Jurnal Teknik Industri: Jurnal Hasil Penelitian dan Karya Ilmiah dalam Bidang Teknik Industri

Vol. 11, No. 2, 2025

The Impact of Green Supply Chain and Digitalization on Environmental Sustainability in Healthcare Clinics: The Moderating Role of Digitalization

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ABSTRACT

Green Supply Chain Management (GSCM) has received increasing attention as a strategy to minimize the environmental impact of the healthcare supply chain. Not only GSCM, but digitalization practices are also believed to improve efficiency and reduce operational costs. This study aims to examine the role of digitalization as a reinforcing factor in the effectiveness of GSCM practices for environmental sustainability. This research began with hypothesis preparation, which consisted of three hypotheses. Furthermore, data on the assessment of the relationship between digitalization, green supply chain, and environmental sustainability were collected through questionnaires to Health Clinics in Padang. Data processing was carried out using the Partial Least Squares-Structural Equation Modelling (PLS-SEM) method with SmartPLS 3.0. The processing stages consist of structural model design, measurement model design, path diagram design, model evaluation, hypothesis testing, and IPMA analysis. From the processing results, digitalization and a green supply chain both make significant contributions to environmental sustainability at the Padang Health Clinic. Furthermore, based on IPMA's analysis, the implementation of green supply chain aspects and digitalization in the field has reached 69%. Nonetheless, there is still room for improvement to achieve better environmental sustainability. Therefore, to achieve environmental sustainability, health clinics need to emphasize and implement green supply chain and digitalization indicators.

Keywords: *Digitalization, Sustainability, Green Supply Chain, Healthcare, PLS-SEM*

Introduction

Environmental sustainability has become a critical issue in the healthcare sector due to its substantial contribution to greenhouse gas emissions and the increasing volume of medical waste. Healthcare facilities generate various types of hazardous and non-hazardous waste that, if not properly managed, can pose serious risks to the environment and public health. [1]. This challenge is particularly evident at the clinic level, where operational activities such as immunization services, maternal and child healthcare, and emergency care contribute significantly to daily medical waste generation. In Padang, for instance, health facilities produced 7,662.88 kg of medical waste in 2024, most of which originated from clinics and primary healthcare services, with waste management relying on third-party providers for collection and disposal. [2]. These conditions highlight the urgent need for effective sustainability-oriented management practices in healthcare clinics.

In response to growing environmental concerns, Green Supply Chain Management (GSCM) has emerged as a strategic approach to reduce environmental impacts across healthcare supply chains. GSCM integrates environmental considerations into procurement, internal operations, and distribution activities, enabling healthcare organizations to improve resource efficiency and manage medical waste more responsibly. The concept of Green Healthcare Supply Chain Management (GHSCM) is increasingly recognized as a viable pathway toward sustainable development in the healthcare industry, as it addresses environmental issues throughout the entire service delivery process rather than focusing solely on end-of-pipe waste treatment [3]. Alongside GSCM, digitalization has rapidly transformed healthcare services by shifting traditional paper-based processes toward digital systems. Digital technologies improve operational efficiency, reduce administrative costs, and support real-time information exchange among healthcare professionals and patients [4]. More importantly, digitalization enhances care coordination, reduces clinical errors, and supports evidence-based decision-making through timely access to health data, thereby improving the overall quality and efficiency of healthcare services [5]. Beyond clinical benefits, digitalization also holds potential to support sustainability initiatives by enabling better monitoring, coordination, and control of supply chain and waste management activities.

Despite the growing body of literature on Green Supply Chain Management (GSCM), prior studies have largely focused on manufacturing industries or large hospitals, leaving smaller healthcare facilities such as clinics relatively underexplored. Existing research has not sufficiently examined how GSCM practices operate at the clinic level, even though clinics are increasing in number and collectively contribute significantly to medical waste generation. In addition, studies examining the relationship between digitalization and sustainability have produced fragmented insights. For instance, a study by Syahfitri [6] Investigated the role of digitalization in influencing sustainability outcomes, but was limited to small and medium-sized enterprises and did not address the healthcare sector. Similarly, a study by Priya et al. [5] focused on the impact of digitalization on healthcare services but did not link digitalization to green supply chain practices or environmental sustainability outcomes. Addressing these gaps, this study aims to examine digitalization not only as a direct driver of environmental sustainability but also as a reinforcing factor that enhances the effectiveness of GSCM practices in healthcare clinics, with digital sustainability indicators incorporated as a moderating variable.

Research Methods

Data collection in this study was conducted using a questionnaire designed to assess the relationships between green supply chain practices, digitalization, and environmental sustainability. In the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach, it is recommended that the minimum sample count be in the range of 30 to 100 respondents. The calculation of the number of samples can also refer to the rule of thumb formula, which is ten times the number of endogenous latent variables contained in the research model [7]. The selection of samples in this study was carried out through purposive sampling techniques, with the main focus on clinics that have implemented or are in the process of implementing a green supply chain system and digitalization practices in Padang. Clinics with these characteristics are prioritized as respondents because they are considered relevant and in accordance with the research objectives.

Respondents evaluated each item using a five-point Likert scale (1–5). Data from respondents were then analyzed using the Partial Least Squares–Structural Equation Modelling (PLS-SEM) method. According to [7] variance-based SEM using PLS aims to examine predictive relationships among construct variables by assessing the presence of effects or relationships between constructs, particularly in situations where theoretical foundations are not yet well established and the available data are limited. Moreover, PLS-SEM is suitable for analyzing models comprising multiple dimensions or latent variables that are not necessarily highly correlated. This method is particularly advantageous when dealing with small or limited sample sizes, as it allows researchers to relax several assumptions of the Ordinary Least Squares (OLS) approach, such as the requirement for multivariate normal data distribution. The systematic stages of data analysis include construct model conceptualization, path diagram development, model evaluation, hypothesis testing, and Importance–Performance Map Analysis (IPMA).

Results and Discussion

Data Collection

The questionnaires were distributed using two approaches, namely through a Google Form link and via direct visits to healthcare clinics in Padang. A total of 50 valid responses were collected and used for further analysis.

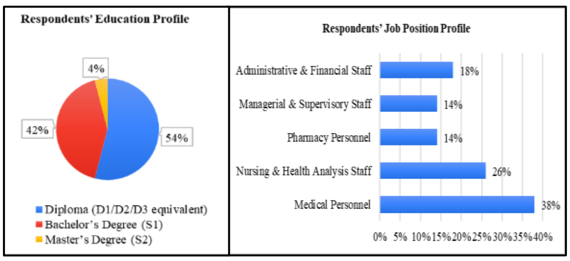

Figure 1. Respondent's Profile

Based on the respondent profile as shown in Figure 1, the results indicate that most respondents hold diploma-level qualifications (D1/D2/D3 equivalent), followed by bachelor's degrees (S1), while only a small proportion have completed master's degrees (S2). This distribution reflects the educational composition commonly found among healthcare clinic personnel. the majority of participants were classified as medical personnel (38%), followed by nursing and health analysis staff (26%). This distribution reflects the operational structure of healthcare clinics, where clinical personnel play a dominant role in daily service delivery and medical waste generation, making their perspectives particularly relevant for assessing green supply chain and sustainability practices.

Conceptualization of Model Constructs

The conceptualization of the model construct consists of designing a structural model (*inner model*) and designing a measurement model (*outer model*). The purpose of designing a structural model is to formulate relationships between latent variables. Independent latent variables are called exogenous latent variables and dependent latent variables are called endogenous latent variables.

Structural Model Design

The structural model (inner model) in this study is designed to describe the causal relationships among latent variables that form the conceptual framework for the influence of health digitalization and a *green supply chain* on environmental sustainability in health clinics. The arrow direction in the model indicates the flow of the cause-and-effect relationship established based on the hypothetical framework shown in Figure 2.

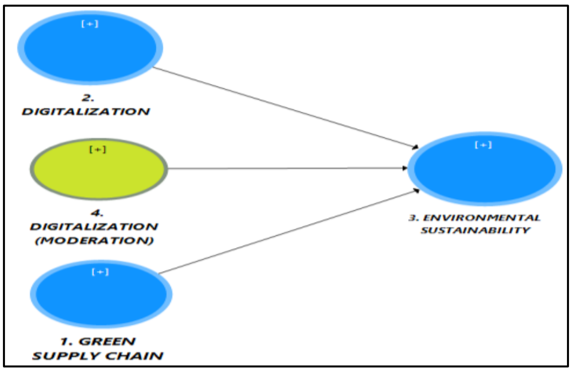

Figure 2. The Inner Model

Measurement Model Design

The measurement model (outer model) is compiled to describe the relationship between each manifest variable (indicator) and the construct it represents. Thus, these indicators serve to illustrate and explain latent variables that cannot be measured directly [8]. The latent variable of digitalization is in the form of a unidimensional one, namely a latent variable (construct) that is formed directly by the manifest variable (indicator). In this study, 15 indicators of health digitalization are presented in Table 1. Meanwhile, the latent variable in the green supply chain is divided into three dimensions: inbound logistics, operations, and outbound logistics where each dimension consists of five indicators, as shown in Table 2.

Meanwhile, the environmental sustainability indicators total 14. These indicators are compiled from various relevant scientific research in the last 10 years. Environmental sustainability is evident in Table 3. The use of 43 indicators is theoretically grounded and aligned with the exploratory nature of this study. This is a relatively large number of indicators, is theoretically justified, as the constructs examined in this study are multidimensional in nature. PLS-SEM is suitable for handling complex models with relatively small sample sizes, provided that rigorous measurement model evaluation is conducted [7]. All indicators were adapted from established studies, and indicators with low loadings were removed to ensure model validity and reliability. Moreover, hierarchical component modeling was applied to manage model complexity.

Path Diagram Design

The next stage is to design a path diagram that visualizes the relationship between the *inner model* path and *the outer model*. This model will form *hierarchical component models* (HCMs) that are multidimensional, as they contain latent variables with multiple interrelated dimensions. In the study, the pathway diagram was designed to illustrate the relationships among the green supply chain, digitalization, and environmental sustainability.

Table 1. Digitalization Indicators in Measurement Model Design

No	Dimension	No.	Indicators	Sources
1	Digitalization	1	Use of electronic information systems to process patient data.	[4], [5], [9], [10], [11], [12]
		2	Ability to communicate through digital tools (email, online platforms).	
		3	Ability to create, edit, and share digital health-related content.	
		4	Understanding of patient data security and health information privacy.	
		5	Access to digital devices (computers, smartphones, digital medical devices)	
		6	Participation in digital technology training programs.	
		7	Internet access in the workplace	
		8	Community participation in the use of health portals (digital platforms).	
		9	Utilization of digital health data for public health monitoring.	
		10	Legal framework for secure health information exchange	
		11	Level of use of digital applications (e-health, m-health, telemedicine)	
		12	Ability to use digital healthcare devices and applications.	
		13	Reduction in medical errors due to digital systems.	
		14	Improvement in service speed through automation.	
		15	Use of patient portals	

Table 2. Green Supply Chain Indicators in Measurement Model Design

No	Dimension	No.	Indicators	Sources
1	*Inbound Logistics*	1	Selection of environmentally friendly suppliers.	[13], [14], [15], [16], [17], [18], [19], [20], [21]
		2	Percentage of suppliers with ISO 14000 certification.	
		3	Percentage of hazardous materials in inventory	
		4	Use of recyclable raw materials	
		5	Compliance with environmental regulations.	
2	Operational	6	Energy efficiency and resource conservation (electricity, water, cooling systems).	
		7	Management of medical and non-medical waste in accordance with standards (segregation, sterilization, recycling)	
		8	Implementation of 3R technologies (reduce, reuse, recycle) for consumables and selected medical devices.	
		9	Control of hazardous substances.	
		10	Environmental training and awareness for healthcare professionals and staff.	
3	*Outbound Logistics*	11	Low-emission transportation practices.	
		12	Medical waste collection and treatment systems (reverse logistics)	
		13	Patient and community education on waste management	

No	Dimension	No.	Indicators	Sources
		14	Patient and community education through green CSR programs.	
		15	Use of environmentally friendly packaging	

Table 3. Environmental Sustainability Indicators in Measurement Model Design

No	Dimension	No.	Indicators	Sources
1	Environmental Sustainability	1	Implementation of energy-efficient technologies	[16], [18], [20], [22], [23], [24], [25], [26]
		2	Utilization of renewable energy sources (solar, wind, tidal energy) to reduce carbon emissions.	
		3	Medical and non-medical waste segregation systems.	
		4	Application of circular economy principles in the management of medical equipment and materials	
		5	Clinical waste management systems	
		6	Control of pollutants and greenhouse gases (CO_2, NO_x) generated by clinical activities	
		7	Environmentally friendly transportation practices	
		8	Sustainable facility design.	
		9	Procurement of environmentally friendly products	
		10	Implementation of environmental management systems (such as ISO 14001).	
		11	Healthcare facilities' capacity to adapt to climate change.	
		12	Noise control to ensure the comfort and safety of patients and staff.	
		13	Optimizing energy use in healthcare facilities.	
		14	Efficient use of materials	

Evaluation of Measurement Model

Validity Test

According to Ghozali [7] the measurement model (*outer model*) with indicators in the form of reflective is evaluated based on the *convergent validity* value and *the discriminant validity value* of the indicators that form the latent construct. In this study, a validity test was carried out on indicators from the latent variables of inbound logistics, operations, outbound logistics, digitalization and environmental sustainability.

Convergent Validity

Convergent validity is related to the principle that the manifest variable (indicator) of a latent variable (construct) should have a high correlation. The value of the convergent validity test using *SmartPLS* 3.0 software can be seen in the loading factor (outer loading) for each indicator. According to Ghozali [7], If the study is confirmatory, the loading factor value is strongly recommended to be higher than 0.70 (>0.70). However, for the early stages of research from the development of the measurement scale, the loading factor value between 0.5 – 0.6 is still considered sufficient.

Based on the initial outer loading results shown in Figure 3, LI3 (percentage of hazardous materials in inventory) and OP1 (energy efficiency and resource conservation related to electricity, water, and cooling systems) exhibit loading values below the acceptable threshold of 0.50, indicating weak contributions to their respective constructs. The low loading of LI3 may reflect limited variability in hazardous-materials inventory management across clinics, as such materials are often standardized and strictly regulated, leading in similar practices among respondents. Meanwhile, the low loading of OP1 suggests that energy efficiency and resource conservation practices may not yet be consistently implemented or systematically monitored at the clinic level, reducing their ability to represent the operational green supply chain construct. To improve measurement quality and ensure convergent validity, both indicators were removed from the model. After re-estimation using SmartPLS 3.0, all remaining indicators demonstrated outer loadings above 0.50, confirming that the convergent validity criteria were met, as shown in Figure 4.

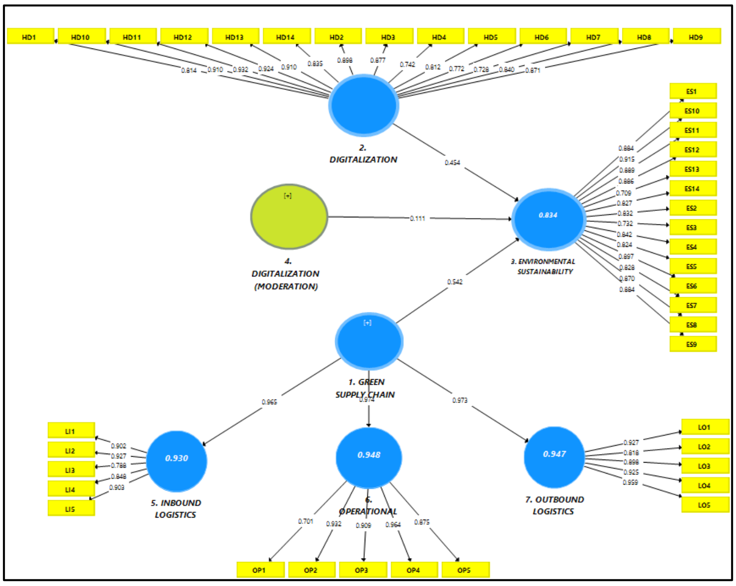

Figure 3. Estimated outer loading value to -1

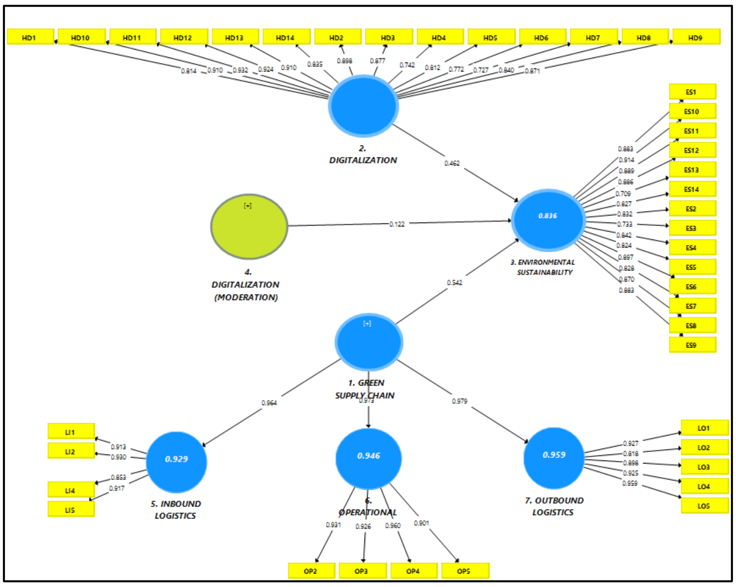

Figure 4. Estimated outer loading value to -2

Discriminant Validity

The discriminant validity test is based on the principle that different indicators (manifest variables) should not be highly correlated. [7]. The way to test the validity of the discriminator can be found by the cross-loading value. The size of the manifest variable can be predicted if the *cross-loading* value on the measurement indicator is greater than that of the other measurement indicators. Based on the processing results, *a cross-loading* value was obtained that met *the criteria for discriminant validity*. All indicators (constructs) show higher values than other indicators. It can be concluded that the indicators (constructs) used as research instruments exhibit good discriminant validity.

Reliability Test

The reliability test aims to prove the accuracy, consistency and precision of the instrument in measuring constructs. In SmartPLS 3.0, reliability is assessed through *composite reliability.* According to [7], *The composite reliability* for *confirmatory research* must be greater than 0.7 (>0.70). As for *exploratory study, the* composite reliability *value* between 0.6-0.7 is still acceptable. Based on Table 4, the *composite reliability* for all latent variables exceeds 0.7. Thus, it can be concluded that the measurement instrument's reliability has been met and is acceptable.

Evaluation of Structural Model

The evaluation of the structural model (*inner model*) aims to measure the relationships among green supply chain variables and environmental sustainability, between digitalization and ecological sustainability, and between green supply chain variables and environmental sustainability moderated by digitalization variables. This measurement value can be seen from the path coefficient and determination coefficient (R2) obtained through bootstrapping in SmartPLS 3.0. Where the tolerance limit used is 5% (α = 5%).

Table 4. Composite Reliability (CR) Value

	CR
1. Green Supply Chain	0,980
2. Digitalization	0,973
3. Environmental Sustainability	0,972
4. Digitalization (Moderation)	1,000
5. Inbound Logistics	0,947
6. Operational	0,962
7. Outbound Logistics	0,958

The value of the path coefficient aims to measure the influence of an exogenous variable on an endogenous variable whose value is between -1 and +1. If the value of the *path coefficient* is positive, then the influence of the variable is directly proportional. This means that if the value of an exogenous variable increases/increases, then the value of the endogenous variable will also increase. On the other hand, if the value of the path coefficient is negative, then the influence of the variable is inversely proportional. This means that if the value of an exogenous variable increases/increases, then the value of the endogenous variable will decrease. Thus, if the value is close to +1 then it represents a strong positive relationship, on the other hand if the value is close to -1 then it represents a weak negative relationship [7]. From the following table, the value of the path coefficient is shown in the original column of the sample, where the overall value is positive. The highest value occurred in the relationship between the green supply chain and environmental sustainability, which was 0.542. This means that the implementation of *a green supply chain* has the greatest influence on environmental sustainability.

The structural model results indicate that Green Supply Chain Management (GSCM) has the strongest direct effect on environmental sustainability (β = 0.542), followed by digitalization (β = 0.462), while the moderating effect of digitalization on the green supply chain on sustainability relationship is relatively weak (β = 0.122). These findings can be theoretically explained by the nature of sustainability practices in healthcare clinics and are consistent with prior empirical studies. The stronger effect of GSCM compared to digitalization suggests that environmental sustainability in healthcare clinics is more directly influenced by operational and supply chain practices than by technological adoption alone. GSCM encompasses tangible activities such as green procurement, environmentally friendly packaging, waste segregation, and reverse logistics, which have an immediate and measurable impact on waste reduction and resource efficiency. Previous studies consistently report that GSCM practices exert a substantial influence on environmental performance, particularly in sectors dealing with hazardous waste, including healthcare [27], [28]. In the clinic context, where medical waste generation is a critical sustainability issue, improvements in supply chain and operational practices naturally produce stronger environmental outcomes than supporting technologies.

Table 5. Path Coefficient

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**
Green Supply Chain -> Environmental Sustainability	0,542	0,539	0,146
Digitalization -> Environmental Sustainability	0,462	0,466	0,133
Digitalization (Moderation) -> Environmental Sustainability	0,122	0,113	0,080

Digitalization, while also showing a significant positive effect, exerts a comparatively weaker influence because digital technologies in clinics are primarily used for clinical services and administrative efficiency rather than for environmental or supply chain management. This finding aligns with prior research indicating that digitalization often contributes indirectly to sustainability by improving information flow, coordination, and efficiency, rather than directly reducing environmental impacts. [5]. As a result, digitalization enhances sustainability outcomes, but its effect remains secondary to core green operational practices.

The weak moderating effect of digitalization (β = 0.122) further indicates that digital tools have not yet been fully integrated into green supply chain processes in healthcare clinics. From a theoretical perspective, moderation would be stronger if digitalization were deeply embedded in procurement systems, supplier monitoring, waste tracking, and environmental performance measurement. However, the current findings suggest that digitalization and GSCM primarily operate in parallel rather than synergistically. Similar results have been reported in previous studies, where digitalization showed a direct effect on performance but failed to significantly strengthen the impact of green supply chain practices due to limited digital maturity and partial implementation. [6]. Overall, these results highlight that while digitalization plays an important supporting role, GSCM remains the primary driver of environmental sustainability in healthcare clinics. The findings emphasize the need for future initiatives to move beyond standalone digital adoption toward deeper digital integration within green supply chain processes to unlock more substantial synergistic effects.

Hypothesis Testing

Hypothesis testing is also carried out through *the bootstrapping* process on *SmartPLS* 3.0. Some literature suggests using 5000 bootstrap samples to correct the standard error estimate in SmartPLS, with a 5% significance level (t-value = 1.96). The hypothesis is acceptable if the resulting p-value is less than 0.05 (*alpha*) or the statistical t-value is greater than the t-table value (1.96) [7]. The *alpha* value (α) represents the acceptable tolerance limit on the study. Based on the processed data, two hypotheses are accepted: H1 and H2. At the same time, the H3 hypothesis was rejected.

The results in Table 6 show that both *GSCM and Digitalization* have a statistically significant impact on environmental sustainability. These findings indicate that higher levels of green supply chain practices and digitalization are associated with better ecological sustainability outcomes in healthcare clinics. The significance of these paths reinforces the theoretical position that both operational environmental practices and digital capabilities contribute meaningfully to sustainability performance, consistent with prior PLS-SEM studies that used bootstrapping to validate such direct effects in sustainability models. For example, similar PLS-SEM analyses with 5,000 bootstrapped samples have identified significant positive relationships between organizational practices and sustainability outcomes [29].

Table 6. Hypothesis Testing

Hypothesis	Construct	T Statistics	P Values	Decision	Description
H1	Green Supply Chain -> Environmental Sustainability	3,709	0,000	Accept H1	Significant Impact
H2	Digitalization -> Environmental Sustainability	3,476	0,001	Accept H2	Significant Impact
H3	Digitalization (Moderation) -> Environmental Sustainability	1,518	0,130	Reject H3	Not Significant Impact

However, the effectiveness of digitalization as a moderator depends heavily on the depth of integration and its strategic alignment with green supply chain activities. Empirical evidence suggests that digitalization interventions often show direct effects on sustainability or performance, but their moderating effects are less consistent or context-dependent. For example, studies on digital supply chain and sustainability have found that specific digital capabilities (e.g., big data analytics) moderate specific paths (e.g., digital logistics to sustainable performance) but may not significantly influence others, likely due to variations in how digital tools are embedded in operational routines. [30].

IPMA Analysis

The Importance-Performance Map Analysis (IPMA) complements the PLS-SEM results by showing not only *how vital* each construct or indicator is in explaining environmental sustainability, but also *how well* clinics currently perform it. IPMA uses two dimensions, importance (total effect) and performance (average latent scores), to highlight areas where managerial action can achieve the most significant improvement [31]. The implications of the research on resilience are evident in the Important and Performance Map Analysis (IPMA) generated with SmartPLS 3.0. The green supply chain has the highest level of importance (54%) compared to digitalization (46%) in achieving environmental sustainability in Health Clinics in Padang. In terms of performance, digitalization and green supply chains show the same performance value of 69%. This indicates that there is still 31% room for improvement in the performance of Health Clinics in Padang, particularly in implementing digitalization and green supply chain initiatives to enhance clinic performance and achieve better environmental sustainability.

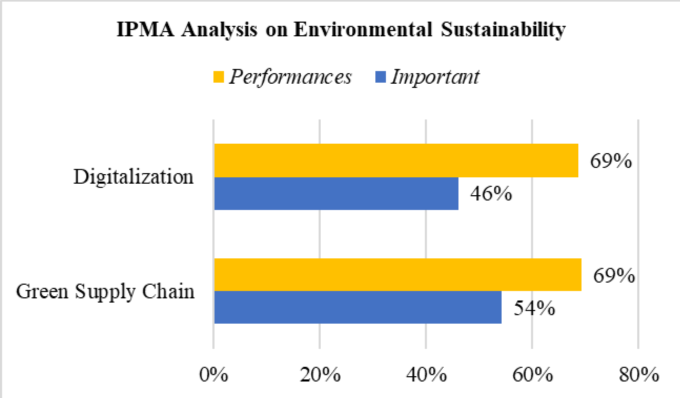

Figure 5. IPMA Analysis

Based on the indicator performance analysis (Figure 6), the highest-performing digitalization indicators are HD8 (community participation in the use of health portals) and HD2 (ability to communicate through digital tools). These results align with prior research showing that digital ecosystems and platforms significantly improve communication, collaboration, and stakeholder engagement in healthcare contexts. For example, integrated digital tools help clinics engage with patients and the broader community more effectively, supporting operational performance and sustainability outcomes.

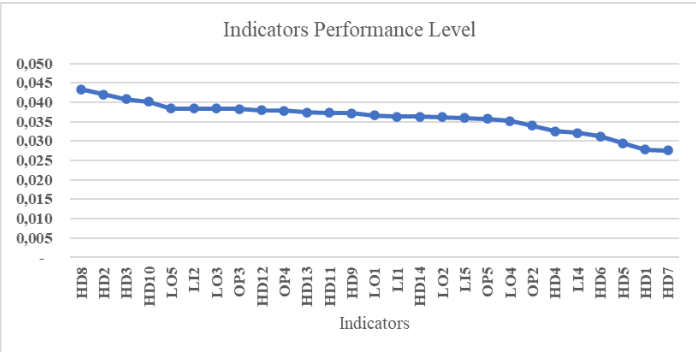

Figure 6. Indicator Performance Level

From a managerial standpoint, performance can be improved by expanding digital health portals beyond patient services to support environmental reporting and waste tracking, and by integrating existing digital communication platforms with supplier coordination, waste service providers, and internal logistics functions. Moreover, well-designed engagement platforms encourage sustained use and active participation, further strengthening performance in digital initiatives. Digitalization has also been shown to enhance efficiency, transparency, and responsiveness in healthcare supply chains, underscoring the role of digital communication and platforms as organizational enablers [32]. The highest-performing green supply chain indicators are LO5 (use of environmentally friendly packaging) and LI2 (percentage of suppliers with ISO 14000 certification). The strong performance of eco-friendly packaging indicates that clinics are adopting packaging practices that reduce material consumption and waste generation, which are essential for lowering environmental impacts across the supply chain. Previous studies confirm that sustainable packaging contributes to waste reduction, supports circular economy principles, and strengthens overall supply chain sustainability performance [33].

Conclusion

From this study, a total of 43 indicators were obtained consisting of 15 green supply chain indicators, 15 digitalization indicators, and 14 environmental sustainability indicators. All indicators are obtained from various relevant scientific studies. From the results of the hypothesis testing, there are two accepted hypotheses, namely Hypothesis H1 and Hypothesis 2 because they have a p-value of < 0.05. Meanwhile, the H3 hypothesis has a p-value of > 0.05 so the hypothesis is rejected. The H1 Hypothesis concludes that there is a significant influence between the green supply chain and environmental sustainability in reducing medical waste at Health Clinics in Padang. Meanwhile, the H2 hypothesis posits a significant relationship between digitalization and ecological sustainability at the Padang Health Clinic. This can also be seen from the performance of green and supply chain implementation in health clinics in Padang has reached 69%. There is still room for improvement in applying these two aspects to achieve environmental sustainability. Meanwhile, digitalization does not moderate the green supply chain's achievement in environmental sustainability, as indicated by the H3 hypothesis test. The subsequent research suggests that the variables used are not only limited to digitalization but also include digital transformation.

From a practical perspective, the findings suggest that healthcare clinics can improve environmental sustainability outcomes, particularly in medical waste reduction and resource efficiency. In addition, Digitalization directly supports sustainability by improving information accuracy, service efficiency, and operational control. Nevertheless, the implementation performance of both GSCM and digitalization reached only 69%, indicating substantial room for improvement. Clinic managers should therefore prioritize digital systems that directly support supply chain activities, such as digital procurement, waste tracking, and environmental performance monitoring. From a policy perspective, the findings underscore the need for local governments and health authorities to strengthen sustainability efforts through clear regulations, standardized digital health systems, and targeted capacity-building programs. Integrating environmental sustainability goals into digital health infrastructure policies can further enhance the effectiveness of green supply chain practices in healthcare facilities. Despite its contributions, this study has several limitations. Although the methodological suitability of PLS-SEM is questionable, the relatively small sample size compared to the number of indicators may affect model stability. Future studies are encouraged to employ larger samples to validate the proposed measurement model further. In addition, digitalization is measured primarily in terms of digital usage and capability, rather than broader organizational digital transformation. Future research is encouraged to incorporate more advanced constructs such as digital transformation, digital maturity, or innovative healthcare systems.

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