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Applications of industry 4.0 to overcome the COVID-19 operational challenges

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ABSTRACT

Background and aims: An epidemic outbreak of COVID-19 has increased the demand for medical equipment, medical accessories along with daily essentials for the safety of healthcare workers. This study aims to identify the operational challenges faced by retailers in providing efficient services. The study also aimed to propose the roadmap of Industry 4.0 to reduce the impact of COVID-19.

Methods: A detailed literature review is done on an epidemic outbreak and supply chain using appropriate keywords on SCOPUS, Science Direct, Google Scholar. Some relevant industry reports and blogs are also taken to get insights.

Results: We have identified twelve significant challenges for the retail sectors that are acting as operational barriers and provided the application of Industry 4.0 technologies to deal with it.

Conclusion: Industry 4.0 can act as a significant driver for reducing the impact of identified challenges on retailers to fight against the pandemic. There is a need to build trust and transparency for the effective management of healthcare essentials. The supply chain partners and government bodies should act wisely for improving the services during COVID-19 and of similar situations. The proposed roadmap provide future research directions for researchers working in the area of epidemic control, supply chain, and disaster management.

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1. Introduction

Pneumonia of unknown cause was detected in the city of Wuhan, China, on December 31, 2019, which was named as COVID-19, short of “coronavirus disease 2019” by world health organization (WHO) [1]. prediction of the global pandemic came right when WHO characterized it as a pandemic on March 11, 2020 [2]. From February 11 to April 14, the number of confirmed cases infected with COVID-19 in the world rose from 45,134 to 2,004,383 in 210 countries [3]. The virus is spreading through an infected person coughs or sneezes or droplets of saliva or expulsion from the nose

[2]. So, it becomes critical to quarantine and to maintain social distancing to slow down the transmission, countries around the world imposed a travel ban, and announced Nation wise lockdown and restricted the movement of citizens. Due to lockdown and limited movement, distribution centers are suddenly become inaccessible that disrupted the entire supply chain. A similar kind of situation was observed during 2003 when the sudden outbreak of severe acute respiratory syndrome (SARS) impacted 26 countries and disrupted the logistics services [4]. The impact of this lockdown brought a significant disruption, as 94% of the Fortune 1000 companies and many small & medium-size enterprises have reported risk in SC due to uncertainty [5]. Supply chain risk has been defined as an unplanned and unexpected incident that disrupts the flow of goods or services within the SC [6–8]. [9] distinguished COVID-19 from other SC disruptions and explained it in terms of seven dimensions (geography, scope, demand & supply, prior planning & experience, financial system, term, and human impact & behavior)

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[10]. reported this epidemic outbreak as a special case of SC risk that will exist for a long duration, propagate with high uncertainty, and impact the logistics infrastructure.

In logistics, retailers are considered as an integrated part of the SC who is closet to consumers [11,12] whose role becomes crucial as they may come under high pressure to supply the essential goods [13]. It becomes critical to distribute products quickly and efficiently from uninfected distribution centers to retail stores [14]. As the CoV spreading continuously, the supply of the essential goods to protect the health of consumers becomes challenging as compared to normal conditions [15]. reported retail stores are facing capacity constraints and excess demand problems due to changing circumstances. Retail organizations around the world like Deloitte, KPMG, Nielsen, Forbes, and IDC are also expressing the difficulties faced by their retail store due to the coronavirus epidemic. Research suggests that technology adoption can play a significant role in controlling the pandemic situations. Adoption of Industry 4.0 can reduce these problems of retailers. Industry 4.0 is the integration of modern technologies like internet of things (IoT), cyber-physical system (CPS), Cloud computing (CC), Bigdata, etc. that provide flexibility, visibility, trackability and reliability in a system [16,17]. [18,19]; and [20] have also explained the use of Industry 4.0, AI, and IoT technologies in dealing with COVID-19 pandemic. This motivated the need to know the answers to essential research questions what are the challenges faced by the retail industries to serve the consumers and how these challenges can be overcome using Industry 4.0. As per the above research question, this research work aimed at identifying the challenges faced by the retailer during the COVID-19 pandemic.

The rest of the paper has been organized in the following succession- Section 2 is a literature review focused on the SC, retail, epidemic outbreak, and COVID-19. In Section 3, a roadmap for implementation of Industry-4.0 for identified challenges of COVID-19 has been explained. The conclusion of the paper is presented in Section 4.

2. Literature review

SC disruption was defined as “an indication of a firm’s inability to match demand and supply” [21]. It is generally caused by natural and human-made disasters that are low in frequency but having a high impact on the SC [22–24]. Because SC disruptions are costly and potentially harmful for the long term [8], there was a surge in the publication in the last decade, and enormous literature is available on SC disruption risk. As the focus of this study is COVID-19, this segment of research focuses primarily on the disruption caused by an epidemic outbreak in SC. The investigation related to the SC and epidemic outbreak is very limited in the literature [10,25].

2.1. SC and epidemic outbreaks

[26] pointed out the global uncertainty caused by SARS in 2003 due to the lack of flexibility that impacted the traditional SC system and international tourism in the Asian region [27]. reported the “lack of government coordination” and “cost-sharing contract” as operational challenges of SC during the Influenza outbreak that resulted in 250,000 to 500,000 deaths annually [28]. explained the “trust issues between SC players”, “poor veterinary infrastructure”, “lack of efficient information exchange system”, “absence of compensation”, and “illegal practices” as barriers that driven the pandemic Influenza in 2006 [29]. explained pandemic as strategic uncertainty that becomes more harmful due to less responsiveness, unreliable facilities, and unreliable transportation system of the SC [30]. developed a modeling framework that provided an

intervention strategy to predict the impact of the outbreak on the SC. Analysis reveals that self-quarantine, isolation of an infected person, contact tracing, and safe burial practice are the extreme measures that reduce the transmission rate of such viruses.

2.2. SC & impact of the epidemic on the retail industry

The retail organization has been considered as the most significant player in the SC as it fulfills the customer demand and shares the actual demand data with suppliers for further forecasting [8,31]. Even though retailers are considered an essential stakeholder of SC [14], literature related to the epidemic outbreak and retail industry is scarce [13]. mentioned the epidemic outbreak as an inherent risk of the SC that causes the loss of demand and disruption in retail organizations due to the unavailability of products. [32]; with a close-loop diagram, explained the transmission of Avian flu among the population, retail staff, and entire SC. The study suggested keeping the record of their team and suppliers to inform them about all the necessary precautions that can be taken care of during the service period.

2.3. SC, retail, and COVID-19

COVID-19, is caused by CoV, is a family of viruses common to humans and animal species, particularly in camels, goats, cats, and bats [33]. The first CoV transmission to humans, which was distinct from previously identified human CoV was reported in Asia in 2003, known as SARS-CoV [34]. The outbreak of Middle East respiratory syndrome coronavirus (MERS-CoV) in 2012 also witnessed the transmission of CoV into humans [35]. In December 2019, the outbreak of respiratory illness was reported in China due to the new virus (SARS-CoV-2) and soon become a serious threat to human existence [36]. COVID-19 came as a supply and demand shock that impacted the productivity of global SC [37]. [10] analyzed that SC performance is directly proportional to the duration of the disruption and illustrated that it depends upon time, disruption propagation scale, and availability of facilities [38,39]. pointed out the importance of SC resilience and viability during exceptional events (like the COVID-19 epidemic). In a survey done on 5800 small businesses [40], found that 43% of retail outlets are temporarily closed as they are more prone to COVID-19 outbreak. Due to travel restriction, health quarantine program, and factory shut-down, retailers are facing problems in maintaining operational continuities offline and online.

2.4. Challenges affecting the operations of SC and retailers during the epidemic outbreak

The epidemic outbreak has been considered as SC disruption risk that can be frequent or infrequent, and it can be for short or long in duration that drops the capacity of suppliers and increases the customer demand by 20% overnight [41]. The various challenges faced during an epidemic outbreak are listed in Table 1.

2.5. Challenges reported during COVID-19 outbreak

As there is limited literature available concerning COVID-19 and SC, this section of the paper contains some web search and industry reports. The reported challenges faced by SC and retailers during this epidemic outbreak are listed in Table 2.

Apart from these challenges, there are many more challenges reported in various reports worldwide, like lack of experience to deal with these situations, education level of workers at ground level, education level of consumers to understand the circumstances, etc.

Table 1
Challenges faced by SC and retailers during the epidemic outbreak.

Challenge	Brief	References
Non-flexible SC	SC has been designed to work under a stable and controlled environment to improve efficiency. A sudden change in demand & supply makes SC unpredictable and causes disruptions.	[26]
Government support & lack of incentives	SC partners always bear the risk of excess production and uncertain demand. There is no cost-sharing and loss contract to provide the incentives to SC players.	[27,28]
Trust among SC players	There is always trust issues due to competency, integrity, and misinterpretation of partners need in an uncertain environment that affects the supply and manufacturing of goods.	[28]
Coordination and information exchange issues	Due to multiple stakeholders of the SC, quick execution of the process is a significant challenge. There have been integration issues between different SC players and government bodies at the time of the outbreak.	[13,27–29,42]
Poor Infrastructure	It includes non-flexible storage space, lack of transportations flexibility	[28,43]
Staff and material safety	During the outbreak, manpower linked to the health center, logistics, and military is always under threat of infection. Their health and physical safety are also a big challenge for the respective organization.	[29]
Delay in the supply of essentials	Lockdown and tighter controls to cope with the epidemic led to severe disruption of supplies, particularly those deemed necessary	[13,43]
Reduction in manpower	During epidemic breakdown due to government policies and unwillingness to work under these conditions creates shortages of workers.	[32]

Table 2
Challenges faced by SC and retailers during COVID-19 outbreak.

Challenges	Brief	Reference
Viability	It is the ability to meet the demand for survival during uncertain conditions. It is a combination of resilience, adaptability, and sustainability that will recover the disruption over the period.	[39]
Balance in supply and demand	There was a drastic increase in demand for some SC (e.g., grocery items, masks, sanitizer) that was not fulfilled by limited supply as this epidemic hit the most country simultaneously.	[39,44]
Safety of employees	It is essential to provide medical safety to workers who are coming in direct contact with consumers. Arrangement of disinfection devices or proper sanitization at the store is critical.	[44,45]
Trust between retailer and consumer	As this virus is spreading through human contact and contaminated things, trust issues become the biggest challenge for retail industries. "No-touch deliveries" become new norms.	[46,47]
Distribution & Transportation capability	Limited capacity and capability due to limited resources and access	[45]
Shortage of manpower	The problem arises due to the migration of workers to their hometown, government guidelines to reduce coronavirus contagion, and fear of infection.	[45,48]
Consumer Behavior	Consumer buying behavior has changed drastically. It is now focused on medical accessories and essential daily goods. Stockpiling of these goods is creating unnecessary pressure on retailers.	[46,48,49]
Information exchange	There is miscommunication between government and police authorities; they have been shutting down all retail stores. It was reported in India, as there is no specific classification of essentials goods, it becomes difficult to decide what to kept open and what to close.	[50,51]
Capacity Constraints	Companies tried to accelerate shipment but were unable to do so due to lack of storage space at the retail center	[15]

3. Proposed challenges and future scope through the lens of industry 4.0

This research work is looking to identify the challenges faced by SC and retailers during an epidemic outbreak and explicitly for the COVID-19 pandemic. In this section, the authors proposed the list of barriers in Table 3 with all other vital elements. These fundamental elements represent the issues under specific challenges. Along with the proposed list, the scope of future research work is discussed with technology related to Industry 4.0.

3.1. Research scope and Industry-4.0 for COVID-19 challenges

This section of paper briefs about research scope for COVID-19 Challenges tabulated in Table 3. Industry 4.0 aims to create intelligent factories where technologies are transformed and upgraded using IoT, CPSs, big data analytics, and CC [62,63]. Industry 4.0 can be helpful to other sectors like service, healthcare, agriculture, and food. This part of the paper discusses the use of Industry 4.0 technologies for COVID-19 challenges.

Regarding 'Lack of SC flexibility (C1)', improving flexibility has been considered as a costly process; the development of a scale for trade between cost, flexibility, and uncertain environment can be exciting contributions. Many types of research work in terms of SC risk and flexibility are available in the literature, but the work related to pandemic situations and flexibility of SC is rarer. Big data

analytics, a model of the SC, can deal with uncertain situations with high flexibility [64]. About 'Lack of government support (C2)', the formation of contract or incentives by involving all SC players and government bodies for the unique condition will be promising research directions. To handle 'Lack of government support (C2)' and 'Lack of trust (C3)', blockchain becomes trendy technology in the last few years, as it makes the SC more transparent [42]. suggested that the government should be ready to transport essential suppliers and relocate the inventory at the most infected place. In situations like an epidemic outbreak, it can be beneficial to trace and track the flow of goods through this technology. The development of a blockchain-enabled integrated framework for SC disruption can be a possible area of research. As per [65]; blockchain can be used for doorstep delivery that opens the vast potential future research opportunities to look for various applications of blockchain.

Industry 4.0 and the techniques associated Cloud of Things [66] offer an excellent promise for 'Communication issues (C4)'. It will be interesting to see how these technologies will stop wrong interpretations of information shared by government bodies. To handle 'Lack of security and safety (C5)', there is a need for effective policies, and distribution strategy is needed for conditions like COVID-19. The polices can be based on variables like wages of workers, incentives to workers, the safety of his/her family, etc. Implementation of robotic and automated devices at the retail center is also a promising direction of research as it can help and

Table 3
Proposed Challenges of COVID-19 outbreak.

Sr. No.	Identified Challenge	Key elements	Brief Description
C1	Lack of SC flexibility	Increased lead time, slow response to changing market	Many organization has improved the flexibility of their SCs to respond rapidly and effectively in an uncertain environment [52]. However, improving flexibility is costly; the organization has been struggling to find the balance point between flexibility and uncertainty. COVID-19 is a similar kind of situation with many unknown variables, where the organization needs a more flexible and more responsive SC. Lack of required flexibility and responsiveness resulted in increased lead time that further slow down the supply of essentials [53]. suggest that a good relationship with the supplier may solve the problem of responsiveness during rough conditions.
C2	Lack of government support	Provision of incentives, cost-sharing contract	During a pandemic, along with the government, many private agencies are working to provide essentials to consumers or the community. Although both the players were operating independently, the manufacturer has been working under threat of loss due to uncertain demand. For example, during influenza vaccination, many medical organizations went under loss due to a sudden decrease in order. This may be the reason why many parts of the world are facing a lack of necessary medical equipment for COVID-19 [27]. suggested that the provision of incentives from the government and well-balanced cost-sharing contracts may solve this kind of operational issues.
C3	Lack of Trust	Trust between SC players, trust between retailers & consumers,	Trust is an essential factor that will help in fighting against COVID-19. Significant issues that cause trust is the lack of visibility and information excess [54]. [55] suggested that the implementation of blockchain and system integrations in the SC will eliminate the issues of trust and make the SC smoother. Issues like contamination of products can also be verified through online tracing of products based on the hotspot location of coronavirus.
C4	Communication issues	Information exchange between organization and government bodies, miscommunication between central and local authorities, Guidelines to reduce infections, coordination between SC players	During the ongoing COVID-19 epidemic in any part of the world due to ineffective communication, it gets spread too quickly. Due to miscommunication of lockdown, the truck carrying goods gets stuck in between somewhere that affected the essential needs of consumers. In India, it was reported that due to a lack of information exchange, police and local authorities are forcing retailers to shut down the stores [56]. mentioned that during the epidemic, effective communication about everything likes symptoms, cause of infections, lockdown periods, the supply of essential goods, etc., is critical for controlling the outbreak. A reported that the use of technology related to Industry 4.0 would help share information effectively among every individual.
C5	Lack of security and safety	Employees physical security and medical safety, consumers safety,	A majority of these critical employees will continue to operate their employment in medical facilities, retail stores, water services, and other workplaces all to ensure that the rest of society will retain a certain sense of a healthy life during this outbreak. As retail staff and medical staffs are at the front line, which puts them under constant risk of infections. Security and safety of workers and organization, working during the epidemic become significant challenges. For example, in Germany, a food delivery company becomes a victim of cyber-attack while in the US, a worker attacked by phishing emails [57]. It is the responsibility of the government to provide them security as they are fighting for nations.
C6	Shortage of manpower	Workers shortage, medical staff shortage, number of experts to deal with situations like this	Due to the COVID-19 outbreak, the world is facing a significant reduction in manpower that may break the global SC. After the announcement of lockdown. India is facing the problem of worker shortages that impact the supply of goods [58]. Similarly, according to the report of [59] world is facing the problem of skilled and experienced workers who can deal with these health crises.
C7	Consumers behavior	Buying behavior, stockpiling, behavior with workers at the store & with administrations	In times of uncertainty, consumer behavior changes significantly. They are buying basic needs and essentials. The sudden change in purchasing behavior increases the demand for certain goods. As the manufacturer was not ready for this sudden change, it becomes difficult to fulfill the order in such a short period. Worldwide stockpiling of essentials by consumers is reported [60] due to coronavirus that creates more disruption in the SC. As these essentials are the basic need for survival, consumers may become aggressive, which brings the need for extra security facilities at retail stores and distribution centers.
C8	Lack of Balance in supply and demand	Reduction in supply, delay in supply, increase in demand	This is the major issue faced by retailers due to the COVID-19 outbreak. This is because the SC is not able to fill the order due to the sudden increase in demand and supply shortages across the globe. For example [39], reported lack of responsiveness and flexibility are the primary reason behind the supply and demand disruptions while [7] mentioned that an epidemic outbreak always comes with SC disruptions.
C9	Poor infrastructure	Non-flexible storage area, capacity constraints, poor infrastructure for transportations and distribution	Retail stores are generally designed for healthy and stable working conditions with limited resources. After the introduction of concept just in time (JIT), very few retail stores kept extra inventory. The lack of

Table 3 (continued)

Sr. No.	Identified Challenge	Key elements	Brief Description
C10	Lack of medical facilities	Wearing kits, sanitization facilities, disinfection of goods	flexible storage capacity is creating more problems, as many distributors are trying to upsurge the supply, but due to capacity constraints, the supply is still limited. One more significant problem with the SC network is the route of transportations is not adjustable. A truck carrying a procurement of goods travels through a fixed route and cannot change in between as per requirement. During an epidemic outbreak, the availability of medical facilities at the retail store is a big concern. As COVID-19 is spreading through human contact or contaminated things, it is necessary to provide primary medical facilities like face masks and sanitizers for workers at work. As per a report published by Ref. [2]; it was advised to increase the manufacturing of masks and other medical accessories by 40% to meet the global demand.
C11	Lack of Viability	Resilience, adaptability, sustainability	Similar to resilience in the regular [61] gives the concept of viability for the integrated SC. Viability is the combination of resilience, adaptability, and sustainability that will fulfill the requirement of goods and services to the community and markets during the disruption.
C12	Lack of access	Access of transportations during the lockdown, access of extra space for storage, access of real-time information	This challenge is more about government policy, security, and safety of the Nation. To stop the transmission of coronavirus government-imposed lockdown and other constraints in society. For example, during the lockdown, workers and goods movement needs special permission from the administration that creates unnecessary pressure on workers. The manufacturer has limited access to production and limited access to the evolution of goods.

**Fig. 1.** Proposed roadmap for implementation of Industry 4.0 for COVID-19.

ignore the situations that can be harmful to humans [18]. The major reason for the 'Shortage of manpower (C6)' may be due to the lack of security to job and fear of getting infected. This needs further investigation on how the world goes under workers' crises. There is a need for training and educations among workers who are dealing with these situations. Developing a training program to deal with COVID-19 or similar kind of situations is also a promising area of research. Cloud-based systems can be used for training and education [67].

To understand 'Consumer Behavior (C7)', a study focusing on consumers' buying patterns during the time of crisis is needed. It became essential to differentiate what consumers want and what they need during epidemic outbreak situations like COVID-19. Big data analytics and Machine learning capabilities can be used to understand the pattern [68]. Regarding 'Lack of balance in supply

and demand (C8)', a cause and effect study on associated factors will help in getting a good insight into each consideration. Identifying essentials features for the development of retail SC for an epidemic outbreak can be a good idea. It can be integrations of modern technology at each stage of the SC to provide more resilience and flexibility. To address 'Poor infrastructure (C9)', the design of a flexible layout may be the possible solution for flexible storage capacity in a retail store. Researchers can be investigated the formation of policies for getting access to extra storage space in private or government buildings during emergencies (see Fig. 1).

Although many technologies can help deal with coronavirus, how to implement that is the biggest challenge due to 'Lack of medical facilities' (C10). Implementation of technologies like AI and blockchain may be financially challenging for small retail stores. The study related to tradeoff between technology, its

applications, and cost will be a good idea [18]. suggested that the use of artificial intelligence (AI) and the Internet of things (IoT) can help in accessing the risk and infection that may further reduce the load of manufacturing. To handle 'Lack of viability (C11)', the use of information technology with viability for the integrated SC to explore their ability to help policymaking for long-term breakdowns is one of the promising areas of research. For 'Lack of access (C12)', the development of a better strategy for the movement of goods without violating movement rule is needed. The focus must be to stop the transmission of viruses and the supply of essentials products only. Supply chain 4.0, a version of Industry 4.0 for SC operations, can address these challenges.

4. Conclusion

Retail stores and SC are providing various services to society and other areas while the country in the world goes quarantine. The retailers (grocery and pharmacies) are trying to meet customers' demands under the fear of getting an infection. To provide services to consumers and keep workers safe retail organization is facing lots of problems. The present study aims to identify the operational challenges faced by the retailer during the COVID-19 outbreak. The analysis of literature provides 12 significant challenges faced by retailers during this health crisis.

Along with each challenge, possible research scopes are also explained in brief. Based on the research scope, a roadmap for implementation of Industry-4.0 was proposed. The proposed framework can help policymakers to develop an action plan for COVID-19. The findings of this study are relevant for both the research and managerial communities. The study is limited to the COVID-19 outbreak that restricts generalization of finding for other epidemic outbreak conditions.

Declaration of competing interest

I, on behalf of all the authors of this manuscript, disclose that this paper has NO financial or personal relationship with people or organizations that could inappropriately influence or bias the contents of the paper and research.

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