause and Effect Diagram. The concept of the Fishbone diagram was initiated in 1920's as a tool for basic quality control.

A Fishbone diagram shows root causes of a specific event or condition [14, 17, 23, 25]. A major advantage of using the Fishbone diagram is that it is a convenient and easy to understand method, which helps one to visually see potential causes and sub-causes of the problem during the identification of its root causes.

Figure 1: is the Ishikawa's causal and effect, fish bone diagram. The figure shows the sources of causal factors influencing human errors in automotive.

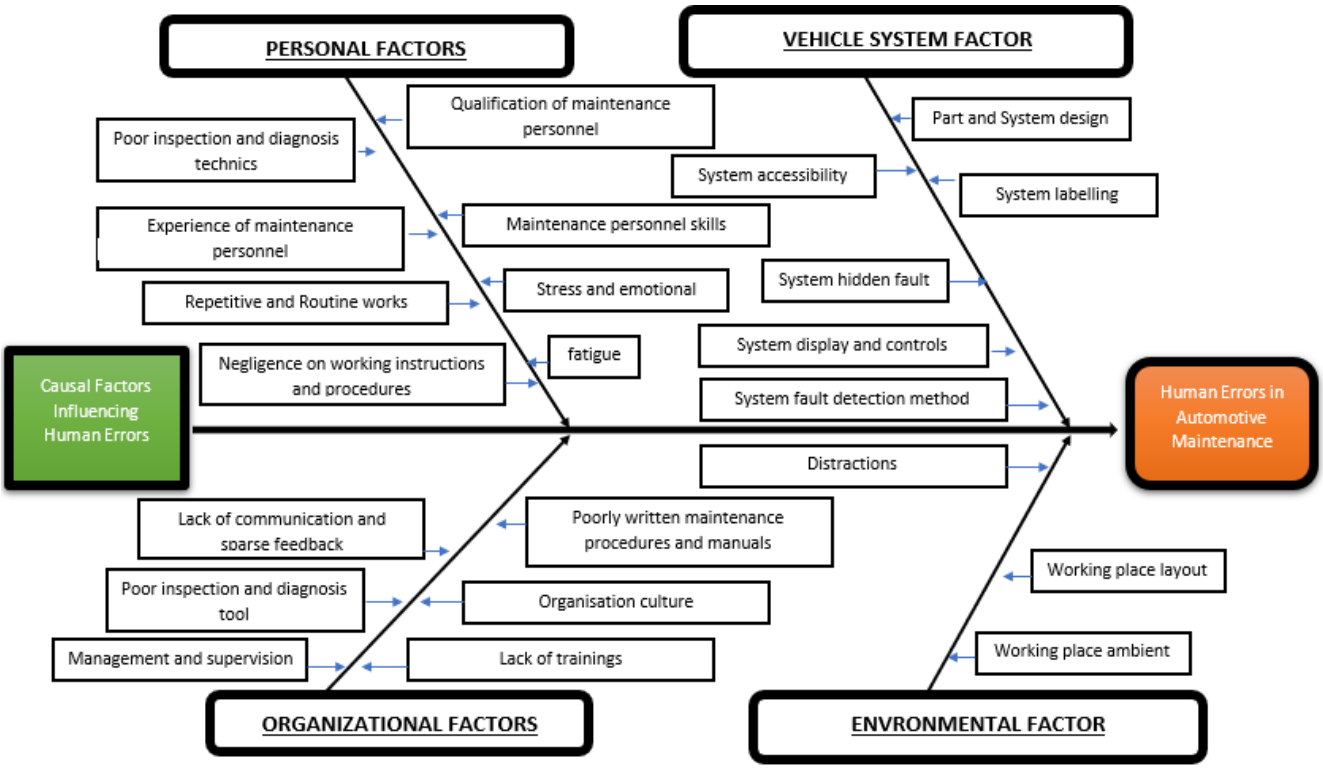

Figure 1. *Ishikawa's causal and effect diagram showing groups of causal factors influencing human errors in automotive maintenance.*

4. Key Funding of Literature Review

Identification of causal factors influencing human errors in automotive maintenance.

Table 1. *Name of author and year of publication for the causal factors influencing human errors in automotive maintenance.*

S/NO	Causal factors influencing human errors in automotive maintenance	Name of author and year of publication
1.	Poor diagnosis and inspection ethnics	Khan et al. 2014; Hockley and Philips 2012; Singh, Kumar and Kumar, 2015; Aju Kumar, Gandhi and Gandhi, 2015; Di Fazio *et al.*, 2014
2.	Qualification of maintenance personnel	Gupta, 2001; Mkilania, 2016 Goh and Tay, 1995 Arts, Knapp and Mann Jr, 1998; Thakur and Panghal, 2021
3.	Experience of maintenance personnel	Mkilania, 2016; Goh and Tay, 1995
4.	System display and control	Dhillon & Liu, 2006; Hobbs, 2008; Dhillon, 2014; Krulak, 2004; Rashid, 2010
5.	Parts, fasteners and consumables	Dhillon & Liu, 2006; Hobbs, 2008; Dhillon, 2014; Krulak, 2004; Rashid, 2010
6.	Maintenance personnel skills	Dhillon & Liu, 2006; Dunn, 2004; Peach, Ellis & Visser, 2016; Badenhorst & Van Tonder, 2004
7.	Negligence on work instructions and procedures	Badenhorst & Van Tonder, 2004); Kovacevic et al., 2016; Dunn, 2004; Singh, Kumar and Kumar, 2015,
8.	Working place ambient	Dhillon & Liu, 2006; Krulak, 2004; Latorella & Prabhu, 2000; Dhillon & Liu, 2006 Dhillon (2014)

S/NO	Causal factors influencing human errors in automotive maintenance	Name of author and year of publication
9.	Parts, equipment or system design	Dhillon & Liu, 2006; Hobbs, 2008; Dhillon, 2014; Krulak, 2004; Rashid, 2010; Dhillon and Singh 1981; Wu and Hwang (1989)
10.	Time pressure	Hobbs, 2008; Dunn, 2004; Virovac, Domitrović & Bazij, 2017.
11.	Part or System accessibility	Wu and Hwang, 1989; Dhillon, 198; Pannell, 1997
12.	Working place layout	Dhillon & Liu, 2006; Peach, Ellis & Visser, 2016; B S Dhillon 2014; Dunn, 2004; Virovac, Domitrović & Bazij, 2017
13.	Weak management and supervision	Timmons, et al., 2014; Peach, Ellis & Visser, 2016; Krulak, 2004; Rashid, 2010
14.	Fatigue	Latorella & Prabhu, 2000; Hobbs, 2008; Dhillon, 2014; Dunn, 2004; Virovac, Domitrović & Bazij, 2017
15.	System hidden fault	Wu and Hwang, 1989; Dhillon, 1981; Pannell, 1997
16.	Lack of trainings	Dhillon & Liu, 2006; Dhillon, 2014; Kovacevic et al., 2016; Rashid, 2010
17.	organizational culture	Timmons, et al., 2014; Alonso & Broadribb, 2018; Latorella & Prabhu, 2000; Rashid, 2010
18.	Lack of communication and sparse feedback	Hobbs, 2008; Virovac, Domitrović & Bazij, 2017; Peach, Ellis & Visser, 2016;
19.	Parts, equipment or system labelling	Dhillon & Liu, 2006; Hobbs, 2008; Dhillon, 2014; Krulak, 2004; Rashid, 2010
20.	Stress and Emotional demands of maintenance personnel	Dunn, 2004; Latorella & Prabhu, 2000; Hobbs, 2008; Alonso & Broadribb, 2018
21.	Repetitive and Routine works	Alonso & Broadribb, 2018; Dunn, 2004
22.	Poorly written maintenance procedures and manuals	Dhillon & Liu, 2006; Gould & Lovell, 2009; Hobbs, 2008; Dhillon, 2014; Dunn, 2004; Rashi, 2010; Singh, Kumar and Kumar, 2015
23.	Poor diagnosis and inspection tools	Khan et al. 2014; Hockley and Philips 2012; Singh, Kumar and Kumar, 2015: Di Fazio *et al.*, 2014
24.	Part or system fault detection method	Dhillon & Liu, 2006; Hobbs, 2008; Dhillon, 2014; Krulak, 2004; Rashid, 2010

Grouping causal factors influencing human errors in automotive maintenance according to their sources as per results from Ishikawa Diagram:

Table 2. *Grouping causal factors influencing human errors in automotive maintenance according to their sources as per results from Ishikawa Diagram.*

S/N	Causal factors influencing human errors in automotive maintenance	The source Group where factor originates
1.	Poor diagnosis and inspection technics	Personal factor
2.	Qualification of maintenance personnel	Personal factor
3.	Experience of maintenance personnel	Personal factor
4.	System display and control	Vehicle factor
5.	Parts, fasteners and consumables	Organizational factor
6.	Maintenance personnel skills	Personal factor
7.	Negligence on work instructions and procedures	Personal factor

S/N	Causal factors influencing human errors in automotive maintenance	The source Group where factor originates
8.	Working place ambient	Environmental factor
9.	Parts, equipment or system design	Vehicle factor
10.	Time pressure	Organizational factor
11.	Part or System accessibility	Vehicle factor
12.	Working place layout	Environmental factor
13.	Weak management and supervision	Organizational factor
14.	Fatigue	Personal factor
15.	Part or System hidden fault	Vehicle factor
16.	Lack of trainings	Organizational factor
17.	organizational culture	Organizational factor
18.	Lack of communication and sparse feedback	Organizational factor
19.	Parts, equipment or system labelling	Vehicle factor
20.	Stress and Emotional demands of maintenance personnel	Personal factor
21.	Repetitive and Routine works	Personal factor
22.	Poorly written maintenance procedures and manuals	Organizational factor
23.	Poor diagnosis and inspection tools	Organizational factor
24.	Part or system fault detection method	Vehicle factor

5. Conclusion and Recommendation

5.1. Conclusion

The paper reviewed published and unpublished literature addressing human error in maintenance of automotive systems. The paper has used literature review to identify causal factors influencing human errors in automotive maintenance. These factors were grouped into four groups according to their sources of origin which are: personal factors, organizational factors, environmental factors and vehicle system factor. The method used for analysis then grouping of these factors is the causal and effect diagram, the Ishikawa's fish bone diagram.

5.2. Recommendations

The study further observed that the causal factors influencing human errors in automotive maintenance discovered in literature review can be examined in local environment of automotive maintenance and come up with methods to minimize their occurrence.

The following are some future works that can be done in the regarding the study of human errors in automotive maintenance:

1) Development and implementation of training on human errors in automotive maintenance to improve awareness for individual and organizational levels.
2) Development and implementation of human errors reporting, controlling and analysis system to minimize the occurrence of accidents due to human errors in automotive maintenance.
3) Introduction, implementation and adaptation of human performance analysis tools in automotive maintenance garages.
4) The use of different system such as computerized systems in prediction and mitigation human errors in automotive maintenance.

Author Contributions

Edward Julius Mwambage: Conceptualization, Data curation, Investigation, Methodology, Resources, Software, Validation, Writing – original draft, Writing – review & editing

Mazuri Erasto Lutema: Methodology, Writing – review & editing

Christian S. Nabora: Data curation, Methodology, Validation, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Aju Kumar, V. N., Gandhi, M. S. and Gandhi, O. P. (2015) 'Identification and assessment of factors influencing human reliability in maintenance using fuzzy cognitive maps', Quality and Reliability Engineering International, 31(2), pp. 169–181.

[2] Alonso, I. J. and Broadribb, M. (2018) 'Human error: A myth eclipsing real causes', Process safety progress, 37(2), pp. 145–149.

[3] Arts, R., Knapp, G. M. and Mann Jr, L. (1998) 'Some aspects of measuring maintenance performance in the process industry', Journal of Quality in Maintenance Engineering, 4(1), pp. 6–11.

[4] Badenhorst, F. W. and Van Tonder, J. (2004) 'Determining the factors causing human error deficiencies at a public utility company', SA Journal of Human Resource Management, 2(3), pp. 62–69.

[5] Dhillon, B. and Liu, Y. (2006) 'Human error in maintenance: A review', Journal of Quality in Maintenance Engineering, 12. Available at: https://doi.org/10.1108/13552510610654510

[6] Dhillon, B. S. (1981) 'Engineering reliability: new techniques and applications'.

[7] Dhillon, B. S. (2002) Engineering maintenance: a modern approach. cRc press.

[8] Dhillon, B. S. (2014) 'Human error in maintenance: an investigative study for the factories of the future', in IOP Conference Series: Materials Science and Engineering. IOP Publishing, p. 012031.

[9] Dunn, S. (2004) 'Managing human error in maintenance', Maintenance Journal, pp. 13–18.

[10] Dupont, G. (1995) 'Maintenance Errors and Their Prevention', in Annual International Air Safety Seminar. Flight Safety Foundation, pp. 353–358.

[11] Di Fazio, A. R. et al. (2014) 'Voltage sags in the automotive industry: Analysis and solutions', Electric Power Systems Research, 110, pp. 25–30.

[12] Goh, M. and Tay, G. (1995) 'Implementing a quality maintenance system in a militaryorganization', International Journal of Quality & Reliability Management, 12(4), pp. 26–39.

[13] Gould, J. and Lovell, S. (2009) 'Human error analysis at a refinery', UK: IChemE [Preprint].

[14] Gupta, S. P. (2001) 'Statistical methods 13th edition Sultan Chand and Sons', New Delhi [Preprint].

[15] Hobbs, A. (2008) 'An overview of human factors in aviation maintenance', ATSB Safty Report, Aviation Research and Analysis Report AR, 55(2008), pp. 1–37.

[16] Hockley, C. and Phillips, P. (2012) 'The impact of no fault found on through-life engineering services', Journal of Quality in Maintenance Engineering, 18(2), pp. 141–153.

[17] Ishikawa, K. (1982) 'Guide to quality control'.

[18] Khan, S. et al. (2014) 'No Fault Found events in maintenance engineering Part 2: Root causes, technical developments and future research', Reliability Engineering & System Safety, 123, pp. 196–208.

[19] Kovacevic, S. et al. (2016) 'The analysis of human error as causes in the maintenance of machines: a case study in mining companies', South African Journal of Industrial Engineering, 27(4), pp. 193–202.

[20] Krulak, D. C. (2004) 'Human factors in maintenance: impact on aircraft mishap frequency and severity', Aviation, space, and environmental medicine, 75(5), pp. 429–432.

[21] Latorella, K. A. and Prabhu, P. V (2017) 'A review of human error in aviation maintenance and inspection', Human Error in Aviation, pp. 521–549.

[22] Mkilania, J. N. (2016) 'Factors related to human resources affecting the maintenance effectiveness in Tanzanian industries', Int. J. Mech. Eng. Technol, 7, pp. 150–160.

[23] Morag, I. et al. (2018) 'Identifying the causes of human error in maintenance work in developing countries', International Journal of Industrial Ergonomics, 68, pp. 222–230.

[24] Moreno, V. C. et al. (2016) 'Analysis of accidents in biogas production and upgrading', Renewable Energy, 96, pp. 1127–1134.

[25] Murugan, R. and Ramasamy, R. (2015) 'Failure analysis of power transformer for effective maintenance planning in electric utilities', Engineering Failure Analysis, 55, pp. 182–192.

[26] Myszewski, J. M. (2012) 'Management responsibility for human errors', The TQM Journal, 24(4), pp. 326–337.

[27] Pannell, D. J. (1997) 'Sensitivity analysis of normative economic models: theoretical framework and practical strategies', Agricultural economics, 16(2), pp. 139–152.

[28] Peach, R., Ellis, H. and Visser, J. K. (2016) 'A maintenance performance measurement framework that includes maintenance human factors: a case study from the electricity transmission industry', South African Journal of Industrial Engineering, 27(2), pp. 177–189.

[29] Rashid, H. (2010) Human factors effects in helicopter maintenance: proactive monitoring and controlling techniques, England: Cranfield University. Cranfield University. Available at: http://hdl.handle.net/1826/4497

[30] Reason, J. (2000) 'Cognitive engineering in aviation domain', Lawrence Erlbaum Associates, Mahwah, NJ, 72, pp. 102–107.

[31] Reason, J. and Hobbs, A. (2017) Managing maintenance error: a practical guide. CRC Press.

[32] Singh, S., Kumar, R. and Kumar, U. (2015) 'Modelling factors affecting human operator failure probability in railway maintenance tasks: an ISM-based analysis', International Journal of System Assurance Engineering and Management, 6, pp. 129–138.

[33] Thakur, R. and Panghal, D. (2021) 'Total productive maintenance', in Lean tools in apparel manufacturing. Elsevier, pp. 355–379.

[34] Timmons, S. et al. (2015) 'Implementing human factors in clinical practice', Emergency Medicine Journal, 32(5), pp. 368–372.

[35] Virovac, D., Domitrović, A. and Bazijanac, E. (2017) 'The influence of human factor in aircraft maintenance', Promet-Traffic&Transportation, 29(3), pp. 257–266.

[36] Wu, T.-M. and Hwang, S.-L. (1989) 'Maintenance error reduction strategies in nuclear power plants, using root cause analysis', Applied ergonomics, 20(2), pp. 115–121.