

**FRAMEWORK FOR READINESS OF BIG DATA
ADOPTION IN HEALTHCARE SUPPLY CHAIN (HSC)**

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FRAMEWORK FOR READINESS OF BIG DATA ADOPTION IN HEALTHCARE SUPPLY CHAIN (HSC)

by

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CERTIFICATE

This is to certify that the thesis titled “**Framework for Readiness of Big Data Adoption in Healthcare Supply Chain (HSC)**”, being submitted by Mr. DINDAYAL AGRAWAL to the Indian Institute of Technology Delhi, for the award of the degree of DOCTOR OF PHILOSOPHY (Ph.D.), is a record of bonafide research work carried out by him. He has worked under my supervision and has fulfilled the requirements for the submission of this thesis, which is in accordance with the standards required for a Ph.D. degree from the institute. The results contained in it have not been submitted in part or full to any other university or Institute for the award of any degree/diploma.

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Dindayal Agrawal

ABSTRACT

The Healthcare system is always in need of the means to improve the service delivery level and quality of care. But the complex and dynamic nature of the healthcare supply chain makes it a difficult task. While the patient demands are changing as per the modern era personalized medical facility requirements, the collective governmental and societal pressures are also forcing organizations to be up to date and provide better services. Researchers have tried to view the healthcare system as a flexible system. It illustrates how to be more patient-oriented by providing customized services and still stay productive and competitive. The advantages of the view can be extracted by different Information Technology (IT) strategies and adoption of Big Data (BD). Over the last few years, continuous data generation at a very fast pace, i.e., big data and better computing facilities, has opened a new avenue for supply chains to gain insights, achieve flexibility and improve their performance. Although the availability of big data is good news for organizations, the management of this huge amount of data in an efficient way is a massive task. It needs enterprises to be prepared with proper collection of this data, creating an environment where data can be easily accessed but maintains privacy aspect, access to latest big data analytics tool and methodologies for gaining the insights from the data, qualified personnel to use those methods for effective analysis and insights, the training facilities for the physician and paramedics to incorporate these insights in their work and so on. Although big data implementation has become an essential aspect in supply chains, still limited consideration has been given in the literature to analyze the issues to big data adoption in the context of the Healthcare Supply Chain (HSC). Therefore, the requirement for decision models to appraise healthcare performance has been realized among the practitioners and academicians. The present research is an attempt to analyze the readiness constraints for the adoption of BD in HSC. This study has been conducted in four phases, which have been designed into eight chapters in the thesis.

In the first phase, a comprehensive framework among readiness constraints of BD adoption in HSC has been proposed on the basis of feedback captured from the industry experts' and the researchers. Total Interpretive Structural Modeling (TISM) methodology interspersed with fuzzy set theory, and MICMAC is employed to extract the interrelationships and develop a hierarchical structure among the identified readiness constraints. This study has identified thirteen readiness constraints of BD and developed an integrated model using Fuzzy TISM and the MICMAC approach, which is helpful to describe and organize the important readiness constraints and reveal the direct and indirect effects of each readiness constraint on the BD adoption in HSC. The study concludes that the readiness constraints 'Lack of health administration support, 'Inadequate funds' and 'Lack of health policy and regulations' are the readiness constraints that have attained the highest driving power. The proposed modeling could empower various governmental and non-governmental regulatory bodies in the formulation of policies to effectively tackle the problem related to BD adoption in HSC. It is expected that the results originated will assist the experts' to relevantly identify the significant and drop the insignificant readiness constraints for successful BD adoption and performance improvement of HSC.

In the second phase, Structural Equation Modeling (SEM) technique is adopted to generate measurement and structural models. The segregation of thirteen readiness constraints into three perspectives, namely ("data governance perspective", "technological and expertise perspective", and "organizational and social perspective") is performed on the basis of results obtained from Exploratory Factor Analysis (EFA). The EFA results recognize that all the readiness constraints that were examined in this study are important for the successful adoption of BD. Further, Confirmatory Factor Analysis (CFA) is performed by collecting judgments

from a large number of experts. CFA was adopted to test the model fit with the empirical data by employing SEM analysis. The measurement model was tested, and the proposed model was found to be compatible with the empirical data. SEM analysis is performed to calculate the model fit, three hypotheses are tested, and it can be concluded from the study that the “data governance perspective”, is positively related to both the “technological and expertise perspective” and “organizational and social perspective”. Also, the “technological and expertise perspective” is positively related to the “organizational and social perspective”. The results deduced from the study can assist companies in electing the important readiness constraints to execute BD practices in HSC.

In the third phase, a framework based on the Fuzzy VIKOR approach is proposed to provide a coherent and systematic process for evaluating and prioritizing the readiness constraints of BD adoption in HSC. The analysis reflects that Security and privacy of health data (B4) are ranked as the highest and is the most important readiness constraint for successful fulfillment of BD practices in HSC. Lack of health administration support (B6) and lack of data standardization and integration (B12) are ranked as second and third positions, respectively. The results of this study provide a vivid picture that would facilitate the organization to understand the importance of readiness constraints relevant to BD adoption and to frame better strategies.

In the fourth and the last phase, a framework has been established for assessing and prioritizing the key drivers that will support HSC against potential disruptions and improve sustainability. 12 potential drivers are established from the literature and suggestion from the experts. Further, the fuzzy DEMATEL technique is applied in conjunction with the MMDE algorithm to prioritize the drivers. The applied Fuzzy DEMATEL analysis has categorized the variables into two groups, i.e., cause group and effect group, as shown in the figure. This study finds

“Regulations for healthcare organizations”, “Development of health protocols for stakeholders across the healthcare supply chain”, as the most important cause group drivers while “Collaboration among organizations to ensure better services” and “international support and information sharing” are the drivers with the highest prominence. The findings from this study are useful for decision-makers to develop better strategies while focusing on important drivers.

Overall, The present study includes a detailed investigation of the readiness constraints relevant to BD adoption in HSC. Also, the drivers pertaining to the sustainability of HSC amid COVID-19 are addressed in this study. This study has used different methods for transacting with the various aspects of BD and HSC. The study was carried out in an effort to fill the gaps established from the literature and also attempts to address the concerns that are most relevant to the industry.

सार

स्वास्थ्य सेवा प्रणाली को सेवा वितरण स्तर और देखभाल की गुणवत्ता में सुधार के लिए हमेशा साधनों की आवश्यकता होती है। लेकिन स्वास्थ्य सेवा आपूर्ति श्रृंखला की जटिल और गतिशील प्रकृति इसे एक कठिन कार्य बनाती है। जहां आधुनिक युग की व्यक्तिगत चिकित्सा सुविधा आवश्यकताओं के अनुसार रोगी की मांगें बदल रही हैं, वहीं सामूहिक सरकारी और सामाजिक दबाव भी संगठनों को अद्यतित होने और बेहतर सेवाएं प्रदान करने के लिए मजबूर कर रहे हैं। शोधकर्ताओं ने स्वास्थ्य प्रणाली को एक लचीली प्रणाली के रूप में देखने की कोशिश की है। यह बताता है कि कैसे अनुकूलित सेवाएं प्रदान करके अधिक रोगी-उन्मुख होना चाहिए और फिर भी उत्पादक और प्रतिस्पर्धी बने रहना चाहिए। विभिन्न सूचना प्रौद्योगिकी (आईटी) रणनीतियों और बिग डेटा (बीडी) को अपनाने से दृश्य के लाभ निकाले जा सकते हैं। पिछले कुछ वर्षों में, बहुत तेज गति से निरंतर डेटा निर्माण, यानी बड़े डेटा और बेहतर कंप्यूटिंग सुविधाओं ने आपूर्ति श्रृंखलाओं के लिए अंतर्दृष्टि प्राप्त करने, लचीलापन प्राप्त करने और उनके प्रदर्शन में सुधार करने के लिए एक नया मार्ग खोला है। हालांकि बड़े डेटा की उपलब्धता संगठनों के लिए अच्छी खबर है, लेकिन इस बड़ी मात्रा में डेटा का कुशल तरीके से प्रबंधन एक बड़ा काम है। इसे इस डेटा के उचित संग्रह के साथ उद्यमों को तैयार करने की आवश्यकता है, एक ऐसा वातावरण बनाना जहां डेटा को आसानी से एक्सेस किया जा सके, लेकिन गोपनीयता पहलू को बनाए रखा जाए, डेटा से अंतर्दृष्टि प्राप्त करने के लिए नवीनतम बड़े डेटा एनालिटिक्स टूल और कार्यप्रणाली तक पहुंच, योग्य कर्मियों को उन तरीकों का उपयोग प्रभावी विश्लेषण और अंतर्दृष्टि के लिए, इन अंतर्दृष्टि को अपने काम में शामिल करने के लिए चिकित्सक और पैरामेडिक्स के लिए प्रशिक्षण सुविधाएं आदि। यद्यपि आपूर्ति श्रृंखलाओं में बड़ा डेटा कार्यान्वयन एक अनिवार्य पहलू बन गया है, फिर भी स्वास्थ्य सेवा आपूर्ति श्रृंखला (एचएससी) के संदर्भ में बड़े डेटा अपनाने के मुद्दों का विश्लेषण करने के लिए साहित्य में सीमित विचार दिया गया है। इसलिए, चिकित्सकों और शिक्षाविदों के बीच स्वास्थ्य देखभाल के प्रदर्शन का मूल्यांकन करने के लिए निर्णय मॉडल की आवश्यकता महसूस की गई है। वर्तमान शोध एचएससी में बीडी को अपनाने के लिए तत्परता बाधाओं का

विश्लेषण करने का एक प्रयास है। यह अध्ययन चार चरणों में किया गया है, जिन्हें थीसिस में आठ अध्यायों में डिजाइन किया गया है।

पहले चरण में, उद्योग विशेषज्ञों और शोधकर्ताओं से प्राप्त फीडबैक के आधार पर एचएससी में बीडी अपनाने की तैयारी बाधाओं के बीच एक व्यापक ढांचा प्रस्तावित किया गया है। टोटल इंटरप्रिटिव स्ट्रक्चरल मॉडलिंग (टीआईएसएम) कार्यप्रणाली फजी सेट थ्योरी से जुड़ी हुई है, और (एमआईसीएमएसी) को अंतर्संबंधों को निकालने और पहचानी गई तत्परता बाधाओं के बीच एक पदानुक्रमित संरचना विकसित करने के लिए नियोजित किया जाता है। इस अध्ययन ने बीडी की तेरह तत्परता बाधाओं की पहचान की है और फ़ज़ी टीआईएसएम और एमआईसीएमएसी दृष्टिकोण का उपयोग करके एक एकीकृत मॉडल विकसित किया है, जो महत्वपूर्ण तत्परता बाधाओं का वर्णन और व्यवस्थित करने और एचएससी में बीडी अपनाने पर प्रत्येक तत्परता बाधा के प्रत्यक्ष और अप्रत्यक्ष प्रभावों को प्रकट करने में सहायक है। . अध्ययन का निष्कर्ष है कि 'स्वास्थ्य प्रशासन समर्थन की कमी', 'अपर्याप्त धन' और 'स्वास्थ्य नीति और विनियमों की कमी' तत्परता की बाधाएं हैं जिन्होंने उच्चतम ड्राइविंग शक्ति प्राप्त की है। प्रस्तावित मॉडलिंग एचएससी में बीडी अपनाने से संबंधित समस्या से प्रभावी ढंग से निपटने के लिए नीतियों के निर्माण में विभिन्न सरकारी और गैर-सरकारी नियामक निकायों को सशक्त बना सकती है। यह उम्मीद की जाती है कि उत्पन्न परिणाम विशेषज्ञों को प्रासंगिक रूप से महत्वपूर्ण पहचान करने में मदद करेंगे और एचएससी के सफल बीडी अपनाने और प्रदर्शन में सुधार के लिए महत्वहीन तत्परता बाधाओं को दूर करेंगे।

दूसरे चरण में, माप और संरचनात्मक मॉडल उत्पन्न करने के लिए स्ट्रक्चरल इक्वेशन मॉडलिंग (एसईएम) तकनीक को अपनाया जाता है। तेरह तत्परता बाधाओं का पृथक्करण तीन दृष्टिकोणों में किया जाता है, अर्थात् ("डेटा गवर्नेंस परिप्रेक्ष्य", "तकनीकी और विशेषज्ञता परिप्रेक्ष्य", और "संगठनात्मक और सामाजिक परिप्रेक्ष्य")

खोजी कारक विश्लेषण (ईएफए) से प्राप्त परिणामों के आधार पर किया जाता है। ईएफए परिणाम मानते हैं कि इस अध्ययन में जांच की गई सभी तैयारी बाधाएं बीडी को सफलतापूर्वक अपनाने के लिए महत्वपूर्ण हैं। इसके अलावा, पुष्टिकारक कारक विश्लेषण (सीएफए) बड़ी संख्या में विशेषज्ञों से निर्णय एकत्र करके किया जाता है। (एसईएम) विश्लेषण को नियोजित करके अनुभवजन्य डेटा के साथ फिट मॉडल का परीक्षण करने के लिए (सीएफए) को अपनाया गया था। माप मॉडल का परीक्षण किया गया था, और प्रस्तावित मॉडल को अनुभवजन्य डेटा के साथ संगत पाया गया था। मॉडल फिट की गणना के लिए एसईएम विश्लेषण किया जाता है, तीन परिकल्पनाओं का परीक्षण किया जाता है, और यह अध्ययन से निष्कर्ष निकाला जा सकता है कि "डेटा शासन परिप्रेक्ष्य", "तकनीकी और विशेषज्ञता परिप्रेक्ष्य" और "संगठनात्मक और सामाजिक परिप्रेक्ष्य" दोनों से सकारात्मक रूप से संबंधित है। . इसके अलावा, "तकनीकी और विशेषज्ञता परिप्रेक्ष्य" सकारात्मक रूप से "संगठनात्मक और सामाजिक परिप्रेक्ष्य" से संबंधित है। अध्ययन से प्राप्त परिणाम एचएससी में बीडी प्रथाओं को निष्पादित करने के लिए महत्वपूर्ण तैयारी बाधाओं को चुनने में कंपनियों की सहायता कर सकते हैं।

तीसरे चरण में, एचएससी में बीडी अपनाने की तत्परता बाधाओं के मूल्यांकन और प्राथमिकता के लिए एक सुसंगत और व्यवस्थित प्रक्रिया प्रदान करने के लिए फ़ज़ी विकोर दृष्टिकोण पर आधारित एक रूपरेखा का प्रस्ताव है। विश्लेषण दर्शाता है कि स्वास्थ्य डेटा की सुरक्षा और गोपनीयता (बी4) को सर्वोच्च स्थान दिया गया है और एचएससी में बीडी प्रथाओं की सफल पूर्ति के लिए सबसे महत्वपूर्ण तैयारी बाधा है। स्वास्थ्य प्रशासन समर्थन की कमी (बी ६) और डेटा मानकीकरण और एकीकरण (बी १२) की कमी को क्रमशः दूसरे और तीसरे स्थान पर रखा गया है। इस अध्ययन के परिणाम एक विशद तस्वीर प्रदान करते हैं जो संगठन को बीडी अपनाने के लिए प्रासंगिक तत्परता बाधाओं के महत्व को समझने और बेहतर रणनीति तैयार करने में सुविधा प्रदान करेगा।

चौथे और अंतिम चरण में, प्रमुख ड्राइवरों के आकलन और प्राथमिकता के लिए एक ढांचा स्थापित किया गया है जो संभावित व्यवधानों के खिलाफ एचएससी का समर्थन करेगा और स्थिरता में सुधार करेगा। साहित्य और विशेषज्ञों के सुझावों से 12 संभावित चालक स्थापित होते हैं। इसके अलावा, ड्राइवरों को प्राथमिकता देने के लिए (एमएमडीई) एल्गोरिथम के संयोजन के साथ अस्पष्ट डीमेटेल तकनीक लागू की जाती है। लागू फ़ज़ी डीमेटेल विश्लेषण ने चरों को दो समूहों में वर्गीकृत किया है, अर्थात्, कारण समूह और प्रभाव समूह, जैसा कि चित्र में दिखाया गया है। यह अध्ययन "स्वास्थ्य सेवा संगठनों के लिए विनियम", "स्वास्थ्य आपूर्ति श्रृंखला में हितधारकों के लिए स्वास्थ्य प्रोटोकॉल का विकास" को सबसे महत्वपूर्ण कारण समूह ड्राइवरों के रूप में पाता है, जबकि "बेहतर सेवाओं को सुनिश्चित करने के लिए संगठनों के बीच सहयोग" और "अंतर्राष्ट्रीय समर्थन और सूचना साझाकरण" हैं। सबसे प्रमुखता वाले ड्राइवर। इस अध्ययन के निष्कर्ष निर्णय लेने वालों के लिए महत्वपूर्ण ड्राइवरों पर ध्यान केंद्रित करते हुए बेहतर रणनीति विकसित करने के लिए उपयोगी हैं।

कुल मिलाकर, वर्तमान अध्ययन में एचएससी में बीडी अपनाने के लिए प्रासंगिक तैयारी बाधाओं की विस्तृत जांच शामिल है। साथ ही, इस अध्ययन में कोविड-19 के बीच एचएससी की स्थिरता से संबंधित ड्राइवरों को संबोधित किया गया है। इस अध्ययन में बीडी और एचएससी के विभिन्न पहलुओं के साथ लेन-देन करने के लिए विभिन्न तरीकों का इस्तेमाल किया गया है। अध्ययन साहित्य से स्थापित अंतराल को भरने के प्रयास में किया गया था और यह उन चिंताओं को दूर करने का भी प्रयास करता है जो उद्योग के लिए सबसे अधिक प्रासंगिक हैं।

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LIST OF ABBREVIATIONS

Abbreviations	Stands For
AMOS	Analysis of Moment Structures
BD	Big Data
BDA	Big Data Analytics
BDRM	Binary Direct Relationship Matrix
CFA	Confirmatory Factor Analysis
CITC	Corrected Item Total Correlation
COVID-19	Coronavirus disease 2019
DEMATEL	Decision-Making Trial and Evaluation Laboratory
DMs	Decision Makers'
EFA	Exploratory Factor Analysis
FDRM	Fuzzy Direct Relationship Matrix
FST	Fuzzy Set Theory
HSC	Healthcare Supply Chain
IoT	Internet of Things
ISM	Interpretive Structural Modelling
KMO	Kaiser-Meyer-Olkin
MCDM	Multi Criteria Decision Making
PCA	Principal Component Analysis
SCM	Supply Chain Management
SE	Standard Error
SEM	Structural Equation Modelling
SPSS	Statistical Package for Social Science
TISM	Total Interpretive Structure Modeling
VIKOR	Multi Criteria Optimization and Compromise Solution