

Biostatistical Analytics and Sustainable Business Performance: The Sequential Mediating Effects of Epidemiological Surveillance and Crisis Preparedness under Digital Transformation Capability

Vimala Venugopal Muthuswamy^{1*}, Daniyork Kurbanov²

¹Department of Management, College of Business, King Faisal University, Al-Ahsa 31982, Saudi Arabia; ²Department of Business, Tashkent State University of Economics, Uzbekistan

ABSTRACT

The increasing frequency of organizational disruptions has highlighted the importance of data-driven capabilities in enhancing resilience and sustaining long-term business performance. This study investigates the relationships among biostatistical analytics effort, epidemiological surveillance design, crisis preparedness, digital transformation capability, and sustainable business performance based on the Dynamic Capabilities Theory. Specifically, the study examines the sequential mediating roles of epidemiological surveillance design and crisis preparedness, as well as the moderating effect of digital transformation capability. A quantitative cross-sectional research design was adopted, and data were collected from 231 employees in pharmaceutical manufacturing companies using a structured questionnaire. The proposed model was analyzed using Structural Equation Modeling. The findings reveal that biostatistical analytics effort significantly enhances epidemiological surveillance design, which subsequently strengthens crisis preparedness and improves sustainable business performance. The results further confirm the sequential mediating effects of epidemiological surveillance design and crisis preparedness, while digital transformation capability significantly strengthens the relationship between biostatistical analytics effort and epidemiological surveillance design. The study contributes to the literature by integrating analytical, surveillance, preparedness, and digital capabilities into a unified framework and provides practical guidance for organizations seeking to strengthen resilience and achieve sustainable business performance under dynamic and uncertain environments.

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1. Introduction

The increasing frequency and complexity of global disruptions have intensified the need for organizations to develop resilient systems capable of sustaining business performance under uncertain conditions (Khattak et al., 2026). Organizations have weak capability to sustain continuity and competitiveness through traditional risk management methods (Lisdiono et al., 2022) in the face of public health crises, environmental disasters, cyber-attacks, and operational disruptions. Instead, firms must be proactive and have the ability to collect, interpret and respond to emerging threats and make informed decisions. Within this context, biostatistical analytics has proven to be a valuable analytical tool (Usha et al., 2026), as it converts complex and operational data into meaningful information and allows for evidence-based planning, resource allocation and organizational resilience. Despite its initial connection with healthcare and epidemiology, biostatistical analytics has gained importance in a wide range of sectors as organizations strive to boost their capacity to manage risks, predict disruptions, and maintain ongoing efficiency.

The increasing volume of big data, artificial intelligence and digital technologies has vastly improved the capacity of organizations to incorporate analytical tools into business processes (Joshi, 2025). Predictive analytics, statistical modelling, and data visualization tools have become key assets in today's organizations for supporting their strategic planning and operational decision-making. However, having sophisticated analytical tools does not necessarily mean better

organizational performance (Gupta et al., 2020). For many organizations, turning the analytical findings into effective surveillance systems that are able to continuously track changing risks and reliably provide information to respond to a crisis remains challenging. Even with significant investments in analytical capacity, organizations vary greatly in their preparedness to act in ways to avoid risk factors (Moury & Islam, 2022). This mismatch implies that the utility of biostatistical analytics is not merely the analytics of data, but much also lies in the mechanisms of organization and knowledge conversion from analytics to actionable intelligence.

Epidemiological surveillance represents one such mechanism by providing a systematic approach for monitoring, detecting, and interpreting emerging threats (Fallatah & Adekola, 2024) before they escalate into major organizational disruptions. Epidemiological surveillance has historically been linked to disease prevention and public health management (Richards et al., 2017), but the core elements of continual monitoring, early warning, and evidence-based intervention are becoming increasingly relevant in the context of uncertainty and interrelated risks within the business world. Good surveillance systems help organizations identify unusual patterns, track vulnerabilities in their operations and facilitate prompt management action (Hansen, 2004). However, although there is conceptual concern with understanding the role of the analytical capabilities of surveillance systems in the development of effective epidemiological surveillance, little attention in the existing business and management literature has been paid to how the end product of the process of epidemiological surveillance, in practice, contributes to sustainable organizational outcomes.

Furthermore, organizations' ability to respond effectively to disruptions depends not only on identifying potential threats but also on translating surveillance information into comprehensive crisis preparedness capabilities. Crisis preparedness involves the organization, communication infrastructure, contingency planning and adaptability to reduce the negative impacts of unexpected events (Cloudman & Hallahan, 2006). While there is extensive literature on the importance of crisis preparedness to improve organizational resilience and continuity (Abubakar, 2026; Barasa et al., 2018; El Idrissi et al., 2023), empirical evidence to understand how analytical capacities influence preparedness indirectly via surveillance mechanisms is limited. Previous research tends to focus on these concepts separately, and fail to account for how analytical skills are linked to sustainable business performance in a sequence of processes. Consequently, the relationships between biostatistical analytics, epidemiological surveillance, crisis preparedness and organizational performance are not fully understood.

Another significant constraint in the existing literature is the factor of digital transformation capability. To enhance their data-driven decision making, organizations continue to invest in digital technologies like cloud computing, artificial intelligence, Internet of Things (IoT) and advanced analytics platforms. While the concept of digital transformation is well known and is heralding a greater level of agility and innovation in organizations (Awad & Martín-Rojas, 2024), the study of digital transformation and its impact on the effectiveness of biostatistical analytics for epidemiological surveillance is limited. Organizations with higher digital transformation capabilities could be better equipped to utilize analytical data to inform surveillance systems and effectiveness. Even though this theoretical relevance, empirical studies that investigate the moderating role of the digital transformation capability in this analytical process are still scarce.

The present study aims to fill these gaps by proposing and testing empirically an integrated framework that connects the biostatistical analytics effort with the epidemiological surveillance design, crisis preparedness, digital transformation capability, and sustainable business performance. Specifically, it examines the mediated relationship between the biostatistical analytics effort and sustainable business performance via the epidemiological surveillance design and crisis preparedness. Furthermore, this study explores how the process of digital transformation capability is a moderator between biostatistical analytics effort and epidemiological surveillance design. This study contributes to the existing body of knowledge by using the analytical capability, surveillance systems, crisis management and digital transformation as one conceptual framework, enabling the study to move beyond the concept of analytical capability alone to provide a broader view of how an organization can transform analytical resources into sustainable competitive outcomes.

The study has a number of significant contributions to the literature. First, it builds on the existing literature, as it emphasizes that biostatistical analytics is a strategic capability of an organization to achieve sustainable business performance via intermediate organizational processes, not actual performance impacts. Secondly, it presents a new way about organizational mechanisms that link analytical capabilities with crisis preparedness: the epidemiological surveillance design. Third, a sequential mediation model is developed and tested to account for the path from analytical insights to organizational resilience and sustainable performance. Last, by introducing the concept of digital transformation capability as a moderator, it offers new evidence about how analytical capabilities create more value for the organization, and under what conditions. These contributions provide a more complete picture of data-driven organizational resilience and practical guidance for managers who want to improve the sustainable performance of their businesses by leveraging the integration of analytical and digital skills.

2. Literature Review

This study builds on Dynamic Capabilities Theory (DCT) that addresses how firms establish sustainable competitive

advantage by adapting to future shifts in the environment (Teece et al., 1997). DCT is different from the traditional resource-based approaches, which focus on the importance of having valuable resources, in that it focuses on the importance of continuously building and putting together organizational capabilities to effectively handle disruptions (Wang & Ahmed, 2007). Given that organizations are operating more frequently in environments that face public health emergencies, technology change, and uncertainty in operations, the need to process information in time and make adaptive choice is essential to ensure the performance of organizations. Therefore, this theoretical perspective is well suited for the present study.

Consequently, the conceptual framework (Figure 1) highlighted biostatistical analytics effort as a strategic capability to draw conclusions from data using biostatistics for finding potential risks. The insights are turned into actionable intelligence via epidemiological surveillance design, a tool that supports ongoing monitoring and early detection of new threats. Good surveillance contributes to crisis preparedness by ensuring that organizations are ready for crises (Sami & Chun, 2024), which in turn leads to sustainable business performance. Additionally, the capability for digital transformation improves the effectiveness of this process by incorporating advanced digital technology capabilities with analytical systems (Raeesi Vanani et al., 2025), improving the link between the biostatistical analytics effort and the epidemiological surveillance design. Therefore, DCT offers a comprehensive theoretical explanation for how the analytical, surveillance and digital capabilities together contribute to the resilience and sustainable performance of an organization.

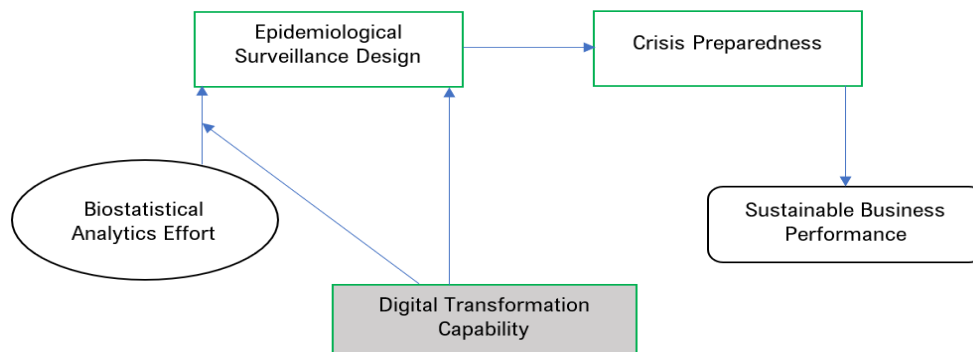


Figure 1: Conceptual Framework of the Study

2.1 Biostatistical Analytics Effort and Epidemiological Surveillance Design

As threats to organizations have become more complex, data-informed decision making has become a critical skill to build robust surveillance networks (Yan, 2019). Biostatistical analytics effort includes how much organizations invest in the collection, analysis and interpretation of statistical data to inform decision making processes based on evidence (Perkins et al., 2016). By utilizing sophisticated statistical analysis, predictive modelling and trend analysis, organizations can detect anomalies, predict potential threats, and produce timely insights to enhance organizational awareness. Analyzing skills help companies to perceive their operating context and convert information into strategic actions. The quality and reliability of analytical information is key to epidemiological surveillance design (Dufour et al., 2006), as surveillance systems need to be able to continuously monitor, detect, and evaluate new threats. There is a correlation between those that invest more in biostatistical analytics and the design of surveillance systems that can bring together multiple data sources and generate acceptable early warning signals. Analytical skills have also been shown to enhance information responsiveness, organizational monitoring, decision quality, and thus surveillance effectiveness in previous studies (Kelly & Vincent, 2011; Marabelli et al., 2020). Thus, more robust biostatistical analytics work should help to build more comprehensive and effective epidemiological surveillance systems.

Hypothesis 1. Biostatistical analytics effort has a relationship with epidemiological surveillance design.

2.2 Epidemiological Surveillance Design and Crisis Preparedness

Epidemiological surveillance design offers organizations a structured way of ongoing surveillance of emerging threats, and an early information system for decision-makers (Wilkins et al., 2008). A good surveillance system gathers, interprets, analyses and shares essential data that will help organizations head off serious crises before they happen (Ali, 2024). The importance of sensing environmental change is the uncertainty, organizations that are able to see changes more effectively can capitalize on opportunities and be prepared to respond. Properly configured surveillance systems can help to gain situational awareness, detect anomalies, track weaknesses in operations, and facilitate quick information sharing between organizational units. These capabilities can help organizations create contingency plans, allocate resources efficiently, and coordinate timely interventions that can help build crisis preparedness. Previous studies have consistently revealed that

well-developed surveillance systems would help organizations to be more resilient, respond quickly and be more prepared for unexpected events (Organization, 2023). Therefore, epidemiological surveillance design is an important organizational capacity, which translates analytical intelligence into proactive crisis management. Therefore, higher crisis preparedness is expected in organizations which have more robust epidemiological surveillance systems.

Hypothesis 2. Epidemiological surveillance design has a relationship with crisis preparedness.

2.3 Crisis Preparedness and Sustainable Business Performance

Crisis preparedness is an organization capacity to anticipate, react, and recover effectively from disruptive events, while keeping the organization functioning (Abubakar, 2026). As business environments become more volatile, it is more important than ever that organizations are ready for emergencies to help reduce operational uncertainty, safeguard organizational resources, and keep stakeholders confident in the organization. According to DCT, firms' adaptability through dynamic capabilities is important for their long-term competitiveness and sustainability (Buzzao & Rizzi, 2021). By enabling prompt decision-making, enhancing organizational resilience, minimizing financial losses, and bolstering strategic agility in crisis situations, crisis preparedness plays a pivotal role in supporting sustainable business performance. Comprehensive crisis preparedness plans enable organizations to better retain customers, ensure supply chain continuity and continue to be productive in the face of external disruptions. Empirical research has shown that proactive crisis management practices are beneficial for strengthening organizations' resilience, financial performance and business sustainability in various industries (Alraja et al., 2022). Thus, crisis preparedness must be seen not only as a way of defending, but also as a strategic capability that allows for sustainable competitive advantage. Therefore, organizations with strong crisis preparedness are likely to have high/strong sustainable business performance.

Hypothesis 3. Crisis preparedness effort has a relationship with sustainable business performance.

2.4 Mediating Role of Epidemiological Surveillance Design and Crisis Preparedness

Collecting and analyzing a vast amount of data to make evidence-based decisions is made possible with biostatistical analytics (Awe et al., 2022). But having analytical insights does not automatically translate to being prepared for the organization unless the insights are translated into practice. DCT focuses on the value creation process within organizations by means of intermediate capabilities transforming information into coordinated actions. In this context, epidemiological surveillance design is a key tool by which biostatistical analytics has contributed to the improvement of the preparedness for a crisis (Andrade-Arenas et al., 2024). Therefore, a good surveillance system can be a permanent surveillance, early warning, and risk assessment system, which can help organizations detect emerging threats before they have become significant disruptions. These surveillance features provide the ability to communicate in time, make informed decisions and preplan contingencies, resulting in increased organizational preparedness for crises (Ali, 2024; Organization, 2023). These valuable analytical insights might otherwise be underutilized, and may not support preparedness initiatives, without an effective surveillance system. This means that when a well-designed epidemiological surveillance system is combined with biostatistical analytics, the resulting capacity to prepare for a crisis is more likely to be robust than will the capacity to prepare for a crisis based purely on the analytical capacity.

Hypothesis 4. Epidemiological surveillance design mediates the relationship between biostatistical analytics and crisis preparedness.

Epidemiological surveillance design can help organizations detect and track new threats (Andrade-Arenas et al., 2024), but it is not sufficient to ensure the best possible organizational results. Instead, the data that is produced via a surveillance system needs to be converted into a strategy for being prepared to respond to disruption. The value is created through the process of converting sensing capabilities to adaptive responses that increase resilience and the ability of the organization to be competitive over time. Crisis preparedness is this adaptive capability, through contingency planning, resource coordination, crisis communication and one-day-offering crisis response mechanisms (Johansen et al., 2012). Situational awareness through effective epidemiological surveillance allows for timely intelligence to inform decision makers and for organizations to plan ahead for prevention actions and limit the effect of unforeseen events. Such readiness events ensure continuity of operations, maintain the trust of stakeholders (Montano et al., 2025) and reduce financial and operational losses, thereby helping the companies to achieve sustainable business performance. Thus, preparedness for crisis is the organizational process by which information from surveillance is translated into enhanced performance results. This means that organizations with more robust epidemiological surveillance mechanisms are likely to deliver better sustainable business performance due to their readiness to effectively manage crises.

Hypothesis 5. Crisis preparedness mediates the relationship between epidemiological surveillance design and sustainable business performance.

2.5 Moderating Role of Digital Transformation Capability

Digital transformation capability is defined as the ability to obtain, incorporate and apply high-tech digital solutions

into the organization to ensure its more efficient functioning and effective decision-making (Ahmed et al., 2021; Nijhum, 2025). The advancements in artificial intelligence, cloud computing, big data analytics, Internet of Things technologies, and real-time information systems have greatly improved the ability of organizations to gather, analyze, and share information (Paramesha et al., 2024). Digital transformation will propel the adaptability of the organizations by empowering the firms to strengthen their resources and to build more responsive operational capability (Akhtar et al., 2023). In the context of epidemiological surveillance, digital technologies enable automatic data collection, real-time monitoring, predictive analysis and fast information sharing across the functions of the organizations. By having strong digital transformation capability, organizations can subsequently be better positioned to develop surveillance systems (Kensbock & Stöckmann, 2021) that will provide adequate detection of new threats, better early warning systems, and evidence-based managerial actions. Past research has shown that digital transformation improves the agility of the organization, information quality, and effectiveness of decision-making, especially in an environment of uncertainty (Atobishi et al., 2024; Wu et al., 2024). As a result, firms with more digital transformation capability will be expected to establish more efficient and comprehensive epidemiological surveillance systems.

Hypothesis 6. Digital transformation capability has a relationship with epidemiological surveillance design.

Digital transformation capability is a business capability of embedding sophisticated digital technologies into its operations and strategy (Weritz et al., 2025). Digital capabilities contribute to the enhancement of the effectiveness of the already available organizational resources (Adhiatma et al., 2024). The present study hypothesizes that the digital transformation capability would improve the linkage of the biostatistical analytics effort and the epidemiological surveillance design. Digital infrastructures in advanced organizations can handle massive amounts of data (Nie et al., 2025), collect data from different sources, and leverage AI, cloud technology, and predictive analytics to enhance surveillance effectiveness and reactivity. But, for organizations that are less digitally competent, it can be difficult to make statistical analysis into effective surveillance systems (Olu-Abiodun et al., 2025). Hence, digital transformation capability is an enabler that increases the organizational value of biostatistical analytics. The benefits of biostatistical analytics for epidemiological surveillance design are likely to grow as digital maturity gains strength, leading to more accurate surveillance, earlier detection of threats and better organizational response.

Hypothesis 7. Digital transformation capability moderates the relationship with biostatistical analytics effort and epidemiological surveillance design.

3. Methodology

3.1 Research Design

This study used a quantitative, cross-sectional research methodology to investigate the relationships between biostatistical analytics effort, epidemiological surveillance design, crisis preparedness, digital transformation capability and sustainable business performance. A quantitative method was deemed suitable, as it serves a number of purposes, such as providing an empirical test of hypothesized relationships and providing a statistical generalisation of the proposed conceptual framework. The cross-sectional design was used in collecting the data of the respondents in one period of time, and it was appropriate for the purpose of investigating organizational perception of analytical capabilities, surveillance practices, crisis management, and business performance.

3.2 Population and Sampling

The target population included employees from the pharmaceutical manufacturing companies. The pharmaceutical industry is selected in this study because all companies in this sector are dealing with a large amount of biostatistical analytics, epidemiological monitoring, digital technologies, and crisis management systems to secure operational continuity, regulatory compliance, ensure product quality and sustain the performance of the organization. Moreover, it is a sector that faces rapidly changing health risks and technological developments, the investigation of analytical and surveillance competencies being especially relevant. Since there is no comprehensive sampling frame of employees in a pharmaceutical organization, the snowball sampling technique was used in this study. Initially, employees were identified from professional business directories, LinkedIn professional networks, pharmaceutical industry associations and organizational contacts. These initial respondents were then asked to introduce other qualified employees in their networks who had specific expertise in the areas of organizational analytics, digital transformation projects, surveillance systems, and crisis management. Snowball sampling is often recommended when the target population either is a specific group of professionals of which information is not easily found in the public domain or the respondents have specific organizational expertise (Parker et al., 2019).

3.3 Data Collection Procedure

A structured online questionnaire was used to collect data for four months. The questionnaire was pre-tested by three academic experts who have special interest in business analytics and strategic management and two senior managers from the pharmaceutical industry to check the clarity, relevance and content validity of the questionnaire before the main survey. Some minor wording changes were added in accordance with their recommendations. Invitations to potential respondents were sent to inform them of the purpose of the study, consider it to be anonymous and confidential. Participants were told that there were no right or wrong answers, and were asked to express their own views without bias as a result of their experiences within their organizations. Finally, 450 questionnaires were distributed and 231 were returned.

3.4 Measurement of Variables

The content validity of the measures for all constructs was established by adapting them from previous studies. Some minor wording changes were used to ensure the measurement items are consistent with the organizational context of pharmaceutical companies when maintaining the original conceptual meaning. Responses were scored on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree). The biostatistical analytics effort was assessed using four items adapted from Li et al. (2024). Epidemiological Surveillance Design was measured using five items adapted from Andrade-Arenas et al. (2024). Four items adapted from Gaile et al. (2026) were used to measure Crisis Preparedness. Digital Transformation Capability was measured with five items adapted from Marczevska et al. (2026), and Sustainable Business Performance was measured with five items adapted from Haseeb et al. (2019). The full list of the measurement items is given in Table 1.

Table 1: Questionnaire Items

Variable	Items	Source
Biostatistical Analytics Effort	1. I plan to apply all biostatistics tool in business activities.	Li et al. (2024)
	2. I plan to work hard on biostatistics tool.	
	3. I plan to attend every biostatistics tool session for business perspective.	
	4. I plan to study every biostatistics tool to apply in business.	
Epidemiological Surveillance Design	1. The design is understandable when entering data	Andrade-Arenas et al. (2024)
	2. The colors are interactive while using.	
	3. All the answers displayed in text are fine.	
	4. Proposed design is satisfactory in all forms.	
	5. The interface meets required expectations.	
Crisis Preparedness	1. My organization is prepared to overcome crisis situations.	Gaile et al. (2026)
	2. We strive to anticipate and proactively mitigate risks that could lead to crisis situations.	
	3. Our organization has strong crisis communication capabilities.	
	4. After the previous crisis, our organization made improvements and implemented necessary changes.	
Digital Transformation Capability	1. Acquiring important digital technologies.	Marczevska et al. (2026)
	2. Identifying new digital opportunities.	
	3. Responding to digital transformation.	
	4. Mastering the state-of-the-art digital technologies.	
	5. Developing innovative products/service/process using digital technology.	
Sustainable Business Performance	1. Net profit margin of our organization increased.	Haseeb et al. (2019)
	2. Return on investment of our organization increased.	
	3. Profitability growth has been outstanding.	
	4. Profitability has exceeded our competitors.	
	5. Overall financial performance has exceeded competitors.	

3.5 Assessment of Common Method Bias

Common method bias (CMB) was tested using both procedure and statistical methods as all variables were measured from the same respondents using one questionnaire (Jordan & Troth, 2020). Full collinearity variance inflation factor (VIF) was explored by following the instructions given in the literature (Thompson et al., 2017). The values of VIF were all below the level of recommended (3.3), therefore the problem of common method bias was not likely to affect the results of this study. Further, the Harman test (one factor) showed that the first factor accounted for less than 50% of the total variance, lending additional support that common method bias is not a major problem.

4. Data Analysis

The descriptive statistics for all the measurement items are given in Table 2. The results show that the mean values

of the constructs of this study are in the mid-range from 2.918 to 3.519 which means there is a moderate level of agreement among the respondents on the study constructs. The standard deviations range from 1.120 to 1.396, which is a good level of variability in the responses. In addition, the skewness values are in the range of -0.477 to 0.129 , with a recommended range of ± 2 , and the range of the kurtosis values is between -1.254 and -0.390 . The results indicate that the data is normally distributed and hence appropriate for further analysis.

Table 2: Data Statistics

	No.	Missing	Mean	Median	Min	Max	Standard Deviation	Excess Kurtosis	Skewness
BAE1	1	0	3.022	3	1	5	1.218	-0.921	-0.143
BAE2	2	0	3.061	3	1	5	1.288	-1.01	-0.187
BAE3	3	0	3.433	3	1	5	1.182	-0.773	-0.306
BAE4	4	0	3.299	3	1	5	1.246	-0.807	-0.312
ESD1	5	0	3.381	3	1	5	1.29	-1.012	-0.276
ESD2	6	0	3.273	3	1	5	1.238	-0.807	-0.228
ESD3	7	0	3.39	4	1	5	1.253	-0.911	-0.371
ESD4	8	0	3.1	3	1	5	1.197	-0.764	-0.132
ESD5	9	0	3.108	3	1	5	1.276	-0.974	-0.167
CP1	10	0	3.147	3	1	5	1.197	-0.826	-0.165
CP2	11	0	3.182	3	1	5	1.228	-0.976	-0.097
CP3	12	0	3.273	3	1	5	1.364	-1.229	-0.226
CP4	13	0	3.294	3	1	5	1.396	-1.254	-0.182
DTC1	14	0	3.377	3	1	5	1.336	-1.182	-0.232
DTC2	15	0	3.381	3	1	5	1.393	-1.219	-0.279
DTC3	16	0	3.087	3	1	5	1.21	-0.856	-0.182
DTC4	17	0	3.139	3	1	5	1.194	-0.833	-0.163
DTC5	18	0	3.121	3	1	5	1.267	-0.992	-0.256
SBP1	19	0	3.078	3	1	5	1.256	-1.043	-0.108
SBP2	20	0	3.013	3	1	5	1.218	-0.835	0.018
SBP3	21	0	2.918	3	1	5	1.216	-0.879	0.129
SBP4	22	0	3.03	3	1	5	1.225	-0.915	-0.101
SBP5	23	0	3.519	4	1	5	1.12	-0.39	-0.477

The measurement model for testing the relationships between the latent constructs and its respective indicators (Purwanto & Sudargini, 2021) is shown in Figure 2. The model shows good indicator loadings in all proposed constructs, which indicates that the observed variables are good representations of their latent variables. Before testing the structural relationships between the constructs, the measurement model is used to evaluate the reliability and validity of the constructs. The convergent validity is presented in Table 3 based on the factor loadings, Cronbach's alpha, Composite Reliability (CR) and Average Variance Extracted (AVE) (Ab Hamid et al., 2017; Mushtaq, 2025). The loadings of most indicators are above the recommended value of 0.70, and the Cronbach's alpha and the Composite Reliability values are above 0.70, suggesting adequate internal consistency reliability. In the same way, the AVE values are generally between or close to the recommended AVE value of 0.50, showing acceptable convergent validity. Therefore, the measurement model has good reliability and convergent validity of the constructs.

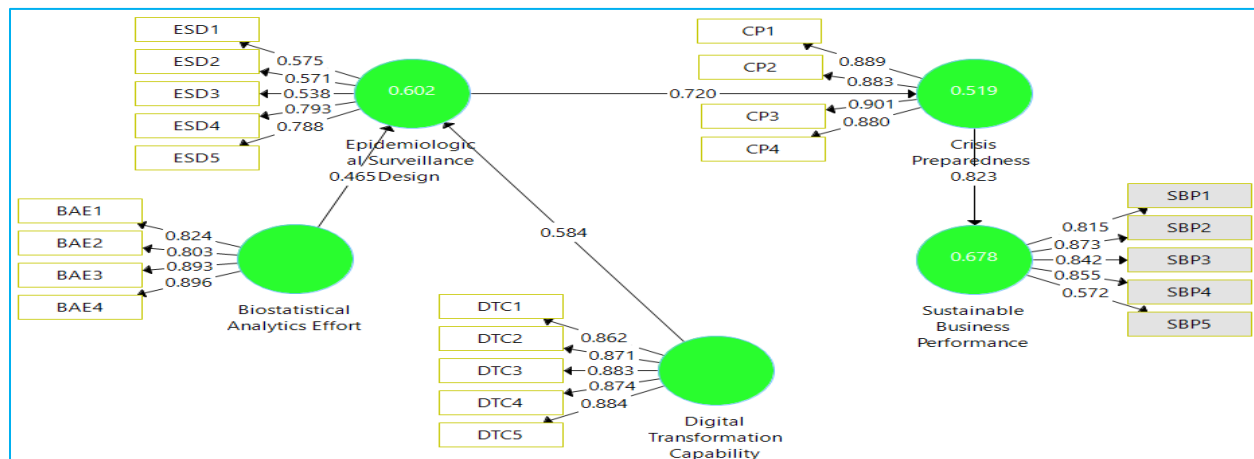


Figure 2: Measurement Model

Table 3: Convergent Validity

Variable	Items	Loading	Alpha	CR	AVE
Biostatistical Analytics Effort	BAE1	0.824	0.879	0.916	0.731
	BAE2	0.803			
	BAE3	0.893			
	BAE4	0.896			
Crisis Preparedness	CP1	0.889	0.911	0.937	0.789
	CP2	0.883			
	CP3	0.901			
	CP4	0.88			
Digital Transformation Capability	DTC1	0.862	0.923	0.942	0.765
	DTC2	0.871			
	DTC3	0.883			
	DTC4	0.874			
	DTC5	0.884			
Epidemiological Surveillance Design	ESD1	0.575	0.717	0.792	0.439
	ESD2	0.571			
	ESD3	0.538			
	ESD4	0.793			
	ESD5	0.788			
Sustainable Business Performance	SBP1	0.815	0.853	0.897	0.639
	SBP2	0.873			
	SBP3	0.842			
	SBP4	0.855			
	SBP5	0.572			

The discriminant validity results obtained on the basis of Fornell-Larcker criterion (Hilkenmeier et al., 2020) is presented in Table 4. The results showed that there was high discriminant validity because each of the constructs had higher variance with the indicators of the same construct and lower variance with the indicators of other constructs. Thus, all latent constructs are empirically different from each other which means that each construct represents a different concept in the proposed research model.

Table 4: Discriminant Validity

	Biostatistical Analytics Effort	Crisis Preparedness	Digital Transformation Capability	Epidemiological Surveillance Design	Sustainable Business Performance
Biostatistical Analytics Effort					
Crisis Preparedness	0.529				
Digital Transformation Capability	0.127	0.521			
Epidemiological Surveillance Design	0.686	0.7	0.598		
Sustainable Business Performance	0.138	0.429	0.318	0.627	

The results of the direct and moderating effects are reported in Table 5 and the structural model is shown in Figure 3. The findings showed that Epidemiological Surveillance Design was positively associated with the Biostatistical Analytics Effort ($\beta = 0.464$, $p = 0.004$) which supports H1. The results show that the higher level of Epidemiological Surveillance Design, the greater the level of Crisis Preparedness ($\beta = 0.720$, $p < 0.001$), supporting H2, while a higher level of Crisis Preparedness, the greater the level of Sustainable Business Performance ($\beta = 0.823$, $p < 0.001$), supporting H3. In addition, Digital Transformation Capability has a significant positive effect on Epidemiological Surveillance Design ($\beta = 0.585$, $p < 0.001$) supporting H6. The moderating effect is also present ($\beta = 0.053$, $p = 0.001$) and Digital Transformation Capability enhances the link between Biostatistical Analytics Effort and Epidemiological Surveillance Design, thereby contributing to H7.

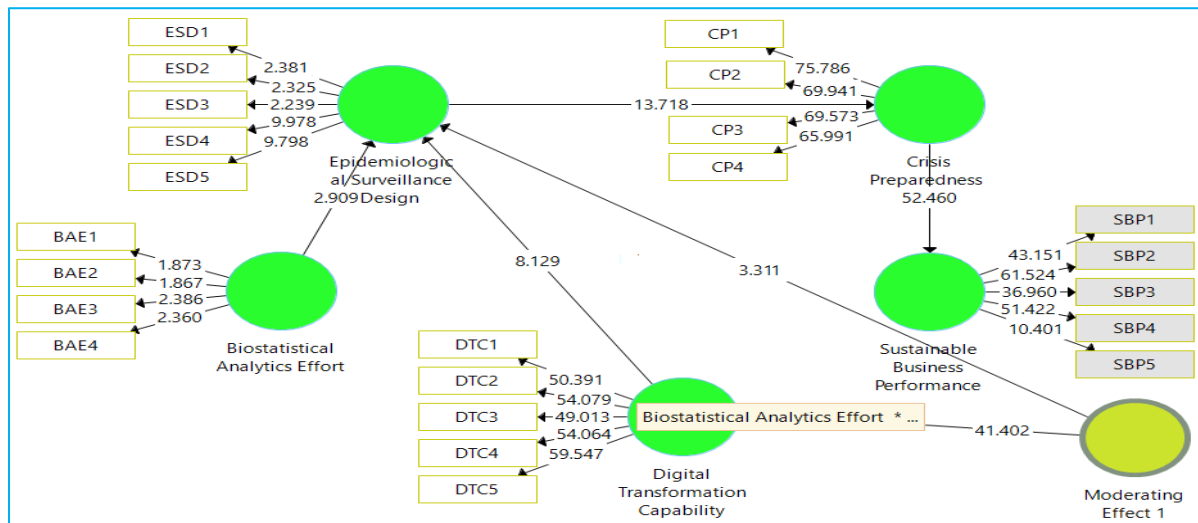


Figure 3: Structural Model

Table 5: Results-Direct Effect and Moderation

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
Biostatistical Analytics Effort -> Epidemiological Surveillance Design	0.464	0.414	0.16	2.909	0.004
Crisis Preparedness -> Sustainable Business Performance	0.823	0.826	0.016	52.46	0
Digital Transformation Capability -> Epidemiological Surveillance Design	0.585	0.598	0.072	8.129	0
Epidemiological Surveillance Design -> Crisis Preparedness	0.72	0.734	0.053	13.718	0
Moderating Effect 1 -> Epidemiological Surveillance Design	0.053	0.049	0.016	3.311	0.001

The moderating role of Digital Transformation Capability is shown in Figure 4. The interaction plot shows that the positive relationship between Biostatistical Analytics Effort and Epidemiological Surveillance Design is greater at higher than at lower levels of Digital Transformation Capability. It is consistent with the results that the extent of digital capacity within an organization tends to be higher in those that can better leverage analytical work into functional epidemiological surveillance systems.

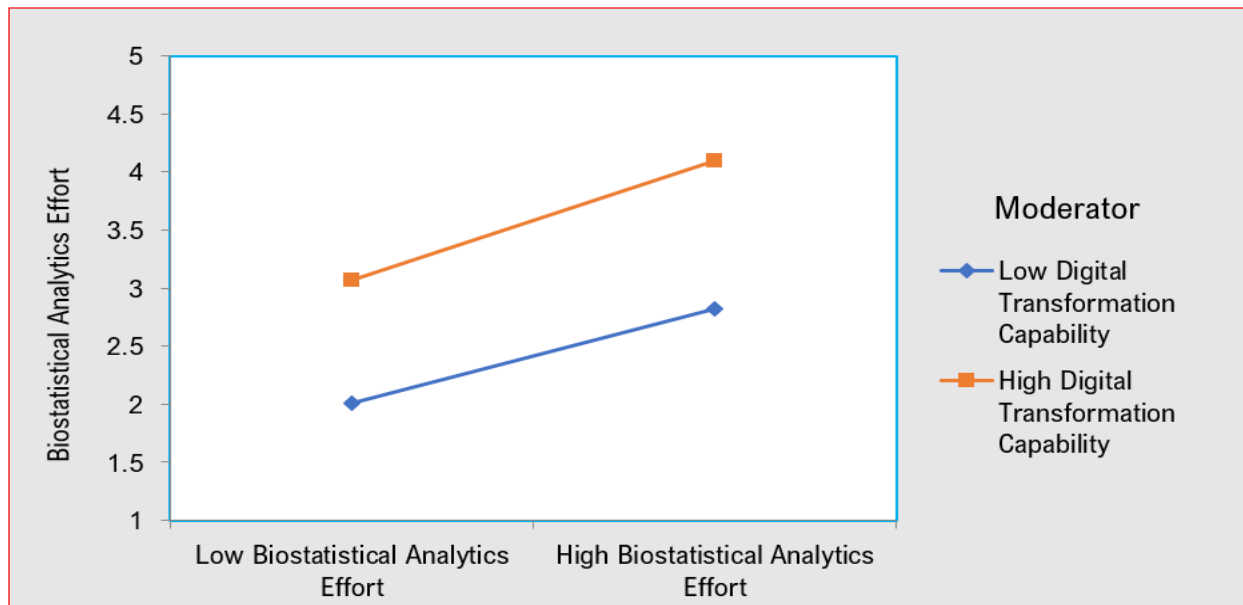


Figure 4: Moderation Effect

Additionally, Table 6 shows the indirect effects of the proposed mediation relationships. The results show that the

mediation mechanism proposed in this study is supported by the sequential indirect effect of Biostatistical Analytics Effort on Epidemiological Surveillance Design on Crisis Preparedness on Sustainable Business Performance ($\beta = 0.275$, $p = 0.001$). Likewise, the link between Epidemiological Surveillance Design and Sustainable Business Performance is significantly mediated by Crisis Preparedness ($\beta = 0.593$, $p < 0.001$). Thus, both H4 and H5 were supported, indicating that the design of epidemiological surveillance and the preparedness for a crisis are intermediary factors between the two.

Table 6: Results-Indirect Effect

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
Biostatistical Analytics Effort -> Epidemiological Surveillance Design -> Crisis Preparedness -> Sustainable Business Performance	0.275	0.245	0.086	3.198	0.001
Epidemiological Surveillance Design -> Crisis Preparedness -> Sustainable Business Performance	0.593	0.607	0.048	12.386	0

5. Discussion

This study investigates the relationships among biostatistical analytics effort, epidemiological surveillance design, crisis preparedness, digital transformation capability, and sustainable business performance based on the Dynamic Capabilities Theory. The results of this study are empirical evidence to support the proposed conceptual framework. The results prove that biostatistical analytics, epidemiological surveillance, crisis preparedness and digital transformation capabilities can be leveraged by organizations to improve sustainable business performance.

Results of hypothesis 1 confirmed that there is a positive relationship between biostatistical analytics effort and epidemiological surveillance design. The results indicate that companies who invest in statistical analysis and decision-making based on evidence are more likely to be well-positioned to design effective surveillance systems that will be able to detect emerging risks and produce information in time. According to the DCT, biostatistical analytics is a sensing capability that helps organizations sense changes in the environment and inform strategic decisions. The findings are in line with the findings of [Li et al. \(2024\)](#) on the necessity of biostatistical skills for analytical decision making, and [Andrade-Arenas et al. \(2024\)](#) on the importance of having well-designed surveillance systems to enable timely monitoring and organizational responsiveness.

The results also validated hypothesis 2, showing that the design of epidemiological surveillance has a significant contribution to improving preparedness for a crisis. Organizations that have an effective surveillance system are better able to monitor the operational conditions continuously, identify deviations from the norm and communicate information to managers in a timely manner. Such capacities enhance institutional resilience to respond to disturbances and plan in advance. The discovery is consistent with literature, which claims that organizations that are better at sensing changes in their surroundings will be able to better exploit opportunities and reduce threats that arise. This finding aligns with prior research that suggests surveillance systems boost organizational preparedness and resilience by maintaining information collection and an early warning system ([Andrade-Arenas et al., 2024](#); [Gaile et al., 2026](#)).

The results further supported hypothesis 3, which posits that having a higher level of crisis preparedness has a positive impact on sustainable business performance. Comprehensive preparedness plans foster operational continuity, quicker disruption response and recovery, and enhanced organizational resiliency, in turn enhancing long-term results. Well-prepared organizations can better safeguard organizational resources, retain the trust of the stakeholders and limit financial losses when conditions are uncertain. This result is consistent with the DCT which states that adaptive organizational capabilities directly affect sustainable competitive advantage. These findings are consistent with those of [Gaile et al. \(2026\)](#) who stated that organizational preparedness during crisis increases organizational adaptability, and [Haseeb et al. \(2019\)](#) who found that resilient organizational practices highly impact sustainable performance of organizations.

Results support Hypothesis 4, which suggested that the epidemiological surveillance design mediates between biostatistical analytics effort and crisis preparedness. These results highlight the need to translate analytical into effective surveillance capacities in order to enhance preparedness. The value that organizations get from biostatistical analytics are improved when the output of the analysis is added to a surveillance system that allows ongoing monitoring and evidence-based decision making. Likewise, the hypothesis 5 was confirmed, indicating that there is a mediation between the epidemiological surveillance design and the sustainable performance of the businesses, in the presence of crisis preparedness. It shows that increased effectiveness in the use of surveillance systems is most likely to enhance preparedness capabilities. The organizations that use surveillance information effectively to create preparedness plans are able to be more resilient, and able to maintain continuity of operations in the event of a crisis ([Anjaria et al., 2023](#); [Atobatele](#)

et al., 2019; Leandro & Maciel-de-Freitas, 2024).

Results provide evidence for both hypotheses 6 and 7, which indicate the importance of the capability of digital transformation. Digital transformation capability not only improves the capabilities of epidemiological surveillance design, but also strengthens the positive association between biostatistical analysis effort and surveillance design. Having sophisticated digital technologies helps organizations process the analytical information more effectively, automate monitoring processes and make better decisions in real-time, maximizing the benefit of surveillance activities. This is aligned with the work of Marczevska et al. (2026) who suggested that digital transformation has brought about organizational adaptability and performance through facilitating information processing capabilities. Thus, the findings show that digital transformation is an important enabler that magnifies the organizational value of biostatistical analytics and enhances data-driven organizational resilience.

6. Conclusion

This study has investigated the relationships of biostatistical analytics effort with epidemiological surveillance design, crisis preparedness, digital transformation capability and sustainable business performance. The results confirm that biostatistical analytics is a great tool for improving the epidemiology surveillance design, thereby making it more robust, improving crisis preparedness at the organizational level, and improving the sustainable business performance. The study also validates the sequential mediating effect of the epidemiological surveillance design and crisis preparedness, suggesting that organizations can perform better by shifting their analytical capacity to effective surveillance and proactive preparedness measures. Further, the ability to undergo digital transformation would directly enhance the design of epidemiological surveillance, and would further strengthen the positive relationship between the effort and effectiveness of biostatistical epidemiological surveillance.

The results contribute to the knowledge about the interaction between analytical, technological and organizational competencies for strengthening business sustainability in the long term. This study did not consider analytics, surveillance, and preparedness as individual organizational activities, but as complementary capabilities that are used together in order to enhance the resilience of an organization and its competitiveness. Thus, organizations aiming for sustainable performance should invest in advanced analytical capabilities, expand surveillance capabilities, build in-depth crisis preparedness plans, and boost digital transformation projects. Together these integrated functions allow organizations to proactively face uncertainty and maintain their operational effectiveness and sustainable competitive advantage.

6.1 Implications, Limitations and Future Directions

The results of this study have several important implications on both the theoretical and practical levels. It can be considered the extension of the DCT by incorporating the concepts of biostatistical analytics, epidemiological surveillance design, crisis preparedness and digital transformation capability into a coherent framework that can be used to explain sustainable business performance. It expands the body of literature by proving the sequential mediating role of the epidemiological surveillance design and the crisis preparedness, and offers a more comprehensive understanding of the process of transforming the analytical capacity into sustainable organizational outcomes. Furthermore, knowledge on the contextual conditions for the analytical capabilities to create more value in organizations is enriched by the moderating effect of digital transformation capability. Managers should go beyond simply investing in analytical tools and create a comprehensive surveillance and preparedness system with digital transformation initiatives. To enhance resilience by closely monitoring and tracking, engaging in predictive analytics, investing in digital infrastructure, and ensuring organizational readiness, managers need to prioritize real-time monitoring, predictive analytics, digital infrastructure, and organizational preparedness to bolster their business performance. These strategic investments can bolster organizational agility in more volatile business climates.

Although this study contributed significantly, it has a number of limitations. First, the cross-sectional research design does not allow causal relationships to be drawn between constructs. Second, the study was based on self-reported perceptions; although common method bias was minimized, there is a potential for respondent bias. Third, the study looked exclusively at pharmaceutical manufacturing companies, which may affect the generalizability of the results. Therefore, longitudinal research design can be used to investigate the development of organizational skills in future studies. The proposed framework could also be tested in other industries and nations in order to enhance its external validity. Moreover, other organizational capabilities including capability of artificial intelligence, organizational learning, innovation capability, and knowledge management can be added to the future research to gain a wider understanding of sustainable business performance in the context of dynamic environmental conditions.

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