Systems Human Factors and Ergonomics methods: applicaons, outcomes, and future direcons

Samantha L. Jackson[1], Gemma J. M. Read[12], Adam Hulme[3], & Paul M. Salmon[1]

[1]Centre for Human Factors and Sociotechnical Systems, University of the Sunshine Coast, Australia
[2]School of Health, University of the Sunshine Coast, Australia
[3]Southern Queensland Rural Health, University of Queensland, Australia

SUMMARY

This systematic literature review identified peer-reviewed applications of systems HFE methods to determine the range of problems examined and how the methods have been applied. The review revealed a growth in applications of systems HFE methods over time. The review suggests that as problem and system complexity continue to intensify, continual evaluation and potential adaption of methods may be required, including using more than one method.

KEYWORDS

Systems HFE methods; systems thinking; sociotechnical systems; systems analysis; systems design.

Introducon

Systems Human Factors and Ergonomics (HFE) continues to grow in popularity, especially given the increasing complexity of contemporary systems and problems to which HFE is now applied. There are a plethora of methods available, often with distinct theoretical underpinnings, generating similarities and differences in approach and outputs (Salmon, et al., 2022). However, the suitability of systems HFE methods in providing solutions to certain problems across domains is largely unknown (Holman et al., 2020; Stanton & Young, 1998). Additionally, it is unclear whether methods are best used in isolation or combination, such as a many models approach (Salmon & Read, 2019). Understanding how the methods are being used and for what problems is critical to determine if they are fit for purpose as sociotechnical system complexity proliferates in a new age, potentially outpacing the value and quality conferred by such approaches.

Method

This systematic literature review identified peer-reviewed applications of systems HFE methods to determine the range of problems examined and how the methods have been applied. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Moher et al., 2009; Page et al., 2021), four databases (Web of Science, Scopus, Science Direct and Sage) were searched for articles that applied systems HFE methods. After applying a set of inclusion criteria, 367 peer-reviewed articles were included in the review.

Results and Discussion

The review revealed a growth in applications of systems HFE methods over time. Overall, Cognitive Work Analysis (CWA), a framework developed to aid the design of complex sociotechnical systems, was the most frequently applied. This was closely followed by the Functional Resonance Analysis Method (FRAM), an accident analysis technique developed from resilience engineering principles, and the Systems Theoretic Accident Model and Process – SystemTheoretic Process Analysis (STAMP-STPA), a risk assessment technique based on systems theory and control theory. Most applications of systems HFE methods to date have occurred in the Healthcare domain, and approximately a third of the articles involved the application of multiple HFE methods (see Figure 1), with more of these including mathematical modelling in recent times.

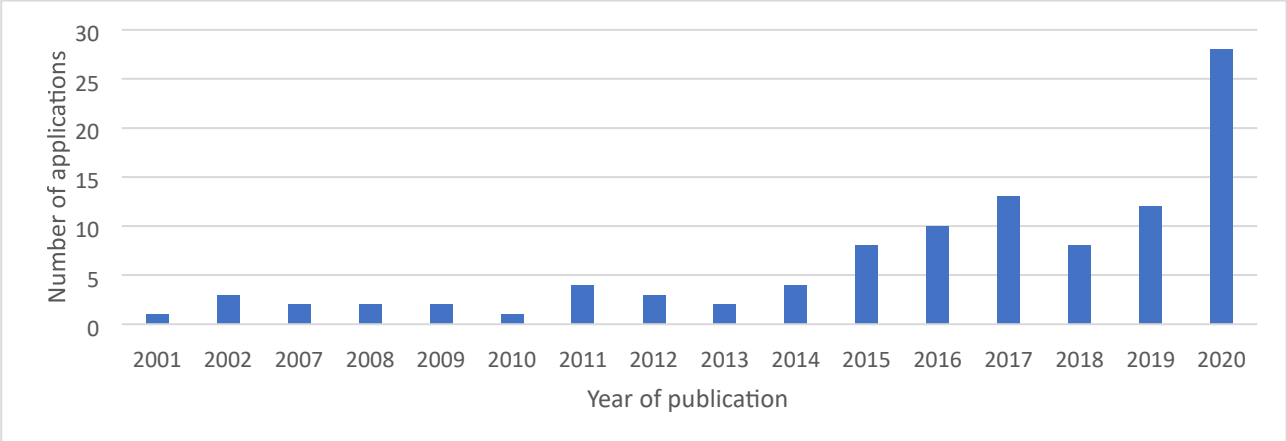

Figure 1: Frequency of application of more than one method over the years

Systems HFE Methods have been broadly applied across different domains to tackle various problems. This may indicate that analysts are selecting methods based on their capacity to address particular problems rather than simply applying the method most familiar. However, a limitation of this review is that the reasons why specific methods or combinations of methods were selected by authors cannot be determined. To better understand method(s) selection, further research could use interviews with analysts to explore this in detail.

Overall, the findings suggest three key implications. First, increased application of system HFE methods is likely to continue. This continued growth might be further facilitated through enhanced support systems, such as software to support analysis and model development (e.g., model conceptualisation). Second, using more than one method to address complex problems is increasing. A systematic multi-layered framework such as the many models systems thinking approach posited by Salmon and colleagues (2022; 2019) is likely to provide a comprehensive approach to modelling complex problems and systems (Read et al., 2020; Salmon, et al., 2022; Salmon & Read, 2019). Third, there is increasing use of computational and mathematical modelling in combination with systems HFE methods, which likely reflects the dynamic nature of the complex real-world problems and systems being analysed. These types of simulation methodologies are not a standard component of current HFE training. Addressing this shortfall is crucial for HFE professionals to continue to contribute meaningfully to complex systems. Given the increasing complexity of problems across various domains and the need for HFE applications to tackle larger-scale, global-level challenges, it is suggested that further applications for multiple methods, including many models approaches, will be critical for understanding and optimising complex systems.

References

Holman, M., Walker, G., Lansdown, T., & Hulme, A. (2020). Radical systems thinking and the future role of computational modelling in ergonomics: An exploration of agent-based modelling. *Ergonomics*, *63*(8), 1057–1074. https://doi.org/10.1080/00140139.2019.1694173 Holman, M., Walker, G., Lansdown, T., Salmon, P., Read, G., & Stanton, N. (2021). The BinaryBased Model (BBM) for Improved Human Factors Method Selection. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *63*(8), 1408–1436. https://doi.org/10.1177/0018720820926875

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & The PRISMA Group. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Medicine*, *6*(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, n71. https://doi.org/10.1136/bmj.n71

Read, G. J. M., Salmon, P. M., Thompson, J., & McClure, R. J. (2020). Simulating the behaviour of complex systems: Computational modelling in ergonomics. *Ergonomics*, *63*(8), 931–937. https://doi.org/10.1080/00140139.2020.1786263

Salmon, P. M., & Read, G. J. M. (2019). Many model thinking in systems ergonomics: A case study in road safety. *Ergonomics*, *62*(5), 612–628. https://doi.org/10.1080/00140139.2018.1550214

Salmon, P. M., Stanton, N. A., Walker, G. H., Hulme, A., Goode, N., Thompson, J., & Read, G. J. M. (2022). *Handbook of Systems Thinking Methods*. CRC PRESS. https://doi.org/10.1201/9780429281624

Stanton, N. A., & Young, M. S. (1998). Is utility in the mind of the beholder? A study of ergonomics methods. *Applied Ergonomics*, *29*(1), 41–54. https://doi.org/10.1016/S0003-6870(97)000240