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RISK PROPAGATION IN HEALTHCARE SUPPLY CHAIN: THE IMPLICATIONS OF FUZZY-ANP AND BAYESIAN INFERENCE

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Abstract: *Since the beginning of 2020, healthcare industry has been under constant pressure to maintain and provide best health related services to the public. Therefore, this study attempts to evaluate and measure the critical supply chain risks in the healthcare industry that troubled the flow of supply chain. For that purpose, a comprehensive list of critical risk factors has been developed that impact on the healthcare supply chain. Fuzzy analytical network processing gives a comprehensive list of risks probability based on expertsí judgment. Hereafter, Bayesian inference helps out to analyze the multi-echelon network with different risk bearing attitudes of healthcare professionalsí simultaneous propagation. The findings of risk prorogation help the professionals to evaluate the critical supply chain risks persist during covid-19 pandemic. Further, a proposed risk modeling gives an opportunity to achieve supply chain goals in terms of cost reduction, quality, and availability of equipment and drugs.*

Keywords: *Supply Chain Management, Risk Assessment, Fuzzy-ANP, Bayesian Inference*

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Introduction

In the supply chain, an unpredicted incident can happen as a result of risk which disturbs entire structure and functioning which have adverse consequences (Etges et al., 2019). The supply chain risks are not only confined to a specific state, production sector, province, or area (Kanyoma et al., 2013). However, it has become difficult to predict the form and structure of undetermined enlargements and their consequences because of escalating complications and interrelatedness among supply chain networks (Heckmann et al., 2015). With the passage of time significance for logistic chain risk management has noticeably increased and canít be neglected (Kanyoma et al., 2013). As a result of impediments and obstructions in the supply chain network sets a considerable number of demands such as; reducing costs, comparative edge, etc.

Numerous studies in various domains have been carried out on the subject of supply chain risk management but healthcare is one of the segments which need concentration and considerable notice (Etges et al., 2019). Health-related supply chain management (HCSCM) is quite distinctive and diverse from conventional supply chain management methods, as HCSCM controls a diverse variety of objects in extensively differing volumes (Abukhousa et al., 2014). The stock, types of equipment, and goods involved in the health-related supply chain segment are considered valuable, these goods need exceptional caution to prevent deterioration and impairment.

Risk in the medical care sector has adverse consequences on the whole system to at large extent, so managing risk is the foremost and necessary approach for minimizing expenditures as well for improvement of serviceís excellence. Correspondingly in supply chain management risk management should be accounted first in medical centers or in clinics because several sellers, dealers, and consumers are closely interconnected. Such circumstances can frequently increase risk in medical care supply chain management as interruption or distraction in one component possibly will have an effect on others. However, generally, the competence and ability of the logistical chain administration system can be determined by both the supply and the demand sides which is always unsure (C.S. Tang, 2006). In medical-care escalating risk in the supply chain network is very damaging especially when assets or capital are limited. But most corporations merely put attention towards the specified

division of supply chain management that is unpredictable (Stauffer, 2006).

It is essential to determine at what level these risks aspects influence the functioning of the health-related sector supply chain system as well to recognize the comparative significance of every risking component. Numerous studies have been conducted in the supply chain for the purpose of controlling and mitigating several kinds of risks that have adverse consequences on the overall system (Ho et al., 2015b). Basically, supply chain risk management practices are repetitive consists of the classification of risk factors, assessing risks, and mitigating those risks. It is concluded from available research that such supply chain practices were enclosed in those studies for managing and analyzing risks (Blackhurst et al., 2011; Meijboom et al., 2011). In the medical care supply chain system, unpredictability and riskiness still need to be examined. Moreover, still, no study has been conducted in which a detailed and systematic structure of managing and controlling risks or models for evaluation of integral functioning of the supply chain network in the medical care sector is discussed. Additionally, there is a need for identifying aspects of risks systematically and more studies are required.

In the proposed study these subject matters are discussed by adopting a systematic approach, for identifying type, aspects of risks in health-related supply chain management. For that reason, some of the following research questions arise in these areas:*RQ1*: Which risk factors are comparatively most significant in medical-care supply chain management operations?*RQ2*: How factors of risk are interrelated with each other?*RQ3*: In case of any disruption, what does afterward propagate risk throughout the supply chain?

Proceeding on this track and by considering previous studies, the basic purpose of this study is addressing immediate practicable requirements also to eliminate gaps in previous studies. The aim of the proposed study is to put forward unprecedented a complete structure also integral risk managing pattern by taking a definite examination of numerous categories of risk aspects for assistance in taking decisions. The different elements engaged with the medicinal services logistical chain arrange, for example, different streams (for example data, money, administration, material stream) and various partners (for example producers, providers, merchants, retailers, medical clinics, governments, and patients), are intertwined into an intricate framework, then again, logistical chain risk controlling is an expansive point that

envelops different angles from which to take a gander at supply chain procedure.

Literature Review

Management of Supply Chain in Healthcare

The entanglement of the upper organization in the logistical channel and its hugeness to the administrations gave to people in general are the issues that acquire the greatest thought by the analyst, solely as a result of the environmental impacts and the business models of the flexible chain in the maintainable change structure in the diverse field of the supply chain network like transportation, food, and the general business. The healthcare area has consistently required more consideration of their ability and the increasing costs. The majority of the emergency clinic logistical chains are utilizing customary models. The primary disappointments of these models are because of separation among the shirking and not consider revamping for the upgrade (Lopes et al., 2018).

In the other division's supply chain, the board methods are effectively received and applied yet the medical care area is as yet slacking in embracing the strategic idea (Moons et al., 2019). As of alliance, the clinic tasks underneath particular logistical channels are not just intended to expand the profitability of the emergency clinics yet additionally to deal with the hazard related to medicinal services. There is no uncertainty that the present medicinal services supply chain is progressively intricate, and it includes innovation, organizations, and union inside the flexible chain network (Mustaffa& Potter, 2009). Human services and clinic activities are conveying products and enterprises from numerous providers to patients with a wide scope of wellbeing necessities because of the requirement for medical clinics to give both arranged and crisis care (FÈnies et al., 2006).

For model, a few medications require unique temperature conditions for putting away and conveying. Moreover, a zero-deformity condition is important for the medicinal services conveyance procedure to patients. By and by, execution estimation and procedure upgrades have been demonstrated as the two fundamental ways to deal with improve medical clinic supply chain operational execution inside the social insurance sector (Trautmann et al., 2009). It is, in any case, significant for scientists and experts to completely comprehend the procedure required to profit by the picked strategies. In like manner, it is fundamental to be learned about the related issues characteristic in the administration conveyance forms and the logistical channel on the grounds that, in industries arrangement, quality, risks, and amount are intently

interrelated all of them (Chakraborty et al., 2014).

As a rule, in a medical logistical network change in occasions are immense and fast. It is crucial to create arrangements that enhance benefit by limiting dissipation while staying adaptable to fluctuating patterns in the medicinal services division (Mustaffa & Potter, 2009). The goal of this area is two-overlap. To start with, existing medical care supply chain management research work somewhere in the range of 2005 and 2020 is introduced. Second, an itemized survey is embraced related to research advancements in medicinal services logistical network administration.

Supply Chain Risk Management Process

As a rule, supply chain risk management includes four procedures that incorporate recognizable proof, appraisal, and controlling and checking of logistical chain risks (Sarac et al., 2010). The complexities of some flexible affixes make it hard to apply these procedures in getting ready for all consequences (Tayur et al., 2012). Tummala & Schoenherr, (2011) extended the past examinations dependent on the organized risks management procedures (RMP), comprising of the accompanying five stages: chance components recognizable proof, chance estimation, chance appraisal, chance assessment, and hazard control and observing. They additionally separated further investigations directed by (Ellegaard, 2008), (Finch, 2004), and (Manuj & Mentzer, 2008) who proposed a methodology comprising of a changed RMP to distinguish, evaluate, and oversee gracefully chain dangers. The last altered methodology is an SCRM procedure including three stages, which are chance distinguishing proof, hazard estimation, and hazard appraisal in Phase I; chance assessment, chance alleviation, and emergency courses of action in Phase II; and hazard control and observing in Phase III. This methodology gives an establishment of the SCRM procedure structure for gracefully chain directors for key dynamics, considering the diverse flexibly chain hazard profiles related to a given circumstance.

All the more explicitly, different procedures make up the procedure of hazard the board in the graceful chain. The procedure of hazard the executives, as a rule, starts with recognizing inside and outer variables in the logistical chain condition (Walker et al., 2008). For instance, in the assembling business, a few enterprises are confronted with climatic hazards, for example, extreme climate, while others experience the danger of the significant expense of moving products (Ali et al., 2020). Associations can distinguish their

flexible chain dangers by planning the graceful chain. Flexible chain planning additionally encourages an association to organize different dangers and address them viably. By and large, the beginning stage in gracefully chain planning is the item or administration that can enormously influence an organization or association's profitability (Mollenkopf et al., 2010). In the wake of seeing how to distinguish risk types, factors, or both, the following stages include a chance appraisal. The procedure includes organizing dangers as per the danger they posture to the prosperity of a business. Hazard appraisal is related to the event of the trigger occasion and the seriousness of the outcomes (Harland et al., 2003). After distinguishing proof and evaluation of the risk, the subsequent stage involves contriving hazard treatment plans. Now, it is essential to devise gauges that can shield the graceful chain from dangers, making intends to react to occasions that might be brought about by the recognized dangers and creating plans to help proceed with tasks on account of interruptions.

At last, the procedure can likewise involve deciding measurements and methods of estimating hazard and the viability of different plans set up to relieve chance (Fawcett & Waller, 2014). By breaking down the information dependent on the inspected articles, the vast majority of the investigations were centered on chance moderation movement. This demonstrated the relative development phase of specialists in supply chain risk management. The RMP isn't finished without checking and audit. Possibility or risk checking can be characterized as observing advancements in the supply chain that may increment or reduce dangers on a progressing premise. The four fundamental standards of SCRM incorporate initiative, administration, the board of progress, and the improvement of a business case (Carter & Rogers, 2008). Observing and survey not just involves checking the viability of hazard the executive's practice yet, in addition, keeping up different designs to meet changes in procedures and providers and the guideline of whatever other components that impact the graceful chain (Walker et al., 2008). Fewer spotlights have been focused on the last phase of the SCRM procedure, chance checking, which implants hazard the executives into the everyday practices of associations. As appeared in Figure 2.3, numerous articles contemplated a particular or individual SCRM process, while a couple of specialists considered comprehensive RMPs.

Supply Chain Risk Sources Identification

As a dynamic help device, the expository pecking order process (AHP) strategy has been applied by a few scientists. It can bolster chiefs in setting up a need chain of importance of hazard the executives. Gaudenzi & Borghesi, (2006) proposed the AHP technique to distinguish supply chain probability components with the end goal of improving the goal of client esteem. Be that as it may, the confinement of the examination is the attention on the single central organization; along these lines, the hazard markers would not be appropriate to different enterprises. Other than this, the accompanying methodologies can help in the distinguishing proof of potential gracefully chain dangers: flexibly chain planning, agendas or check sheets, occasion tree examination, deficiency tree investigation, Ishikawa circumstances and logical results investigation (V. M. R. Tummala et al., 1994), and disappointment mode and impact investigation (FMEA) (Tuncel & Alpan, 2010). As per Adhitya et al, (2009), the peril and operability examination technique from synthetic procedure risk management has been utilized for chance components distinguishing proof and result from analysis. Mauricio F. Blos et al, (2009) recognized the supply chain risks in the car and electronic businesses in Brazil by actualizing a flexible chain weakness map. The downside of their investigation originates from the little example size. A fishbone outline has been utilized as a productive strategy to identify and outwardly portray the likely reasons for basic issues in the flexible chain (Desai et al., 2015). Four classifications of potential impacts have been inspected in their examination, for example, surrenders, deferrals, fakes, and general mistakes. In any case, the absence of a contextual investigation is the fundamental downside for this exploration.

An expanding number of hazard evaluation techniques have been created over the most recent two decades, particularly for flexibly chance appraisal (Ho et al., 2015b). Procedures, for example, the Delphi technique, master center gatherings, five-point estimation, or Monte Carlo reproduction can help in the evaluation of the probabilities of the dangers. There is a lot of examination considers concentrated on the monetary hazard appraisal in the flexible chain. Incentive in danger and contingent incentives in danger are regular techniques that have been utilized in portfolio hypothesis as percentile proportions of drawback chance related to bothersome results (F. Y. Chen & Yano, 2010; Hahn & Kuhn, 2012; Sawik, 2013; Soleimani & Govindan, 2014). Besides, change or standard deviations are to a great extent utilized

as a proportion of gracefully chain money related dangers as well (Babazadeh & Razmi, 2012; Hahn & Kuhn, 2012).

In any case, a few articles contended that deviation-based measures are hazardous proportions of hazard all in all (Majid et al. 2020). Cigolini & Rossi, (2010) conducted a deficiency tree strategy to survey the operational hazard at three phases of the oil gracefully chain (boring, essential vehicle, and refining). The constraint of the examination is overlooking operational hazard evaluation at other significant stages like structure, development, and redistributing. Wagner and Neshat (2010) applied chart hypothesis to change over the 'fluffy' development of logistical network weakness to a list (the SCVI). They uncovered that diagrams can be utilized as visual guides that encourage the comprehension of flexibly chain weakness and bolster dynamic in SCRM. Nonetheless, the proposed approach vigorously relies upon the master decisions and accessibility of information that evaluates the drivers of SCV.

Ruiz-Torres et al (2013) proposed the model to use the choice tree way to deal with consider the conceivable circumstance in which at least one provider falls flat and creates alternate courses of action. Nonetheless, the exploration didn't consider the dynamic qualities of the graceful chain system, and all the information boundaries and provider attributes were viewed as deterministic. Kumar et al. (2010) applied the artificial bee colony procedure, genetic calculations, and molecule swarm streamlining to distinguish operational risk factors, their normal worth, the likelihood of an event, and the related extra expense. In any case, they are not without restrictions, as they just centered on a solitary item supply chain a arrangement. Tummala & Schoenherr (2011) suggested the risk control hierarchy (HTP) investigation for the precise assessment of flexibly chain dangers, incorporating the hazard evaluation parts of their seriousness, likelihood, and cost.

Ramkumar (2016) proposed a risk evaluation philosophy for in-house and outsider kind of e-acquirement execution dependent on an adjusted scientific system process (ANP) combined with fluffy derivation frameworks. They researched the mechanical usage dangers, which are seen as higher for both in-house and third-party e-acquisition frameworks. Be that as it may, the over two strategies are additionally for the most part contingent upon the suspicion and abstract nature of the rankings and assessments.

Additionally, there is a significant number of quantitative strategies that have been comprehensively proposed for the hazard evaluation, for example, multi criteria dynamic and AHP approaches (Abdel-Basset et al., 2019; Chen et al., 2014; Guersola et al., 2018; Kamath et al., 2012; Anil Kumar et al., 2019; Li et al., 2016; Lin and Ho, 2014; Wang et al., 2012), MRP-DRP stochastic demonstrating (Bogataj & Bogataj, 2007), fuzzy TOPSIS (Chatterjee & Kar, 2016), BNs (Badurdeen et al., 2014), adjusted FMEA technique (P.- S. Chen & Wu, 2013) and various leveled holographic modeling (Kazemzadeh et al., 2012). Clearly, there is an enormous assemblage of writing on chance evaluation concentrated on the need for risk factors. It is likewise important to recognize cause-impact relations between each risk factor as far as their immediate and circuitous impact in the system. Henceforth, approaches, for example, interpretive auxiliary displaying (ISM) or dynamic preliminary and assessment research facility can be utilized to introduce a various leveled model indicating the interrelationships between the risk sources (Govindan & Chaudhuri, 2016). The fundamental downside of those methodologies is the absence of capacity to manage the mind-boggling framework, while just thinking about a set number of factors in the advancement of the model.

Research Methodology

This proposed study peruses ëdeductive exploration methodí utilizing information triangulating both subjective along with quantitative examination techniques. The exploration chiefly expects to build up a thorough structure and a coordinated hazard the board model for distinguishing and surveying the hazard factors in emergency clinics gracefully chains. Thus, the exact examination was picked to improve the comprehension of this intricate human services distribution channel framework and to help the analyst just as specialists hold an inside and out an investigation of this genuine circumstance. Detailing of experimental inside and out examinations on dealing with the medication logistical network linked risk in the emergency clinic setting is fairly scant in academic work. Along these lines, the experimental investigations were led in Pakistan medicinal services businesses and information was gathered by means of checking on writing editorial, formal records and other distributed information, equivocal perceptions, a progression of meetings from industry specialists, professionals just as scholastics those has authentic information and knowledge of administration risk, and poll studies.

The surveys were preliminary tried, through outcomes have utilized to adjust the substance. Likewise, the polls were conveyed by means of either email with an introductory letter and substance structure to the focused on specialists. The member specialists, for example, Head of Acquirement, Executive of Emergency clinic, Stock Administrator, senior supervisor in Pharmaceutical Organization, Boss Drug store Obtainment IT Director, Head of the logistical channel and Web-based business and academicians with industry experience are the proficient people who can give the important remarks to all parts of the review. The significant writing audit was utilized as a base to recognize hazard sources. A risk factor poll review and semi-organized meetings with member specialists from both scholastic and modern fields were directed to approve the distinguished peril factors. Also, a progression of email and eye to eye interviews were dispersed and directed to additionally investigate the propriety of the created pecking order model where the recognized hazard factors were summed up. To survey the hazard factors, it is basic to quantify the dangers by deciding their need weighting and assessing their proliferation. Other survey reviews (named as risk appraisal overview) were directed and examined by utilizing ìFuzzy analytical network process (ANP) also by Bayesian Belief Networks (BBN).

Data Analysis Methods

The information gathered in the past segments is disclosed and dissected before being utilized in different phases of the exploration. Some particular strategies and procedures are required to examine gathered information so as to create excellent outcomes. In this proposal, Fuzzy ANP and BBN have been utilized to dissect the review results from poll B and C individually. To guarantee the unwavering quality and consistency of the assembled information, a progression of tests (for example factual test, consistency check, and affectability investigation) ought to be directed preceding doing the assessment of hazard factors and their proliferation.

In this study, a sample of experts is considered to participate in the survey. As this study is exploratory so the questionnaire survey conducts with 30 experts from the healthcare sector to address concerned risk-related events. For this study sample size is considered acceptable because a small sample size (which is less than 10) is necessary if the data is collected from the experts (Wang, 2018). In the meantime, the group of experts from an extensive multiplicity of specialized with capability from the dissimilar practical set, for example, healthcare supply

chain manager, stock management, and pharmaceutical managers those have experience of 15-25 years. In this research first of all a simple questionnaire is used based on i and j where i= yes, j=, no which risk is relevant to the healthcare supply chain management and those risk has the weightage above 60% are selected for the further hierarchy model matrix.

Different experts have a different impact on the final decision and results, so assessment weightage benchmarks have been established and assign to each expert based on their qualifications, experience, and job position.

Table 1: Provides a Clear Image of Weight Assign to Expert

Explanation	Keyword	Weightage
Those experts have rich experience in pharmaceutical supply chain management and always held a top position in pharmaceutical logistic activities.	Extremely appropriate	40%-45%
Those experts have at least 15 yearsí experience in pharmaceutical supply chain management.	Fairly appropriate	20%-30%
Those experts have done at least 15 yearsí experience in supply chain management but having 5-7 yearsí experience in other than pharmaceutical supply chain management.	Appropriate	5%-15%
Those have no experience or knowledge in pharmaceutical supply chain management	Inappropriate	0

From the literature review identify risks as shown in table no.4.2 gives a comprehensive list of risks after removing the common risk factors. That list of risk factors was sorted with the help of experts. The result table is shown below,

Table 2: Shows That Risk Which is related to Healthcare Supply Chain Management

No.	Name of Risk	Total Responses	Percentage	Mean
1	Demand Risks	27	90.0	0.90
2	Safety/Security Risk	27	90.0	0.90
3	Delay Risks	26	86.7	0.87
4	System Risks	26	86.7	0.87
5	Transportation Risks	26	86.7	0.87
6	Strategic Risks	26	86.7	0.87
7	Operational Risks	26	86.7	0.87
8	Skill/Performance Risks	26	86.7	0.87
9	Poor Management Risks	26	86.7	0.87
10	Supply Capacity Risks	26	86.7	0.87

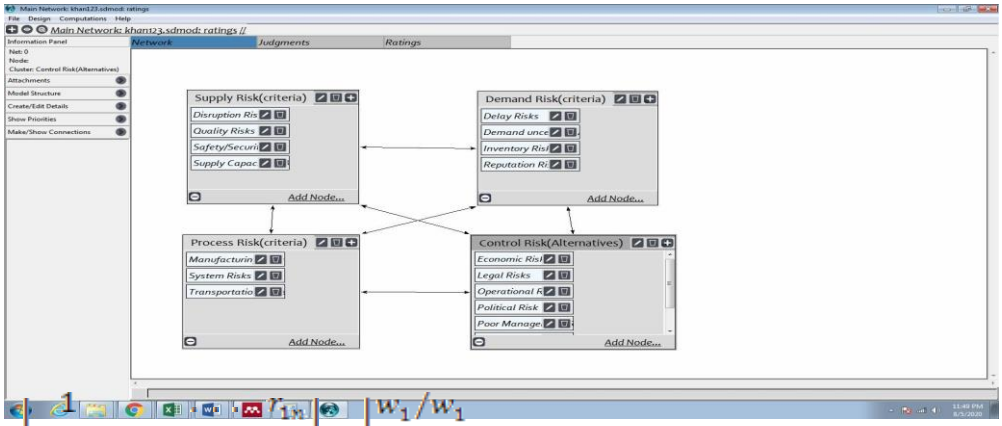
11	Disruption Risks	25	83.3	0.83
12	Inventory Risks	25	83.3	0.83
13	Manufacturing (process) breakdown Risks	25	83.3	0.83
14	Political Risk	23	76.7	0.77
15	Economic Risks	23	76.7	0.77
16	Reputation Risks	22	73.3	0.73
17	Legal Risks	21	70.0	0.70
18	Quality Risks	20	66.7	0.67
19	Supply (procurement) Risks	13	43.3	0.43
20	Culture Risks	12	40.0	0.40
21	Social Risks	10	33.3	0.33
22	Industrial Risks	9	30.0	0.30
23	Sovereign Risks	8	26.7	0.27
24	Distortion Risks	8	26.7	0.27
25	Product Design Risks	6	20.0	0.20
26	Information Risks	6	20.0	0.20
27	Financial Risks	5	16.7	0.17
28	Tactical Risk	5	16.7	0.17

The above table shows the risk which is more relevant to the healthcare supply chain management. Those risk having less than 50% percent weightage are reject and those have the weightage above 50% are selected for the future process which is a hierarchy by using ANP for that purpose we used super decision software.

Building an Analytical Network Processing

The ANP model is working after defining the cluster and nodes from the item that define the problem. The risk priority table is developed using analytical network processing. Pair-wise assessment between clusters and nodes. A hypercritical practice starts with mathematical assessment between the nodes (risk Element) and cluster (parents Risk) of the network model. A 9 point assessment gage for comparative pair wise contrast with random crisp values is assumed counter to a linguistic scale to find the likelihood of risk occurrence, where 9 means ìextremely more likely" and 1 means ìequally as likely as"

Figure 1: Shows the Connection Between the Nodes and Clusters in the Super Decision Software.



Aggregation rule of the geometric mean is used to consolidate the experts opinion in a square matrix. In the criterion matrix, each node and cluster judgment reflects the domain relative to another node and cluster in the same matrix. The conditional importance weight carried out by pairwise comparison. For the comparisons

$$\mathbf{R} = \begin{vmatrix} 1 & r_{12} & r_{1n} \\ 1/r_{12} & 1 & r_{2n} \\ 1/r_{1n} & 1/r_{2n} & 1 \end{vmatrix} \quad \begin{vmatrix} w_1/w_1 & w_1/w_2 & w_1/w_n \\ w_2/w_1 & w_2/w_2 & w_1/w_n \\ w_m/w_1 & w_m/w_2 & w_m/w_n \end{vmatrix} \qquad (1)$$

matrix, these are the general form of the equations. Where R= (r_{ij}) for the ranking of supply chain risk alternative in the comparison matrix. Where r_{ij} is value of *i*-alternative with respect to *j*-criterion, *i*=1, 2, 3,.... , n , *j*=1, 2 ,3, ,m. The set of weights gives relative importance to each criterion. Where W= ($w_1, w_2, \ldots ,w_n$), and its sum is equal to 1.

The normalized vector originates the priority value of each attribute. The obtain the normalized weight, the weight (*w*) of each pair wise comparison matrix of a column or row is divided by the sum of each column and row $\sum_{j=1}^{n} = \overline{wi}$. The tendency of risk depends on the value of the weight w_i so it shows that higher the weight higher risk and vice versa. The cumulative weight of $\overline{w} = (\overline{w1}, \overline{w2}, \ldots, \overline{wn})$ is normalized by w_i derived weight

$$.w_i = \frac{\overline{w_i}}{\sum_{i=1}^{n} \overline{w_i}} \qquad (2)$$

$$w_i = \sum_{j=1}^{n} a\,ij\,,$$

Where *i*= 1, 2, 3, Ö,m and *j*= 1, 2, 3, Ö., n.

The inconsistency ratios (1-10%) for the nodes and clusters on priority. To

calculate the risk probability associated with the each node risk probability index (RPI) formula were used, and its value remain from 0 to 1.

$$RPI = {}^{w_i}/_{\sum w_i}$$

Where w_i shows the risk probability weight and sum of weightage of risk probability $\sum w_i$.

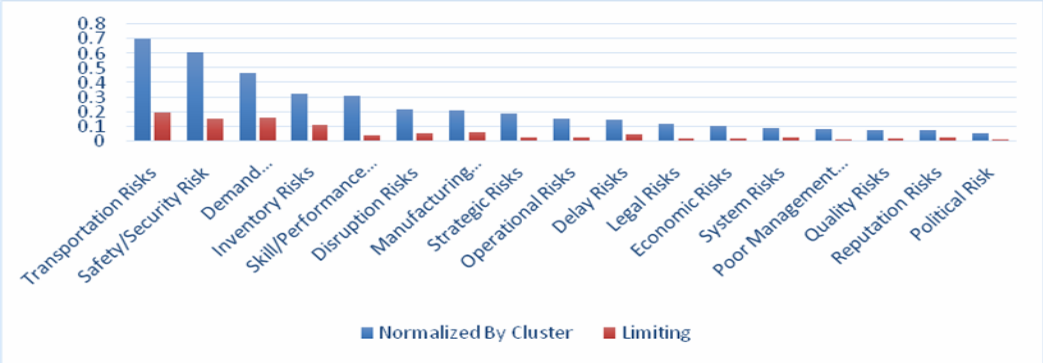
According to Saaty & Vargas (2013) recommended value inconsistency for the priority scale in nodes and clusters strictly kept between (1-10%). As in the super decision software in the inconsistency ratio remain <10% as seen below (Afzal et al., 2019).

Table 3: ANP Weights of Likelihood

Health Care Supply Chain Risks	WNBC	WNBL
Transportation Risks	0.70185	0.196099
Safety/Security Risk	0.60803	0.152441
Demand uncertainty Risks	0.462	0.156319
Inventory Risks	0.32309	0.109316
Skill/Performance Risks	0.30971	0.040737
Disruption Risks	0.2138	0.053603
Manufacturing (process) breakdown Risks	0.20723	0.057902
Strategic Risks	0.18506	0.024342
Operational Risks	0.15316	0.020146
Delay Risks	0.14226	0.048132
Legal Risks	0.11713	0.015406
Economic Risks	0.09911	0.013036
System Risks	0.09092	0.025402
Poor Management Risks	0.08047	0.010585
Quality Risks	0.07642	0.01916
Reputation Risks	0.07266	0.024583
Political Risk	0.05536	0.007282

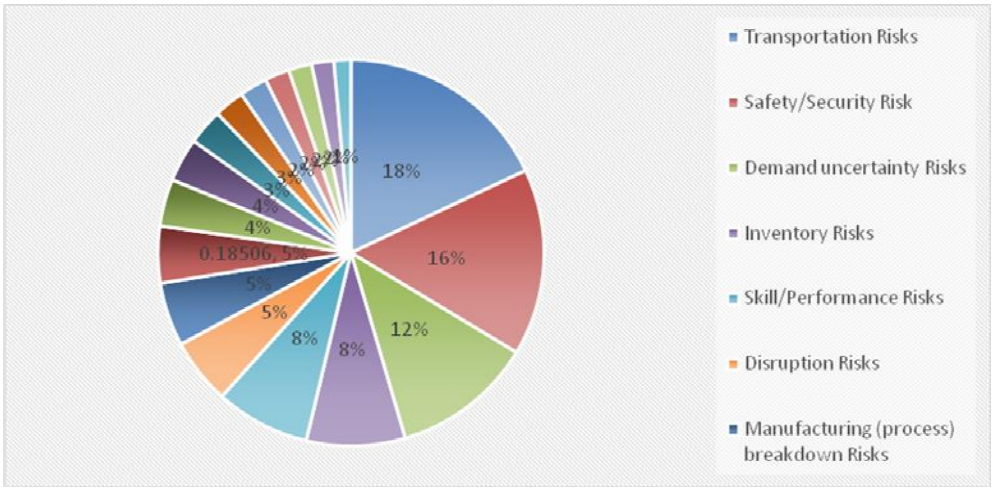
Where NWBC= Normalized Weight By Cluster, NWBN= Normalized Weight By Likelihood

Figure 2: important risk in the sense of the likelihood of occurrence.



The above bar chart shows the clear image of the most important risk in the sense of the likelihood of occurrence.

Figure 3: Shows the Most Important Risk in the Pie Chart in the Sense of the Likelihood of Occurrence.



From the above table the show that the most important risk in healthcare supply chain management on the base of the analytical networks process in the sense of likelihood. To get the actual probability of occurrence of risks there was a need for the value of risk consequences. So repeat the same function in the sense of consequences of risk in the super decision software and the results are shown below.

Table 4: Shows the Most Important Risk According to Consequences

Health Care Supply Chain Risks	NWBC
Transportation Risks	0.197
Safety/Security Risk	0.158

Demand uncertainty Risks	0.153
Inventory Risks	0.107
Skill/Performance Risks	0.059
Disruption Risks	0.055
Manufacturing (process) breakdown Risks	0.047
Strategic Risks	0.041
Operational Risks	0.024
Delay Risks	0.026
Legal Risks	0.025
Economic Risks	0.020
System Risks	0.018
Poor Management Risks	0.016
Quality Risks	0.014
Reputation Risks	0.010
Political Risk	0.008

Where NWBC= Normalized Weight By Consequence

After getting the result values are converted into Trapezoidal fuzzy numbers for better results.

Fuzzy Analytical Networks Process

Fuzzy Analytical network process (FANP) most complex and advance multi-criteria-technique. The analytical network process supports feedback and modeling dependencies between the network elements. Due to this feature analytical network process is one of the most suitable technique in the field of decision making because it has the features to examine the remaining dependencies between the lower-level element to high-level element (Kadoi,„ Divjak, & Begičevi,„Ređep, 2019). The analytical hierarchy process helps as an initial point of analytical network programming. The analytical hierarchy process shows the indicator of reliability through the contingency ratio. For consistency judgment, the ratio will be less than 0.1 (Moons et al., 2019).

Table 5: Value of Trapoziodal Fuzzy Number

Trapoziodal Fuzzy Numbers				
0.196	0.17	0.18	0.19	0.2
0.156	0.15	0.16	0.17	0.18
0.109	0.1	0.11	0.12	0.13
0.058	0.05	0.06	0.07	0.08
0.048	0.048	0.049	0.05	0.051
0.025	0.024	0.025	0.026	0.027
0.020	0.02	0.021	0.022	0.023
0.019	0.019	0.02	0.021	0.022
0.015	0.015	0.016	0.017	0.018
0.013	0.013	0.014	0.015	0.016
0.011	0.01	0.011	0.012	0.013
0.007	0.007	0.008	0.009	0.01

Figure 4: The Membership Functions of the Triangular Fuzzy Numbers

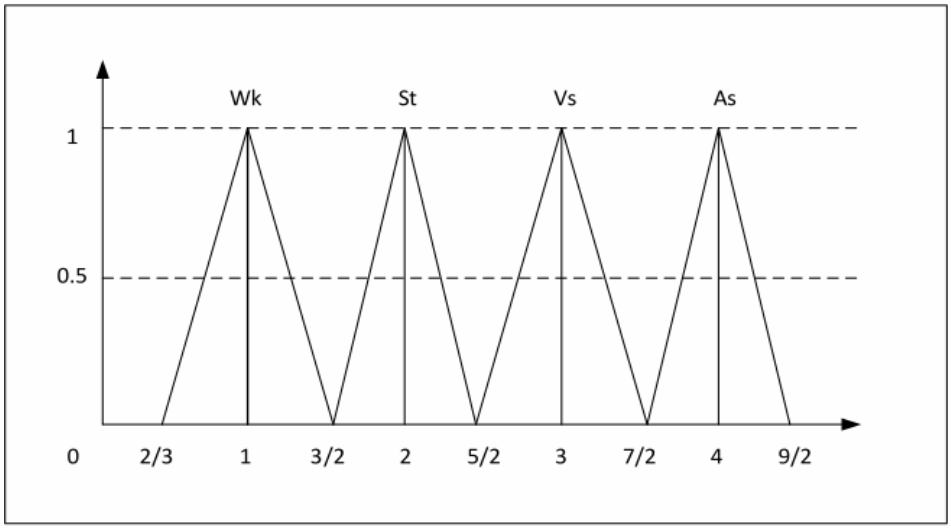


Figure 4: The Membership Functions of the Triangular Fuzzy Numbers After converting the values in Trapozidal fuzzy number the results table is shown below,

Table.6: Shows the More Appropriate Results of Risk in the Sense of the Likelihood

Name of the Risk	NWL	Trapoziodal Fuzzy Numbers				Total Weightage
Transportation Risks	0.196099	0.17	0.18	0.19	0.2	0.185
Safety/Security Risk	0.156319	0.15	0.16	0.17	0.18	0.165
Demand uncertainty Risks	0.152441	0.15	0.16	0.17	0.18	0.165
Inventory Risks	0.109316	0.1	0.11	0.12	0.13	0.115
Skill/Performance Risks	0.057902	0.05	0.06	0.07	0.08	0.065
Disruption Risks	0.053603	0.05	0.06	0.07	0.08	0.065
Manufacturing (process) breakdown Risks	0.048132	0.048	0.049	0.05	0.051	0.0495
Strategic Risks	0.040737	0.048	0.049	0.05	0.051	0.0495
Operational Risks	0.025402	0.024	0.025	0.026	0.027	0.0255
Delay Risks	0.024583	0.024	0.025	0.026	0.027	0.0255
Legal Risks	0.024342	0.024	0.025	0.026	0.027	0.0255
Economic Risks	0.020146	0.02	0.021	0.022	0.023	0.0215
System Risks	0.01916	0.019	0.02	0.021	0.022	0.0205
Poor Management Risks	0.015406	0.015	0.016	0.017	0.018	0.0165
Quality Risks	0.013036	0.013	0.014	0.015	0.016	0.0145
Reputation Risks	0.010585	0.01	0.011	0.012	0.013	0.0115
Political Risk	0.007282	0.007	0.008	0.009	0.01	0.0085

Table 7: Shows the More Appropriate Results of Risk in the Sense of the Consequence

Name of the Risk	NWC	Trapoziodal Fuzzy Numbers				Total Weightage
Transportation Risks	0.197	0.17	0.18	0.19	0.2	0.185
Safety/Security Risk	0.158	0.15	0.16	0.17	0.18	0.165
Demand uncertainty Risks	0.153	0.15	0.16	0.17	0.18	0.165
Inventory Risks	0.107	0.1	0.11	0.12	0.13	0.115
Skill/Performance Risks	0.059	0.05	0.06	0.07	0.08	0.065
Disruption Risks	0.055	0.05	0.06	0.07	0.08	0.065
Manufacturing (process) breakdown Risks	0.047	0.048	0.049	0.05	0.051	0.0495
Strategic Risks	0.041	0.048	0.049	0.05	0.051	0.0495
Operational Risks	0.024	0.024	0.025	0.026	0.027	0.0255

Delay Risks	0.026	0.024	0.025	0.026	0.027	0.0255
Legal Risks	0.025	0.024	0.025	0.026	0.027	0.0255
Economic Risks	0.020	0.02	0.021	0.022	0.023	0.0215
System Risks	0.018	0.019	0.02	0.021	0.022	0.0205
Poor Management Risks	0.016	0.015	0.016	0.017	0.018	0.0165
Quality Risks	0.014	0.013	0.014	0.015	0.016	0.0145
Reputation Risks	0.010	0.01	0.011	0.012	0.013	0.0115
Political Risk	0.008	0.007	0.008	0.009	0.01	0.0085

Table 8: Shows the Risk Probability and Risk Probability Index

TFWL	TFWC	Risk Probability	RPI
0.185	0.185	0.185	0.179874
0.165	0.165	0.165	0.160428
0.165	0.165	0.165	0.160428
0.115	0.115	0.115	0.111813
0.065	0.065	0.065	0.063199
0.065	0.065	0.065	0.063199
0.0495	0.0495	0.0495	0.048128
0.0495	0.0495	0.0495	0.048128
0.0255	0.0255	0.0255	0.024793
0.0255	0.0255	0.0255	0.024793
0.0255	0.0255	0.0255	0.024793
0.0215	0.0215	0.0215	0.020904
0.0205	0.0205	0.0205	0.019932
0.0165	0.0165	0.0165	0.016043
0.0145	0.0145	0.0145	0.014098
0.0115	0.0115	0.0115	0.011181
0.0085	0.0085	0.0085	0.008264

Where TFWL= Total Fuzzy Weightage of Likelihood, TFWC= Total Fuzzy Weightage of Consequences, and RPI=Risk Probability Index. The above table shows the clear image of risk probability. As the aim of the study now risk propagation was made on the Hug In Software on the base of BBN.

Bayesian Belief Network

Bayesian belief is centered on the supposed that scholar grip opinions in convinced actions certain our preceding acquaintance on them. If further events happen, though, scholar tends to modification our preliminary opinions of the similar measures. Many Bayesian

belief theories are created based on the belief of provisional probability. If scholar supposes∑ characterizes the entire of our preceding information, then scholar can make a practical assumption on likelihoods that interpretation for latest information which turns into accessible to research. Bayesian belief system influence theory on likelihoods by take advantage of uncertain likelihoods in addition to a thought known as conditional independence. An additional reputation to the Bayesian belief network is the thought of probabilistic learning and supposition. Interpretation denotes the reality that scholars have preceding theories of the world around us organized in the arrangement of a Bayesian belief network. When a scholar assumes that a specific event in our system has happened, scholar essentially brings up-to-date every opinion with the purpose of reliance on an event which scholar presumed to happen; this leads to a subsequent certainty. Erudition on the other side includes permanently bring up-to-date our belief network once scholars have essentially experiential an event occurs (Ojha et al., 2018; Rodgers & Oppenheim, 2019; Wan et al., 2019). Bayesian belief networks typically characterize the combined likelihood distribution purpose of all the variables in the system as a creation of the minor conditional likelihood distributions of each variable by manipulating the extension rule:

$$P(X|\sum) = \sum i=1\ P(X|Y = yi, \sum)P(Y = yi|\sum) \quad (3)$$

Conditional independence

The concept of uncertain independence necessity is a properly definite meanwhile the Bayesian belief network depends on it. If scholar undertake that related information ∑, scholars are able to frequently determine whether two events are probably dependent or independent. Assume scholar has two events, A1 and A2 around which scholar recognizes the light of their dependence to each other. Now assume for the instant that scholar detected a third event, A3, by means of which scholar can now achieve the primary two proceedings as free. This is acknowledged as conditional independence, further properly:

$$P(A1, A2|A3, \sum) = P(A1|A3, \sum)\ P(A2|A3, \sum) \quad (4)$$

A corresponding and additional convenient expression would be:

$$P(A1|A2, A3, \sum) = P(A1|A3, \sum) \quad (5)$$

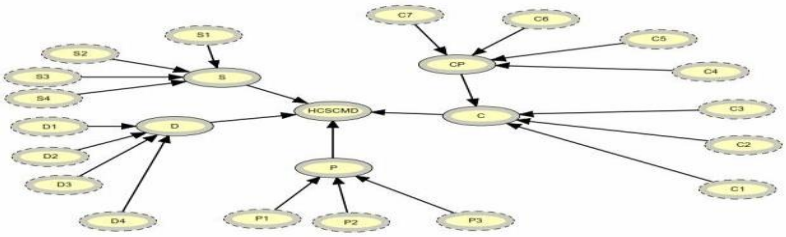
In the graphical Bayesian belief system, the theory of departing would subsist, mentioned in direction to regulate the conditional independence relations among nodes. (Garvey et al., 2015). To get the probability of propagation Hugin

Lite 8.9 software was used. After getting the Risk probability and go to the propagation risk tolerance calculation is used on the base of the risk pessimistic, most likely, and optimistic.

Risk Management and Bayesian Networks

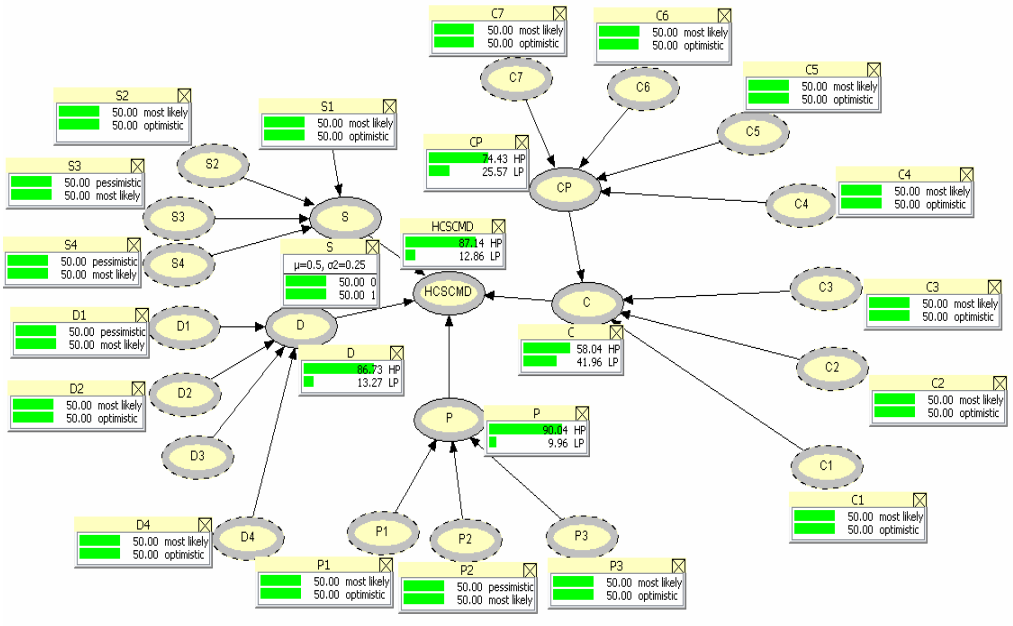
Networks of Bayesian have been in survival for over dual spans here and now, numerous areas of learning had adopted them mostly to the model of risk and information. Furthermost fundamental classification, this network is intended for graphical representation of an additional wide-ranging likelihood dependence construct in which nodes characterize causal variables and intended for boundaries that characterize the fundamental associations between variables (Qazi et al., 2018). Characteristically, Bayesian networks are made up of two prime mechanisms: the particular fundamental associations determined moreover by specialist judgment and the unbiased conditional probability deliveries. Although the usages of the Bayesian network in further fields of learning inside the business have succeeded concerning risks, supply chain management has only got a limited such framework anticipated. In supply chain management, numerous models have been proposed using Bayesian networks. Nevertheless, specifically within the supply chain network, the risk at the position, dependencies, propagation, and ultimate consequences short of studies have appeared. Researchers established a framework of risk by Bayesian network where the variables further down contemplation were risk types (Lockamy & McCormack, 2012). But this is unsuccessful how to utilize such frameworks in circumstances based and systematic examination over and above their risk proliferation. Moreover, existing studies have made an effort to make a foundation for possibility study within supply chain networks by means of the Bayesian network in which two categories of nodes, logistics and production nodes, were being adopted to revise risks. Though, in the interior individually of these sorts of nodes, they modeled risk by splitting the Bayesian network intended for every node. The prime problem in that frame of work is, it is not adequate in judiciously explaining convinced expectations that looked-for chosen ended as well as trials that were general and flexible for prospect application (Garvey et al., 2015).

Figure 5



where HCSCMD= Healthcare Supply Chain Management Disruption, S= Supply Risk (parent node), D=Demand Risk(parent node), P=Process Risk (parent node) C= Control Risk(parent node 1), CP= Control risk(parent node2), S1=Quality Risks, S2=Supply Capacity Risks, S3=Disruption Risks, S4= Safety/Security Risk, D1= Demand uncertainty Risks, D2=Inventory Risks, D3=Delay Risks, D4=Reputation Risks, P1=System Risks, P2=Transportation Risks, P3=Manufacturing (process) breakdown Risks, C1=Strategic Risks, C2=Skill/Performance Risks, C3=Poor Management Risks, C4=Operational Risks, C5=Economic Risks, C6=Political Risk, C7=Legal Risks

Figure 6: Shows the Propagation Weightage with the Risk Tolerances Weight



Conclusion and Recommendation

From the literature review and analysis give a clear image of risks their propagation. During the literature review, it is clear healthcare supply chain risk management failed to gain the intention of the researcher. Most of the healthcare sectors still used the basic supply chain model. Some of the developed countries doing some research to enhance it but that still needs more intention. This study gives a comprehensive list of risks that are related to healthcare supply chain management. The Healthcare supply chain is different from other sectors' supply chain because its end-user has no purchasing selection power, it depends on its consultant or any healthcare-related professional.This study helps the manager to understand the most important risk and their probability weightage and also their propagation weight which risk is propagated to another and their propagation probability weight.

Risk factor identification, risk assessment, and their propagation, although narrow thoughtfulness in the direction of organized risk factor identification healthcare supply chain. To address these gaps, the research question was made. *RQ1*was related to the comprehensive list of risk factors that are related to the healthcare supply chain management. With the help of experts panel and literature on the supply chain, a common list of risk factors provides them and asks to select the risks which are related to healthcare supply chain management. For better results, the selection criteria were made (risk selected for further study must be equal to greater than 50% weightage). Results give a comprehensive list of risk factors in table no. (4.2) that are related to the health care supply chain management. *RQ2* concerns which risk is more important than others. For that purpose, MCDM technique, ANP is used with Fuzzy numbers. This technique gives the most important risk with their probability in healthcare supply chain management Transportation, and Safety/security has the maximum probability as shown in Table 4.8. *RQ3* related to which risks are propagated to others are create the distribution to the overall healthcare supply chain and which probability. HugIn Expert software used to check the risk propagation on two-state that risk propagates to that risk or not with their probability of maximum and minimum. Results show in fig (4.5), for example from the results it is clear D node, C node, and p node effect more in overall healthcare supply chain management.

Contribution of Research

The study contributes to the existing literature review in the healthcare supply chain, by providing a

comprehensive list of risk factors that are related to the healthcare supply chain with their importance and propagation on each other which may cause the disturbance in whole healthcare supply chain management. First of all, this research identifies the risk from the literature review and shortlist that factors which are more related to healthcare supply chain management. To get the most important risk and their probability FANP techniques were used. Completing the previous step this study gives the propagation of risks in the healthcare supply chain on the base of the theory BBN. This is briefly explained in the analysis chapter.

Managerial Application

This study helps the manager to view the most important risk and their propagation towards the disturbance in the healthcare supply chain disturbance. This helps a lot at the time of making risk mitigation strategies. This study provides the current situation of risks in healthcare supply chain management. Although this study helps the managers to handle the most potential risk and gives a clear view during the construction of mitigation strategies. By controlling the risk managers can enhance the supply chain management and also minimize the cost and time in the healthcare sectors.

Future Recommendation and Limitations

In the healthcare sector supply chain has two domains, inside the healthcare and outside the healthcare supply chain. This study analyses the risk factors which affect the outside healthcare supply chain management due to the lack of research done in this sector. First of all, research has to understand factors of supply chain inside the healthcare for example inside the healthcare drugs are store in one place and deliver to the required place at the required time.

In this study risk factors are taken from the literature review, some of the risk factors will be selected after taking a thorough interview from the supply chain and upper management who also deal with the supply chain. Also, make a comprehensive list of mitigation strategies based on their importance. There is a need to propose a model who deals with the whole supply chain management of healthcare including internal and external.

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