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Urban Community Sustainable Development Patterns under the Influence of COVID-19: A Case Study Based on the Non-Contact Interaction Perspective of Hangzhou City

Jiwu Wang [1,2], Xuewei Hu [1,3,*] and Chengyu Tong [1]

[1] Institute of Urban Planning & Design, Zhejiang University, Hangzhou 310058, China; wangjiwu@zju.edu.cn (J.W.); 21912256@zju.edu.cn (C.T.)
[2] Center for Balance Architecture, Zhejiang University, Hangzhou 310058, China
[3] College of Water Resources and Architectural Engineering, Tarim University, Alear 843300, China
* Correspondence: huxuewei@zju.edu.cn

Abstract: A community is the basic organization and living unit of a city. During COVID-19, China's epidemic prevention and isolation measures against COVID-19 based on the community as the basic unit achieved excellent results and strengthened the impact of non-contact interaction activities on the lifestyles of resident communities. We surveyed and interviewed 1610 respondents on how the epidemic changed residents' lifestyle habits "before, during, and after COVID-19" in 12 communities in Hangzhou, China. Then, we undertook a comparative analysis and found that, under the stimulus of COVID-19, the frequency of residents using non-contact interaction had increased to varying degrees, community lifestyles had undergone significant changes, and the impact of non-contact interaction on community service facilities was complicated. Our conclusions are as following: (1) under COVID-19, the community space had become a composite space—that is, a new type of community space formed by the fusion of community physical space and community virtual space; (2) non-contact interactive activities were the main content in the community composite space, which differently influenced people's habits of using existing community service facilities; (3) the influence mechanism was manifested in significant differences and spatial scale effects. Therefore, based on the research results, we propose a model for the configuration of service facilities in community composite spaces. It is necessary to build communities into a healthy, safe, and convenient urban space governance unit to ensure the sustainable development of cities.

Keywords: COVID-19; non-contact interaction; community space; service facilities; Hangzhou

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1. Introduction

In early 2020, the outbreak of coronavirus disease 2019 (COVID-19) not only posed a serious threat to public health but also greatly disrupted normal social life; how to respond to the epidemic appropriately and efficiently is an urgent issue. Western urban planning theories including the "neighborhood unit" in the 1920s and the "smart growth" and "transit-oriented development" ("TOD") models in the 1980s and 1990s all reflect the important idea that communities are the basic organizational unit of a city [1–6]. During the COVID-19 pandemic, the community-based isolation measures implemented in China achieved excellent results in overcoming difficulties [7]. We thought these measures further highlighted the importance of "community" as a basic unit of living and social governance. Therefore, it is important to respond to public health emergencies in a timely manner by taking the community as the basic spatial unit to study urban phenomena and solve urban problems.

The urban community life circle planning model is not significantly different from the neighborhood unit theory or the neighborhood centre model, both of which emphasize the provision of basic services facilities and public living spaces within walking distance.

The planning model attaches importance to the characteristics of community residents' daily life. It has become an important method of urban community planning [8] and is applied to community planning practices in many countries [9–12]. In 2018, the Chinese government issued the Urban Residential Area Planning and Design Standards (GB50180-2018) (hereinafter referred to as the Standard), and this event signified that the concept of the "community life circle" had become the main theoretical and practical model for community planning in China. The Standard divides communities into 15-min, 10-min, and 5-min community life circles based on average walking speed and stipulates providing different service facility scales in the three life circles. The aim is to configure equal and precise public service facilities to meet the growing needs of residents for a better life. Therefore, using the community living circle planning model is an effective method to resolve issues such as the allocation of community services and facilities. This model is highly compatible with global sustainable development and the goals of healthy and resilient cities [13,14].

COVID-19 accelerated the virtualization of public services in the community, especially in the form of non-contact interactions. These interventions hindered the transmission of COVID-19. Non-contact interactions not only meet many of residents' practical demands and support the effective operation of the community, but also ensure the effective implementation of isolation measures during the pandemic. This shows the great vitality and resilience in the process of urban development. The changes in residents' traditional living habits and the reshaping of the new pattern of community lifestyles have enhanced the resilient development of communities and introduced new requirements for urban community planning. Therefore, keeping abreast of the changes in residents' lifestyles will be particularly important for safety and health-oriented urban community sustainable planning in the post-pandemic period.

In this study, we observe and analyze the new behaviors and needs of residents before, during, and after the COVID-19 pandemic. This will help us to further understand and put into perspective the changes in urban community space, as well as to guide urban community planning practice by using the interaction mechanism between virtual space and physical space. Therefore, from the perspective of non-contact interaction, this article takes typical Hangzhou communities as its research object to investigate the lifestyle changes of community residents before, during, and after COVID-19. We will also clarify the relationship between "virtual space", characterized by non-contact interaction, and "physical space", characterized by face-to-face interaction. Finally, we establish a model for configuring composite space service facilities in communities during the post-pandemic period. It is believed that introducing non-contact interaction applications for the development of innovative, sustainable, and smart urban communities will be a new method for urban planners.

The rest of the paper is structured as follows: Section 2 contains a review of relevant research literature. Section 3 introduces the study area, study methods, data collection, and analysis. Section 4 mainly discusses the changing characteristics of community residents' life behaviors before, during, and after the COVID-19 pandemic. Section 5 mainly discusses how "community virtual space" is characterized by the effect of non-contact interaction on community service facilities and establishes a model for configuring composite space service facilities in the community in the post-pandemic period. The last section of the paper contains a summary of the full text.

2. Literature Review

2.1. The Development of "Non-Contact" Interaction

According to the World Internet Development Report 2020 statistics, the number of global Internet users was about 4.54 billion in 2020, with a penetration rate of 59%—an increase of nearly 300 million users compared to 2019. Under the influence of COVID-19, countries around the world have become increasingly dependent on the Internet, and the importance of the Internet's influence on urban development is becoming more and more

evident [15,16]. China is the second-largest country in terms of Internet development and shows strong growth potential. By June 2020, the number of Chinese Internet users had reached 940 million, while the "distance" and "non-contact" mode of interaction had penetrated all areas of social life and had a profound impact on economic activities and lifestyles (Table 1).

Table 1. Scale and utilization rate of Chinese residents' Internet application users.

Category	User Size (Billion)	Percentage (%)	Category	User Size (Billion)	Percentage (%)
Instant Messaging	9.3079	99.0%	Online Healthcare	2.7602	29.4%
Online Education	3.8060	40.5%	Work from Home	1.9908	21.2%
Network Literature	4.6704	49.7%	Online Government Affairs	7.7300	82.2%
Network News	7.2507	77.1%	Network Payment	8.0500	85.7%
Network Video	8.8821	94.5%	Network Shopping	7.4939	79.7%
Live Streaming	5.6230	59.8%	Online Takeout	4.0903	43.5%
Network Music	6.3855	67.9%	Online Investment	1.4938	15.9%
Network Game	5.3987	57.4%	Online Car-hailing	3.4011	36.2%

Note: Data source: compiled according to "China Internet Development Statistics Report". Note: The deadline for data collection is June 2020.

Non-contact interaction is an interaction activity supported by information technology and is carried out through the relatively isolated physical space of "human-virtual space-human". Its most significant features are no face-to-face contact and no spatial proximity between people. Non-contact interaction makes the time, place, and some types of activities more convenient and highlights the importance of human needs and distance safety. In particular, during the COVID-19 pandemic the public outbreaks greatly contributed to the development of virtual community spaces featuring non-contact activities. Residents are dependent on non-contact interaction activities, and this will profoundly affect the organizational mode of urban communities. The contact between humans and space means that it is difficult to completely get rid of technology. New technology will constantly change and optimize methods of service acquisition and travel. Along with the new urban phenomenon and the development trends of communities, urban planning research should be forward-looking and actively explore measures to optimize the allocation of community services using new technologies.

2.2. The Development of Community Space under the Influence of "Non-Contact" Interaction

As early as the 1980s, some scholars predicted that virtual space would replace the functions of physical space and lead to the "dematerialization" of the city [17]. The concept of "end of the place, city, and geography" was proposed, which caused extensive discussions among scholars [18,19]. From the perspective of urban spatial changes, land-scale transformation, and land use proportions, some scholars found that technology had weakened the importance of geographic distance [20], blurred the boundaries of urban functions, and enhanced land compatibility [21], as well as accelerating the decentralization and suburbanization of the city [22,23]. Generally, it caused a reconfiguration of urban space [24,25]. However, from the perspective of socio-economic structure, other scholars believed that physical space still played an important role in daily life, although virtual space

had greatly changed the organizational mechanism of urban space [26–28]. Virtual space is a new type of social space based on physical space [29], which is also a "location-based" technology with roots in the real world [30]. It cannot exist independently of physical space [31]. Therefore, urban space under the influence of "non-contact interaction" is a symbiosis in which physical space and virtual space are interdependent. The community, as an important spatial unit of the city, is the grassroots organization of society and a microcosm of the city. The spatial structure of the community will change. Residents obtain community public services mainly by walking, and community service facilities are a space carrier for providing services. Non-contact interaction activities re-interpret traditional community activities and lead to the reconstruction of community functions and spaces. This phenomenon should be paid attention to. Researchers of the urban scale have laid a good theoretical foundation for exploring the impact of non-contact interactive activities on space. However, there are few studies on the urban community scale. Based on this, this article will carry out research at the community scale to respond to urban community planning.

2.3. Residents' Behavioral Habits under the Influence of "Non-Contact" Interaction

With the rapid development of virtual space, residents' activity behavior has changed over time and space and shows the characteristics of fragmentation and liberalization [32]. The impact of residents' activity behavior on urban space has received increasing attention from urban planning scholars [33]. The development of virtual space has changed the traditional patterns of life and value creation processes. It has also changed consumption patterns, reduced transaction costs and spatial-temporal barriers, promoted the rapid geographical diffusion of innovation and knowledge, and changed the spatial organization of society and the economy [34]. Some scholars have argued that virtual space greatly affects the traditional lifestyles of residents [35–37] and conducted numerous empirical studies examining residences [38,39], work [40,41], leisure [42,43], tourism [44,45], and shopping [46–48]. In general, the impact of virtual space is mainly manifested as substitution, promotion, change, and neutrality [49–51]. However, other scholars have also questioned these manifested impacts and argued that the relationship between virtual and physical space could not simply be divided into the four types mentioned above but must be acknowledged to be more complicated [52–56]. Previous studies have provided us with a framework. Non-contact interaction activities liberate people from spatio-temporal constraints, traffic congestion, and other physical space problems [57]. The behavioral needs of residents have undergone a dramatic shift from reliance on physical facilities to virtual ones, while virtual information networks have undermined the dominance of physical transportation networks. COVID-19 served as a catalyst to accelerate the impact of virtual space on residents' lifestyles and also caused changes in the uses of community service facilities. Whether there is a difference in the impact mechanism of virtual community space on physical community space is a matter that requires deeper investigation in order to guide the sustainable development of urban communities effectively.

2.4. The Planning of Community Life Circles under the Influence of COVID-19

Around the world, scholars have used the kernel density method [58], spatial autocorrelation [59], and buffer zone analysis [60] to conduct a large number of empirical studies on community planning, and they have used software technologies such as multi-source data, ArcGIS [61], and UNA [62] to explore the fairness [63–65], accessibility [66–71], and optimization of supply allocation [72–76]. Previous studies have accurately described the objective characteristics of community space, which has helped us to understand the current situation of the community intuitively and clearly. However, urban planners still lack sufficient understanding to design a high-quality community [77]. Most community planning still focuses on the residential function in physical space and favors the importance of pedestrian scale factors. It does not pay sufficient attention to new technological elements and ignores the changing situation of residents' subjective needs. The devel-

opment of non-contact interaction activities provides community services to community residents at a larger scale. In fact, with the changes in urban spatial structure, the equity of community services has gone beyond the physical space, showing the characteristics of non-contact interaction. The fairness and sharing of community services can be solved to some extent. However, these new trends are less discussed at the level of urban community planning. The outbreak of COVID-19 disrupted the previous order of life and made residents more profoundly aware of the convenience and safety of non-contact interaction. Lifestyle changes in the community also show changes in the subjective needs of residents. A new service system needs to be established to satisfy residents. Therefore, this article intends to start with the characteristics of residents' subjective behaviors, understand the changes in the lifestyles of residents affected by the pandemic, and further understand the development trend of urban communities affected by the pandemic. Residents are increasingly likely to depend on non-contact interactive activities, and this shift in community lifestyle has demonstrated the subjective changes in residents' needs. Community space has gradually transcended the limits of the spatial pattern of temporal activities and physical proximity. The emergence of new demands of residents requires the establishment of a new service system to meet them. Therefore, based on the perspective of residents' subjective behavior characteristics, we have gained a practical understanding of the lifestyle changes of residents affected by the pandemic and further aimed to understand the development trend of urban communities.

In general, the impact of virtual community space on the community is mainly manifested at two levels: one is the evolution trend of the spatial structure of urban communities overall; the other is the impact on the behavioral activities of residents at the individual level. However, the concept of "space in terms of space" cannot fully explain the future trends of community space development. We often end up ignoring the role of other factors if we consider activity-mobility behavior as only a simplification of the travel behavior process. Previous research has provided the basis for our study. Are there also alternative, complementary, or other types of effects of the impact of non-contact interaction activities on urban community service facilities? How should we use the influence mechanism to promote the sustainable development of the community? This study concludes that a large amount of reliable and valid data will need to be collected in order to clearly and systematically explain the mechanisms existing between virtual and physical space and guide the development of healthy and resilient urban community planning. Established studies on urban community planning [78–81] focus on the role of Internet technology and digital integration. However, practical community planning in the era of information technology needs to emphasize the spatial supply and changing needs of residents. In particular, COVID-19 as a "driving force" has further catalyzed the development of non-contact interaction and will certainly have an impact on urban community planning. Therefore, it is necessary for planners to coordinate the "unchanging" pedestrian scale with the "changing" technical elements to ensure the normal order of life and increase the resilience of urban communities. Communities bring together the individual behaviors of urban residents and respond to the overall development trend of a city. Under the influence of COVID-19, conducting an analysis of the new trend in urban community development, observing the changes in residents' needs, and discussing the response strategies of urban community planning will have positive practical significance for promoting healthy and sustainable community development.

In the context of the new era, we need a new connotation and organizational mechanism for community planning under the combined effect of virtual and physical space [82,83]. As the basic unit of a city, the community is a "spatial projection" of urban spatial transformation and social changes at the urban microscale. It is closely related to residents' quality of life. We observe that using the frequency of residents' non-contact interaction in different periods in a community can show residents' external travel behavior characteristics and effectively portray residents' real needs and preferences. In this way, we can explain the influence of virtual space on community space, which has extensive explanatory significance and

practical value. Therefore, we believe that urban planning with physical space as the main practical object should fully consider the community service virtualization phenomenon. In this study, we start by analyzing the impact of non-contact interaction activities on residents' community lifestyles and explaining the community life circle of virtual and physical space. We need to understand the impact of non-contact interactive activities on the urban community space and propose ways to use non-contact interactive activities to optimize the spatial layout of urban community service facilities. This study will provide high-quality development planning suggestions for community planning in the post-pandemic period.

3. Study Design

3.1. Study Area

We selected Hangzhou, a representative city in China, as our study area. Hangzhou is the capital of the Zhejiang Province and is situated in the southeast coastal area of China. As a digital economy developed city, it ranked first in 2019 in Urban Digital Development Index Report in China. Three districts of the city were included in this study—i.e., Shangcheng, Xiacheng, and Xihu districts—with a total population of 1,690,700. At present, China is working hard to promote and configure community service facilities in accordance with the Standard. Before conducting a questionnaire survey, we visited many communities and finally selected 12 mature communities with relatively complete service facilities based on community living circle construction referring to the Standard. The population size of these communities is usually 5000–10,000. The community we choose must meet the following two conditions: (1) the present services and facilities in the 15-10-5-min community life circle must correspond to the Planning and Design Standards for Urban Residential Areas decreed by the Chinese government; (2) the communities' pandemic prevention and control measures must be effective during COVID-19. These communities represent the division of social and spatial, which is characterized by a street-based economy, mixed land use, and compact community forms.

3.2. Study Methods

Questionnaire survey and field research are the two most commonly used empirical research methods in sociological survey studies. We adopted these methods to obtain first-hand information in a timely and accurately manner, including residents' living habits, demand willingness, and service facilities, in different life circles before, during, and after COVID-19. When designing the questionnaire, we chose some reliable and validated scales or items which have been commonly used in previous surveys or studies. Before the main phase of the survey, a pilot study was conducted to test the feasibility of the questionnaire.

We divided the service facilities into seven categories in the 12 communities: educational facilities, cultural and sports facilities, medical and health facilities, social welfare facilities, administrative office facilities, commercial service facilities, and public transportation facilities. We analyzed the data using an inductive method to ensure the scientificity and validity of the sample data (Table 2).

With the help of the community committee, we recruited respondents who had lived in the community for at least 1–2 years. According to the size of the adult population of each community reported in the Sixth National Census of China, a total of 1610 questionnaires were proportionally distributed to the 12 sampled communities (i.e., each community had a specific sample size). During the main phase of the survey, participants were randomly selected from the adult residents in each sampled community based on the given sample size. All the participants were fully informed about the study design and provided their informed consent. After checking the original data, questionnaires with incomplete and inconsistent responses were excluded from the study. Finally, 1505 questionnaires obtained from the participants were deemed to be valid and useable.

Table 2. Classification of service facilities in community life circle.

Category	15-min Community Service Facilities	10-min Community Service Facilities	5-min Community Service Facilities
Educational Facilities	Middle School	Primary School	Kindergarten
Cultural and Sports Facilities	Large Multifunctional Sports Ground, Cultural Activity Center	Medium-sized Multi-Functional Sports Ground	Small Multifunctional Playground, Outdoor Fitness Complex, Cultural Activities
Medical and Health Facilities	Health Service Center (Community Hospital), Outpatient Department	——	——
Social Welfare Facilities	Nursing Homes, Senior Care Homes	——	Daycare Center
Administrative Office Facilities	Community Service Center, Street Office, Judicial Office	——	Community Service Station (Neighborhood Committees, Public Security Defense Station, the Sisabled Rehabilitation Room)
Commercial Service Facilities	Mall, Catering Facilities, Banking Outlets, Telecom Outlets, Postal Business Premises	Mall, Vegetable Market or Fresh Supermarket, Catering Facilities, Banking Outlets, Telecom Outlets	Community Commercial Outlets (Supermarkets, Pharmacies, Laundries, Beauty Shops, etc.)
Public Transport Facilities	Bus Stop	Bus Stop	——

Source: Organized and drawn according to "Urban Residential Area Planning and Design Standard (GB50180-2018)".

3.3. Data Collection and Analysis

We collect the data in two periods. The first period was March 2020. We divided the survey content into two parts. The first part was "before COVID-19". We investigated which ways residents chose to make use of community services in three life circles before the outbreak of COVID-19. Secondly, we surveyed the access of residents using community services during COVID-19. The second period was September 2020, a period we called "after COVID-19", and we similarly focused on how residents accessed community services in three life circles. Questionnaires were conducted online and offline. Field survey interviews were conducted with community residents, property managers, committee members, and many other community members.

Considering that the interviewees lacked understanding of the concept of 15–10–5-min community life circle, we referenced the Standard facility configuration requirements and conducted investigations on the service facilities of three life circle.

Investigations started from three aspects. First, we counted the average times per month that respondents used non-contract interaction activities and existing community service facilities. For example, we would ask them "how many times did you use the Community Hospital before the epidemic (within one month)" and provided answer options including 0 times, 1–3 times, 3–5 times, 5–10 times, or more than 10 times. This answered how often the interviewees used medical and health facilities in the 15-min community life circle. Then, we asked "Have you ever used non-contact medical services" and "If you have used them, how many times did you used (within one month)". This collected the data of frequency of use non-contact services. Accordingly, we calculated the virtualization level of residents' use of these services, which was expressed as the ratio of the frequency

of using non-contact interaction or using the existing service facilities to the total frequency of using certain types of services. Second, it was a satisfaction survey on respondents who used the non-contact interaction activities. We might ask the respondents "If you have used online courses, how did you feel about it?" We bout the satisfaction of various types of community service facilities on a 5-point scale (very dissatisfied, dissatisfied, fair, satisfied, and very satisfied). Third, we explored the new needs and willingness of respondents' using community services under the influence of COVID-19. We learned about this by asking "After the epidemic, would you continue to use or try the non-contact services?" Based on the survey, we further analyzed the mechanism of the virtual community space characterized by non-contact interaction on community planning.

4. Results and Analysis

The survey found that the proportion of residents who used the non-contact interaction in the community before, during, and after COVID-19 was, respectively, 60.1%, 89.3%, and 84.5%. Under the effect of COVID-19, the frequency of residents using non-contact interaction activities significantly improved. Compared to before and after the epidemic, the frequency of residents using no-contact interaction activities increased in different degrees (Figure 1). This indicates that the community residents' lifestyle changed significantly under COVID-19, and at the same time, there were differences to some extent in the effects of non-contact interactive activities on the seven types of service facilities in the community.

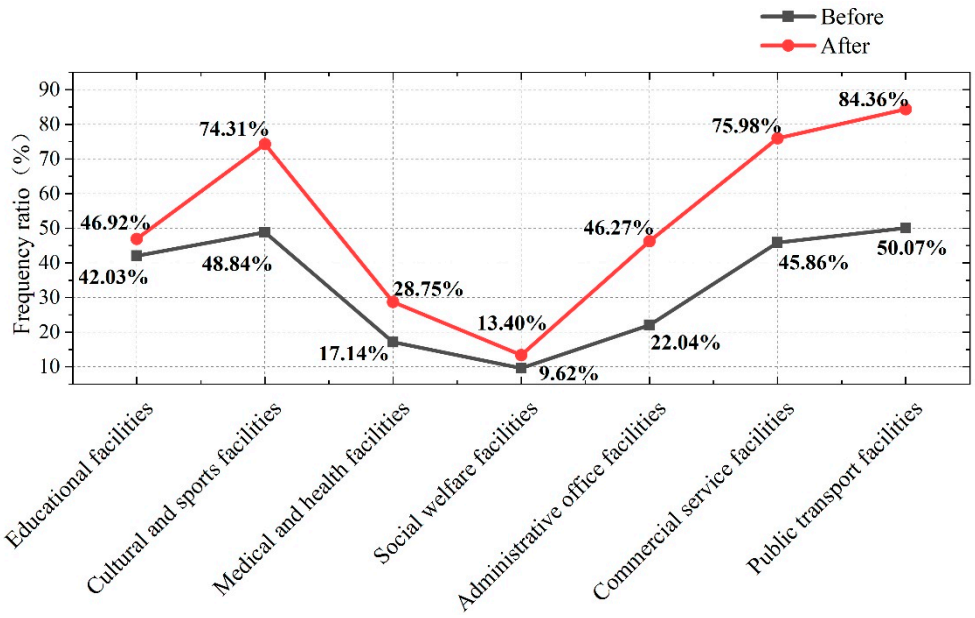

Figure 1. Changes of using community service facilities.

4.1. Education Facilities

According to the Standard, the configuration of education facilities in the community includes a secondary school in the 15-min community life circle, an elementary school in the 10-min community life circle, and a kindergarten in the 5-min community life circle. In the survey of respondents (or families) with educational needs, the result showed that non-contact interactive teaching activities are mainly assisted teaching before COVID-19, among which 95.63% of respondents (or families) have online assisted teaching. With the guidance of the "suspend classes but keep studying" policy during COVID-19, 282 million students (National Bureau of Statistics, *China Statistical Yearbook 2019*) generally turned to online courses in China, among which 75.81% of the respondents (or families) were satisfied, and the main reasons for dissatisfaction were the worries about the quality of online teaching and unprotected working hours of parents. After the event, the proportion of respondents

(or families) who used online assisted teaching methods was 96.02%, which was the same as before COVID-19. At the same time, 92.38% of the respondents thought that online teaching methods did not affect the use of offline education facilities, mainly because online teaching was mainly focused on during COVID-19, but offline teaching activities were still dominant when the teaching order returned to normal.

According to the survey, the non-contact interaction teaching during COVID-19 played a temporary substitute role in maintaining the daily teaching work. Face-to-face teaching was still irreplaceable in the post-pandemic period. Now, non-contact teaching is accelerating into the sink market, and online merge offline (OMO) is becoming the mainstream model of education industry development. Therefore, in the post-epidemic period, non-contact teaching activities generally played a role of "tenacious guarantee" for the teaching order. Residents' demand for community education facilities had not changed significantly, so there would be no need to carry out necessary "physical space" allocation in three circles.

4.2. Cultural and Sports Facilities

The cultural and sports facilities in the community include a large multi-functional sports field and a cultural activity center in the 15-min community life circle, medium-sized multi-function sports grounds in the 10-min community life circle. They also include the small multi-function sports grounds, outdoor comprehensive fitness grounds, and cultural activity stations in the 5-min community life circle. According to the survey, the results showed that the demand for community cultural and sports facilities before COVID-19 had obvious circle characteristics, as appeared in the 15–10–5-min community life circle, the proportion of residents considering the most important community cultural facilities was, respectively, 24.07%, 34.43%, and 41.50%. The percentage of respondents who were satisfied with the existing facilities was 78.62%. During COVID-19, in compliance with the requirements of epidemic prevention, community cultural and sports facilities were out of use, 73.50% of the respondents used the non-contact interaction of cultural and sports activities to relieve recreation demand. After COVID-19, respondent's demand for these facilities changed significantly. The demand in the 5-min community life circle increased significantly, while in the 15-min and 10-min communities the life circles decreased to different degrees (Table 3). The proportion of respondents satisfied with existing facilities decreased from 78.62% before COVID-19 to 61.54% after COVID-19. At the same time, 40.42% of the respondents said the frequency of using community cultural and sports facilities had increased, 28.83% said a significant increase, and about 69.25% thought participating in the cultural and sports activities needed the support of physical space.

Table 3. Usage and demand of community recreational and sports facilities.

Stage	Satisfaction	Proportion of Community Cultural and Sports Facilities That Residents Believe Are Most Needed		
		15-min Community Life Circle	**10-min Community Life Circle**	**5-min Community Life Circle**
Facilities	——	Large Multifunctional Sports Ground and Cultural Activity Center	Medium-Sized Multi-Functional Sports Ground	Small Multifunctional Playground, Outdoor Fitness Fomplex, Cultural Activities
Before	78.62%	24.07%	34.43%	41.50%
During	84.57%	-	-	-
After	61.54%	19.36%	10.68%	69.96%

Note: the "During" satisfaction is the evaluation of non-contact interactive stylistic activities.

According to the survey results, the supply of cultural and sports activities by non-contact interaction had enriched the residents' daily activities and at the same time promoted the demand for community cultural and sports facilities. However, the demand features in three life circles before COVID-19 transformed changed to a significant increase in the 5-min community life circle, which was correlated to the decrease in residents' satisfaction with cultural and sports facilities in the community and the dependence on non-contact interaction. Therefore, we need to attach importance to the 5-min community life circle to plan the community cultural facilities under COVID-19. We should increase the configuration of recreational facilities and pay attention to the organization of virtual communities.

4.3. Medical and Health Facilities

The medical and health facilities in community life circles include the health service center and the outpatient department in the 15-min community life circle, which mainly undertakes the community preventive health care, triage, and rehabilitation work. The advantages of network medical service were significant, and it played a positive role in the period of COVID-19 prevention [84,85]. However, the survey showed that residents did not use non-contact medical services very frequently, with, respectively, 7.62%, 14.33%, and 8.07% before, during, and after COVID-19. We can see that residents' use of online medical services is mainly reflected during COVID-19. However, 79.56% of respondents thought if the level of online medical services is improved, they will consider using online medical services and reduce the use of offline medical facilities.

The threat of COVID-19 strengthened the importance of community health, but the safe and efficient non-contact medical services such as online medical treatment and drug distribution had only changed a small percentage of the population who used the facilities. We could not play the role of non-contact medical services fully. However, the acceptance of online medical services was relatively high. As the quality of online medical services improves and the application spreads, the number of residents choosing networked medical services will increase significantly. This process will have a substitution effect on the allocation scale of community medical and health facilities. It has a significant impact on the supply pattern of medical and health services.

4.4. Community Welfare Facilities

According to the Standard, the community welfare facilities include nursing homes and elderly care homes in the 15-min community life circle and nursing homes for elderly care in the 5-min community life circle. Research on community welfare facilities has shown that only 4.07% of respondents (or families) with elderly people aged above 60 used the community welfare facilities before COVID-19. The vast majority of them adopt the traditional family model of elder caring (Table 4). However, 76.67% of the respondents (or families) indicated that they would consider using non-contact welfare services in the future. It could be seen that the non-contact elderly care services had not been fully developed and utilized, and thus had not had a significant impact on the existing community welfare facilities.

Table 4. Usage of community welfare facilities.

Stage	15-min Community Life Circle Service Facilities Use	5-min Community Life Circle Service Facilities Use
Facilities	Nursing Homes and Geriatric homes	Daycare Center
Before	1.21%	2.86%
During	0.36%	0.14%
After	1.20%	2.84%

Intelligent elderly services have been widely used in the world, and the "Internet + home pension" model is gradually becoming the ideal community pension mode in the future in China [86,87]. With the acceptance and popularization of the new model, the configuration of community welfare facilities will be changed greatly. The medical diagnosis, drug distribution, living assistance, catering services, and other services influence welfare facilities planning. It promised the function, scale, layout, organization of facilities all need new requirements. Therefore, there is a necessity to strengthen community service for the elderly at home by using the internet. It is important to consider the particularity of the service object and the service radius of the facilities. We should reorganize the necessary resource elements, to promote the online and offline utilization rate of the community welfare facilities. The purpose is to create convenient conditions for the elderly in the community.

4.5. Community Administrative Office Facilities

According to the Standard, the community administrative office facilities include community service centers, street offices, and judicial offices in the 15-min community life circle and community service stations in the 5-min community life circle. According to the survey, the proportion of residents who selected the non-contract interaction after COVID-19 had increased significantly compared with the before COVID-19 (Table 5). A total of 81.27% of the respondents believed that online services could reduce the proportion of using physical facilities. 67.01% of respondents had not experienced online administrative office services and were willing to try to use them in the future.

Table 5. Usage of community administrative office facilities.

Stage	15-min Community Life Circle Service Facilities Use	5-min Community Life Circle Service Facilities Use	Relative Scale
Facilities	Community Service Center, Street Office, Judicial Office	Community Service Station	——
Before	10.57%	16.55%	1:1.57
During	33.01%	81.56%	1:2.47
After	18.23%	52.82%	1:2.90

On the other hand, the development of non-contact community administrative office services was different in the 15-min and 5-min community life circles. No matter whether it was before, during, or after COVID-19, the online administrative services in the 5-min community life circle were significantly more than those in the 15-min community life circle. At the same time, the related non-contract activities in the 5-min community life circle increased most significantly, from 16.55% before COVID-19 to 52.82% after the COVID-19. It not only indicated that online non-contact interaction had become an important way of community administration and office services in the post-epidemic period. This also showed that the occurrence and development of non-contact community administrative office activities had an obvious spatial scale effect which represented the significant differences in the development of three living circles.

After the outbreak of COVID-19, the importance of non-contact administrative office services with no meeting, no errands, and no cost was highlighted. This partially replaced the needs of residents in handling daily life affairs and changed their habits of using administrative office facilities. In particular, we had put forward new functional requirements for non-contract services in the 5-min community life circle. Therefore, in the post-epidemic period, community administrative office facilities will need to be adjusted to promote the organic integration of non-contact and physical community administrative office services. This way, we can provide a convenient supply for efficient and intelligent service management and also provide more choices of service paths for residents.

4.6. Commercial Service Facilities

According to the Standard, community commercial service facilities involve many types of facilities. Shopping malls, catering, banks, telecommunications, and postal outlets are mainly included in the 5-min community life circle. There are shopping malls, vegetable markets, fresh supermarkets, restaurants, banks, and telecommunications in the 10-min community living circle and the community commercial outlets in the 5-min community life circle. According to the survey, there were differences in the changes in the frequency of non-contact interaction in different circles (Table 6). During COVID-19, the commercial activities carried out by non-contact ways in the 15-min community and 5-min community life circle decreased significantly, but the user level after COVID-19 was the same as before COVID-19. Compared with before COVID-19, the frequency of non-contract commercial activities in the 10-min community life circle increased during and after COVID-19. This increased significantly during COVID-19 which from 20.26% to 56.13%. This indicated that the changes in using commercial services in the community life circles mainly occurred in the 5-min community life circle during the post-pandemic period.

Table 6. Proportion of online use of community commercial service facilities.

Stage	15-min Community Life Circle Service Facilities Use	10-min Community Life Circle Service Facilities Use	5-min Community Life Circle Service Facilities Use
Facilities	Mall, Catering Facilities, Banking Outlets, Telecom Outlets, Postal Business Premises	Mall, Vegetable Market or Fresh Supermarket, Catering Facilities, Banking Outlets, Telecom Outlets	Community Commercial Outlets (Supermarkets, Pharmacies, Laundries, Beauty Shops, etc.)
Before	10.37%	20.26%	8.39%
During	2.63%	77.27%	3.26%
After	11.40%	56.13%	9.01%

According to the interviews, after COVID-19 the increase in the frequency of non-contact commercial services in the 10-min community life circle mainly involved three types of facilities, such as vegetable markets, fresh supermarkets, and shopping malls. A total of 87.65% of the respondents reported feeling satisfied with these online services. A total of 74.33% of respondents who had not used non-contact commercial activities said they would consider such activities in the future. A total of 83.64% of respondents thought online commerce platforms would reduce the use frequency of physical facilities.

We found that non-contact interaction services had had a significant impact on physical community commercial service facilities. The impact would be greater. Non-contact interaction services played a role of complementary security in response to COVID-19. They also changed traditional consumption habits and needs. Particularly, the demand for physical commercial service facilities in the 10-min community life circle decreased. Therefore, the new pattern of community commercial services needs to be adjusted and reconfigured in a timely way. It is appropriate to consider the addition of new facilities and the planning of convenient commercial service facilities in three circles.

4.7. Community Public Transport Facilities

The public transportation facilities in the community mainly include bus stations in the 15-min and 5-min community life circles. Due to the lack of online public transport services, the study investigated travel options such as online car-hailing and shared bikes. The survey results showed that the proportion of online ride-hailing and shared bikes increased greatly. The proportion increased from 32.71% before COVID-19 to 66.95% after COVID-19 and from 32.44% to 43.37%. At the same time, 62.10% of respondents thought

online car-hailing and shared bikes would significantly reduce the frequency of using public transport facilities".

As a result, travel mode had a significant structural change between before and after COVID-19. The non-contact transportation services enriched the travel pattern of residents and had an elastic supplement role. It was necessary to configure new facility space to adapt to the generation of new services mode. Therefore, under the influence of COVID-19 epidemic, we should consider the spatial configuration requirements of new facilities in three life circles while basing on the existing bus stations and actively promote the non-contact transportation services.

5. Discussion and Suggestions

The research analysis showed that non-contact interaction activities had a subversive impact on the lifestyle of community residents under the influence of COVID-19. The residents' new habitats of accessing community services presented new characteristics, which weakened the spatial and temporal constraints of activities and further reconstructed the spatial organization of urban communities. Non-contact interaction's impact on community planning was mainly manifested in three aspects: First, physical space cannot be completely replaced by virtual space for gathering and communicating in community service spaces. However, the non-contract interaction also created more demands from residents and made the development trend of composite space in urban communities more remarkable. Second, it was significantly different for non-contract interaction to impact on the seven types of service facilities in the community life circle and on facility planning and configuration. Third, the impact of different facilities in three circles based on non-contact interaction was different. It had a significant spatial scale effect. Therefore, based on the non-contact interaction perspective, it is necessary to identify the changes in residents' demands for community services accurately and explore the human-oriented planning pattern of high-quality community service facilities. In this way, we can promote the healthy spatial organization and resilient development of the community.

5.1. The Development Trend of Community Composite Space

The outbreak of COVID-19 and the community-based quarantine measures accelerated the development of non-contact interaction in the community. Non-contact interaction ensured the normal operation of community life and led to significant changes in residents' living habits and needs. From the data, it can be seen that, through non-contact interaction, the activities of the seven types of service facilities in the community life circle increased (Table 7). To some extent, some community activities that once took place in physical space have migrated to virtual space. Thus, a composite space formed by the fusion of virtual space and physical space has become the basis of community life and organization in the post-epidemic period. COVID-19 has strengthened the development of urban communities. The new organization of community space has put forward new requirements for the configuration of community service facilities. Non-contact interaction activities have become the main content of the community composite space, which has produced significant differences and scale effects on the use of physical community service facilities.

Table 7. Changes of the residents' use frequency of non-contact service activities after the COVID-19.

Stage	Educational Facilities	Cultural and Sports Facilities	Medical Facilities	Social Welfare Facilities	Administrative Office Equipment	Commercial Service Facilities	Community Public Transport Facilities
After the change	↑ 4.89%	↑ 25.47%	↑ 11.61%	↑ 3.78%	↑ 24.23%	↑ 30.12%	↑ 34.29%

Note: The "↑" means increase.

Therefore, we should limit the planning and construction of physical spaces or physical service facilities in community planning. We need to create a composite community living space that organically integrates "virtual community living space" and "physical

community living space" through the adaptability of community life, dynamic reorganization, multiple and coordinated planning participation, and community operation mechanisms.

5.2. Complex and Obvious Difference Changes

From the perspective of the rapid development of non-contact interaction, in the post-epidemic period the impacts of non-contact interaction on the seven types of service facilities in three community life circles were significantly different. The impacts can be summarized into three types: non-significant impact, potential impact, and significant impact. Type one is the non-significant effect represented by education facilities, showing that non-contract services played a temporary irreplaceable role during COVID-19. We could not replace physical teaching facilities before or after COVID-19. Type two is the potential impact represented by health and welfare facilities, showing that related non-contact activities were fully utilized before or during COVID-19, but that their advantages were recognized by some users. The potential demands of residents were huge after the COVID-19 pandemic. Type three is the significant impact represented by community cultural and sports facilities, administrative and office facilities, commercial facilities, and public transportation facilities. This showed that non-contract interaction changed residents' lifestyles and needs, with significant spatial variability and complexity (Table 8).

Therefore, we should consider the differential impact of non-contact interaction on the seven types of service facilities in community planning in the post-epidemic period. We carried out forward-looking research to form a dynamic planning strategy and shape a service support system that can adapt to the various needs of community residents. These methods will play an important role in improving the quality of community services.

5.3. Significant Spatial Scale Effect

Non-contact interaction activities have a significant spatial scale effect on the spatial impact of community service facilities. This is mainly manifested as: (1) In the same community life circle, non-contact interaction has varying degrees of impact on seven types of service facilities. For instance, in the 15-min community life circle, the impact of non-contact interaction activities on educational facilities is auxiliary, on public transportation facilities it is supplementary and changing, and on commercial facilities it is multi-faceted. Therefore, we need to carry out targeted research on different types of facilities and optimize the configuration of community service facilities based on the different effects. (2) Non-contract interaction activities also had different degrees of impacts on the same type of facility in 5-min, 10-min, and 15-min community life circles. From the data, it can be seen that the impact of non-contact interaction activities on community culture and sports facilities is represented by declines of 4.71% and 23.75% in the 15-min and 10-min community life circles after COVID-19, while it showed an increase of 28.46% in the 5-min community life circle. For the administrative office service facilities, it can be seen that residents need more services in the 5-min community living circle than in the 15-min community living circle. The use frequency of the non-contact service activities of the administrative office service facilities has also improved to varying degrees after COVID-19. It has increased 36.27% in the 5-min community life circle, while it only increased 7.66% in the 15-min community life circle. At the same time, the impact on community commercial service facilities has mainly increased significantly for service facilities in the 10-min community life circle but has had little impact on the 5-min and 15-min community living circles. The increase or decrease in the frequency of residents using non-contact interaction service activities has caused new requirements for the spatial configuration of various service facilities in the community. We need to actively make corresponding adjustments in response to these new requirements. This impact mechanism will be important to guide the planning of community service facilities. During the COVID-19 pandemic, the urgency of people using community service facilities also had a significant scale effect. The 5-min community life circle was the benchmark of residents' comfortable walking area, and the

majority of facilities in the 5-min community life circles served the residents. This circle was used as the protection circle for disaster relief, thus we should pay more attention to the improvement and optimization of its service facilities.

Although the non-contact interaction largely influenced and changed the use characteristics of community service facilities, this influence had a complex correlation with geographic space and was manifested as different spatial scale effects. Therefore, it is necessary for community planning to shift from "meeting spatial coverage rate" to "comprehensively evaluating the spatial and temporal characteristics + residents' needs" in order to implement demand-oriented, spatial, and temporal community planning.

5.4. A Model of Community Composite Service Facilities Space

The outbreak of COVID-19 has caused a growing recognition of the value of communities in protecting residents' health and fulfilling basic daily activity needs. Non-contact interaction become an important part of the community life in the post-pandemic period and fundamentally broadened the concept of community space. It endured new aspects of the community lifestyle and significantly accelerated the integration of virtual and physical space in the community.

It is necessary to state that although urban construction technology is constantly developing, the criteria for dividing urban units has not changed significantly in different periods. The spatial division of community units based on the human walking scale is a stable principle. According to previous studies, dividing spatial community units based on walking scale into 15-min, 10-min, and 5-min walking times will still be applicable in the future. However, the non-contact interaction activities under the influence of COVID-19 had a significant impact on the community planning model based on walking distance. The accessibility of facilities and non-contact interaction service radius reconfigured the organization mechanisms of community space. In terms of walking scale, community planning should include pedestrian scale factors and include the spatial scale changes brought about by non-contact interaction activities. In the post-pandemic period, community planning should be based on the walking scale, utilize the development of new technologies such as non-contact interaction, and allocate community service facilities and public space more flexibly in order to further expand the spatial scale of the community. At the same time, it should be noted that virtual space is not simply an extended imitation of physical space and non-contact interaction does not simply mean smoothing out the limit of geographic space. In the post-pandemic period, an intelligent community composite space should include both physical and virtual space.

Based on our results, we argued that the integration of virtual space and physical space created a new type of community spatial organization. Using the non-contact mechanism of impact on community service facilities—that is, significant differences and spatial scale effects—we proposed a model for composite spatial service facility planning in communities in the post-pandemic period (Figure 2). The model shows that the functional boundaries of the existing community will become blurred and the traditional "physical circle" will appear as a "virtual circle". We can take advantage of the concepts of community composite space service facility to guide "one-stop" facility planning and also form a comprehensive community service system. The model of composite spatial services facility is conducive to improve the service efficiency of various resource elements. This will simplify the service procedures to meet the diverse needs of different people in different scenarios. It will also provide support for daily life and special periods in the post-pandemic period. The community planning carried out by this model is of great significance for tackling public health emergencies and promoting the health of urban communities.

Table 8. The impact of no-contact interaction on usage of community service facilities.

Type	I	II	II	III	III	III	III
Stage	Educational Facilities	Medical Facilities	Social Welfare Facilities	Cultural and Sports Facilities	Administrative Office Equipment	Commercial Service Facilities	Community Public Transport Facilities
During	Toughness assurance	Not significant	Not significant	Limited mitigation	Partial substitution	Supplemental benefits	Elastic supplement
After	Not significant Auxiliary action	Potential impact Change	Potential impact Change	Significant impact Promote. Change	Significant impact Change. Substitute	Significant impact Multiple effects	Significant impact Change

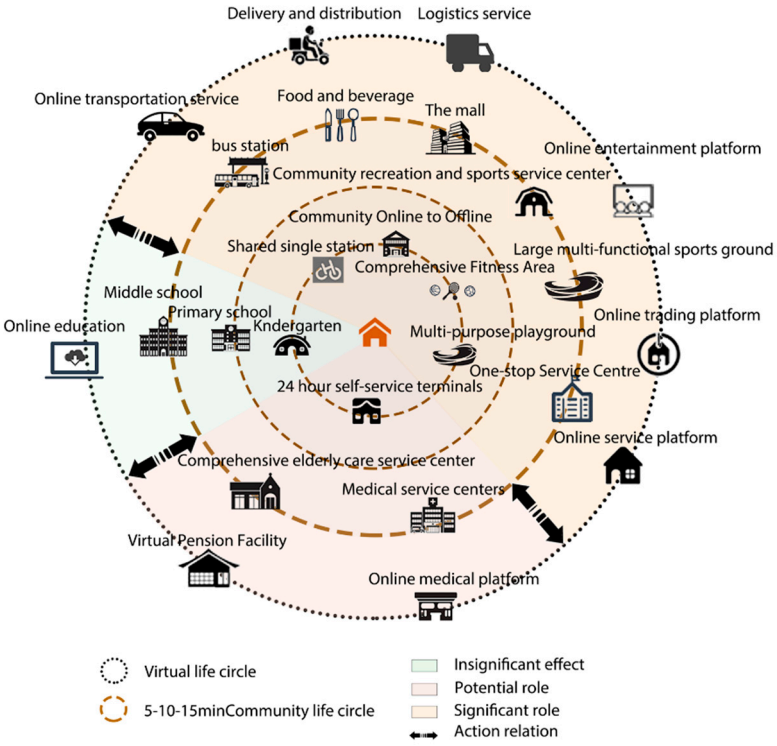

Figure 2. Layout model of community complex space service facilities.

In this unique period, this research aimed to examine the impact of virtual space and physical space based on previous research. It used the community scale and examined to community planning. From the perspective of non-contact interaction, we explored residents' use of community services and the changes in their needs in different circles before, during, and after COVID-19. We analyzed the development trends of urban community space in the post-pandemic period and the impact of non-interaction activities on the configuration of community service facilities. The difference in the impact between virtual space and physical space and the spatial scale effect fully reflect their complexity. Non-contact interactive activities have different impacts on different service facilities. These impacts are not fixed and will change due to changes in external conditions. We need to pay attention to the changes in community service facility planning and make corresponding adjustments to it. In addition, the development of non-contact interaction activities has improved fairness and sharing in communities to some extent. Community services go beyond physical space. It was effective for us to make full use of the relationship between

virtual space and physical space to construct a composite community space to promote the sustainable development of the community.

6. Conclusions

COVID-19 was a public health event with an enormous impact on the world's history, and the process of the pandemic prevention measures was also a compelling practical test of the health and sustainability of human settlements. The outbreak of COVID-19 triggered a profound reflection on the development of urban communities.

Based on previous studies, we considered the effects of the rapid development of non-contact interaction activities on urban communities under the influence of the pandemic. We explored the issues and further thought about the sustainable development model of urban communities through timely observations of the residents' lifestyle changes before, during, and after COVID-19. We found that virtual community living spaces characterized by non-contact interaction activities developed rapidly in urban communities under the impact of the pandemic. These were integrated deeply with physical community spaces to form composite community spaces. Non-contact interactive activities are the main uses of the composite community space and have different impacts on people's habits of using existing community service facilities. The influence mechanism mainly manifests in significant differences and spatial scale effects. Thus, the construction of a spatial service facility configuration model for urban composite communities can better promote the sustainable development of communities.

This study has profound implications for the theory, method, and practice of urban community planning. This research supplements the practice of community planning so that the concept of non-contact interactive activities can be effectively integrated into the knowledge system of community construction. It enriches the ideas of community construction and provides new perspectives for planning communities, including inclusiveness, resilience, and adaptability, to achieve sustainable development.

Of course, this study also had certain limitations. In the context of COVID-19, we were concerned about the sustainable development of the community and thus carried out this public welfare research. We chose a questionnaire survey to explore the impact of non-contact interaction activities on residents' spatial behavior. It was indeed difficult for us to carry out surveys focusing on face-to-face communication with interviewees during the peak breakout of COVID-19 and the subsequent epidemic prevention periods in China. China's epidemic prevention and control measures were so strict that we could not survey on a large scale, so the sample size may be limited to some extent. We will continuously expand the research scope and collect data samples in a more scientific and standardized way in future research. In this way, we can provide strong support for the sustainable development of urban community planning in the post-pandemic period.

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