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# Impacts of community-level grassroots organizations on household food security during the COVID-19 epidemic period in China

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## ABSTRACT

Purchasing food via community-level grassroots organizations was a new pattern of food patronage for Wuhan residents during the COVID-19 lockdown in 2020, but little attention was paid to it. The study examined the relationship between community-level grassroots organizations and household food insecurity based on an online survey of household food insecurity in Wuhan in March 2020. The study found that problems in all three domains of food insecurity including food anxiety, insufficient quality and inadequate quantity existed but were uneven. Community-level grassroots organizations played an important role in promoting food security including reducing worries about food supply and providing enough food intake, but did not ensure households had adequate food quality due to increasing food prices, fewer varieties of food and decreased food freshness. Compared to other grassroots organizations, the community committee had actually become an extension of the government to run administrative grassroots affairs before the epidemic, so its tight relationship with local government made it become the major grassroots power in ensuring household food security at the residential community level.

## 1. Introduction

Food-based community organizations have played a non-negligible role in reducing food insecurity caused by disaster, contingency and emergency. Food-based community organizations can be grouped into two types, those who aim to increase access to food and those who aim to provide food-relevant education [1]. Community kitchens are community-based organizations focusing on food and nutrition-relevant education [2]. Food banks or food pantries are food-based community organizations aiming to provide emergency food supply to those in need [3]. There is a difference between food banks and food pantries in the US, Canada, and Australia. In Canada, food banks usually receive food resources from the public and corporate sectors, then distribute food to food pantries and soup kitchens [4,5]. While in the US and Australia, food pantries tend to be smaller than food banks and provide food directly to those in need [6,7]. In the UK, food banks include both operations [8]. Generally, food banks and food pantries have been well operated under normal circumstances, and they have been a critical food source for people with low income in some high-income countries [9].

However, the COVID-19 epidemic has caused challenges for those food-based community organizations to continue their service [10]. Lockdown measures were essential to halting the spread of the virus, but also led to economic and social consequences, including global food insecurity. A set of compulsory measures to reduce community transmission of COVID-19 posed huge difficulties for stable food availability because of disrupted food production, and caused huge challenges for people to generate daily incomes to access adequate and preferred food. According to FAO's 2021 report, during the COVID-19 epidemic close to 318 million more people worldwide faced food insecurity at moderate or severe levels in 2020 than in 2019 [11]. The interruption of traditional purchasing

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channel due to the COVID-19 outbreak has caused a surge in demand for contingent food distribution [10]. Food banks in Canada provided more people with food assistance in March 2020 compared to the previous year [3]. At the same time, about 42% of food banks in Canada encountered a decrease in volunteers who could dedicate their time, physical labor and knowledge to the organizations in 2020 [3]. The loss of available volunteers could lead to the reduction of the service of food-based community organizations. For instance, about 14% of communal food service sites were closed in the Canadian city of Hamilton during the COVID-19 epidemic [3]. During the COVID-19 epidemic, people seeking assistance from food banks have been almost overwhelming in the UK [12]. The surge of demand for food has caused challenges for food banks because of reduced revenue, as well as a lack of human resources and volunteers [13,14]. Large food assistance organizations have struggled to effectively protect the food security of households or individuals since the outbreak of COVID-19 [15,16]. As the largest federal food assistance program in the United States, the Supplemental Nutrition Assistance Program (SNAP) encountered increasing applications due to the COVID-19 epidemic and the daily application rate in April 2020 was nearly 4 times higher than usual. In California, nearly half of the applicants were first-time participants [17], while studies demonstrated that people using the SNAP program had a higher likelihood of experiencing food insecurity [18].

Besides food-based community organizations, non-food-based community organizations have also been involved in food distribution during the COVID-19 epidemic. One kind of community-level grassroots power is local NGOs (non-government organizations). They took action to provide food to vulnerable groups during the lockdown when they realized that the public administration was facing great difficulties making effective emergency food plans [19–21]. In Greenland, the volunteers of local NGOs distributed between sixty to ninety meals per day to homeless people during 5 weeks of lockdown [22]. Community-level organizations quickly and spontaneously organized food support campaigns, which played a significant role in ensuring food access, provisioning, and distribution for residents in communities [23,24]. Roughly 9% of households used a community organization to access free food in Canada [25]. In the Andes, different grassroots communities organized to respond to the epidemic effectively. They sold and delivered Agroecological Baskets to each home in middle and upper-level class neighborhoods, then the generated profit was used to distribute food to the neediest poor homes [26]. Community organizers also paid attention to marginalized people's food security, for instance, they were the first to provide food support for Black and Brown communities during the emergence of COVID-19 in the USA [27].

There remain notable research gaps in understanding the role of community-level grassroots organizations in ensuring food security. Firstly, existing studies have generally focused on the effect of food-based community organizations on food insecurity mitigation. Despite growing studies of community organizations' influence on food insecurity, the role of non-food-based community organizations in ensuring large-scale emergency food security remains largely understudied. Secondly, most existing studies have placed emphasis on the overall security of food, but little attention has been paid to community-level grassroots organizations' different influences on three domains of food security - food anxiety, food consumption quality and food intake quantity. Furthermore, there are numerous community-level grassroots organizations such as the community residential committee (*Shequ jumin weiyuanhui*) and property management company (*Wuye gongsi*) in China, which are not food-relevant organizations. Some of those community-level grassroots organizations were involved in addressing food provisioning during the COVID-19 epidemic period. Few empirical studies have examined the role of those non-food-based community organizations in emergency food supply during COVID-19 epidemic, especially in the early stage of COVID-19 epidemic in 2020. This study aims to narrow the gaps. This study attempts to investigate household food purchasing supported by community-level grassroots organizations during the lockdown period, then uses a regression model to examine the relationship between community-level grassroots organizations and three domains of household food insecurity based on cross-sectional data. The rest of the paper is structured as follows. Section two constructs an analytical framework to analyze the effects of community-level grassroots organizations on ensuring emergency food provisioning, and provides a brief background on residential community and its relevant grassroots organizations in China. Section three briefly presents data sources and processing, and describes variables and estimation methods. The descriptive statistics and estimated results of models are shown in section four. In section five, the study discusses the reasons why community-level grassroots organizations had different impacts on three domains of household food security. Section six concludes the findings and provides policy implications.

## 2. Theoretical framework

### 2.1. Community-level grassroots organizations and emergency food provision

During the lockdown period in Wuhan, China, governments released policies and recommendations such as mobility restrictions and social distancing due to the high transmission of COVID-19. These measures were beneficial to reduce the risk of the virus spreading, but increased the difficulties of ensuring household food security. Thus, community-level grassroots organizations quickly participated in ensuring households' food security. There are mainly three effects of community-level grassroots organizations on ensuring emergency food provision (Fig. 1).

The first effect is termed as "recovering effect" in this study, referring to how community-level grassroots organizations contributed to recovering food availability that was damaged by the COVID-19 epidemic. Due to the outbreak of COVID-19 in early 2020, the operation of food wholesale markets in Wuhan was affected and led to decreased availability at wholesale markets. Moreover, most wet markets and many supermarkets were closed, which are the primary outlets of urban household food sources. Food delivery labor force shortages and limited food transportation also contributed to decreased food availability at the community or neighborhood level. Grassroots organizations could directly cooperate with local farmers and food retailers to formulate a simple but stable food supply chain. This kind of purchase services increased the availability of food at the community level, which was beneficial for households to purchase foods.

Another is termed as "filling up effect", which refers to that community-level grassroots organizations providing physical access to food outlets during the COVID-19 epidemic. The infection risk increased households' willingness to stay at home, while communities

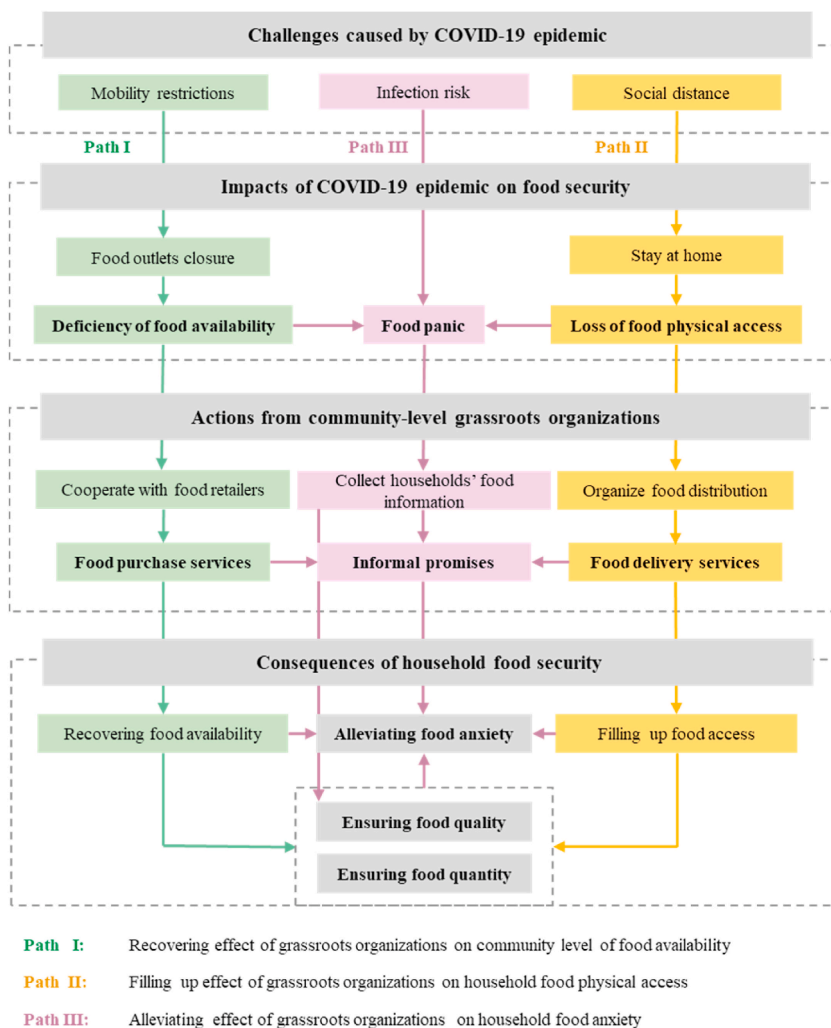


Fig. 1. Role of community-level grassroots organizations in ensuring household food security.

that implemented partial lockdowns strictly limited the times for households going out to buy food, such as three times a week. Especially, familiar food outlets could even be closed. Therefore, time, food items choice and outlets availability for households' food purchasing were reduced largely, which increased the difficulties in ensuring household food quality and quantity. The additional service from grassroots organizations could fill the decreased physical access to food to a certain extent. Besides transporting food from wholesale markets or supermarkets, community-level grassroots organizations could also organize food distribution inside neighborhoods and provide delivery services. Those food delivery services included handling, sanitization, and home delivery, which contributes to solve the last hundred yards problem (from the neighborhood gate to household door).

The term "alleviating effect" is used to refer to the role of community-level grassroots organizations in reducing household food anxiety. The epidemic was unprecedented and caused wide disruptions in the urban food provisioning system. Actions of grassroots organizations involved in food provisioning probably provided an informal promises for residents who were being faced with disrupted food supply chains, and helped to alleviate households' anxiety, or even panic, about food shortages. WeChat groups provided a platform for grassroots organizations to collect the information of households' demands for food diversity. Grassroots organizations also paid attention to the food demands of vulnerable groups such as the elderly and the disabled, who are not as likely to be familiar with using smartphones and/or have mobility issues. With the growing maturity of the practices, the food purchase and delivery services from grassroots organizations not only ensured households' food quality and quantity, but also played an important role in decreasing households' worries and concerns about food supply and consumption.

## 2.2. Community and its relevant grassroots organizations in China

There are two meanings for "community (*Shequ*)" in China in view of government administration and geographic space. The first one is that "community" is viewed as a geographical unit (Fig. 2). A community is a spatial unit composed of several neighboring residential complexes (*Xiaoqu*) where a residential complex is commonly served by a property management company. Those neighboring residential complexes could be separated by roads or open spaces such as woodland, river or park.

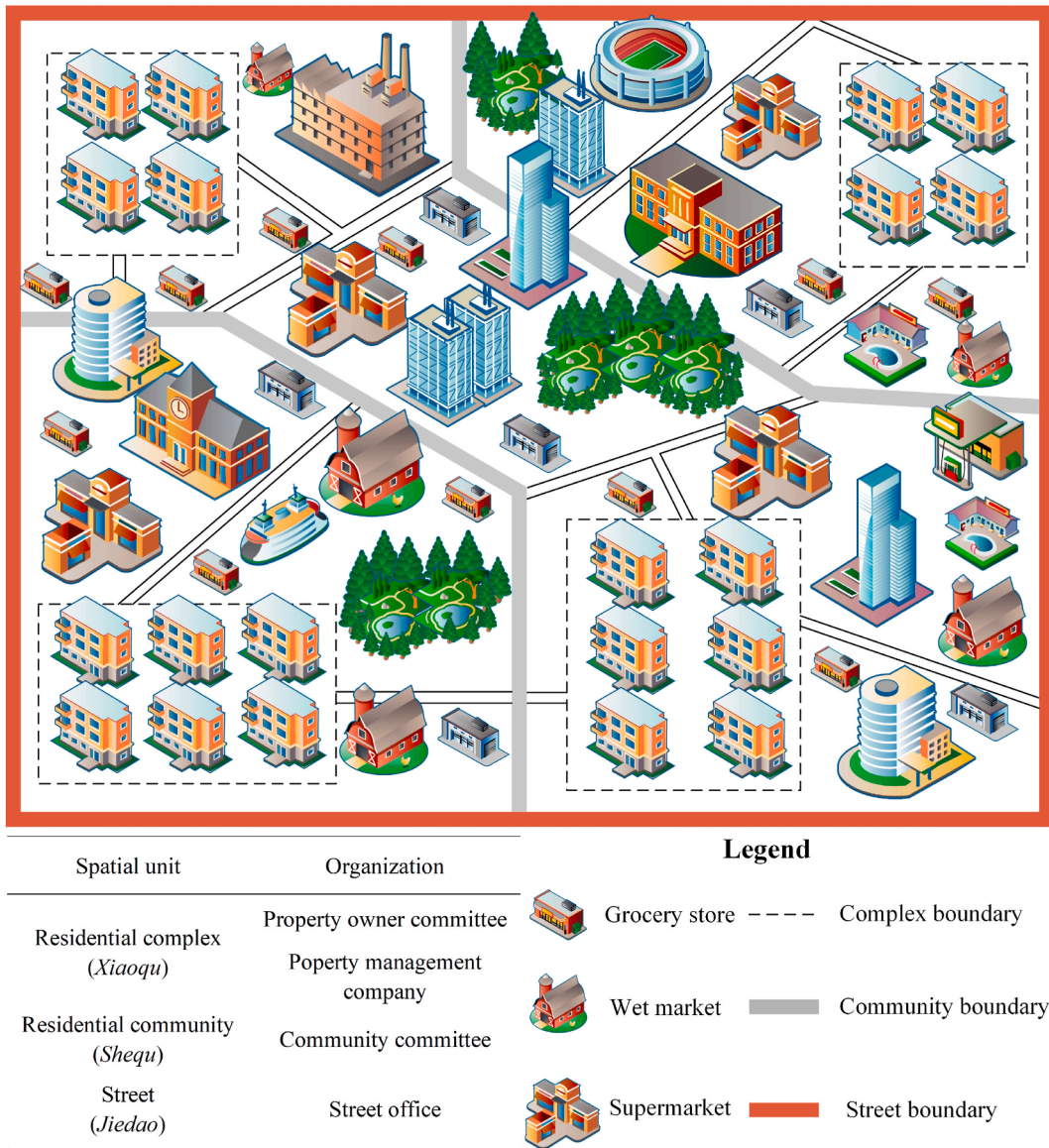


Fig. 2. Street, community and residential complex in China.

The second meaning is that a community is also an administrative unit. There are five levels of government in China, including central, provincial, prefectural, county and township-level governments. A township-level government in a city is commonly called a street office. A region governed by a street office (township-level government) is called a “street” (*Jiedao*), which is usually composed of several communities. A community residential committee is a self-governing mass organization in law that is financially and personally supported by the government, which thus could be regarded as a quasi-administrative organization. Therefore, community is *de jure* an administrative spatial unit.

As a grassroots organization, a community residential committee provides services for residents and conducts administration required by the government. For a residential complex (*Xiaoqu*), members of the property owner committee are elected by the apartment or house owners. The property owner committee is responsible for selecting and employing a property management company. A community residential committee has the power to supervise and require property management companies to conduct or implement governmental policies such as lockdown measures. Both the community residential committee and property management company can also establish volunteer teams that can be involved in conventional and emergent management. Thus, there could be three kinds of grassroots organizations acting within a residential complex in COVID-19 epidemic, including a community residential committee, a property management company and a volunteer team. All these community-level of grassroots organizations are non-food-based. Before the outbreak of the epidemic, the responsibilities of community residential committees focused on carrying out the initiatives

to improve public etiquette and ethical standards and the maintenance of residents' public welfare [28,29]. Property management companies worked to improve the buildings and facilities in the residential complex [30].

### 3. Methods and data sources

#### 3.1. Data sources

Wuhan was chosen as the study area. Wuhan was the first city that reported confirmed cases of COVID-19. Residents in Wuhan experienced both partial and complete enclosures of residential complexes between February 11th and April 8th, 2020 [31]. Partial enclosure policy required residents to stay at home and allowed one member per household to leave and return to their residential complex with limited frequency; while complete enclosure policy allowed no one to go outside their residential complex [31]. As a secondary-tier city in China, Wuhan has a large number of grassroots organizations. It has a total resident population of 12.45 million and 13 districts (county-level administrative units), with 1431 residential communities (neighborhoods) [32], which means that a community committee served about 8700 persons or about 3522 households in 2020. A community residential committee usually consists of 5–9 staff members [29,33]. The policy of “community group buying” was implemented as a contingent food provision policy in response to disrupted access to food outlets caused by complete enclosure [31]. Under the lockdown measures such as partial and complete enclosure, people's mobility was restricted and enclosed public places including wet markets were asked to close, which directly increased the difficulty for residents to access food. Community-level grassroots organizations thus played an indispensable role in securing the food supply of households by involving in “community group buying” and other patterns of food provisioning.

As mobility restrictions were implemented, the study distributed an online questionnaire survey between March 24th and 31st, 2020. The electronic questionnaire was compiled on a platform called Wenjuanxing, which is a convenient tool to design questionnaires as well as retrieve and analyze data. WeChat is the most widely used social media in China, and WeChat groups are generally established on kinship, work and life where people from different backgrounds can gather [34], so it is a good channel to invite people from different regions and classes to participate in the questionnaire. By limiting the IP address, we ensured the online survey could only be seen and filled in by respondents who stayed in Wuhan at the time. This was the only feasible method to capture real-time experience of households during the COVID-19 responses in Wuhan, although it was not the most ideal.

The strategy used to collect data was similar to snowball sampling. First, our research team shared the online questionnaire with friends who lived in Wuhan based on personal relationships, and encouraged them to invite more respondents to join in various WeChat groups. Then, in order to keep the samples representative of the community's diversity, our team tried our best to obtain interviewed households of diverse locations, structures, and economic levels. Finally, 874 respondents filled in the questionnaire with those respondents spatially covering almost areas of Wuhan. There were 820 valid cases after removing cases with missing data for relevant variables.

The questionnaire aimed to investigate the status of household food security in Wuhan, and mainly included three aspects of information. The first aspect was basic information about the household, such as household size, the head of household, and household living environment; The second aspect was household food security status, which was measured based on the Household Food Insecurity Access Score (HFIAS). HFIAS is proposed by the FANTA project, and it has been assumed that it is able to effectively distinguish whether the household is food secure, and it is widely used in cross-sectional surveys due to its low cost [35]; The third aspect was the information about household food purchase approaches, food consumption and difficulties or challenges for household access to food during the COVID-19 lockdown. In this part, the questionnaire asked households whether and how often they purchased food via community-level grassroots organizations, as well as for comments about this purchase approach if they were willing to share.

#### 3.2. Household food insecurity measurement and its dependent variables

It is important to know how severe the experience was and the characteristics of food insecure status the household had. The household food insecurity happens on a gradient and mainly includes three periods []: (1) the first period is when a household feels anxiety and uncertainty about future physical or economic access to food, which is an initial and mild household food insecure status; (2) the second period is when a household's diet quality and diversity have to be adjusted because of difficulties of food access, but family members do not need to endure hunger, which is a moderate household food insecure status; (3) the last period is when a household encounters limited food quality and quantity, family members have to skip meals and even starvation appears, which is a severe household food insecure status. These periods correspond to three domains of household food insecurity based on HFIAS metrics. Table 1 shows the nine questions for measuring the household food insecurity scale [36]. The nine questions can be grouped as three domains, including the domain of food anxiety, the domain of food quality (insufficient quality) and the domain of food quantity (inadequate food intake). Thus, three dependent variables were used to represent three domains of household food insecurity, symbolized as *FA*, *FQL*, and *FQT*, respectively. The study comprehensively examined relationships between grassroots organizations and the three domains of food security.

As shown in Table 1, the nine-item scale of HFIAS measures people's perceptions about food insecurity including anxiety about food supply, limited food variety and quality, and insufficient food quantity. Generally, each question had four response options in the questionnaire including ‘Never’, ‘Rarely’, ‘Sometimes’ and ‘Often’. HFIAS offers an algorithm that guides users to respectively measure three different domains of household food insecurity [36]. The study added the option of ‘All the time’ due to the complete lockdown policy in Wuhan, which was unprecedented and lasted more than four weeks, then divided the five response options into four groups, the last group including two options - ‘Often’ and ‘All the time’. The coding rules of variables *FA*, *FQL*, and *FQT* were presented as follows (Fig. 3). For variable *FA*, if a surveyed household never felt anxiety about food access, the value of variables *FA* equals 1, if it felt anxiety about food access sometimes, the value of variables *FA* equals 2, and if it always felt anxiety about food ac-

**Table 1**  
Nine questions used to measure household food insecurity scale.

Question (During the lockdown period)	Occurrence frequency options
Food anxiety (used to generate variable <i>FA</i> ) Q1: Did you worry about household would not have sufficient food?	0 = Never, 1 = Rarely, 2 = Sometimes, 3 = Often or all the time
Food quality (used to generate variable <i>FQL</i> ) Q2: Were your household not able to eat preferred food? Q3: Did your household have to eat only a few kinds of foods? Q4: Did your household have to eat some kinds of foods that not really want?	For each question, options include: 0 = Never, 1 = Rarely, 2 = Sometimes, 3 = Often or all the time
Food quantity (used to generate variable <i>FQT</i> ) Q5: Did your household have to eat a smaller meal than needed? Q6: Did your household have to eat fewer meals in a day? Q7: Did your household have no food to eat? Q8: Did your household have to go to sleep hungry? Q9: Did your household eat nothing for a whole day and night?	For each question, options include: 0 = Never, 1 = Rarely, 2 = Sometimes, 3 = Often or all the time

Source: Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide(version 3) [36].

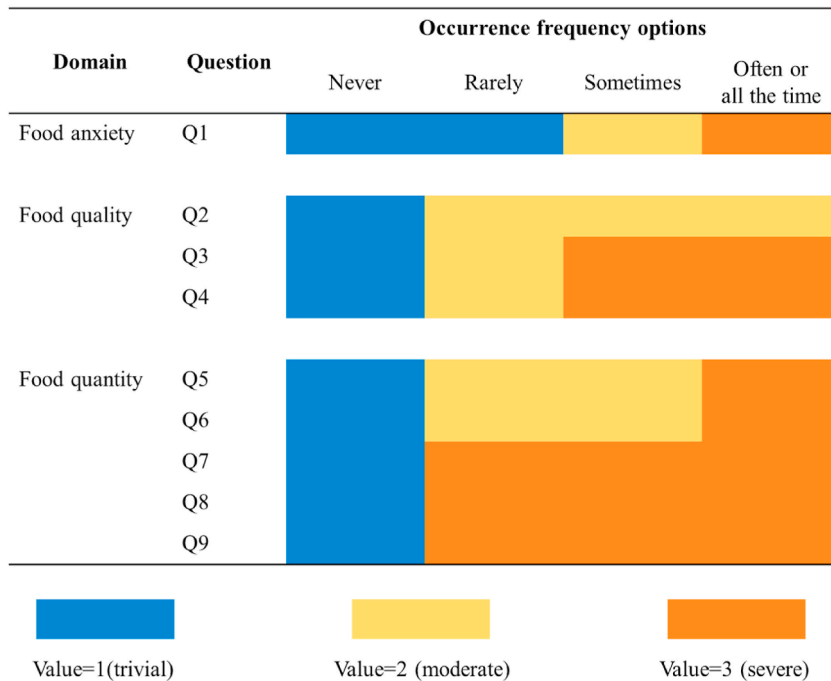


Fig. 3. Value assignment for the variable *FA*, *FQL* and *FQT*.

cess, *FA* equals 3. The value of variable *FQL* was given based on Q2-4, and the value of variable *FQT* was given based on Q5-9. The rule of applying 1, 2, or 3 is shown in Fig. 3. The value 1, 2 and 3 represent the levels of trivial (including none and mild), moderate and severe, respectively.

Table 2 shows the definition and statistics of three dependent variables. Variables *FA*, *FQL* and *FQT* were used in model 1, model 2 and model 3, respectively. The highest mean among them was variable *FQL*, while the lowest was variable *FQT*. Meanwhile, standard deviation of variable *FQL* also meant that the distribution of household food quality was more concentrated than the two other domains. These data indicated that the lockdown may mainly have worsened the severity of household food quality.

### 3.3. Independent variables

The binary variable *GRO* was used to reflect whether households purchased food through grassroots organizations. A food contingency planning policy has been in place since 2004 (after the 2003 SARS outbreak) in China. However, the COVID-19 epidemic confining millions of people in residential communities was unprecedented, which led to an urgent need for additional and effective actions to address “last mile” and “last hundred yards” problems of food distribution. The “last mile” refers to food transportation from wholesale markets or supermarkets to a residential complex and the “last hundred yards” refers to food delivery from the residential

**Table 2**  
Definition and statistics of dependent variables.

Variable	Definition	Model			Mean	Standard deviation
		1	2	3		
<i>FA</i>	Household food anxiety, never food anxiety = 1, moderate food anxiety = 2, severe food anxiety = 3	✓			2.36	0.76
<i>FQL</i>	Household food quality and variety, adequate food quality = 1, moderate insufficient food quality = 2, severe insufficient food quality = 3		✓		2.60	0.61
<i>FQT</i>	Household food quantity, enough food quantity = 1, moderate insufficient food quantity = 2, severe insufficient food quantity = 3			✓	1.92	0.85

complex gate to every household's doorstep. Some community-level grassroots organizations were involved in addressing the last mile and last hundred yards problems. In terms of formality, there are two main types of community-level grassroots organizations. One is formal grassroots organizations, which includes community committees and property management companies, and the other is informal grassroots organizations such as volunteer teams. Along with rapid urbanization and marketization, the Chinese central government adopted the policy of “community service as an alternative way of providing the supplemental safety net in urban areas” in 1994 [37]; p199]. Therefore, community committees take an important role in providing neighborhood security, sanitation, welfare, mediation services and promoting neighborhood development [38]. A property management agent is a management company that provides professional housing management and services for homeowners, which contributes to keeping a safe and comfortable living environment [39], and plays the role of go-between in mediating conflicts between homeowners [40]. Volunteer teams work as informal grassroots organizations, for instance, some residents undertake work such as purchasing and distributing food. The variable *GRO* was computed by answers to the question - “Since January 23, did your household buy food through any of the following means?” If the surveyed household chose any of the options including ‘Residential property management committee’, ‘Local government (community committee)’ and ‘Volunteers’, the value of variable *GRO* equals 1, and 0 for otherwise. Using the service from community-level grassroots organizations could decrease household food security, the coefficient of variable *GRO* thus is assumed to be negative.

The binary variable *FC* was used to indicate whether an interviewed household is female-centered. The variable is based on the question - “Which of the following best describes your household structure?” If the interviewed household chose the option of ‘Female-centered (No husband/male partner in the household, may include relatives, children, friends)’, variable *FC* equals 1, 0 for otherwise. It has generally been observed that female-headed households were more likely to experience higher rates of poverty compared to male-headed households [41]. The reasons are mainly attributed to gender inequality, including females facing more disadvantages in the labor market, having more time spent on child care and household chores, and having fewer opportunities to gain a high level of education [42,43]. Therefore, as female-centered households faced more challenges that could increase household food insecurity, the coefficient of variable *FC* thus is assumed to be positive.

The variable *NFM* was used to represent the number of family members. It was generated based on the question - “During quarantine, how many household members are you living with?” The options included 0 to 9 (more than 9). Social transformation has caused a surge in one-person households and multigenerational households in China [44]. Variable *NFM* thus is measured using three dummy variables to distinguish household size and structure: one dummy variable for 2 to 4 family members, one dummy variable for 5 to 8 family members, and one dummy variable for more than 8 family members. There is a complex relationship between household size and household food insecurity, the coefficient of variable *NFM* thus is uncertain. It is generally assumed that moderate household size is beneficial to ensuring household food security [45], but as the number of family members increases, the incidence of severe food insecurity increases significantly [46], especially for households that have many children or adolescents.

Previous studies indicated that living in a leased or rented home could be associated with household food insecurity [47]. Housing costs are a big financial burden for a low-income household and the financial constraints force the household to try to balance other aspects of expenditure, which causes difficulties for those households to have access to nutritious, preferred and adequate food [2]. Therefore, the binary variable *RP* was used to reflect whether the household rented a property. If interviewed household answered ‘I'm renting the property’ to the question - “Do you own your current place of residence or are you renting it?”, the value of *RP* equals 1, and equals 0 otherwise. Additional financial pressure caused by renting a house would increase the risk of household food insecurity, the variable *RP* thus is assumed to have a positive coefficient.

Economic access is one important aspect of household food security. An increase in food prices would harm household economic access to food. For example, the sharp increase in food prices caused about 1 billion undernourished people in the world from 2005 to 2008 [48]. The study used a dummy variable *FPI* to examine whether food price affected household food insecurity during the epidemic period. The variable *FPI* was generated based on the question - “Since January 23, did you or any member of your household experience any of the following challenges?” If the surveyed household chose the option of ‘Food price increase’, the value of *FPI* equals 1, and equals 0 otherwise. Decreased food affordability would increase household food insecurity, therefore the coefficient of *FPI* is assumed to be positive.

Conventional food patronage is undoubtedly an indispensable factor in ensuring household food security. Although purchasing food from online stores is not a traditional method for households, with the rapid development of e-commerce, online food purchasing has become a more and more popular option for urban residents in China [49]. Purchasing food from public food markets (wet markets), supermarkets and online were conventional food purchasing methods in economically-developed cities such as Nanjing before the outbreak of COVID-19. Therefore, variable *RA* was used to reflect whether surveyed households experienced restricted access



to physical markets and online food markets. The variable *RA* was generated based on the answer to the multiple-choice question - "Since January 23, did you or any member of your household experience any of the following challenges?" If a surveyed household chose any of the options including 'Restricted access to food markets and supermarkets' or 'Restricted access to online stores', variable *RA* equals 1, it equals 0 otherwise. Variable *LFA* was used to denote whether surveyed households experienced limited variety and amount of food. If a surveyed household chose any of the options including, 'Limited food availability and lack of food variety at wet markets or supermarkets' or 'Limited food availability and lack of food variety at online stores', the value of variable *LFA* equals 1, otherwise it equals 0. Restricted access to food and insufficient food supply would increase the risk of facing household food insecurity, variable *RA* and *LFA* are thus assumed to have a positive coefficient.

For the model with *FA* as dependent variable, there were ten additional binary control variables to reflect whether and the extent to which different types of food groups affect household food anxiety. The ten variables were based on the multiple-choice question - "Has the COVID-19 outbreak affected your consumption of the following foods?" The definitions of variables were made according to the household dietary diversity scores (HDDS) by FAO [50]. Variables *HCC*, *HRTC*, *HMEC*, *HVC*, *HFC*, *HSC*, *HEC*, *HFSC*, *HMIC*, *HSCC* and denoted whether the epidemic affected household consumption of cereal, roots and tubers, meat, vegetables, fruits, foods made from soybeans, eggs, fish and seafood, milk and food made from milk, spice and condiments, respectively. If surveyed households confirmed that the COVID-19 outbreak affected the consumption of one or some food groups, the value of the related variable is 1, otherwise it is 0. As the variables *HMEC* and *HVC* included several food groups, once the household chose any of the groups, the value of the variable equals 1, 0 for otherwise. Variable *HMEC* consisted of organ meat and flesh meat. Variable *HVC* included several food groups, such as green leafy vegetables, vitamin A-rich vegetables and tubers, and other vegetables. Any kind of affected food consumption would increase the probability of household food insecurity, therefore the coefficients of these variables are assumed to be positive.

The definition and statistics of all independent variables are shown in Table 3. Variables *HCC*, *HRTC*, *HMEC*, *HVC*, *HFC*, *HSC*, *HEC*, *HFSC*, *HMIC*, *HSCC* are only used in model 1.

### 3.4. Ordered logit model

The dependent variables in models 1–3 were variables *FA*, *FQL*, *FQT*, respectively, independent variables in models 2 and 3 were the same, but model 1 added additional variables. As variables *FA*, *FQL*, *FQT* are ordinal and discrete, ordered logit/probit models are a reasonable regression approach. However, the parallel-lines assumption needs to be satisfied when using ordered logit model, which assumes that the relationship between any pairs of outcome categories is equal. If some explanatory variables violate the parallel-lines assumptions, the results of the ordered model are biased and misleading. One major method to test the assumption is using

**Table 3**  
Definition and statistics of independent variables.

Variable	Definition	Expected Sign	Mean	Standard deviation
<i>GRO</i>	Grassroots organization, <i>GO</i> = 1 for household obtained food from grassroots organization, otherwise, <i>GO</i> = 0	-	0.79	0.40
<i>FC</i>	Female-centered household, <i>FC</i> = 1 for the head of household was female, otherwise, <i>FC</i> = 0	+	0.06	0.24
<i>NFM</i>	Number of Family members, <i>NFM</i> range from 1 to 4		2.28	0.66
<i>RP</i>	Rent the property, <i>RP</i> = 1 for household rented the property, otherwise, <i>RP</i> = 0	+	0.12	0.32
<i>FPI</i>	Food price increase, <i>FPI</i> = 1 for the price of food increased, otherwise, <i>FPI</i> = 0	+	0.60	0.49
<i>LA</i>	Limited access to stores, <i>LA</i> = 1 for household experienced limited access to offline or online stores, otherwise, <i>LA</i> = 0	+	0.89	0.32
<i>LFA</i>	Limited food availability in stores, <i>LFA</i> = 1 for household Limited food availability in offline or online stores, otherwise, <i>LFA</i> = 0	+	0.45	0.50
<i>HCC</i>	Household cereal consumption, <i>HCC</i> = 1 for the COVID-19 epidemic affected household cereal consumption, otherwise, <i>HCC</i> = 0	+	0.21	0.41
<i>HRTC</i>	Household roots and tubers consumption, <i>HRTC</i> = 1 for the COVID-19 epidemic affected household roots and tubers consumption, otherwise, <i>HRTC</i> = 0	+	0.12	0.33
<i>HMEC</i>	Household meat consumption, <i>HMEC</i> = 1 for epidemic affected household meat consumption, otherwise, <i>HMEC</i> = 0	+	0.60	0.49
<i>HVC</i>	Household vegetables consumption, <i>HVC</i> = 1 for the COVID-19 epidemic affected household vegetables consumption, otherwise, <i>HVC</i> = 0	+	0.38	0.48
<i>HFC</i>	Household fruits consumption, <i>HFC</i> = 1 for the COVID-19 epidemic affected household fruits consumption, otherwise, <i>HFC</i> = 0	+	0.31	0.46
<i>HSC</i>	Household consumption of food made from soybeans, <i>HSC</i> = 1 for the COVID-19 epidemic affected household consumption of food made from soybeans, otherwise, <i>HSC</i> = 0	+	0.34	0.47
<i>HEC</i>	Household eggs consumption, <i>HEC</i> = 1 for the COVID-19 epidemic affected household eggs consumption, otherwise, <i>HEC</i> = 0	+	0.07	0.26
<i>HFSC</i>	Household fish and seafood consumption, <i>HFSC</i> = 1 for the COVID-19 epidemic affected household fish and seafood consumption, otherwise, <i>HFSC</i> = 0	+	0.42	0.49
<i>HMIC</i>	Household consumption of milk and food made from milk, <i>HMIC</i> = 1 for the COVID-19 epidemic affected household consumption of milk and food made from milk, otherwise, <i>HMIC</i> = 0	+	0.25	0.44
<i>HSCC</i>	Household spice and condiments consumption, <i>HSCC</i> = 1 for the COVID-19 epidemic affected household spice and condiments consumption, otherwise, <i>HSCC</i> = 0	+	0.10	0.30

Note: The expected sign shows the relationship of this variable to the independent variables, with '+' indicating a positive correlation and '-' indicating a negative correlation.

the Brant test. The specification of the ordinary ordered logit model is as follows (Equation (1)).  $F_i^*$  is a latent but continuous variable in the function, whose value determines what the observed but ordinal  $F_i$  equals, the specific functions are shown in Equation (2).

$$F_i^* = a^*X + \varepsilon_i \tag{1}$$

$$F_i = \begin{cases} 1 & \text{if } -\infty < F_i^* < w_1 & \text{trivial level} \\ 2 & \text{if } w_1 < F_i^* < w_2 & \text{moderate level} \\ 3 & \text{if } F_i^* > w_2 & \text{severe level} \end{cases} \tag{2}$$

where the dependent variable  $F_i$  represents three types of food insecurity status, which include food anxiety, food quality (insufficient quality) and food intake (inadequate quantity). The higher the value, the more severe the food insecurity status.  $X$  is a vector of independent variables including explanatory variables, household characteristics and food consumption characteristics.  $a^*$  are unknown coefficients of explanatory variables that need to be estimated,  $\varepsilon_i$  is the random error term that is assumed to obey logistic distribution, and  $w_k$  is also an unknown threshold that needs to be estimated.

Unlike the linear regression model, the logistics model uses odds ratio (OR) rather than coefficient to indicate the degree of explanatory variable influencing the dependent variable on the underlying scale [51]. OR is a commonly used tool to compare proportions, and can be calculated as follows (Equation (3)).

$$\begin{cases} OR = \frac{p}{1-p} = \exp(X'a) \\ p = (F = 1|X) = \frac{\exp(X'a)}{1+\exp(X'a)} \end{cases} \tag{3}$$

## 4. Results

### 4.1. Household food security and community-based grassroots organization

A total of 820 interviewed households were included in the analysis (Table 4). There were 651 households out of 820 which bought food via grassroots organizations. Table 4 demonstrated that the COVID-19 outbreak had severe impacts on household food security. Among the three domains of food insecurity, households faced the least problem in obtaining sufficient food quantity, while food quality was the most prominent challenge to food security during this period of the COVID-19 epidemic. Most households purchased food with assistance from community-based grassroots organizations during the lockdown. Regarding food anxiety, about 17%, 29% and 53% of households experienced trivial, moderate and severe anxiety about food access. For those households with trivial and moderate food anxiety, about 81% used services from grassroots organizations. 78% of households with severe food anxiety bought food through the assistance of grassroots organizations. As far as limited food quality, 7%, 26% and 67% of households encountered trivial, moderate and severe insufficiency in food consumption quality. For those households with trivial food quality insufficiency, 71% purchased food from grassroots organizations, while the proportions of households with moderate and severe food quality insufficiency who purchased through grassroots organizations were 82% and 80%, respectively. With regard to limited food quantity, 40%, 28% and 32% of households experienced trivial, moderate and severe inadequate food intake during the COVID-19 epidemic outbreak in 2020. For those households with trivial food quantity insufficiency, 82% purchased food assisted by grassroots organizations. 80% and 76% of households with moderate and severe food intake insufficiency purchased food with assistance from grassroots organizations.

### 4.2. Model estimation results

Tables 5–7 presents the estimation results of Model 1, Model 2 and Model 3. The P-value of the Brant test of models 1–3 shows that the assumptions in the three models were not violated (p-value>0.10), which indicates traditional ordered logit model is suitable to examine the relationship between household food security and grassroots organizations.

#### 4.2.1. Estimation results for model 1 with FA (food anxiety) as dependent variable

The estimation results of Model 1 show that twelve different independent variables had a significant relationship with household food anxiety (Table 5). Firstly, the coefficients of the first two dummy variables of *NFM* are significant at a 5%-level, which indicates that bigger household size had a greater impact on household food anxiety. Compared to households of one person, households with

**Table 4**  
Descriptive statistics of three domains of food insecurity.

Value	Food anxiety (FA)			Food quality (FQL)			Food quantity (FQT)		
	No.	%	% using service	No.	%	% using service	No.	%	% using service
1	143	17.44	81.12	55	6.71	70.91	330	40.24	81.82
2	241	29.39	80.91	215	26.22	82.33	228	27.81	79.82
3	436	53.17	77.98	550	67.07	79.09	262	31.95	75.95

Note: value refers to the value of the variable FA, FQL and FQT. % using service refers to the percentage of household buying food via community-level grassroots organization.

**Table 5**  
Estimation results of model 1 with FA as dependent variable.

variables	Coef.	Odds Ratio	Standard error	Z-score	95% Confidence Interval	
GRO	-0.42**	0.66	0.12	-2.28	0.46	0.94
FC	0.21	1.24	0.39	0.68	0.67	2.29
NFM(ref:live alone)						
2-4	0.59**	1.81	0.48	2.24	1.08	3.05
5-8	0.69**	1.99	0.56	2.41	1.14	3.46
more than 8	0.00	1.00	0.51	-0.01	0.37	2.70
RP	0.45*	1.57	0.39	1.83	0.97	2.54
FPI	0.70***	2.02	0.32	4.38	1.48	2.77
LA	0.45**	1.57	0.35	2.02	1.01	2.44
LFA	0.00	1.00	0.16	0.00	0.74	1.36
HCC	0.46**	1.58	0.33	2.22	1.06	2.37
HRTC	0.65**	1.91	0.56	2.22	1.08	3.39
HMEC	0.32**	1.38	0.23	1.94	1.00	1.91
HVC	0.56***	1.76	0.29	3.36	1.26	2.44
HFC	0.35**	1.42	0.26	1.95	1.00	2.02
HEC	0.14	1.15	0.19	0.80	0.82	1.60
HFSC	0.35	1.42	0.55	0.92	0.67	3.02
HSC	0.02	1.02	0.17	0.10	0.73	1.41
HMIC	0.42**	1.53	0.30	2.12	1.03	2.26
HSCC	0.04	1.04	0.30	0.13	0.59	1.83
Log likelihood		-737.87	LR Chi-square		164.77 (p-value = 0.00)	
Pseudo R <sup>2</sup>		0.10	Brant test		14.02 (p-value = 0.78)	

Note: \*, \*\*, \*\*\* represents significant at the level of 10%, 5% and 1%, respectively.

**Table 6**  
Estimation results of model 2 with FQL as dependent variable.

variables	Coef.	Odds Ratio	Standard error	Z-score	95% Confidence Interval (OR)	
GRO	-0.13	0.88	0.17	-0.65	0.61	1.29
FC	-0.40	0.67	0.21	-1.29	0.38	1.27
NFM(ref:live alone)						
2-4	-0.42	0.66	0.20	-1.36	0.36	1.19
5-8	-0.29	0.75	0.25	-0.89	0.39	1.44
more than 8	-0.79	0.45	0.25	-1.44	0.15	1.33
RP	0.39	1.47	0.40	1.43	0.86	2.49
FPI	0.70***	2.01	0.32	4.33	1.48	2.78
LA	1.05***	2.86	0.63	4.78	1.80	4.12
LFA	0.74***	2.10	0.35	4.50	1.51	2.89
Log likelihood		-609.42	LR Chi-square		93.32 (p-value = 0.00)	
Pseudo R <sup>2</sup>		0.07	Brant tes		14.02 (p-value = 0.14)	

Note: \*, \*\*, \*\*\* represents significant at the level of 10%, 5% and 1%, respectively.

**Table 7**  
Estimation results of model 3 with FQT as dependent variable.

variables	Coef.	Odds Ratio	Standard error	Z-score	95% Confidence Interval (OR)	
GRO	-0.32**	0.73	0.12	-1.96	0.53	1.00
FC	-0.25	0.78	0.21	-0.92	0.46	1.33
NFM(ref:live alone)						
2-4	-0.54**	0.58	0.14	-2.20	0.36	0.94
5-8	-0.76***	0.47	0.12	-2.87	0.28	0.79
more than 8	-0.80*	0.45	0.22	-1.65	0.17	1.16
RP	0.36*	1.44	0.30	1.75	0.96	2.16
FPI	0.39***	1.48	0.21	2.74	1.12	1.96
LA	0.66***	1.94	0.43	2.97	1.25	3.00
LFA	0.28**	1.33	0.18	2.04	1.01	1.75
Log likelihood		-868.11	LR Chi-square		46.03 (p-value = 0.00)	
Pseudo R <sup>2</sup>		0.03	Brant test		4.49 (p-value = 0.88)	

Note: \*, \*\*, \*\*\* represents significant at the level of 10%, 5% and 1%, respectively.

the number of family members ranging from 2 to 8 had roughly two times greater odds of feeling anxiety or uncertainty about their food supply, given all other variables as constant. Second, the coefficient of *RP* is 0.45 with a significance of 10%, which indicated that renting a property had a higher probability of increasing the level of food anxiety than not renting. Households who rented property had 1.57 times greater odds of feeling anxiety about food, with all other variables constant. Third, the coefficient of *FPI* is 0.70, significant at a 1%-level, indicating that increasing food prices was a key factor that led to household food anxiety. Increasing food prices caused 2.02 times greater odds of living in a household experiencing food anxiety, holding constant all other variables. Additionally, the coefficient of *LA* is 0.45, significant at a 5%-level, which indicated that households who experienced limited access to offline or online stores were more likely to feel food anxiety. Households who claimed that they experienced limited access to offline or online stores during the epidemic, had the odds of feeling more anxiety about household food supply of 1.57 times than those who did not, with all other variables constant. Finally, different categories of impaired food consumption influenced a household's food anxiety to varying degrees. The coefficient of *HCC*, *HRTC*, *HMEC*, *HFC*, *HMIC* ranges from 0.32 to 0.65, with a significance of 5%, while the coefficient of *HVC* is significant at a 1%-level. This demonstrated that households had a higher likelihood to worry about food supply when it was affected by the impaired food groups including cereal, roots and tubers, meat, fruits, milk and food made from milk, and vegetables. Meanwhile, households who claimed difficulties in obtaining roots and tubers had odds of being more likely to worry about food 1.91 times than those who did not have difficulties, given all other variables as constant.

#### 4.2.2. Estimation results for model 2 with *FQL* (food quality) as dependent variable

In model 2, three different independent variables that had a significant relationship with food quality (Table 6). Firstly, the coefficient of *FPI* is 0.70, significant at a 1%-level, indicating that increasing food prices was more likely to result in household insufficient food quality. Households who judged food prices increased during the epidemic were 2.01 times more likely to experience insufficient food quality than those who did not affirm it, given all other variables as constant. Second, the coefficient of *LA* and *LFA* is 1.05 and 0.74, respectively, significant at a 1%-level. This indicates that households who had difficulties in conventional food patronage were more likely to encounter insufficient food quality. For households who stated that they experienced limited access to stores and limited food availability and variety in stores, respectively, the odds of facing severe insufficient food quality was 2.86 and 2.10 times that of those who did not experience these issues, holding constant all other variables.

#### 4.2.3. Estimation results for model 3 with *FQT* (food quantity) as dependent variable

In model 3, the results show that five different independent variables had a significant relationship with food quantity (Table 7). The coefficient of three dummy variables of *NFM* was  $-0.54$ ,  $-0.76$ , and  $-0.80$ , respectively, and significant at a 5%-level, 1%-level and 10%-level. This indicates that a bigger household size was beneficial to reduce the risk of insufficient food quantity. Households who had a small, medium and large family experienced insufficient food quantity, respectively, 0.58, 0.47 and 0.45 times that of those who lived alone, with all other variables constant. The coefficient of *RP* is 0.36 with 10%-level significance, which meant that households who rented property were more likely to experience inadequate food quantity. Households who rented property had 1.44 times greater odds of experiencing insufficient food quantity, all other variables being constant. The coefficient of *FPI* is 0.39 with 1%-level significance, indicating that increasing food prices was more likely to increase the severity of insufficient food quantity. Increasing food prices caused 1.48 times greater odds of living in a household experiencing inadequate food quantity, holding constant all other variables. Similarly, the coefficient of *LA* is 0.66 with 1%-level significance and *LFA* is 0.28 with 5%-level significance, which indicated that households who faced difficulties in conventional food patronage had a high likelihood to encounter insufficient food quantity. For households who experienced limited access to offline or online stores and limited food availability and variety in stores, respectively, the odds of facing more severe insufficient food quality was 1.94 and 1.33 times that of those who did not experience these limits, given all other variables as constant.

## 5. Discussions

### 5.1. Grassroots organizations contributed to ensuring household food security

The estimation results show that households who purchased food from grassroots organizations significantly reduced food anxiety and ensured households would have adequate food quantity. The coefficient of variable *GRO* in models 1 and 3 is  $-0.42$  and  $-0.32$ , respectively, with 5%-level significance (Tables 5 and 7). For households who did not purchase food via grassroots organizations, the odds of feeling more anxious about food and facing more severe insufficient food quality was 0.66 and 0.73 times that of those who did, holding other variables constant. The results confirmed the observation that grassroots organizations helped residents decrease food anxiety and increase their access to food. In terms of food anxiety, previous studies confirmed that when households encountered inadequate food supply, they were more likely to feel stressed [52,53]. Owing to the existence of grassroots organizations in China, households had an additional approach to purchase food and realized that people care about them and provided kind care for them. This assistance from grassroots organizations greatly alleviated their anxiety about food supply and the panic of sudden lockdown. Because of community cohesion based on trust, cooperation and support, this kind of harmonious environment was also beneficial to decrease the risk of food anxiety [54,55].

Grassroots organizations provided an alternative pattern that increased households' access to food. Households could purchase enough food without going outside their neighborhoods. Usually, households obtaining food via grassroots organizations consisted of three steps: firstly, residents submitted their food requests based on food supply lists posted by grassroots organizations in the WeChat group; then an organization's members purchased the food from wet markets or supermarkets, or even from wholesale markets; finally, the organizations delivered food to households or notified households to pick up the food in a designated spot. This kind of food

purchasing approach was similar to online food purchase and delivery, but the organization members took on every job between food purchase and distribution.

### 5.2. Community committee played a leading role at residential community-level

Community committee is the major force of organizations in ensuring household food security at the community level. About 52% of households reported that they purchased food with assistance from a community committee, while the proportion of purchasing food from a property management company or a volunteer team was 39% and 36%, respectively (Fig. 4). The result is not surprising because community committee is an organization that has a tight relationship with local government. In China, community committees are a social institution led by the Communist Party of China. In practice, the levels of government above community committee treated community committee as an anchor or leg to run grassroots affairs [56]. Meanwhile, the community committee members receive office expenses from the municipal government and the community committee accepts performance assessments from the township-level government (street office). Therefore, the city-level government required that the community committees took the responsibility of ensuring basic living services for residents during the epidemic. Moreover, community committees have the basic information on permanent resident populations in their respective complexes, which helped the community committees decide the sequence of assisting households according to the degree of obtaining food difficulty. Compared to other social organizations, the community committees adapted to the circumstances more effectively and flexibly because of greater government involvement and support. The most vital role of the community committee in ensuring household food security is that it solved the last hundred yards problem based on the community grid governance scheme [57]. Wuhan constructed the community grid governance scheme by equipping one member for one grid in 2019, and one grid has 300–500 households or 1000 permanent residents. These grid members played an important role in contacting residents and delivering goods and materials during the lockdown. Meanwhile, the community committees were effective at recruiting volunteers and mobilizing property management companies as well. Guided by community committees, roughly 24,000 volunteers took on the task of delivering food to households in need, such as the elderly and persons with disability in Wuhan [58].

Moreover, community committees were believed by residents to be the backbone force for contingency food provisioning. One question was asked in the questionnaire - “What do you perceive to be the best measures to purchase food since the outbreak of COVID-19?” More than 60% of participants shared their views and experience, and 87 participants mentioned that purchasing food through their community committees was a good channel to purchase food in an emergency situation. Community committees met their residents' daily food needs, which made a significant contribution to making residents willingly stay at home during the extended lockdown [59]. Besides the leading role of community committees, property management companies and volunteer teams played a supplementary role in ensuring household food security during the COVID-19 epidemic, reflecting their partnerships with community committees. As for volunteer teams, their major work was delivering food from the complex's gate to a household's doorstep, which reduced the workload for the community committees. The “Volunteer service care action” for preventing and controlling the epidemic in Wuhan recruited volunteers to provide local residents with daily necessities such as grain, oil, vegetables, medicines and other purchasing and delivery services, which greatly ensured the basic livelihood of residents during the lockdown period [60].

### 5.3. Difficulties of grassroots organizations to effectively ensure household food consumption quality

The results of model 3 show that grassroots organizations did not make a difference in ensuring households' adequate food quality. The coefficient of variable *FQL* is  $-0.13$  in model 2, but not significant (Table 6). Answers to one question in the online questionnaire were helpful to find out the reasons. The question was - “Your comments about any aspect of your personal food-related experience during the COVID-19 epidemic.” More than 200 interviewees shared their food-related experiences and opinions about contin-

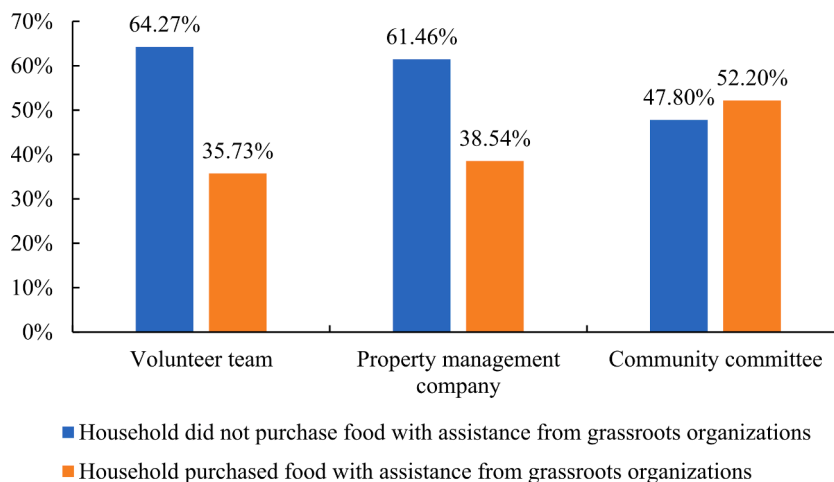


Fig. 4. Statistics of households re: purchasing food from community-level grassroots organizations.

gent food purchasing activities in Wuhan. Based on the responses, the study concluded there were three aspects of problems causing inadequate food quality, including the rising prices of food, limited diversity of food, and decreased food freshness.

### 5.3.1. Soaring food prices and inadequate food consumption quality

Increasing food prices was a significant problem that affected the capacity and choices of household food purchase, the results of variable *FPI* in models 1–3 all provided the confirmation that grassroots organizations were hard-pressed to ensure sufficient food consumption quality for households (Tables 5–7). Firstly, lockdown measures caused havoc on the distribution of food, and inadequate food supply in the short term made food prices increase sharply; grassroots organizations did not have the capacity to control those increasing food prices. About 60% of households said that food prices were higher than before the COVID-19 outbreak, and roughly 38% of households reported that they were spending more than twice as much on food. Meanwhile, food prices are closely related to their storability, thus the price of perishable food was more likely to increase during the lockdown [61]. Therefore, one of the reasons for inadequate food consumption quality could be attributed to decreased consumption of perishable food such as leafy vegetables. Additionally, the increase in food prices decreased the economic access to food, which led to difficulties for households to ensure adequate food consumption quality. People were asked to stay at home, which could lead to an income loss in some households. This caused a negative impact on people's purchasing capacity. For those residents or households with no or little savings, income loss could cause a more severe problem to maintain food affordability during COVID-19 epidemic period. Some responders also reported that food prices decreased after the first several weeks of lockdown, this is consistent with the findings of other studies [62]. Since the quarantine measures were implemented, more than half of households thought the most difficult period in food access they experienced was from February 1st to February 16th, while less than 10% of households faced huge difficulty in food access after March 11th. This indicated that the impact of lockdown policies on the deterioration of food consumption quality and an increase in food prices was mitigated when the reaction of government and markets rapidly changed and became more positive.

### 5.3.2. Fewer varieties of food and insufficient food consumption quality

Another problem is food purchased via grassroots organizations did not have a rich diversity during the lockdown period. Dietary diversity is a key element of high-quality and healthy diets, which ensures the intake of essential nutrients and energy required to perform daily work efficiently. But during the lockdown period in Wuhan, it was hard to ensure rich dietary diversity [31,63]. Many interviewed households reported experiencing a limited diversity of food. Fig. 5 showed that the consumption of different kinds of food groups was affected by the epidemic. The consumption of meat was most affected; roughly 60% of households complained that they did not have enough kinds of meat during the lockdown. Nearly 42% of households had difficulties in purchasing fish and other seafood. About 38% of households reported that their consumption of vegetables was affected by the lockdown, in particular leafy vegetables. Households also reported that the consumption of fruits and milk and food made from milk was limited, by 31% and 25%, respectively. The consumption of cereal, roots and tubers was less affected by the epidemic, with only 7% of households claiming that COVID-19 affected their consumption of eggs. This finding is consistent with results in Pakistan, that is, cereals remained the largest source to support daily calorie consumption for households, and non-perishable food items accounted for a large proportion [64,65]. Thus, it is reasonable that households who had difficulties in purchasing roots and tubers had the highest odds to encounter severe food anxiety (Table 5).

### 5.3.3. Decreased food freshness and insufficient food consumption quality

The last reason that community-based grassroots organizations did not make a difference in food consumption quality could arise from the difficulty in ensuring the freshness of food during the COVID-19 epidemic. The freshness of food matters in terms of the food being healthy, safe and tasty [66]. Therefore, freshness is the primary consideration in food shopping, and this characteristic is especially strong in southern China [67,68]. For instance, in order to meet the residents' demand for meat, both the central government and municipal government released reserved frozen meat to market, but some surveyed households complained that those meat was not fresh. There were definitely some constraints that reduced the freshness of food during the lockdown in Wuhan. The first was in-

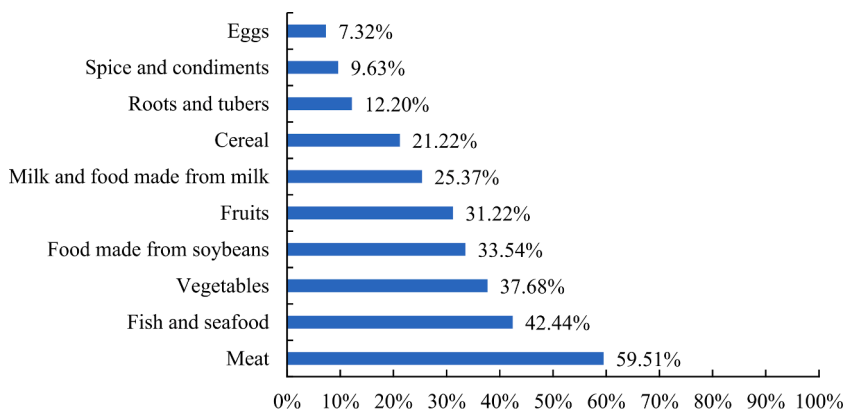


Fig. 5. Proportion of households reported the consumption of food items were affected by the COVID-19 epidemic.

sufficient transportation capacity and delayed distribution. The lack of food transport vehicles made it impossible for community-based grassroots organizations to ensure the same level of efficiency of purchasing food by households as that before the COVID-19 outbreak. On the other hand, the frequency of food purchasing organized by grassroots organizations was limited in both timing and product diversity. Studies also show that people may have deliberately reduced the frequency of food shopping to diminish the risk of infection [69], so households chose storable food such as tubers rather than perishable leafy vegetables, which caused a loss of food freshness to some extent.

#### 5.4. Research limitations

The movement restriction led to the study gaining interviews with households by using the method of snowball sampling, which resulted in a weak heterogeneity of participants. In particular marginalized households such as the elder who was not familiar with smartphones but lived in hardship may have been not included in the survey, which may cause a lower proportion of food insecure households in the whole sample. The study was a quick online survey that aimed to investigate residents' specific food experiences during the lockdown, and due to travel restrictions the survey needed to be completed independently without professional guidance. It was hard to evaluate whether their understandings of questions were accurate. Additionally, the socio-economic characteristics of communities was not considered in this research because of data availability, for instance, lacking the data of community grassroots organizations' coping capacity.

### 6. Conclusions

The COVID-19 crisis brought an enormous challenge to society and urban food emergency system. Residents of Wuhan encountered greatly increased difficulties in purchasing food due to food supply disruption and decreased access to food. The fear of infection and a series of lockdown measures led to traditional food retail modes not operating effectively and generated urgent demand for innovative food purchasing methods to adapt to COVID-19-related challenges. Community-level grassroots organizations could be regarded as the first to perceive and react to the changes at the initial stage of the COVID-19 outbreak. Therefore, the new mode of purchasing food via non-food-based community grassroots organizations became an important feature in ensuring household food security during the epidemic in Wuhan.

Using data collected by an online survey conducted during March 2020 in Wuhan, the study showed that most serious households encountered the issue of insufficient food quality, as less than 10% of households had adequate food quality and variety during the lockdown. Meanwhile, there was a high proportion of households purchasing food via community grassroots organizations. The estimated results of the ordered logit model showed that community grassroots organizations played a significant role in ensuring household food security, especially in alleviating anxiety about food supply and providing enough food quantity by increasing food access and supplementing food availability. But community grassroots organizations faced challenges including increasing food prices, fewer varieties and decreased freshness of food, which made it hard to guarantee adequate food quality.

On the other hand, the study indicated that community committees played an effective and active role in ensuring household food security in Wuhan. This is attributed to the administrative system in urban China, where the community committee is a grassroots mass autonomous organization, and has actually become an extension of the government's administrative functions, and acts as a strong liaison between the government and residents in practice. The local government can require community committees to take responsibility of ensuring food provisioning in an emergent context. Government support in turn strengthen community committees' capacity to ensure food supply. Additionally, community committees can cooperate with property management companies, property owner committees and volunteer teams to addressing the challenges of food supply in COVID-19 pandemic.

This study contributes to the literature of emergency food supply. To our knowledge, this is the first study to examine the relationship between purchasing food via non-food-based community grassroots organizations and household food insecurity mitigation. Unlike existing studies focusing on the overall effect [57], this study explored the specific influence of grassroots organizations on three domains of food insecurity including food anxiety, food quality and food quantity. This study obtained a new finding that grassroots organizations played an important role in reducing worries about food supply and ensuring food intake, but had little influence in addressing the problem of inadequate food quality. This study thus contributes to the empirical understanding of the role of community-level grassroots organization in large-scale emergency food provisioning.

Facing such a large-scale disaster like COVID-19, government and community grassroots organizations need to work together. The evidence and experiences of community-level grassroots organizations in Wuhan combating COVID-19 provide important lessons to improve the existing food emergency systems. It is reasonable and necessary to include non-food-based community-level grassroots in urban emergency food supply planning system. Moreover, with roughly 30 years of development, community committees can become an important sector for urban residents in solving public affairs. The pattern of emergency food purchasing via a team of community grassroots organizations where community committees play a leading role can increase the resilience of the community-level food system to respond to unexpected disasters.

#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

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