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Compliance Paradox in Complex Organizations: Evidence from Medication Errors Healthcare Management in Healthcare Systems

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ABSTRACT: Medication errors remain a persistent challenge in healthcare systems despite various efforts to improve procedural compliance. This study aims to analyze the relationship between compliance behavior and medication errors by integrating socio-technical perspectives and the moderating role of system of complexity. Data were collected from 260 healthcare professionals in Manado, North Sulawesi, Indonesia and analyzed using the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach to test direct, mediation, and moderation relationships among variables. The results show that socio-technical factors have a positive and significant effect on compliance behavior and a negative effect on medication errors. Furthermore, compliance behavior was found to have a negative effect on medication errors and acted as partial mediator in this relationship. However, system complexity significantly weakened the negative effect of compliance behavior on medication errors, indicating that increased compliance does not always lead to decrease in errors under complex system conditions. These findings reveal a phenomenon of compliance paradox, where procedural compliance become less effective in environments with high complexity. This study contributes to the development of socio-technical perspective and provides practical implications regarding the importance of system simplification and cognitive load reduction to enhance patient safety.

KEYWORDS: Medication error, compliance behavior, system complexity, compliance paradox, PLS-SEM

INTRODUCTION

Medication errors remain one of the critical issues in global healthcare systems due to their direct impact on patient safety and service quality. Several systematic reviews have shown that medication errors are consistently identified as a major contributor to adverse drug events in the hospital setting, which are associated with increased morbidity, mortality, and healthcare costs (Durand et al. 2024; Hodkinson et al. 2020; Isfahani et al. 2024; Tobaiqy and MacLure 2024). These errors can occur at various stages of the process, from prescription, transcription, to medication administration (Brennan-Bourdon et al. 2020; Pastó-Cardona et al. 2009), reflecting the complexity of modern healthcare systems involving numerous actors and processes. This indicates that medication errors are not merely isolated clinical mistakes, but also reflect broader weaknesses in organizational systems, coordination mechanisms, and process governance.

Despite continuous investments in healthcare technologies and procedural controls, medication errors continue to persist. Many healthcare institutions have implemented electronic medical records, computerized provider order entry systems, incident reporting systems, and standardized operating procedures to improve accountability and reduce risk exposure. Various interventions have been developed to reduce medication errors, including the implementation of digital technologies such as *electronic medical records* (EMR), incident reporting systems, and the strengthening of standard operating procedures. Nevertheless, empirical findings show that errors persist, even in environments that have adopted advanced technological systems (Alex et al. 2016; FitzHenry et al. 2007). In some cases, technology adoption may even increase workflow complexity, administrative burden, and new forms of human-system interaction risks(Ash et al. 2009; Koppel 2005). These findings suggest that procedural control alone is often insufficient to solve systemic organizational problems.

From a management perspective, the socio-technical systems approach provides an important framework for understanding this phenomenon. Socio-technical theory emphasizes that organizational outcomes are shaped by the interaction among human resources, technology, and structural

arrangements rather than by any single component alone. In healthcare settings, system usability, workload pressure, communication quality, managerial support, and workflow integration jointly influence service reliability and safety performance (Carayon et al. 2014; Stevens et al. 2023). Furthermore, fragmented information systems, poor coordination, and misalignment between technology design and actual work practices may increase the likelihood of medication errors (Greenhalgh et al. 2017; Yusuff, Mustafa, and Al-Qahtani 2021). Therefore, medication errors should be examined not only as clinical failures, but also as consequences of ineffective organizational design.

One common managerial strategy for reducing operational risk is strengthening compliance behavior. Compliance behavior refers to the extent to which employees adhere to established procedures, safety standards, and formal operational rules. Conceptually, higher compliance should reduce process variation, improve consistency, and lower the probability of error occurrence. Previous studies have shown that adherence to standard procedures can contribute to reducing medical and medication-related errors (Bates DW et al. 1995; Shojania and Thomas 2013). Consequently, many organizations rely on compliance systems as a core mechanism of governance and quality assurance.

However, the relationship between compliance and safety outcomes is not always linear. In highly complex systems, employees often face multiple rules, heavy workloads, time pressure, and cross-functional coordination demands simultaneously. Under such conditions, procedural compliance may become symbolic rather than substantive. Employees may formally comply with rules without fully achieving the intended safety outcomes. This condition may create a compliance paradox, in which increased adherence does not necessarily result in lower medication error rates. Prior studies have also highlighted that system complexity can weaken the effectiveness of standardized controls because excessive complexity increases cognitive load and implementation difficulty (Braithwaite et al. 2018; Hollnagel 2018; Sittig and Singh 2010).

Although previous studies have examined medication errors, healthcare technology, and compliance separately, empirical research integrating these variables within a single organizational framework remains limited. In particular, the mediating role of compliance behavior and the moderating role of system complexity in explaining how socio-technical factors influence medication errors have not been sufficiently explored, especially in developing-country healthcare contexts where resource constraints and system pressures are often more pronounced.

Based on this research gap, the present study develops and tests an integrative model examining the influence of socio-technical factors on medication errors through the mediating role of compliance behavior and the moderating role of system complexity. Theoretically, this study contributes to the advancement of socio-technical systems theory and contingency perspectives in organizational risk management. Practically, the findings are expected to provide managerial implications for designing healthcare systems that are simpler, more adaptive, and more supportive of employee performance in order to enhance patient safety and service reliability.

LITERATURE REVIEW

Socio-Technical Factors

Socio-technical factors refer to interactions between humans, technology and organizations in a work system that jointly influence performance and safety. In the context of healthcare, this approach is used to understand that errors are not only caused by individuals, but also by the design of suboptimal systems. (Carayon et al. 2014) shows that work system design has an important role in determining patient safety outcomes through the interaction of various system elements.

Other studies have shown that human factors such as workload and fatigue, as well as technological factors such as usability and system integration, contribute to the emergence of errors in clinical practice (Holden et al., 2013). Organizational factors such as safety culture and management support also play a role in shaping the behavior of health workers (Ismail and Khalid 2022).

Furthermore, recent studies have shown that poorly integrated systems can increase the risk of errors due to information fragmentation and workflow disruption (Cresswell, Bates, and Sheikh 2013). Therefore, socio-technical factors are important determinants in influencing patient compliance and safety behavior.

Compliance Behavior

Compliance behavior refers to the degree to which healthcare workers' actions align with established standard operating procedures. Compliance is seen as a crucial mechanism for reducing practice variation and improving service consistency.

Research shows that adherence to clinical procedures contributes to a reduction in medical errors, particularly in medication administration (Elliott et al. 2021). In addition, compliance is also influenced by implementation factors, such as clarity of guidelines and organizational support (Wensing and Grol 2019).

However, in practice, compliance often faces challenges. High workloads and time pressures can reduce the ability of healthcare workers to consistently follow procedures (Westbrook et al. 2011). In addition, the complexity of the system and the multitude of rules can cause compliance to become an administrative formality with no real impact on patient safety.

Medication Errors

Medication errors are mistakes that occur during the medication use process that can cause or potentially cause harm to patients. These errors can occur at various stages, from prescribing to administering the medication.

Studies show that medication errors are a leading cause of adverse events in healthcare (Elliott et al. 2021). Furthermore, these errors are multifactorial and influenced by a combination of human, technological, and organizational factors (Keers et al. 2013).

Other research indicates that factors such as ineffective communication, healthcare worker fatigue, and poor system design can increase the risk of errors (Assiri et al., 2018). The digitalization of healthcare systems also brings new risks related to errors due to system failures or lack of technology integration (Black et al. 2011; Ratwani, Reider, and Singh 2019).

System Complexity

System complexity refers to the level of complexity of a system, characterized by the number of interacting components and the interdependencies between elements. In healthcare systems, complexity arises from the multitude of procedures, rules, and the need for cross-unit coordination.

Research shows that system complexity can increase the cognitive load of healthcare workers, thus impacting their decision-making abilities. (Dixon-Woods 2019). In addition, complexity is also associated with an increased risk of error because individuals have to process large amounts of information simultaneously (Carayon et al. 2014).

Other studies have shown that overly complex systems can reduce the effectiveness of adherence-based interventions, as complex procedures are difficult to implement consistently (Schmutz and Manser 2013). Therefore, system complexity acts as a contingency factor influencing the relationship between patient compliance and safety.

Hypothesis Development

Based on the literature review, socio-technical factors are hypothesized to have a positive influence on compliance behavior, because a well-integrated system will encourage individuals to adhere to established procedures. Additionally, socio-technical factors are also hypothesized to have a negative influence on medication errors through improvements in the work system.

Subsequently, compliance behavior is expected to play a role in reducing error rates through consistent procedure application. In this relationship, compliance behavior is also hypothesized to function as a mediator, bridging the influence of socio-technical factors on medication errors.

However, the relationship between compliance and error reduction is not always linear. System complexity is hypothesized to moderate this relationship, where a high level of complexity will weaken the negative influence of compliance on errors.

H1: Socio-technical factors have a positive effect on compliance behavior.

H2: Socio-technical factors have a negative effect on medication errors.

H3: Compliance behavior has a negative effect on medication errors.

H4: Compliance behavior mediates the relationship between socio-technical factors and medication errors.

H5: System complexity moderates the relationship between compliance behavior and medication errors, where high complexity weakens the negative influence of compliance behavior on medication errors.

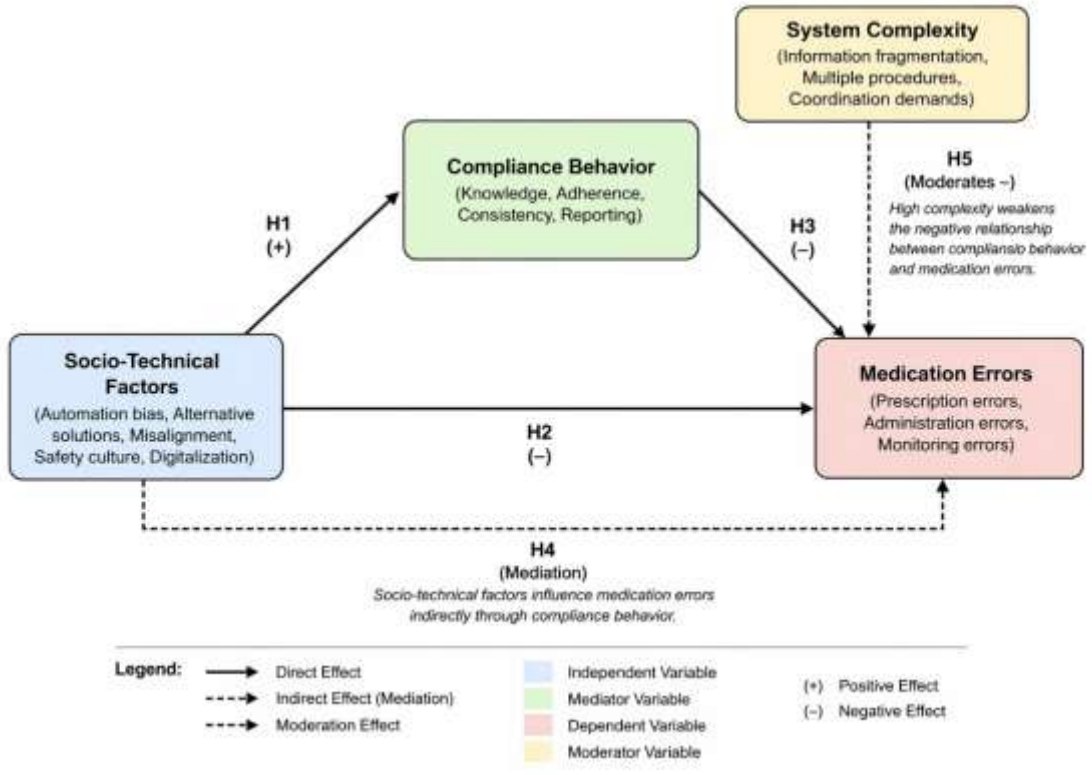

Figure 1. Conceptual Framework

METHODOLOGY

Research Design

This study employs a quantitative approach with an explanatory design to test the causal relationships among variables in the research model. This approach is used to analyze the influence of socio-technical factors on medication errors, taking into account the mediating role of compliance behavior and the moderating role of system complexity.

Samples and Data Collection

The study population consists of healthcare workers employed at hospitals, clinics, and other healthcare facilities in Indonesia who are involved in the medication administration process. Respondents include nurses, doctors, pharmacists, pharmacy technicians, and other related healthcare professionals in Manado, North Sulawesi, Indonesia.

The sampling technique used purposive sampling, specifically selecting respondents who met the criteria of being active healthcare workers, involved in the process of administering or supervising medication, and having at least one year of work experience. The number of respondents used in this study was 260, and this number was deemed sufficient for PLS-SEM analysis. Primary data was collected through an online

questionnaire distributed via a digital survey platform. The questionnaire was distributed through professional healthcare networks, hospital communities, and relevant social media platforms. Before analysis, responses that were incomplete or inconsistent were filtered out. All respondents' identities were kept confidential, and participation was voluntary.

Variable Measurement

The research instruments were adapted from relevant previous studies and tailored to the healthcare context. All variables were measured using a five-point Likert scale, ranging from strongly disagree to strongly agree. The socio-technical factors variable reflects the human, technological, and organizational aspects of the work system. Compliance behavior describes the level of healthcare workers' adherence to operational procedures. System complexity indicates the level of complexity in the system, procedures, and work coordination. Medication errors measure the rate of errors in the medication administration process.

Data Analysis Techniques

Data analysis was conducted using Structural Equation Modeling (SEM) with the Partial Least Squares (PLS) approach via the SmartPLS software. The analysis included an evaluation of the measurement model through construct validity and reliability tests, as well as an evaluation of the structural model to test the relationships among variables. Hypothesis testing was conducted based on path coefficients, t-statistics, p-values, and the coefficient of determination (R^2). Significance testing was performed using a bootstrapping procedure with 5,000 subsamples. Additionally, this study also examined the mediating effect of compliance behavior and the moderating effect of system complexity within the research model.

RESULTS AND DISCUSSION

Measurement Model Evaluation (Outer Model)

Measurement model evaluation was conducted to ensure the validity and reliability of constructs through testing *outer loading*, *Average Variance Extracted (AVE)*, *Composite Reliability (CR)*, and *discriminant validity* using HTMT.

Table 1. Measurement Model Evaluation

Construct	Item	Loading	AVE	CR
Human Factors (HF)	HF1	0.812	0.650	0.881
	HF2	0.845		
	HF3	0.781		
	HF4	0.794		
Technological Factors (TF)	TF1	0.768	0.621	0.867
	TF2	0.802		
	TF3	0.785		
	TF4	0.799		
Organizational Factors (OF)	OF1	0.801	0.633	0.873
	OF2	0.822		
	OF3	0.776		
	OF4	0.790		
Compliance Behavior (CB)	CB1	0.865	0.702	0.904
	CB2	0.842		
	CB3	0.821		
	CB4	0.839		
System Complexity (SC)	SC1	0.798	0.648	0.880
	SC2	0.812		
	SC3	0.776		
	SC4	0.809		
Medication Errors (ME)	ME1	0.834	0.671	0.890
	ME2	0.812		
	ME3	0.798		
	ME4	0.820		

The results in Table 1 show that all indicators have *outer loading* above 0, 70. Additionally, the AVE values for all constructs are above 0, 50, and the CR values exceed 0.70. Thus, the model has met the criteria for *convergent validity* and construct reliability.

Discriminant Validity

Table 2. Discriminant Validity (HTMT)

Construct	HF	TF	OF	CB	SC	ME
HF	—					
TF	0.71	—				
OF	0.68	0.73	—			
CB	0.74	0.69	0.72	—		
SC	0.65	0.67	0.70	0.75	—	
ME	0.72	0.70	0.71	0.78	0.76	—

Based on Table 2, all HTMT values are below the threshold of 0, 85, thus it can be concluded that each construct possesses good discriminant validity.

Structural Model Evaluation (Inner Model)

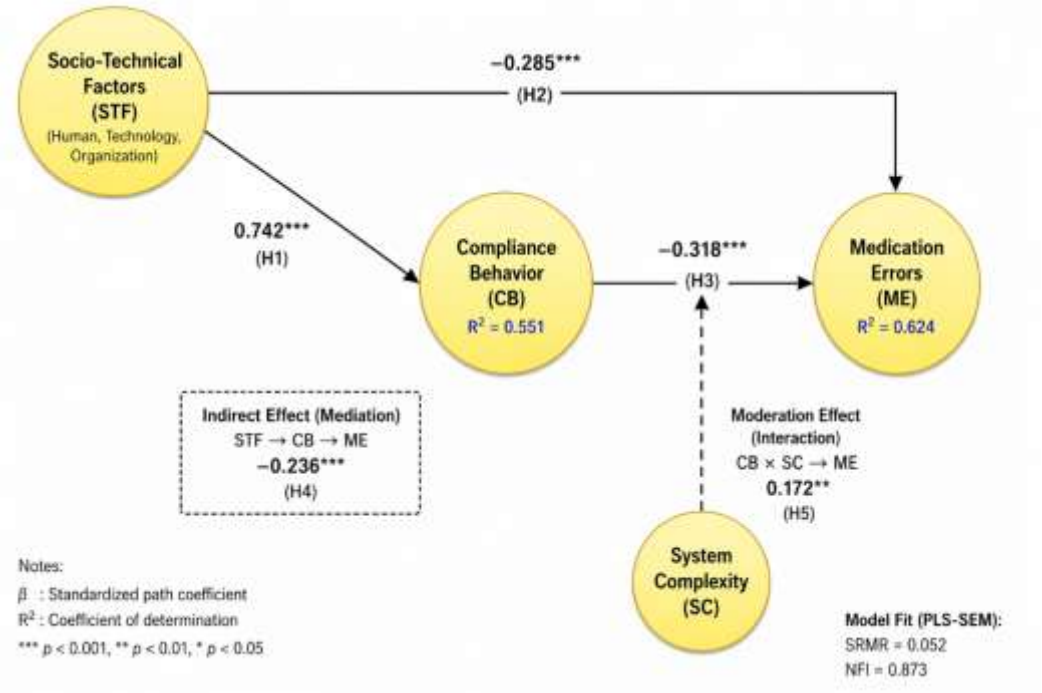

Figure 1. Structural Model Results (PLS-SEM)

Coefficient of Determination (R^2)

Table 3. Coefficient of Determination (R^2)

Endogenous Variable	R^2	Interpretation
Compliance Behavior	0.551	Moderate
Medication Errors	0.624	Substantial

The R^2 values indicate that socio-technical factors explain 55,1% of the variation in *compliance behavior*, which falls into the moderate category. Meanwhile, the *medication errors* variable has an R^2 value of 0.624, demonstrating strong explanatory power of the model.

Hypothesis Test

Table 4. Path Coefficients and Hypothesis Testing

Hypothesis	Relationship	β	t-stat	p-value	Result
H1	STF → CB	0.742	18.215	0.000	Supported
H2	STF → ME	-0.285	3.912	0.000	Supported
H3	CB → ME	-0.318	4.276	0.000	Supported

The test results show that socio-technical factors have a positive and significant influence on *compliance behavior*. Furthermore, socio-technical factors and *compliance behavior* were found to have a negative influence on *medication errors*. This indicates that improving system quality and adherence to procedures can reduce the incidence of medication errors.

Mediation dan Moderation Test

Table 5. Mediation and Moderation Effects

Hypothesis	Relationship	β	t-stat	p-value	Result
H4	STF → CB → ME	-0.236	3.845	0.000	Supported
H5	CB × SC → ME	0.172	2.654	0.008	Supported

Mediation test results indicate that *compliance behavior* plays a significant mediating role in the relationship between socio-technical factors and *medication errors*.

Meanwhile, moderation test results show that *system complexity* weakens the negative influence of *compliance behavior* on *medication errors*. In other words, under more complex system conditions, the effectiveness of compliance in reducing errors is diminished.

These findings suggest that although compliance plays an important role in reducing *medication errors*, its effectiveness is highly dependent on system conditions. High system complexity can create cognitive and administrative burdens, ultimately reducing the positive impact of compliance. This phenomenon indicates the existence of a compliance paradox, where an increase in compliance is not always followed by a decrease in errors in complex systems.

DISCUSSION

The results of this study indicate that socio-technical factors have a strong influence in shaping healthcare professionals' *compliance behavior*, which in turn contributes to the reduction of *medication errors*. This finding confirms that the interaction between human, technological, and organizational aspects is the primary foundation for creating work behaviors that align with safety standards. In this context, factors such as workload, competence, system usability, and organizational support play a crucial role in promoting adherence to procedures. This aligns with the perspective of *socio-technical systems theory*, which emphasizes that system performance is determined not only by individuals but also by the alignment between human and technical system components.

Furthermore, the research results show that *compliance behavior* has a negative effect on *medication errors*, meaning that the higher the level of adherence to procedures, the lower the likelihood of errors occurring. This finding is consistent with traditional approaches to patient safety that consider adherence to operational standards as the primary mechanism for error prevention. Additionally, the analysis results also indicate that *compliance behavior* acts as a mediator in the relationship between socio-technical factors and *medication errors*, suggesting that the system's influence on safety is not only direct but also operates through individual behavior as a connecting mechanism.

However, the most significant finding in this study is the role of *system complexity*, which significantly moderates the relationship between compliance and errors. The results indicate that system complexity weakens the negative influence of *compliance behavior* on *medication errors*. In situations where healthcare professionals are faced with numerous procedures, rules, and high administrative burdens, individual cognitive capacity becomes limited. Consequently, even with high compliance, its effectiveness in preventing errors is reduced. This phenomenon can be explained by the concept of *cognitive overload*, where individuals experience difficulty processing excessive information simultaneously.

Overall, these findings point to a phenomenon that can be termed the *compliance paradox*, which is a condition where increased compliance is not always followed by a decrease in errors. In complex systems, compliance can potentially become a mere formality of administrative activity, thus losing its primary function as a mechanism for error protection. Therefore, this study not only confirms the important role of compliance in patient safety but also highlights its limitations in the context of complex systems. These findings expand the understanding of the relationship between systems, behavior, and safety outcomes, and emphasize the importance of a more holistic approach in designing work systems in the health sector.

CONCLUSION AND IMPLICATIONS

This study concludes that socio-technical factors play a significant role in enhancing *compliance behavior* and reducing *medication errors*, both directly and through mediation mechanisms. However, the effectiveness of compliance in reducing errors is not absolute but depends on the level of system complexity encountered. In complex system conditions, the influence of compliance on error reduction weakens, indicating that compliance alone is insufficient to guarantee patient safety. This study contributes theoretically by integrating socio-technical perspectives and compliance behavior, and introduces the concept of *compliance paradox* as a new framework for understanding the limitations of compliance-based approaches.

From a practical standpoint, this study emphasizes the importance of simplifying work systems and reducing procedural complexity in healthcare organizations. Efforts to improve patient safety should not only focus on enhancing compliance but also on designing systems that are simpler, more intuitive, and supportive of healthcare professionals' cognitive capacities. Nevertheless, this study has limitations, including the use of perception-based data and a cross-sectional design that limits causal inference. Therefore, future research is recommended to use longitudinal approaches and integrate additional variables such as cognitive load or work fatigue to enrich the understanding of error dynamics in health system.

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