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Literature Review

A Systematic Literature Review of System Dynamics Application on Safety Culture

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A B S T R A C T

The increasing complexity of modern industrial systems has increased the need for effective approaches to understand and improve safety performance. Safety culture is widely recognized as an important factor influencing worker behavior, accident prevention, and organizational safety outcomes, while safety programs serve as structured interventions to improve safety performance. This study aims to systematically review the application of System Dynamics (SD) in safety culture and safety program studies. A systematic literature review was conducted using the PRISMA approach which led to 22 collected articles from ScienceDirect. The review focused on publication trends, countries, industrial sectors, research designs, SD techniques, safety related variables, safety culture aspects, and the intended outcomes of SD implementation. The findings show that SD has been widely used to represent complex interactions and feedback structures in safety-related systems. However, most previous studies remain focused on model development and relationship analysis, while only a limited number have evaluated safety programs as intervention mechanisms. These findings indicate that current SD applications are still largely oriented toward understanding system complexity rather than supporting practical decision-making and intervention evaluation. Therefore, future studies should further integrate safety programs into SD-based safety culture models to support proactive intervention factor and improved safety performance.

1. INTRODUCTION

The increasing complexity of modern industrial systems has heightened the importance of effective occupational safety management to achieve desired safety outcomes in various industrial sectors such as construction, aviation and chemical, where dynamic environments and multiple interacting factors contribute to elevated safety risks [1], [2], [3]. Where these sectors involve dynamic environments, human behavior, organizational factors, technical systems, and external conditions that interact with one another and contribute to safety risks. Within this context, Safety culture plays a fundamental role in achieving safety performance by shaping workers' perception, psychological conditions and attitudes that drive safe behavior and reduce accident risk while weak safety outcomes are often linked to system level issues such as poor safety culture and inadequate system arrangement [4], [5], [6]. Weak safety outcomes are often associated with system level problems, including poor safety culture, ineffective communication, inadequate organizational support, and insufficient safety management practices.

Safety programs are one of the important mechanisms used by organizations to improve safety culture and safety performance. Safety programs can be viewed as important leverage factors where previous studies have shown that such programs can strengthen safety culture and contribute to reduced accident rates as well as improved system stability, as they provide structured interventions aimed at influencing behavior and improving safety outcomes [2], [7]. However, the effectiveness of these

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interactions cannot be fully understood through linear cause and effect approaches, as their impact is shaped by complex and dynamic interactions [8], [9]. Therefore, a linear cause and effect approach is not sufficient to explain how safety interventions influence safety performance over time.

System Dynamic (SD) offers a useful perspective for modeling complex systems as it captures interactions across multiple factors and hierarchical levels and enables the analysis of feedback mechanisms and nonlinear dynamics conditions which improves understanding of how risks emerge and supports predictions of future system behavior was known to enable a more comprehensive analysis of how interventions influence overall safety performance [10], [11], [12], [13]. Previous review study has examined the usage of SD as potential tool in improving safety by capturing complex interaction within a safety system and identified key influencing factors such as external conditions, organizational influences, and unsafe supervision [14]. However, previous reviews have mainly focused on system representation, causal analysis, and general safety improvement, with limited attention to the role of safety programs as intervention mechanisms within safety culture systems.

Although previous studies have demonstrated the usefulness of SD in representing complex safety systems, most of them remain focused on identifying causal structures, explaining accident dynamics, and understanding system behavior. Limited attention has been given to how safety programs can be modeled and evaluated as intervention mechanisms within safety culture systems. This condition highlights an important research gap between understanding safety systems conceptually and applying SD models to support intervention-based safety management.

Therefore, this study aims to systematically review the application of System Dynamics in safety culture and safety program studies. Specifically, this review examines publication trends, geographical distribution, industrial sectors, research designs, SD techniques, safety-related variables, safety culture aspects, and intended outcomes of SD implementation in previous studies. The contribution of this study lies in providing a structured synthesis of existing SD applications in safety-related research and identifying future research directions for integrating safety programs as intervention mechanisms within safety culture models.

2. METHOD

This study employed a systematic literature review (SLR) approach to examine the application of System Dynamics (SD) in safety culture and safety program studies. The SLR method was selected because it enables a structured, transparent, and replicable process for identifying, selecting, and synthesizing previous studies relevant to the research objectives. The review process consisted of three main stages: planning the review, selecting relevant articles, and analyzing the selected studies.

Table 1.
Primary Question (PQ)

Code	Questions
PQ1	How varied were System Dynamics (SD) on Safety Culture used in the previous study?
PQ2	How did they conduct their studies?
PQ3	How were the results of the previous studies processed and analyzed?
PQ4	How were the result of System Dynamics (SD) usage on Safety Culture wanted to be achieved in previous studies?

2.1. *Review Questions*

The review questions were developed in two levels, namely Primary Questions (PQs) and Structured Research Questions (SRQs). The Primary Questions were formulated to provide a broad understanding of how System Dynamics has been applied in previous safety-related studies. Meanwhile, the Structured Research Questions were used to guide the detailed analysis of publication trends, countries, industrial sectors, study designs, SD techniques, safety-related variables, and safety culture aspects. The Primary Questions used in this study are presented in Table 1, while the Structured Research Questions are presented in Table 2.

Table 2.
Structured Research Questions (SRQ)

Code	Questions
SRQ1	How is the study trend which use System Dynamics to study safety culture and safety programs?
SRQ2	Which country mostly uses System Dynamics to study safety culture and safety programs?
SRQ3	In which industrial sectors have System Dynamics been used to study safety culture and safety programs?
SRQ4	What types of study designs have been employed in previous studies?

SRQ5	What system dynamics techniques have been used in previous studies?
SRQ6	What is the Safety related variable used in the study?
SRQ7	Which aspects of safety culture have been considered in previous studies?

2.2. Search Strategy

The literature search was conducted using the ScienceDirect database. The search was conducted using combinations of keywords related to safety culture, safety programs, safety performance, and System Dynamics. The initial search keywords were formulated as [("Safety Culture" OR "Safety Climate") AND ("Safety Program" OR "Program") AND ("Safety Performance" OR "Safety Outcome" OR "Accident" OR "Incident" OR "Injury")]. To ensure that the selected articles specifically applied System Dynamics as the related modeling approaches, an additional query of advanced keywords were formulated as [("system dynamic" OR "System Dynamics" OR "Stock Flow Diagrams" OR "Stock Flow Diagram" OR "Dynamic Modeling" OR "System Thinking")].

2.3. Inclusion and Exclusion Criteria

The inclusion and exclusion criteria were defined to ensure that the selected articles were relevant to the scope of this study. The criteria of this review are presented in Table 3.

Table 3.
Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Topic relevance	Studies related to safety culture, safety performance, safety programs, accidents, incidents, injuries, or safety outcomes	Studies unrelated to safety management or safety performance
Methodological approach	Studies applying System Dynamics, Causal Loop Diagram, Stock Flow Diagram, dynamic modeling, or system thinking approaches	Studies that do not apply SD-related methods
Accessibility	Full-text articles available	Articles with inaccessible full text
Document type	Research articles	Review papers, book chapters, editorials, conference abstracts, and non-research articles

2.4. Study Selection Process

The study selection process followed the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) approach. The first screening was conducted using the initial search query related to safety culture, safety programs, and safety performance, resulting in 4,904 articles. The second screening was conducted by applying additional System Dynamics related keywords, which excluded 4,817 articles that were not relevant to SD based analysis.

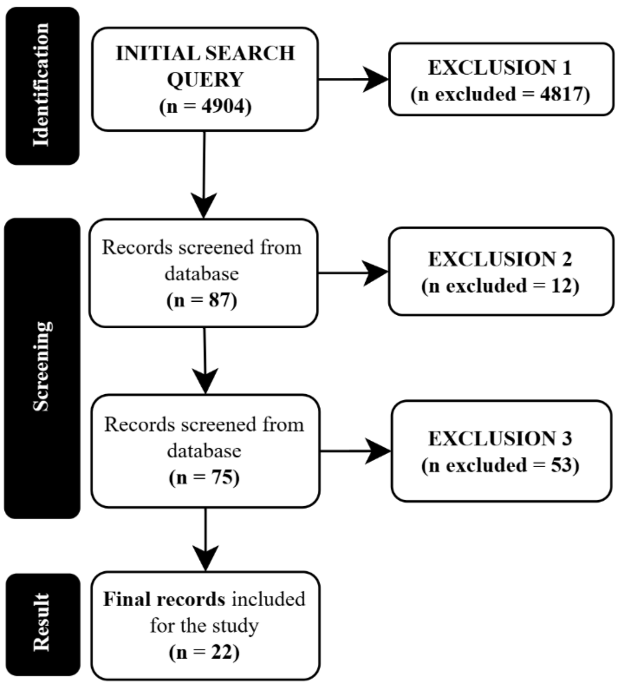

Figure 1.
Example of Caption Writing for Figures

The next screening process was conducted by limiting the publication type to research articles, resulting in the exclusion of 12 articles. After the final eligibility assessment, 22 articles were selected because they met the research objectives and provided sufficient information to answer the PQs and SRQs.

2.5. Data Extraction and Classification

The selected articles were analyzed using a structured data extraction process based on Structured Research Questions as presented on Table 1 and Table 2. Each article was classified based on the year of publication, country, industrial sector, study design, data collection method, SD technique, safety-related variables, safety culture aspects, and result type. The result type was categorized into three groups: model development, relationship analysis, and intervention evaluation. Model development refers to studies that developed SD-based models to represent safety systems. Relationship analysis refers to studies that used SD to explain causal relationships and feedback structures among safety-related variables. Intervention evaluation refers to studies that used SD to evaluate the effect of safety strategies, policies, or programs on safety outcomes.

2.6. Quality Assessment

A quality assessment was conducted to ensure that the selected articles provided sufficient methodological and analytical information. The assessment focused on five criteria: relevance to the research topic, clarity of research design, explicit use of SD techniques, relevance of safety-related variables, and clarity of findings. Articles that did not provide adequate information related to SD applications or safety-related analysis were excluded from the final synthesis. This process was conducted to improve the reliability and validity of the review findings.

3. RESULT AND DISCUSSION

3.1. PQ 1: How varied were System Dynamics (SD) on Safety Culture used in the previous study?

To answer "SRQ 1: How is the study trend which use System Dynamics (SD) to study safety culture and safety programs?", The publication trend Figure 2 shows that the number of relevant articles published annually from 2006 to 2026 remained relatively low, with only one to two articles per year. Although the sociotechnical domain remained largely underappreciated during the 1960s and 1970s reemerged in the 1980s with the introduction of important theoretical and practice oriented approaches, laying the foundation for system-based thinking in safety research [15]. Furthermore, it was emphasized that system dynamics has been recognized as an effective method for generating insights into dynamic complexity, reinforcing its relevance in analyzing complex safety systems [16].

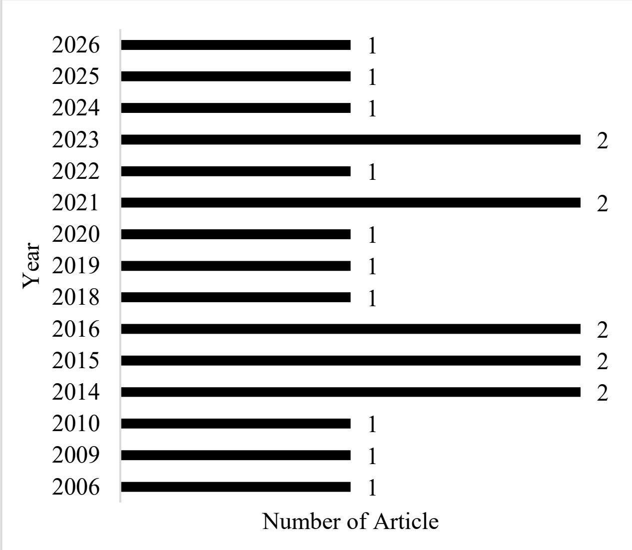

Figure 2.
Research by year published

This theoretical recognition is reflected in the empirical trend observed in previous review article when publication output is slightly increased particularly during 2015–2016 which reported a rise in safety applications using SD [14]. Despite this increase, the overall trend suggests that the application of system dynamics in examining safety culture specifically as a complex system remains underexplored as indicated by the lack of sustained growth in subsequent years (Figure 3).

For "SRQ 2: Which country mostly uses System Dynamics (SD) to study safety culture and safety programs?", From a geographical perspective China dominates the publication output at 35% followed by Australia and the USA at 15% each. Singapore contributes 10% while other countries each account for 5%. These findings shows that SD applications in safety related studies are more common in countries with strong industrial development and high concern for occupational safety. However, the uneven distribution of studies across countries also suggests that the application of SD in safety culture research is still context dependent. And "SRQ 3: In which industrial sectors have systems dynamics approaches been used to study safety culture and safety programs?", The distribution of studies across industrial fields shows that research on system dynamics in safety culture is mainly concentrated in high risk sectors (Figure 2).

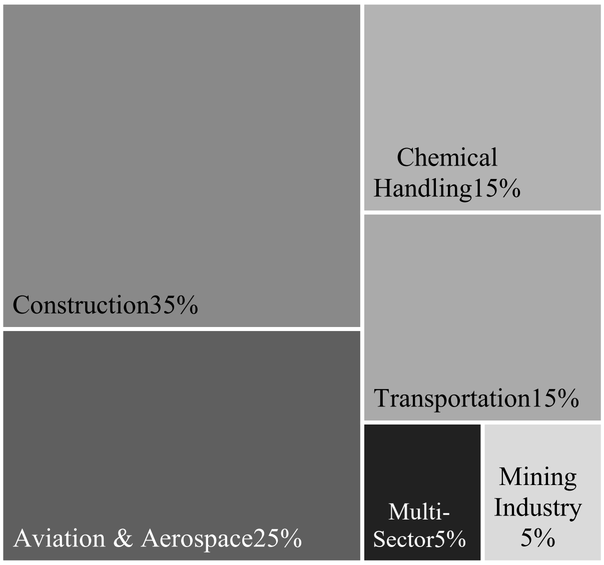

Figure 3.
Research by industrial type

The construction industry represents the largest share at 35% followed by aviation and aerospace at 25% then Chemical handling and transportation each account for 15%. Multi-sector and mining industry studies remain limited at 5% each which indicates lower research attention. As coal mining is a high-risk industry, the complexity and interrelationships of factors influencing unsafe behaviors make them difficult to analyze, highlighting the need for system dynamics to model and understand these interactions within complex systems [17]. SD is suitable for analyzing safety problems in these industries because it can represent feedback relationships and nonlinear system behavior. However, the limited number of studies in mining and multi-sector contexts indicates that SD has not been widely applied across different industrial settings.

3.2. PQ2: How did they conduct their studies?

As "SRQ 4: What types of study designs have been employed in previous studies?", The study classification reveals a clear dominance of empirical research, accounting for 75% of the total studies, while conceptual studies comprise only 25%. This indicates that the field is largely driven by data-oriented studies rather than theoretical development. In terms of data collection methods, historical data and case studies represent the largest proportion (42%), followed by literature-based approaches (25%) and expert involvement (21%), while participant-based methods account for only 13% (Figure 4).

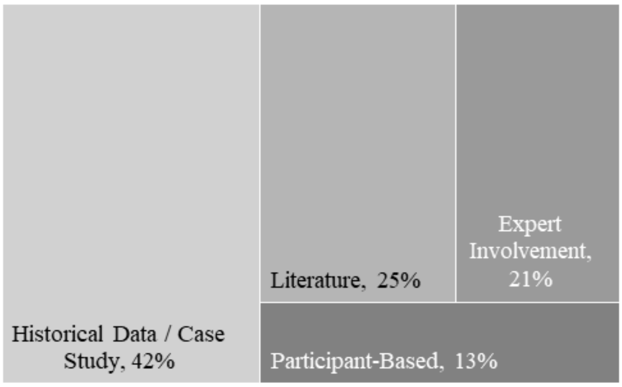

Figure 4.
Data Collecting Method

This distribution suggests that most studies rely on existing data and documented cases rather than primary data collection, reinforcing the empirical nature of the field and its focus on analyzing real world safety phenomena. Also the limited use of participant-based data indicates that worker perceptions, attitudes, and behavioral responses are still underrepresented in SD-based safety culture studies. Since safety culture is closely related to human and organizational behavior, future studies should consider incorporating more primary data from workers, managers, and safety practitioners to improve model validity.

"SRQ 5: What system dynamics techniques have been used in previous studies?", In terms of system dynamics modeling approaches, Causal Loop Diagrams (CLD) are slightly more prevalent (55%) than Stock Flow Diagrams (SFD) (45%), indicating a greater focus on identifying causal relationships and feedback structures. Studies employing CLD are predominantly based on historical data or case study evidence indicates that many previous studies remain focused on qualitative mapping of causal relationships and feedback structures. While CLD is useful for identifying system structure, SFD provides stronger support for quantitative simulation and policy testing. Therefore, the relatively lower use of SFD may explain why intervention evaluation remains limited in previous studies. Future studies should further develop quantitative SD models that can simulate the longterm effects of safety programs on safety culture and safety performance.

Notably, a significant proportion of studies utilizing SFD adopt hybrid approaches by integrating additional analytical methods such as Analytic Network Process (ANP) [17], Human Factors

Analysis and Classification System (HFACS) [3], Event Sequence Diagram, Fault Tree Analysis, Bayesian Belief Network [18], [19], Association Rule Mining [20], and Monte Carlo simulation [10]. This integration highlights efforts to enhance model robustness and capture both qualitative and quantitative dynamics within complex safety systems.

3.3. *PQ3: How were the results of the previous studies processed and analyzed?*

To answer the Primary Question 3 through "SRQ 6: What is the Safety related variable used in the study?", Safety culture is widely recognized as a key variable in safety related studies, appearing in 90% of the reviewed literature and commonly positioned as a primary factor influencing safety outcomes. However, incident number remains the most frequently used variable (100%), indicating a strong reliance on outcome-based indicators such as accident rates to assess safety performance. In contrast, safety programs are considered in only 15% of studies, suggesting their limited exploration as proactive intervention mechanisms. Existing literature highlights the importance of safety programs in improving safety outcomes. Safety Program such behavior-based safety programs aim to reduce unsafe behaviors, particularly in high-risk industries [2]. Other safety programs also contribute by improving communication and aligning organizational objectives, although their effectiveness depends on appropriate design, as poorly structured incentives may reduce compliance and remain reactive [12]. The limited inclusion of safety programs represents an important research gap. Safety programs can function as leverage points that influence worker behavior, safety compliance, risk perception, and accident reduction over time. However, previous SD studies tend to treat safety culture mainly as an explanatory construct rather than as a system that can be improved through structured interventions. Therefore, future research should move beyond descriptive modeling and relationship analysis toward intervention evaluation and decision support applications.

Table 4.
Situational Variable

Situational variable	(%)	Situational variable	(%)
Government Influence	30%	Reward & Punishment	30%
Social Influence	10%	Feedback & Communication	25%
External Influence	5%	Equipment	35%
Internal Organization	75%	Environment	35%
Training	35%	Technology	20%

"SRQ 7: Which aspects of safety culture have been considered in previous studies?", The findings indicate that safety culture has been examined as a multidimensional construct encompassing situational, individual, and behavioral aspects. From a Situational perspective, internal organizational factors (75%) are the most dominant, followed by training (35%), government influence (30%), and reward and punishment systems (30%), highlighting the importance of organizational structures and management practices. Environmental and technical factors such as equipment (35%), environment (35%), and technology (20%) further demonstrate that safety culture is influenced by both organizational and physical conditions (Table 4).

Table 5.
Situational Variable

Person variable	(%)	Person variable	(%)
Cognitive	5%	Competency	10%
Motivation	30%	Perception	35%
Personality	5%	Satisfaction	15%
Knowledge	15%	Effort	10%
Experience	35%	Attitude	20%

On the Personal Aspect level, key variables include experience (35%), perception (35%), and motivation (30%), followed by attitude (20%) and knowledge (15%), emphasizing the role of psychological and experiential factors (Table 5). Behavioral aspects are mainly represented by accident/incident (75%), risk (45%), and compliance (10%), indicating a stronger focus on reactive outcomes. Overall, safety culture is largely shaped by organizational and individual dimensions, with limited emphasis on proactive behavioral elements. Yu (2019) proposed the combination intervention strategies mainly from the aspects of safety management, individual factors, group factors, safety leadership and physical environment, which can provide theoretical support and guidance methods for improving the safety production level of coal miners [17].

"PQ 4: How were the result of System Dynamics (SD) usage on Safety Culture wanted to be achieved

Table 6.
Result type of study

Author	Industrial Type	Result Type	Result Description
[1]	Chemical Handling	Model Development	The study model quantifies explosion risk and identifies leverage points for improving safety strategies in hydrogen methane industrial systems
[7]	Aviation & Aerospace	Model Development	The CLD simulates development risks in eVTOL systems to optimize safety performance and balance risk management with schedule advancement
[8]	Transportation	Relationship Analysis	The CLD analyzes systemic structures and feedback relationships to explain underlying causes of railway accidents in complex systems
[9]	Chemical Handling	Relationship Analysis	CLD analyzes interactions among organizational actors to explain systemic structures sustaining poor safety culture in major incident cases
[10]	Transportation	Intervention Evaluation	Hybrid SD-Monte Carlo model evaluates strategies to reduce vulnerability in urban metro systems under long term dynamic uncertainty
[11]	Construction	Relationship Analysis	Identify interactions among organizational factors to understand dynamic complexity in construction safety systems
[18]	Aviation & Aerospace	Model Development	Hybrid SD model represents organizational risk dynamics in aviation maintenance systems for complex socio technical risk analysis
[20]	Aviation & Aerospace	Model Development	Hybrid ARM and SD model predicts and monitors pilots' unsafe behavior risks to support early warning and aviation safety decision making
[2]	Construction	Relationship Analysis	CLD analyzes dynamic relationships among behavioral and contextual factors influencing BBS program effectiveness
[3]	Aviation & Aerospace	Model Development	Hybrid HFACS-SD model simulates aviation risk evolution to identify critical factors and reduce accident rates through system level insights
[12]	Aviation & Aerospace	Relationship Analysis	The study analyzes organizational interactions and feedback structures to explain how systemic factors contribute to accidents in complex systems
[17]	Mining	Intervention Evaluation	SD model evaluates intervention strategies to reduce unsafe behaviors of coal miners by analyzing influencing factors and system interactions
[19]	Construction	Model Development	Integration of SD and BBN model analyzes risk migration and safety performance in tunnel construction systems
[6]	Construction	Model Development	Hybrid simulation model integrates DES ABS and SD to represent complex construction safety behavior dynamics
[13]	Construction	Intervention Evaluation	SD model evaluates effectiveness of safety interventions influencing workers attitudes and unsafe behavior dynamics
[21]	Construction	Relationship Analysis	SD analyze relationships between production pressure safety programs and accident occurrence dynamics
[22]	General / multi-sector	Intervention Evaluation	SD model evaluates management policies influencing near miss reporting behavior and fatigue related tradeoffs in complex systems
[23]	Construction	Relationship Analysis	Identify recurring behavioral patterns to understand systemic relationships driving construction accident dynamics
[24]	Transportation	Relationship Analysis	CLD identifies interactions among occupational factors influencing work-related musculoskeletal disorders (WRMSD) risk dynamics in tram driving systems
[25]	Chemical Handling	Model Development	The proposed dynamic model helps organizations identify the underlying causes of errors, allowing them to improve their maintenance strategies

in the previous studies?", The findings show that the use of System Dynamics (SD) in safety culture studies is mainly focused on model development (40%) and relationship analysis (40%), while intervention evaluation represents only 20%. Compared with previous review studies that mainly emphasized the general potential of SD for system safety improvement, this study specifically highlights the limited use of SD for evaluating safety programs within safety culture studies (Table 5). This distinction is important because understanding system complexity alone is not sufficient to improve safety performance. Practical intervention mechanisms are needed to translate system understanding into safety management actions. Therefore, integrating safety programs into SD-based safety culture models can provide stronger practical contributions for proactive safety management.

4. CONCLUSIONS

This study systematically reviewed the application of System Dynamics in safety culture and safety program studies. The review analysed publication trends, countries, industrial sectors, research designs, SD techniques, safety related variables, safety culture aspects, and intended outcomes of SD implementation in previous studies. The findings show that SD has been widely used to understand complex interactions and feedback structures in safety-related systems.

However, most previous studies remain focused on model development and relationship analysis, while intervention evaluation is still limited. The review also found that safety culture and incident-related variables dominate previous studies, indicating a strong emphasis on understanding safety outcomes and accident dynamics. In contrast, safety programs are rarely examined as proactive intervention mechanisms. This indicates an important research gap, as safety programs can serve as leverage points for improving worker behaviour, safety compliance, and safety performance over time.

This study contributes to the literature by highlighting the need to move from descriptive and analytical SD models toward intervention oriented and decision-support models. Future studies should further integrate safety programs into SD based safety culture models, apply quantitative simulation through Stock Flow Diagrams, and use broader empirical data to improve model validity. In practical terms, SD can support safety managers in evaluating intervention strategies and strengthening proactive safety management. Future reviews should include multiple databases and broader study types to provide a more comprehensive understanding of SD applications in safety related research.

5. STUDY LIMITATION

This review has several limitations that should be acknowledged. The literature search was conducted only through the ScienceDirect database. Therefore, relevant studies indexed in other databases, such as Scopus, Web of Science, or Google Scholar, may not have been captured. The scope of analysis was also limited to studies that explicitly applied System Dynamics or closely related techniques, such as Causal Loop Diagrams and Stock Flow Diagrams. As a result, safety studies using other systems-based approaches were not included in the synthesis. Future reviews may address these limitations by incorporating multiple databases, broader publication types, and more diverse systems-based methodologies to provide a more comprehensive understanding of System Dynamics applications in safety culture and safety program to enhance safety performance research.

REFERENCES

[1] J. A. Dueñas Santana, E. Salzano, and A. Di Benedetto, "Systems Thinking for explosion safety management," *J. Loss Prev. Process Ind.*, vol. 96, Aug. 2025, doi: 10.1016/j.jlp.2025.105621.

[2] B. H. W. Guo, Y. M. Goh, and K. Le Xin Wong, "A system dynamics view of a behavior-based safety program in the construction industry," *Saf. Sci.*, vol. 104, pp. 202–215, Apr. 2018, doi: 10.1016/j.ssci.2018.01.014.

[3] Y. Wu, S. Zhang, X. Zhang, Y. Lu, and Z. Xiong, "Analysis on coupling dynamic effect of human errors in aviation safety," *Accid. Anal. Prev.*, vol. 192, Nov. 2023, doi: 10.1016/j.aap.2023.107277.

[4] G. M. A. Naji *et al.*, "Impact of safety culture on safety performance; mediating role of psychosocial hazard: An integrated modelling approach," *Int. J. Environ. Res. Public Health*,

vol. 18, no. 16, Aug. 2021, doi: 10.3390/ijerph18168568.

[5] A. Sudiarno and A. A. C. Sudarni, "Assessment of Safety Culture Maturity Level in Production Area of a Steel Manufacturer," in *IOP Conference Series: Materials Science and Engineering*, Institute of Physics Publishing, May 2020. doi: 10.1088/1757-899X/847/1/012076.

[6] Y. M. Goh and M. J. Askar Ali, "A hybrid simulation approach for integrating safety behavior into construction planning: An earthmoving case study," *Accid. Anal. Prev.*, vol. 93, pp. 310–318, Aug. 2016, doi: 10.1016/j.aap.2015.09.015.

[7] Y. Wu, S. Zhang, X. Ni, and X. Li, "System dynamics analysis of development risks in emerging eVTOL aircraft," *Expert Syst. Appl.*, vol. 300, Mar. 2026, doi: 10.1016/j.eswa.2025.130363.

[8] Y. Fan, Z. Li, J. Pei, H. Li, and J. Sun, "Applying systems thinking approach to accident analysis in China: Case study of '7.23' Yong-Tai-Wen High-Speed train accident," *Saf. Sci.*, vol. 76, pp. 190–201, Jul. 2015, doi: 10.1016/j.ssci.2015.02.017.

[9] Y. M. Goh, H. Brown, and J. Spickett, "Applying systems thinking concepts in the analysis of major incidents and safety culture," *Saf. Sci.*, vol. 48, no. 3, pp. 302–309, Mar. 2010, doi: 10.1016/j.ssci.2009.11.006.

[10] H. Chen, B. Chen, L. Zhang, and H. X. Li, "Vulnerability modeling, assessment, and improvement in urban metro systems: A probabilistic system dynamics approach," *Sustain. Cities Soc.*, vol. 75, Dec. 2021, doi: 10.1016/j.scs.2021.103329.

[11] B. H. W. Guo, T. W. Yiu, and V. A. González, "Identifying behaviour patterns of construction safety using system archetypes," *Accid. Anal. Prev.*, vol. 80, pp. 125–141, Jul. 2015, doi: 10.1016/j.aap.2015.04.008.

[12] K. Marais, J. H. Saleh, and N. G. Leveson, "Archetypes for organizational safety," *Saf. Sci.*, vol. 44, no. 7, pp. 565–582, Aug. 2006, doi: 10.1016/j.ssci.2005.12.004.

[13] M. Shin, H. S. Lee, M. Park, M. Moon, and S. Han, "A system dynamics approach for modeling construction workers' safety attitudes and behaviors," *Accid. Anal. Prev.*, vol. 68, pp. 95–105, 2014, doi: 10.1016/j.aap.2013.09.019.

[14] M. Ibrahim Shire, G. T. Jun, and S. Robinson, "The application of system dynamics modelling to system safety improvement: Present use and future potential," Jul. 01, 2018, *Elsevier B.V.* doi: 10.1016/j.ssci.2018.03.010.

[15] L. J. Hettinger, A. Kirlik, Y. M. Goh, and P. Buckle, "Modelling and simulation of complex sociotechnical systems: envisioning and analysing work environments," *Ergonomics*, vol. 58, no. 4, pp. 600–614, Apr. 2015, doi: 10.1080/00140139.2015.1008586.

[16] John. Sterman, *Business dynamics : systems thinking and modeling for a complex world*. Irwin/McGraw-Hill, 2000.

[17] K. Yu, Q. Cao, C. Xie, N. Qu, and L. Zhou, "Analysis of intervention strategies for coal miners' unsafe behaviors based on analytic network process and system dynamics," *Saf. Sci.*, vol. 118, pp. 145–157, Oct. 2019, doi: 10.1016/j.ssci.2019.05.002.

[18] Z. Mohaghegh, R. Kazemi, and A. Mosleh, "Incorporating organizational factors into Probabilistic Risk Assessment (PRA) of complex socio-technical systems: A hybrid technique formalization," *Reliab. Eng. Syst. Saf.*, vol. 94, no. 5, pp. 1000–1018, May 2009, doi: 10.1016/j.ress.2008.11.006.

[19] F. Wang, L. Ding, P. E. D. Love, and D. J. Edwards, "Modeling tunnel construction risk dynamics: Addressing the production versus protection problem," *Saf. Sci.*, vol. 87, pp. 101–115, Aug. 2016, doi: 10.1016/j.ssci.2016.01.014.

[20] Q. Xiao, F. Luo, Y. Li, and D. Pan, "Risk prediction and early warning of pilots' unsafe behaviors using association rule mining and system dynamics," *J. Air Transp. Manag.*, vol. 110, Jul. 2023, doi: 10.1016/j.jairtraman.2023.102422.

[21] S. Han, F. Saba, S. Lee, Y. Mohamed, and F. Peña-Mora, "Toward an understanding of the impact of production pressure on safety performance in construction operations," *Accid. Anal. Prev.*, vol. 68, pp. 106–116, 2014, doi: 10.1016/j.aap.2013.10.007.

[22] N. Bugalia, Y. Maemura, and K. Ozawa, "A system dynamics model for near-miss reporting

in complex systems," *Saf. Sci.*, vol. 142, Oct. 2021, doi: 10.1016/j.ssci.2021.105368.

[23] A. Mohammadi and M. Tavakolan, "Identifying safety archetypes of construction workers using system dynamics and content analysis," *Saf. Sci.*, vol. 129, Sep. 2020, doi: 10.1016/j.ssci.2020.104831.

[24] A. Naweed, L. Bowditch, J. Trigg, and C. Unsworth, "Injury by design: A thematic networks and system dynamics analysis of work-related musculoskeletal disorders in tram drivers," *Appl. Ergon.*, vol. 100, Apr. 2022, doi: 10.1016/j.apergo.2021.103644.

[25] N. Golestani, E. Arzaghi, R. Abbassi, and V. Garaniya, "Modelling error chains in offshore wind energy systems: Examining the interplay of human performance and machine state," *Ocean Engineering*, vol. 308, Sep. 2024, doi: 10.1016/j.oceaneng.2024.118157.