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Research Paper

Association Between Sterilization Governance and Perceived Productivity Among Healthcare Facilities in Tuguegarao City, Philippines

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Abstract

Sterilization of reusable medical devices (RMDs) is central to infection prevention and healthcare quality, yet limited empirical evidence links sterilization governance to perceived productivity outcomes in provincial health systems. This quantitative investigation examined the association between sterilization practices and perceived healthcare provider productivity in Tuguegarao City, Philippines, and explored implications for outsourcing readiness and centralized planning. A cross-sectional survey was conducted among 189 healthcare professionals across hospitals, dental clinics, and ambulatory facilities. The adapted instrument underwent formal Content Validity Index (CVI) evaluation by a seven-member multidisciplinary expert panel (S-CVI/Ave = 0.91), demonstrating excellent content validity. Perceptions across eight sterilization domains were measured using structured four-point Likert-scale items. Descriptive statistics, Mann–Whitney U tests, and Spearman's rank-order correlation were applied. Technical compliance domains demonstrated uniformly high agreement with no significant group differences ($p = 1.000$). Significant differences emerged in coordination-related domains—process standardization, customer service, sterile storage and distribution, and education and training ($p < 0.001$; $r = 0.86$). A perfect positive monotonic association was identified between perceived sterilization practices and perceived productivity ($\rho = 1.000$). Given the bounded ordinal scale and ceiling effects, this likely reflects perceptual alignment rather than independent construct variability. Findings suggest governance refinement should prioritize coordination mechanisms and service-level clarity rather than core technical compliance. The study introduces the Gacias Sterilization Systems Intelligence Framework (G-SSIF) to guide outsourcing readiness in resource-variable healthcare systems.

Keywords: *Centralized Sterilization, Healthcare Governance, Infection Prevention And Control, Outsourcing Readiness, Perceived Productivity, Reusable Medical Devices, Sterile Processing*

INTRODUCTION

Reprocessing reusable medical devices (RMDs) is a foundational element of infection prevention and control (IPC) and patient safety. Healthcare-associated infections (HAIs) remain a major global safety concern, affecting an estimated 7–10% of hospitalized patients worldwide and contributing to prolonged hospital stays, increased antimicrobial resistance, and avoidable mortality, with disproportionate impact in resource-variable health systems (World Health Organization [WHO], 2016). Effective sterilization of RMDs therefore, serves as a critical safeguard in reducing preventable infection risk and sustaining safe clinical operations.

In resource-variable provincial health systems such as those in the Philippines, variability in infrastructure capacity, workforce competency monitoring, and instrument tracking mechanisms may further amplify operational risk. In the absence of integrated surveillance and standardized governance oversight across facilities, sterilization system maturity may differ substantially between institutions. Quantitative assessment of sterilization governance and its operational implications is therefore essential for informing context-specific health systems strengthening and outsourcing readiness decisions.

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Despite national IPC guidelines, implementation variability persists across provincial healthcare facilities, particularly in infrastructure capacity, instrument tracking systems, competency monitoring, and workflow standardization. These operational inconsistencies may influence provider productivity and service turnaround reliability. However, limited local evidence exists to guide outsourcing or centralization decisions within regional Philippine healthcare systems. Administrators lack context-specific data linking sterilization compliance perceptions to perceived productivity outcomes that can inform governance and outsourcing readiness decisions (Lastrucci et al., 2023).

Sterilization governance functions as a core quality assurance infrastructure within modern health systems. International infection prevention frameworks, including the World Health Organization's (2016) core components for IPC, ANSI/AAMI ST79 standards for steam sterilization and sterility assurance (Association for the Advancement of Medical Instrumentation [AAMI], 2017), and updated disinfection and sterilization technology guidance (Rutala et al., 2023), emphasize validated processes, traceability systems, environmental control, and competency monitoring as foundational safeguards. Within Donabedian's (1988) structure–process–outcome framework, sterilization represents both a structural and procedural determinant directly influencing clinical risk mitigation and care quality. As such, sterile processing systems extend beyond technical back-end operations and serve as governance mechanisms that sustain safe surgical and clinical practice.

Outsourcing and centralization models have been explored internationally as mechanisms to enhance compliance consistency, cost control, and operational coordination. Make-or-buy decision theory suggests that organizations externalize services when specialized capabilities, economies of scale, or monitoring efficiencies outweigh internal coordination costs (McIvor et al., 1997). Empirical health sector studies further demonstrate that structured outsourcing arrangements, when supported by robust governance oversight and service-level agreements, may improve compliance standardization and process reliability in sterile processing systems (Khosravizadeh et al., 2022; Merola et al., 2016; Mittenzwei et al., 2017). However, the effectiveness of outsourcing depends on capability maturity, contractual clarity, and oversight mechanisms, underscoring the importance of governance alignment rather than cost considerations alone.

Productivity within healthcare operations extends beyond output volume and incorporates workflow coordination, service responsiveness, and value creation across interdependent units (Porter, 1985). In sterile processing contexts, productivity is closely associated with instrument turnaround reliability, reduction of procedural delays, and stabilization of clinical workload (Farrokhi et al., 2015; Swenson & Conklin, 2016). Because sterile processing functions as a service interface between reprocessing units and clinical end users, perception-based productivity measures provide meaningful insight into operational effectiveness. Frontline healthcare providers experience performance not only through compliance metrics but through timeliness, communication transparency, and process consistency.

Despite expanding international literature on sterilization outsourcing and productivity optimization, data-driven integration of sterilization governance and perceived healthcare productivity remains limited in provincial Philippine settings. In particular, insufficient province-level data examine whether perceived sterilization practice maturity is associated with perceived operational productivity and whether stakeholder groups interpret governance performance differently. Addressing this gap is essential for informing governance refinement and evidence-based outsourcing readiness decisions within resource-variable healthcare systems.

Tuguegarao City represents a mixed healthcare landscape consisting of hospitals, dental clinics, ambulatory centers, and other clinical facilities operating with varying sterilization infrastructures. The diversity of facility types makes it an appropriate setting to examine

sterilization governance readiness and productivity implications within a provincial health system.

The present analysis provides provincial quantitative evidence to inform sterilization outsourcing and centralization decisions, strengthen infection prevention monitoring structures, and improve workflow productivity alignment between sterile processing units and clinical service departments.

Conceptual Integration: The Gacias Sterilization Systems Intelligence Framework (G-SSIF)

The investigation is conceptually grounded within a governance lens that integrates capability maturity, operational intelligence, transaction considerations, and partnership mechanisms into strategic sterilization decision pathways. Building on make-or-buy and core competency approaches in the outsourcing literature (McIvor et al., 1997; Prahalad & Hamel, 1990), the Gacias Sterilization Systems Intelligence Framework (G-SSIF) is proposed as a structured health-systems–specific decision architecture for sterile processing services.

Beyond outsourcing decisions, G-SSIF provides a foundation for future integration of artificial intelligence (AI) into sterilization governance. As healthcare systems adopt digital traceability platforms and predictive analytics, sterilization services may transition from reactive operational models to intelligence-enabled systems. G-SSIF anticipates this evolution by embedding digital readiness and systems intelligence within its architecture, supporting AI-enabled demand forecasting, capacity optimization, compliance monitoring, and centralized hub coordination.

Figure 1. The Gacias Sterilization Systems Intelligence Framework (G-SSIF): a multi-domain governance architecture with an AI-enabled systems intelligence overlay

Research Questions

The investigation was guided by the following research questions:

- Is there a significant association between sterilization practice domains and perceived healthcare provider productivity in provincial healthcare facilities?

- Do perceptions of sterilization practices and productivity differ significantly between sterile processing personnel and clinical end users?
- What governance implications do observed perception patterns have for outsourcing readiness and centralized sterilization planning?

Research Objectives

This study aims to examine the association between sterilization practices and perceived healthcare provider productivity in Tuguegarao City, Philippines. Specifically, it seeks to:

1. Assess sterilization practice compliance across key operational domains.
2. Measure perceived healthcare provider productivity related to IPC standards.
3. Examine the association between sterilization practices and perceived productivity.
4. Compare perceptions between sterile processing personnel and clinical end users.
5. Evaluate implications for outsourcing readiness and governance alignment.

RESEARCH METHOD

Research Design

A cross-sectional descriptive-correlational quantitative design was employed to examine perceived sterilization practices and productivity across healthcare facilities. Data were collected at a single point in time to assess stakeholder perceptions without intervention or longitudinal follow-up. The descriptive component summarized domain-level perceptions, while the correlational component examined group differences between clinical end users and sterile processing personnel.

Study Setting and Sampling Strategy

The study was conducted across 54 healthcare facilities, including hospitals, dental clinics, and ambulatory settings. A purposive nonprobability sampling strategy was employed. All healthcare personnel involved in the handling, processing, or utilization of reusable medical devices within participating institutions were eligible for inclusion.

Due to the absence of a centralized workforce registry across the participating facilities, the total eligible population could not be precisely determined. Consequently, a formal a priori sample size calculation was not conducted. Participation was voluntary, and data collection remained open during the approved study period. A total of 189 completed responses were obtained. This sample size is considered adequate for descriptive analysis and nonparametric group comparison procedures.

For this study, “clinical end users” refers to healthcare personnel who directly use reusable instruments in patient care rather than the total institutional workforce. Based on facility-level approximations provided during institutional coordination, the number of personnel involved in the handling, processing, or use of reusable medical devices across the 54 participating facilities was estimated at approximately 650 individuals. Using this estimate, the achieved sample (n = 189) corresponds to an approximate response rate of 29%. This figure should be interpreted cautiously, as the denominator reflects a facility-level workforce estimate and the sampling strategy was purposive and nonprobability-based. The achieved sample size exceeded common rules of thumb for nonparametric group comparisons and correlation analyses in applied health surveys, supporting adequate statistical power for the analyses conducted.

Data Collection Procedure

The study followed a structured process: (1) institutional coordination and written authorization; (2) instrument contextual review and finalization; (3) participant recruitment and

informed consent; (4) survey distribution in printed and digital formats; and (5) data encoding and statistical analysis.

Formal written authorization was secured from participating healthcare institutions prior to data collection. Institutional endorsement facilitated survey dissemination while ensuring voluntary participation and confidentiality safeguards. Participation was anonymous, and no identifying information was collected.

Research Instrument

Data were collected using a structured questionnaire adapted from established infection prevention and healthcare governance instruments, including the Outsourcing Practices Quantitative Data Collection Tool (Mujasi et al., 2016), the Infection Prevention and Control Program Tool (Health Facility Development Bureau, 2021), the Infection Control Assessment Tool (Centers for Disease Control and Prevention [CDC], 2023), and the APSIC Guidelines for Disinfection and Sterilization of Instruments in Healthcare Facilities (Asia Pacific Society of Infection Control, 2017).

The instrument was adapted to align with the study's objective of examining sterilization governance and perceived productivity within healthcare facilities. Items were retained when directly relevant to sterilization workflow, infection prevention compliance, and service interface constructs. Contextual wording adjustments were made to ensure clarity across clinical end users and sterile processing personnel. Redundant or non-applicable items were excluded to reduce respondent burden. All retained items were harmonized into a unified four-point Likert response format to ensure consistency in scoring across domains.

The final instrument consisted of three sections: (1) demographic profile of respondents; (2) factors influencing sterilization practices and governance effectiveness; and (3) indicators of perceived productivity among healthcare providers. Productivity was assessed using self-reported (perceived) indicators reflecting workflow efficiency, interdepartmental coordination, and IPC-related practices rather than objective productivity metrics (e.g., instrument turnaround time) (Huynh et al., 2019; Nichol et al., 2024).

The instrument comprised eight domains: core functions, patient safety, process standardization, customer service, infection control standards, sterilization of reusable medical devices, sterile storage and distribution, and education and training. Responses were rated on a four-point Likert scale ranging from 1 (Strongly Disagree) to 4 (Strongly Agree). Instrument adaptation followed standard methodological guidance for scale modification in applied health research (Beaton et al., 2000; Boateng et al., 2018).

The instrument underwent pilot testing among 10 healthcare professionals in an international clinical setting to assess clarity, readability, and structural alignment. Minor wording revisions were incorporated before full-scale administration. The pilot was conducted solely for refinement purposes and did not involve formal data analysis.

Content Validity

Content validity of the adapted instrument was formally evaluated using the Content Validity Index (CVI) methodology. A seven-member multidisciplinary expert panel was purposively selected to ensure domain breadth and institutional diversity. Panel composition included professionals from infection prevention and control, sterile processing services, nursing leadership, biomedical engineering, quality management, supply chain oversight, and healthcare administration. Experts represented different healthcare facilities to enhance contextual neutrality and reduce single-institution bias.

Each expert independently rated item-level relevance using a four-point ordinal scale (1 = Not Relevant, 2 = Somewhat Relevant, 3 = Quite Relevant, 4 = Highly Relevant). Consistent with established CVI procedures, ratings of 3 or 4 were considered content-valid endorsements. The Item-Level Content Validity Index (I-CVI) was calculated as the proportion of experts assigning ratings of 3 or 4 for each item. For a seven-member panel, an I-CVI threshold of ≥ 0.78 was applied to indicate acceptable content validity.

The initial instrument contained 20 evaluative items across eight sterilization governance domains. One item demonstrating insufficient expert agreement (I-CVI < 0.78) was removed following panel review due to limited construct alignment, resulting in a final instrument comprising 19 retained items. The remaining items demonstrated acceptable to universal agreement. Twelve items achieved universal agreement (I-CVI = 1.00), while the remaining retained items met or exceeded the established acceptability threshold.

The Scale-Level Content Validity Index using the averaging method (S-CVI/Ave) was 0.91, indicating excellent overall content validity. These results support strong expert consensus regarding the instrument's relevance to sterilization governance and perceived productivity constructs within provincial healthcare settings.

Internal Consistency Reliability

Following content validation, internal consistency reliability was assessed using Cronbach's alpha (Cronbach, 1951). Domains demonstrating adequate variance showed acceptable to excellent reliability coefficients. Domains exhibiting ceiling effects produced undefined alpha values due to restricted variance, reflecting perception convergence rather than instrument instability.

Data Analysis

Data were encoded and analyzed using statistical software. Descriptive statistics (means and standard deviations) were computed for each domain. Although Likert-scale responses are ordinal, composite domain scores were treated as approximately continuous for descriptive purposes, consistent with common practice in applied health research when items are aggregated across multiple indicators.

Distributional assumptions were assessed using the Shapiro–Wilk test (Shapiro & Wilk, 1965). Domains exhibiting uniform response patterns showed zero variance, while the remaining domains showed significant deviation from normality ($W = 0.634$, $p < 0.001$). Due to the ordinal nature of Likert-scale composite scores and violation of parametric assumptions, Mann–Whitney U tests were conducted using two-tailed significance criteria for group comparisons (Mann & Whitney, 1947).

Because responses were measured on a bounded four-point scale and demonstrated clustered distribution patterns, substantial tied ranks and near-complete rank separation occurred in certain domains, which can yield extreme U statistics (e.g., $U = 0$) and very small p-values. Exact p-values were reported for all inferential tests. Effect sizes (r) were calculated to estimate practical significance in accordance with established recommendations for nonparametric analyses (Fritz et al., 2012).

Ethical Considerations

Written authorization to conduct the study was obtained from participating healthcare institutions before data collection. Participation was voluntary, and informed consent was secured before survey completion. All responses were anonymous and used solely for research purposes.

RESULTS AND DISCUSSION

Respondent Characteristics

A total of 189 healthcare professionals participated in the study. The majority were aged between 20 and 40 years (73.5%), indicating a predominantly early- to mid-career workforce. Female respondents comprised 61.4% of the sample. Most participants were college graduates (65.6%) and were primarily employed in hospital settings (55.0%), followed by dental clinics (36.5%). Clinical end users accounted for 54.5% of respondents, while sterile processing personnel represented 45.5%, providing balanced stakeholder representation. More than 81% of participants had ten years or less of service, and annual training exposure varied, with most reporting one to five sterilization-related trainings per year.

Table 1. Demographic Characteristics of Respondents (N = 189)

Variable	Category	n	%
Age Group	20–30 years	63	33.3%
	31-40 years	76	40.2%
	41-50 years	37	19.6%
	Above 51 years	13	6.9%
Gender	Female	116	61.4%
	Male	73	38.6%
Professional Role	Clinical End Users	103	54.5%
	Sterile Processing Personnel	86	45.5%

Source: Survey data (2024).

Descriptive Statistics of Sterilization Practices and Perceived Productivity

Table 2 presents the normality assessment results using the Shapiro–Wilk test. Four domains exhibited zero variance (ceiling effects), while the remaining domains deviated significantly from normality ($W = 0.634$, $p < 0.001$), supporting the use of nonparametric testing procedures.

Technical sterilization domains demonstrated uniformly high levels of agreement, particularly in infection control standards, sterilization of reusable medical devices (RMDs), patient safety, and core functions. Greater dispersion was observed in coordination-related domains, including sterile storage and distribution, education and training, process standardization, and customer service, suggesting variability in workflow alignment and service interface perceptions.

Table 2. Statistics for Sterilization Practices and Perceived Productivity Domains (N = 189)

Domain	Mean	SD
Infection Control Standards	4.0	0.00
Sterilization of RMDs	4.0	0.00
Sterile Storage and Distribution	3.73	0.30
Education and Training	3.36	0.40
Core Functions	3.90	0.00
Patient Safety	4.00	0.00
Process Standardization	3.89	0.10
Customer Service	3.61	0.10

Source: Survey data (2024).

The uniformly high agreement observed in technical sterilization domains aligns with international infection prevention frameworks emphasizing standardized reprocessing protocols as foundational safeguards for patient safety (WHO, 2016). However, the comparatively lower scores in coordination-related domains suggest that workflow alignment and service interface factors may influence productivity perceptions beyond technical compliance. This pattern reinforces the importance of governance mechanisms that extend beyond procedural validation toward interdepartmental coordination efficiency.

Group Differences Between Clinical End Users and Sterile Processing Personnel

Mann–Whitney U analyses (Table 3) showed no statistically significant differences between groups in core functions, patient safety, infection control standards, and sterilization of RMDs ($p = 1.000$). This pattern reflects identical response distributions and tied ranks under a bounded ordinal scale rather than the absence of underlying variability. However, statistically significant differences were observed in process standardization, customer service, sterile storage and distribution, and education and training ($p = 8.87 \times 10^{-43}$). Large effect sizes ($r = 0.86$) indicate substantial divergence in coordination-related domains.

Table 3. Mann–Whitney U Test Results (N = 189)

Domain	U	Exact p-value	Effect Size (r)
Core Functions	4429	1.000	0.00
Patient Safety	4429	1.000	0.00
Infection Control Standards	4429	1.000	0.00
Sterilization of RMDs	4429	1.000	0.00
Process Standardization	8858	8.87×10^{-43}	0.86
Customer Service	0	8.87×10^{-43}	0.86
Sterile Storage & Distribution	0	8.87×10^{-43}	0.86
Education & Training	8858	8.87×10^{-43}	0.86

Source: Survey data (2024). Mann–Whitney U test; two-tailed analysis.

The divergence observed in coordination-related domains is consistent with organizational theory, suggesting that stakeholder perceptions vary according to functional role exposure and interaction frequency (Barney, 1991; Williamson, 1985). Clinical end users evaluate sterilization performance through responsiveness and availability, whereas sterile processing personnel assess adherence through protocol execution. Such role-based perception asymmetry is common in interdependent service systems and does not necessarily indicate structural failure but may signal coordination inefficiencies.

Internal Consistency Reliability

Internal consistency reliability results are presented in Table 4. Process standardization and customer service demonstrated good to excellent reliability. Sterile storage and distribution, education, and training exhibited moderate reliability. Domains showing ceiling effects produced undefined alpha coefficients due to restricted variance, reflecting perception convergence rather than measurement instability.

Table 4. Internal Consistency Reliability (Cronbach's Alpha)

Domain	Cronbach's Alpha	Interpretation
Process Standardization	0.802	Good
Customer Service	0.972	Excellent
Sterile Storage & Distribution	0.556	Moderate
Education & Training	0.556	Moderate
Infection Control Standards	—	Not computed due to the ceiling effect
Sterilization of RMDs	—	Not computed due to the ceiling effect
Core Functions	—	Not computed due to the ceiling effect
Patient Safety	—	Not computed due to the ceiling effect

Source: Survey data (2024). Cronbach's alpha reliability analysis.

Reliability findings are consistent with measurement theory, indicating that restricted variance may produce undefined internal consistency coefficients in uniformly endorsed constructs (Tavakol & Dennick, 2011). The ceiling effects observed in several domains, therefore, reflect perception convergence rather than instrument weakness.

Association Between Sterilization Practices and Perceived Productivity

A Spearman rank-order correlation analysis examined the association between the composite sterilization practices index and the composite perceived productivity index. A perfect positive monotonic relationship was observed ($\rho = 1.000$, $p < 0.001$), indicating that higher perceived sterilization practice scores corresponded directly with higher perceived productivity scores. Table 5 presents the correlation result.

Table 5. Spearman Correlation Between Sterilization Practices and Perceived Productivity (N = 189)

Variables	Spearman's ρ	Exact p-value
Sterilization Composite – Productivity Composite	1.000	< 0.0001

Source: Survey data (2024). Spearman's rank-order correlation.

The strong monotonic association observed between perceived sterilization practices and perceived productivity aligns with systems-based perspectives in healthcare operations, which conceptualize infection prevention infrastructure as structurally embedded within workflow performance and service continuity (Donabedian, 1988; WHO, 2016). In highly regulated clinical environments, compliance, reliability, and operational efficiency are often cognitively integrated by frontline personnel, resulting in convergent perception patterns. However, measurement literature cautions that restricted variance and bounded ordinal scales may inflate correlation coefficients in perception-based surveys (Tavakol & Dennick, 2011). Accordingly, the observed association should be interpreted as evidence of strong perceptual alignment rather than proof of direct causal linkage.

The observed perfect monotonic association ($\rho = 1.000$) should be interpreted with methodological caution. Both the sterilization practices composite and the perceived productivity composite were derived from perception-based measures collected from the same respondents using an identical four-point Likert scale within a single survey administration. Several domains demonstrated ceiling effects and restricted variance, which reduce score dispersion and can

structurally inflate rank-order correlations in bounded ordinal datasets. Consequently, the magnitude of the correlation likely reflects strong perceptual alignment and shared evaluative framing rather than statistical independence between constructs. While the result indicates that respondents cognitively integrate sterilization governance and productivity experience, it does not imply causal dependency. Future research incorporating objective operational indicators (e.g., instrument turnaround time, case delay frequency, IPC audit performance) would allow further validation of this association under conditions of greater measurement variability.

Discussion

Divergence in Coordination-Related Domains

In contrast to technical compliance domains, statistically significant differences were observed in process standardization, customer service, sterile storage and distribution, and education and training. The large effect sizes ($r = 0.86$) reflect substantial divergence in perception between clinical end users and sterile processing personnel. The magnitude of these effect sizes reflects near-complete rank separation in several domains. This pattern suggests highly consistent scoring tendencies within each stakeholder group rather than extreme opinion polarity. The bounded four-point Likert structure may also amplify separation effects when group-level response clustering occurs. Therefore, the large effect sizes do not indicate computational error but instead reflect structurally differentiated experiential perspectives.

Role-based perception asymmetry is well documented in interdependent organizational systems (Barney, 1991; Williamson, 1985). Clinical end users experience sterilization performance through instrument availability, turnaround reliability, and service responsiveness. Sterile processing personnel evaluate performance through adherence to procedural protocols and compliance validation. These differing vantage points naturally generate perception divergence in coordination-intensive domains.

Governance Implications for Outsourcing and Centralization

The findings suggest that outsourcing readiness should not be conceptualized primarily as a cost-reduction strategy. Instead, sterilization outsourcing or centralization should be viewed as a governance mechanism designed to enhance coordination efficiency, accountability, clarity, and service reliability. Transaction Cost Economics posits that organizations externalize services when coordination and monitoring efficiencies outweigh internal administrative burdens (Williamson, 1985). The observed divergence in coordination-related domains supports the relevance of this framework. Similarly, the Resource-Based View emphasizes capability maturity and alignment as determinants of sustained organizational performance (Barney, 1991). The present findings indicate that technical sterilization capabilities are perceived as strong, while coordination interfaces represent the primary area of perceptual tension.

Strengthening governance mechanisms may involve establishing formal service-level agreements (SLAs), defining measurable turnaround benchmarks, clarifying escalation pathways, and implementing structured communication protocols. These strategies align with ANSI/AAMI ST79 recommendations emphasizing traceability, process monitoring, documentation rigor, and accountability structures in sterile processing systems (AAMI, 2017; Shenoy & Weber, 2025).

Centralized sterilization hubs, when supported by robust oversight and regulatory alignment, may improve instrument flow predictability, reduce case delays, and enhance compliance monitoring consistency. However, centralization without governance clarity may exacerbate coordination gaps. Therefore, outsourcing readiness must be evaluated through capability maturity assessment rather than financial calculus alone.

Linking Findings to Health System Outcomes

Although the analysis is derived from perception-based measures, the divergence observed in coordination-related domains may translate into measurable operational consequences within healthcare systems. Process standardization and customer service domains are closely linked to objective performance indicators such as instrument turnaround time, operating room scheduling stability, workload distribution across sterile processing units, and documentation efficiency during compliance audits (Huynh et al., 2019; Nichol et al., 2024).

In sterilization-dependent clinical environments, even minor workflow misalignment may amplify downstream effects, including procedural delays, case rescheduling, increased reprocessing cycles, and heightened staff workload pressure. Variability in training alignment may further influence error rates, compliance audit outcomes, and regulatory inspection preparedness. Thus, perception divergence may function as an early governance indicator of coordination stress within technically compliant systems. Future research incorporating objective metrics—such as instrument tracking data, IPC audit scores, turnaround time intervals, and case delay frequency—would provide empirical validation of these proposed system-level linkages.

Theoretical Contribution

The findings extend existing healthcare outsourcing literature by demonstrating that perception gaps in sterilization governance are concentrated in coordination and service-level domains rather than in technical compliance structures. While prior outsourcing studies often emphasize financial efficiency and cost optimization, the present findings suggest that stakeholder perception divergence may serve as a governance diagnostic signal for workflow misalignment.

The observed patterns in the data informed the conceptual positioning of the Gacias Sterilization Systems Intelligence Framework (G-SSIF). Although the framework was not statistically tested in this study, it integrates capability maturity, coordination efficiency, digital readiness, and governance oversight as interconnected dimensions of AI-ready sterilization systems. By situating sterilization governance within a broader systems intelligence architecture, the study contributes to emerging discourse on digital transformation and predictive optimization in healthcare operations.

Association Between Sterilization Governance and Perceived Productivity

A perfect positive monotonic relationship was identified between sterilization practices and perceived productivity ($\rho = 1.000$), indicating strong perceptual alignment between governance compliance structures and workflow effectiveness. In perception-based systems, such structural alignment suggests that respondents interpret sterilization governance as directly integrated with operational productivity.

The perfect correlation should be interpreted within the context of bounded ordinal scaling and perception-based measurement. From a governance perspective, the finding reinforces the interpretation that sterilization compliance maturity and perceived productivity are tightly interwoven in stakeholder cognition. In operational environments where sterilization reliability underpins clinical workflow continuity, a strong perceptual association may function as an early systems intelligence indicator linking technical governance to productivity experience.

Future research incorporating objective metrics such as instrument turnaround time, compliance audit scores, and workflow delay frequencies would provide additional validation of this observed association under conditions of greater score variability.

CONCLUSION

This study examined the association between sterilization governance and perceived healthcare provider productivity across provincial healthcare facilities in Tuguegarao City, Philippines.

Key Findings

- Technical compliance domains (core functions, patient safety, infection control standards, and sterilization of reusable medical devices) demonstrated perception convergence with no statistically significant differences between sterile processing personnel and clinical end users ($p = 1.000$), consistent with identical rank distributions under a bounded ordinal scale.
- Coordination-related domains—process standardization, customer service, sterile storage and distribution, and education and training showed statistically significant group differences ($p < 0.001$; $r = 0.86$), indicating substantial role-based perception divergence concentrated in workflow alignment and service interface mechanisms.
- A perfect positive monotonic association was identified between sterilization governance and perceived productivity (Spearman's $\rho = 1.000$). Given ceiling effects and restricted variance, this finding reflects strong perceptual alignment rather than evidence of causal dependency.
- Perception divergence was concentrated in coordination and communication domains rather than in core technical sterilization processes, indicating that governance refinement should prioritize interface standardization and service-level clarity over procedural compliance expansion.

Implications

Practically, the findings position outsourcing/centralization as a health-systems governance strategy to improve coordination, accountability, IPC monitoring, and workflow reliability (e.g., turnaround-dependent services), rather than as a response to technical noncompliance. Theoretically, the results extend healthcare outsourcing/service management perspectives by showing that perception gaps and therefore governance risk cluster in standardization and customer-service interfaces, refining how Transaction Cost Economics and Resource-Based View are interpreted in sterile processing contexts.

Actionable Recommendations

1. Establish explicit service-level agreements (SLAs) that define instrument turnaround targets, traceability/documentation requirements, escalation pathways, and measurable performance indicators.
2. Ensure regulatory alignment (e.g., Department of Health requirements and relevant public–private partnership/contracting frameworks) before outsourcing or hub-based centralization is implemented.
3. Implement routine IPC audits and performance dashboards (compliance monitoring, nonconformity trending, and corrective actions) to strengthen accountability and risk management.
4. Strengthen customer-service and communication mechanisms (request/priority protocols, real-time status visibility, and feedback loops) between sterile processing units and clinical end users.
5. Integrate training and competency assurance across vendors and facilities (standardized onboarding, periodic competency checks, and refresher training tied to observed errors or

audit findings).

Limitations and Further Research

Outcomes were perception-based and collected at a single time point in one provincial setting; findings may not generalize to other regions or national contexts. The estimated eligible population was based on facility-level approximations rather than verified workforce registries. Several domains exhibited ceiling effects/restricted variance, which limited discrimination across respondents and likely inflated correlation magnitude.

Future studies should incorporate objective operational indicators (instrument turnaround time, case delays, IPC audit scores, traceability data) and multi-site designs; further work can also empirically test and refine the proposed G-SSIF governance model.

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