



Design for Resilient Last-Mile Delivery for the Community to Respond to the Public Health Crisis During COVID-19

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Abstract. Last-mile delivery has evolved into a crucial lifeline activity for citizens to secure necessities under urban lockdown management, while also revealing various deficiencies. It is essential for communities to promote resilient logistics in order to face the challenges of COVID-19. This research aims to explore how community last-mile delivery can adapt to the pandemic through a literature review, providing the theoretical basis for developing resilient community logistics. It analyzed the changes in distribution expectations and obstacles that occurred during an epidemic, and also summarized the strategies from different perspectives. As the epidemic becomes more normalized, this article will provide new insights into urban logistics to better respond to the future public health crisis.

Keywords: last-mile delivery · COVID-19 · public health crisis · literature review

1 Introduction

Last-mile delivery is redefined as a result of further digitalization in services during the epidemic. Under the national epidemic management policy, people's demand for the delivery of basic living supplies such as water and food surged. E-commerce has become the main choice of many consumers, making delivery service an essential channel for the purchase of necessities [1].

In this particular context, the delivery of goods in the community safeguards the most fundamental requirements of people for survival. It has progressively evolved into an indispensable lifeline as well as a vital daily activity for people during the pandemic [2]. The “contagion” and “containment” have broken down the original urban distribution channels, even making the flow of materials a source of danger. Due to the lack of consideration for such an emergency, the last mile of urban distribution exposed many problems during the epidemic, which exacerbated the pressure of urban epidemic prevention [3].

However, the impact of the epidemic on last-mile delivery will not disappear, and the future will be a new normal in which crisis and daily construction coexist. Therefore, research on how to deal with the sudden public health crisis in last-mile delivery is very important for resilient city construction.

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The current academic research on last-mile distribution is mostly based on the perspectives of sustainability, unmanned distribution, and new retail. After the occurrence of COVID-19, the research on the last mile delivery in response to the epidemic has increased, but its research results are relatively scattered. Therefore, this article aims to develop a foundation for establishing a theoretical framework for resilient urban last-mile delivery in response to the public health crisis by literature review, and attempts to answer the following research questions:

RQ1: What are the changes and challenges for last-mile delivery due to the occurrence of COVID-19 in communities?

RQ2: How can communities respond to the difficulties of last-mile delivery during the epidemic?

The article is divided into five main sections. The first section introduces the research background and research question of this article, while the second section describes the methodology, including the process of literature search, selection, and output. Based on the findings of the literature review, the third section analyzes the changes and challenges in community last-mile distribution and collates the issues that emerged during the epidemic. The fourth part sorts out the solution strategies currently proposed by scholars from different perspectives. The fifth part summarizes the main research results and looks into the future development trend, to provide a research basis for resilient community last-mile delivery under the new normal demand in the post-epidemic era.

2 Methodology

This study focuses on a systematic literature review approach, consisting of five main stages, including problem definition, literature search, literature selection and full-text quality review, analysis, and output.

2.1 Problem Definition

In the problem definition stage, the study was based on the background of the normalization of the epidemic, to summarize the commonalities of the problems that occurred in community delivery during COVID-19, and the solution strategies proposed by different fields, to provide a theoretical basis for the methodological framework of the last mile delivery in response to the sudden public health crisis.

2.2 Literature Search

In the literature search phase, this research used last-mile delivery and COVID-19 as keywords. The literature was sourced from CNKI and Web of science. All publications released since the outbreak of COVID-19 were searched.

Table 1. Criteria for literature selection.

Criteria
1. Must be a published and readable journal article or conference paper.
2. The research article must be related to community last-mile delivery during the epidemic.
3. Literature review articles must mention last-mile delivery in the aftermath of the epidemic.

2.3 Literature Selection and Full-Text Quality Review

In the literature selection and full-text quality review phase, criteria were established for screening. (Table 1) 24 relevant research papers were ultimately selected for a specialized literature review after reading their titles and abstracts.

2.4 Analysis

In the analysis phase, the information related to the key issues was extracted based on the selected literature so that the information can be summarized and categorized into narratives.

2.5 Output

In the output stage, the issues and difficulties encountered in the last-mile delivery of the community and its future strategies were systematically described.

3 The Changes and Challenges for Last-Mile Delivery During the Epidemic

The main research areas of last-mile delivery focus on distribution models, fresh produce, sustainability, and smart logistics. Furthermore, resilience in emergency situations has begun to receive greater attention. The new demands and difficulties of last-mile community distribution in the context of COVID-19 are deeply discussed by many scholars. New forms of purchase under the closed management policy of communities have led to changes in the distribution needs of residents. At the same time, the increasing focus on transport safety has promoted the rise of contactless delivery and puts forward new requirements for the space and infrastructure of urban communities.

3.1 Changes in Distribution Needs Due to the Lockdown

As cities go through a period of lockdown, the purchasing business is becoming more digital. Movarrei et al. (2022) note that delivery has become a new interface between retailers and consumers. The service provided by delivery staff represents the retailer's image. For example, the speed and quality of delivery will affect consumers' perceptions of the brand [4]. Additionally, neighborhood social networks are becoming integrated

with last-mile delivery. Ke ke (2021) points out that community group purchase is a material procurement mode emerging in China during the epidemic, that is, “a new retail method for the circulation of group buying goods relying on the personal resources of community leaders (usually convenience store operators or community residents around the community)” [5]. However, as the community group purchase is still in the preliminary development stage, there are numerous issues with its last-mile distribution, including an inconvenient pick-up process and a poor sense of experience.

3.2 Transport Safety and Contactless Distribution

Due to the emergence of the concept of infection, the original space environment has the possibility of spreading the virus, making the movement of things another dangerous way of transmission. In order to reduce the potential infection risk caused by distribution, Sułkowski et al. (2022) stress the necessity to protect the security of the food and drug supply chain during the pandemic and avoid contact by keeping social distance [6].

As a result, the epidemic's occurrence has sped up the adoption of contactless delivery and unmanned distribution [7]. Contactless delivery is a new type of delivery method that has emerged in times of epidemics, according to Zhang Huiyun and Zhang Linlin (2021), which has decreased the danger of infection from contact in traditional delivery modes. Intelligent express cabinets, delivery at predetermined locations, unmanned vehicles, unmanned aerial vehicles, and other techniques are examples of technologies that have gained popularity. However, there are still many limitations to the operation of unmanned devices. The movement of unmanned vehicles in communities, campuses, and other scenarios is affected by many factors such as security, technology, and weather [8]. Tang Yuliang (2020) points out that the spatial infrastructure within the community cannot adapt to the intelligent distribution robot equipment, so the current unmanned distribution scheme is still in the conceptual stage and cannot be applied on a large scale [9].

3.3 New Demands on Community Infrastructure

The original community space is not able to adapt to the needs of distribution at specific periods, resulting in numerous distribution issues. New adjustments and alterations are required. Home delivery services have experienced transformations as a consequence of the epidemic lockdown policy, according to Villa and Monzón (2021), who also emphasize its new requirements for future urban infrastructure. Urban logistics must be more adaptable to address current issues in urban distribution, such as inefficient utilization of areas reserved for unloading activities [10].

Most communities have implanted the equipment needed for distribution based on the original community space, without contingency considerations for emergencies. Kim hae jin and Jibok Chung (2021) state that the enhancement of services of unmanned delivery storage lockers requires cooperation and awareness with users so that they can be truly integrated into residential infrastructure and meet their needs [11].

As a necessary community activity, last-mile delivery needs to be seen in a way that integrates daily use and emergency response. In the future, new types of community

distribution space and smart infrastructure will emerge, driven by dynamic distribution needs and new mechanical equipment.

4 Strategies for Promoting Resilient Last-Mile Delivery During the Epidemic

In response to the new needs and challenges of urban last-mile delivery during the epidemic, scholars have proposed relevant response strategies from different perspectives to promote future resilient last-mile delivery in response to public health crises.

4.1 Optimized Last-Mile Distribution Mode

New community material distribution modes have been proposed to adapt to the shift in demand caused by the closed management during the epidemic.

To satisfy the residents of the community's desire for material distribution, Cai Xiaoran and Zhu Xinge (2020) suggest establishing a distributed and centralized community distribution system [12]. Li Lei and Gui Lin (2021) summarize three modes of fresh community delivery in Beijing, including the home delivery mode, the community convenience store mode, and the smart delivery counter mode. They also propose technology acceptance theory and perceived value acceptance theory to explore the new development model of provincial fresh food delivery in the post-epidemic era [13]. In order to increase community satisfaction with distribution, Zhang Chunyan (2021) uses fuzzy theory and grey correlation analysis to carry out distribution priority grading. This research constructs an evaluation index system and optimizes the model for community vegetable distribution [14].

4.2 Collaborative Community Distribution Network

The socialization of community distribution has driven the emergence of a collaborative delivery network. Breitbarth et al. (2021) studies the food supply and door-to-door delivery of vulnerable groups during the pandemic from the perspective of logistics distribution and proposed the concept of collaborative delivery to optimize the existing distribution mode, to protect vulnerable groups during the epidemic through the door-to-door distribution and logistics mode of basic materials [15]. In the event of an epidemic, community residents can form different mutual assistance groups to carry out collaborative distribution within the community, relieving the pressure on community volunteers to deliver goods.

At the same time, the emergence of barter behavior activities makes the delivery of materials become the emotional link of community residents. Some scholars have proposed the concept of item sharing through new logistics infrastructures. Community residents can utilize products more effectively and sustainably by exchanging and sharing them through platforms based on crowdsourcing systems. The exchange of goods during the epidemic can be perpetuated through the support of spaces and platforms within the community [16].

4.3 Delivery System Combined with Daily Use and Emergency Response

In the face of an unexpected public health crisis such as COVID-19, last-mile distribution needs to be able to respond quickly. Many studies focus its future optimization strategies based on a combination of daily use and emergency response, to develop a sustainable last-mile delivery emergency network that can be continuously used even during daily periods.

Jiang Kaikai et al. (2021) link the emergency supplies terminal distribution system with the convenience store system. This research refers to the example of Japanese convenience stores playing a role in emergency material storage during earthquakes, aiming to build an efficient emergency material terminal system that combines normal operation and emergency response [17]. Lin Xiaoling (2021) conducts a relevant discussion on how to establish an effective protective material stockpile system in the post-epidemic era, exploring the strategic approach to constructing an emergency material storage based on the perspective of cost optimization and effective contractual constraints [18]. For community distribution, a more diversified distribution system can be created in conjunction with community commerce, thus enabling the use of more resource power to quickly respond to last-mile distribution during an epidemic.

4.4 Unmanned Logistics for Multi-scenario Applications

In response to the potential delivery risks caused by the epidemic due to face-to-face contact, scholars suggest using various forms of unmanned infrastructure to realize contactless delivery.

Zhou Xiang (2021) proposes the combination of unmanned delivery equipment and warehouses, as well as setting up mobile delivery sites, to enable the use of delivery robots to improve door-to-door delivery services [19]. Shen Yingchun and Wang Yiqi (2020) point out that more application scenarios for unmanned delivery can be explored. Special delivery requirements will be the focus of unmanned delivery promotion. For example, hospital drug delivery during this epidemic is a good application scenario [20]. Sun Han and Yang Fan (2020) introduce a distribution design scheme for logistics robots to transport daily necessities. Taking each residential area as a unit, this research has established a relevant model based on the distribution capacity of each robot and the number of distribution orders, to realize distribution to households or buildings. Transfer stations can be set near supermarkets and distribution stations to achieve effective distribution scheduling [21]. Peng Yong and Li Yuanjun (2020) propose a method of collaborative distribution between trucks and UAVs. Trucks with packages and UAVs can move at the same time, and UAVs can return to trucks within a certain flight time [22].

4.5 Adaptive Urban Space

Based on the type of community delivery, which has gradually changed from a single type in the past to a complex and diverse type of transport, new requirements have been put forward for the original community delivery service. Scholars have explored this

issue from the perspective of adaptive urban community space renewal in order to create a more resilient urban delivery system.

Urban micro-integration centers (UMCs) are used by Arrieta-Prieto et al. (2022) as a starting point to promote more sustainable distribution services in Manhattan, which is essential for enabling resilient last-mile distribution. According to the report, the UMC will redefine public space. The physical foundation of delivery space will be made up of street lanes, parking lots, and even curb space [23]. Some academics have, in the meantime, accelerated the adaptive regeneration of urban space based on the perspective of new urban infrastructure for optimizing the last-mile delivery of goods. Settey et al. (2021) evaluate the feasibility of using electric vehicles for logistics distribution from the perspective of carriers, pointing out the potential possibility of combining goods distribution with electric vehicles [24]. Such space and infrastructure modifications will create a new path for the development of resilient logistics.

5 Conclusion

To sum up, the impact of the pandemic on the last mile is mainly manifested in the dramatic change in urban mobility brought about by the spread of the virus, which results in a series of changes in delivery. The urban space under this scenario has not been able to accommodate the implantation of new delivery technologies, while the traditional delivery methods are still unable to meet the new demands, leading to many delivery issues and obstacles during the epidemic. In this scenario, various disciplines have different solutions for this field to face the challenges of last-mile delivery.

However, there are contradictions between micro and macro, daily and emergency, and smart and traditional approaches to last-mile delivery. First of all, existing research has started from the perspective of transportation and logistics, mainly from the macroscopic scale, but there is a lack of emergency design of community logistics systems at the microscopic scale. Logistics and community design are two disciplines that straddle a wide range of disciplines, and it is difficult for scholars to coordinate information between them. Urban designers in this context need to promote the integration between last-mile logistics and community design. By fostering collaborative exchanges between scholars, and improving the gap between their disciplines, it can establish a theoretical system for resilient last-mile urban distribution in response to crises.

Furthermore, last-mile distribution has paid little attention to the research related to distribution in emergency scenarios before the epidemic occurred. The urban emergency distribution system combined with normal and emergency response began to emerge after the epidemic. Scholars need to focus on changes in community delivery modes and space so that its daily operating patterns can quickly respond to changes in emergency scenarios during an epidemic.

Finally, intelligent distribution in smart cities requires the involvement of human and community space as intermediary areas to interface with unmanned logistics infrastructure. With the socialization of the distribution, the last mile of smart logistics construction should not eliminate the participation of people. Urban community-based distribution may no longer be limited to a single point-to-point delivery like courier cabinets, but also include spaces that are integrated with people's daily behavior and community activities and eventually merge with community-making. Through the combination between

highly intelligent equipment and distributed spatial delivery points, the social interaction of distribution during the epidemic will be brought into force. A collaborative network in the evolution of the distribution system will be established to accelerate the application of intelligent distribution equipment and to avoid the disconnect between spatial infrastructure and high-tech logistics equipment to create a more resilient urban last-mile delivery system.

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