REPERCUSSIONS OF THE COVID-19 PANDEMIC IN THE FOOD SUPPLY CHAIN: PERSPECTIVES FROM RIO DE JANEIRO, BRAZIL

Marcelle Candido Cordeiro

Tese de Doutorado apresentada ao Programa de Pós-graduação em Engenharia de Produção, COPPE, da Universidade Federal do Rio de Janeiro, como parte dos requisitos necessários à obtenção do título de Doutor em Engenharia de Produção.

Orientadores: Luan dos Santos
Lino Guimarães Marujo

Rio de Janeiro
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Orientadores: Luan dos Santos
Lino Guimarães Marujo

Aprovada por:

Prof. Luan dos Santos
Prof. Lino Guimarães Marujo
Prof. Tharcisio Cotta Fontainha
Prof. Vinícius Picanço Rodrigues
Prof[a]. Ana Carolina Maia Angelo

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Cordeiro, Marcelle Candido

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Orientadores: Luan dos Santos

Lino Guimarães Marujo

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OS DESDOBRAMENTOS DA PANDEMIA DE COVID-19 NAS CADEIAS DE SUPRIMENTOS ALIMENTARES NO RIO DE JANEIRO, BRASIL

Marcelle Candido Cordeiro

Abril/2022

Orientadores: Luan dos Santos
Lino Guimarães Marujo

Programa: Engenharia de Produção

Diante das dificuldades das CSs frente a pandemia de COVID-19, tais como o aumento do risco de desabastecimento de produtos devido as oscilações da demanda e as políticas de isolamento social, essa tese inicialmente investigou as lacunas na literatura científica sobre os desdobramentos de pandemias em CSs. O principal resultado desse estudo foi uma agenda de pesquisa para o enfrentamento da pandemia de COVID-19. A agenda de pesquisa destacou que a pandemia apresenta riscos graves à segurança alimentar, como o risco de aumento da fome e da desnutrição, o que motivou o direcionamento da tese para cadeias de suprimentos alimentares. Diante disso, o segundo passo foi compreender a realidade do agronegócio familiar brasileiro no contexto da pandemia (visão do produtor). Para tal, foram entrevistados dois pequenos produtores e a presidente de uma cooperativa de agricultores familiares do Rio de Janeiro. Os resultados dessa pesquisa indicam que durante a pandemia, os fechamento temporário das feiras de rua prejudicou o escoamento da produção dos pequenos produtores. Por outro, lado essa dificuldade acabou por motivar o uso de mídias sociais para escoamento da produção. Por fim, investigaram-se os desdobramentos da pandemia sobre as CSs alimentares sobre a perspectiva do consumidor por meio de uma survey sobre os hábitos alimentares. Os resultados dessa pesquisa indicam a deterioração dos hábitos alimentares durante a pandemia.

ABSTRACT OF THESIS PRESENTED TO COPPE/UFRJ AS A PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF SCIENCE (D.SC.)

REPERCUSSIONS OF THE COVID-19 PANDEMIC IN THE FOOD SUPPLY CHAIN: PERSPECTIVES FROM RIO DE JANEIRO, BRAZIL

Marcelle Candido Cordeiro

Abril/2022

Advisors: Luan dos Santos
Lino Guimarães Marujo

Department: Production Engineering

Due the difficulties of SCs during the pandemic, in some cases, demand has increased, while in others it has dropped, causing cascading disruptions, this thesis initially investigates the gaps in the scientific literature on the consequences of pandemics in SCs. The main output of this study was a research agenda for COVID-19 confronting, which highlighted that the pandemic poses severe risks to food security, such as the risk of increasing hunger and malnutrition, which motivated the direction of the thesis for food supply chains. Then, the second step was to understand the reality of Brazilian family agribusiness in the context of the pandemic (farmer's view). To this end, two small producers and the president of a cooperative of family farmers in Rio de Janeiro were interviewed. The results indicate that during the pandemic, the temporary closure of street fairs hampered the flow of production from small producers. On the other hand, this difficulty ended up motivating the use of social media to sell production. Finally, the last study investigates food SCs from the consumer's perspective through a survey on the eating habits. Our results indicate the deterioration of eating habits during the pandemic.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACIPTA	Association of Citriculturists and Rural Producers of Tanguá
AFSC	Agri-food supply chain
CEASA	Supply Center
CONEP	Brazilian National Commission on Ethics in Research
Embrapa	Brazilian Agricultural Research Corporation
FAO	Food and Agriculture Organization
GDP	Gross domestic product
IHMC	Institute for Human and Machine Cognition
INCRA	National Institute of Colonization and Agrarian Reform
INPI	National Institute of Industrial Property
LA	Latin America
MAPA	Ministry of Agriculture, Livestock and Supply
PAA	Food Purchase Program
PFSC	Perishable food supply chain
PGPAF	Program of Assurance of Prices in Family Farming
PhD	Philosophy Doctor
PNAE	Brazilian National School Feeding Program
PRONAF	National Program for Strengthening Family Farming
RJ	Rio de Janeiro
SAF	Secretariat of Family Agriculture and Cooperatives
SCs	Supply chains
SEAF	Family Farming Insurance
Tomatec	Tomato sustainable production system

CHAPTER 1: INTRODUCTION

This introductory chapter presents the doctoral dissertation context and motivation. It also defines the theoretical principles that underpin the doctoral research.

1.1. Context and motivation

In December 2019, COVID-19 broke out in Wuhan, China, probably derived from bat coronavirus and rapidly spread across the world (LAI et al., 2020). More than 75% of patients have lungs function impaired by the COVID-19 (CHEN et al., 2020). Droplets from lungs of infected individuals, even asymptomatic, are the main way of the viral transmission (ROTHAN; BYRAREDDY, 2020). The less severe fatality of COVID-19 and the globalization may have favored the rapid spread of the new coronavirus (PETROSILLO et al., 2020; WUEST et al., 2020). On March 11, the World Health Organization (WHO) declared COVID-19 to be a global pandemic (ALOI et al., 2020).

This pandemic affected supply chains (SCs) in different ways: in some cases, demand increased while in others dropped, causing cascading disruptions (HOEK, 2020). Nevertheless, the literature involving pandemic outbreaks and SCs are still scarce (GOVINDAN; MINA; ALAVI, 2020). In this sense, improving firms resilience to absorb the negative disturbances is crucial to survive to crisis (SCAVARDA et al., 2015), however, unfortunately, SCs are usually optimized for efficiency and not for resilience (SODHI; TANG, 2009). As an evidence of it, literature reviews involving pandemic outbreaks and SCs are still scarce (GOVINDAN; MINA; ALAVI, 2020).

Most of this doctoral dissertation was written in 2020 and 2021, during the period of social isolation caused by the COVID-19 pandemic. Up to 2020, we could identify only two literature reviews about the impacts of epidemic outbreaks on SCs (DASAKLIS; PAPPIS; RACHANIOTIS, 2012; QUEIROZ et al., 2020). Dasaklis, Pappis, and Rachaniotis (2012) reviewed 73 papers to identify the role of logistics operations to contain epidemic outbreaks and bioterrorist attacks. Queiroz et al. (2020) reviewed 32 papers between 2003 and 2020 (March 22) to investigate the effects of epidemic outbreaks on SCs.

1.2. Theoretical background

This PhD thesis starts by investigating the critical questions in scientific literature concerning the poorly understood effects of pandemic in SCs. In this context, section 1.2.1 briefly describes the importance of the supply chain resilience. Considering that the global pandemic COVID-19 (BELHADI et al., 2020) has worsened the risk of increasing hunger and malnutrition along food supply chain (Fan et al., 2020), the repercussions of COVID-19 in food supply chains are further investigated. Then we investigate family farmers' ongoing strategies to adapt to changes in the local food SCs due to COVID-19. In this way, the background section 1.2.2 discusses SC resilience in the context of food chains and the section 1.2.3 reviews the evolution of family farming public policies in Brazil. Finally, section 1.2.4 discusses the changes in food demand during COVID-19.

1.2.1. Supply chain resilience

The global economy increased the countries interdependence, which most of times means a highest vulnerability to unforeseen disruptions in SCs (PETTIT; CROXTON; FIKSEL, 2019). SC resilience is the ability of a SC to respond to unexpected risk events, recovering quickly to potential disruptions and, sometimes, using the threat scenario as opportunity to move to a better state (HOHENSTEIN; FEISEL; HARTMANN, 2014).

Under Sodhi and Tang (2009), the response to supply chain chock can be classified into disruption detection strategies, design the response, and deploy the response. Governmental agencies and companies should be able to react quickly to the control of outbreaks in SC in order to reduce the recovery time and the total impact of the event. To develop the capacities for dealing with uncertainty, most of times require financial and intellectual investments. In peacetime, these efforts can be mistakenly interpreted as simple erosion of profits, but in crises time could be decisive to reduce the exposure to risk (PETTIT; CROXTON; FIKSEL, 2019).

Disruptions at different levels are an inherent part of the global SCs. The disruption risks may be caused by natural disasters (e.g. hurricanes, earthquakes, or floods) or by man-made disasters, such as terrorist attacks or labor strikes (HOSSEINI; IVANOV; DOLGUI, 2019). For example, in 2011, due to an earthquake in Japan, General Motors had to temporarily close a truck plant in Louisiana (GOLAN; JERNEGAN; LINKOV, 2020). In 2020, because of COVID-19, companies such as Airbus, BMW, Boeing, Ford, GM, and Volkswagen have to temporarily close factories and reduce manufacturing capacity (WUEST et al., 2020).

According to Stecke and Kumar (2009), the global supply chains´ vulnerabilities are primarily associated to the high number of decentralized stakeholders, the geographically dispersed material flows, flexibility (with less stock, the global supply chain are more vulnerable to stock out during pandemic outbreaks), lower redundancy (in this cases, more efficiency, means lower ability to absorb unusual system disturbances).

Besides, Macdonald et al. (2018) highlight that the extent of the potential damage depends upon the duration of the shock in SC and the magnitude of the initial negative impact and its spread. Despite the risks, the investments in disruption management strategies are still modest. Since most of the events are seen as rare and unforeseeable, the managers find it difficult to justify the net investment. Indeed, supply chains are usually optimized for efficiency and not for resilience (SODHI; TANG, 2009).

Nevertheless, the unprecedented series of shocks caused in SCs by the recent COVID-19 outbreak has created a great incentive to demystify this mistaken vision. This pandemic affected SCs in different ways, some demand has sharply increased, such as hand sanitizer and toilet paper, and others have drastically dropped (e.g., automotive industry). Firms started to ask how to make supply chains more agile to positive changes and more resilient to absorb negative disturbances in order to survive in a full of uncertainties scenario (BODE; MACDONALD, 2016).

To deal with extraordinary events, agility, resilience, and sustainability are fundamental perspectives (ALTAY et al., 2018). Agility means fast responsiveness to the environment changes. Resilience is the ability to go back to the normal performance after a disruptive event, means being able to maintain itself and to survive in a setting of fast changes. Backup facilities, inventory buffers, flexible capacities, and a visibility

control system can give more robustness to the SC. Sustainability means that profit-seeking must be in line with nature and societal interests (IVANOV, 2020a). Hosseini, Ivanov and Dolgui (2019) point out some common abilities found in resilient supply chains: anticipating disruptive events (management planning), responding quickly to disruptions, flexibility, sharing information, and collaboration between supplier and buyer. In the case of food supply chain, resilience is extremely important to ensure that the food reaches the tables (MU; ASSELT; FELS-KLERX, 2021).

1.2.2. Food supply chain

Food supply chain consists in a set of interdependent companies working together to delivery agri-food commodities and food products to the final consumers, covering the entire "farm to fork" process (GOVINDAN, 2017). Latin America is a leading region in the production of agri-food commodities (RAMIREZ et al., 2021). Nevertheless, between 2016 and 2018, about 190 million people were suffering from moderate or severe food insecurity in Latin America (FAO, 2019).

The global pandemic COVID-19 (BELHADI et al., 2020) has worsened the risk of increasing hunger and malnutrition along food supply chain (Fan et al., 2020). In Kenya, households food insecurity increased 8 percentage points within 30 days of the implementation of COVID-19 restrictions (HUSS et al., 2021). Francesconi *et al.* (2021) highlights that even rural communities with zero cases of COVID-19 can have labor shortages causing delays in harvesting activities and aggravating the hunger and food insecurity.

Lawson-Lartego and Cohen (2020) recommend that agri-food supply chain (AFSC) should be considered as an essential service to ensure food security. Zhu and Krikke (2020) argue perishable food supply chain (PFSC) is especially threatened by

shortages during pandemic outbreaks, due to product's short lifetime. In India, PFSC claims 80% of food supply, evidencing the relevance of the issue (REARDON et al., 2020). In 2017, Brazilian AFSC was responsible for 13% of the national gross domestic product (GDP), with fruits exports representing US$ 946.79 million. However, COVID-19 has threatened PFSC (FARIAS; ARAÚJO, 2020). For example, in Shanghai, approximately 60% of the vegetable consumed are produced outside the city, so the pandemic has greatly impacted the logistic of vegetables since many products could not be shipped in time due to traffic restrictions (GU; WANG, 2020).

Nevertheless, according to Ali et al. (2021) the scientific literature involving supply chain resilience in food chain is still limited. It is important to note that is not possible to achieve food security for consumers, if the links in food chain are unable to respond efficiently to adverse conditions (ALI et al., 2021). In this context, food chain resilience involves avoiding food SCs disruption.

Hobbs (2021) point out that in the first weeks after the countries implementing measures to avoid COVID-19 contagion, most of food SCs faced several sharp demand and supply shocks. The scenario of uncertainty stimulates panic buying behavior that caused a temporary lack of some foodstuffs in supermarkets. Besides with people spending more time at home due to social isolation measures, food SCs also faced changes in food habits, and consequently in food demand (WEERSINK et al., 2021). According to Wang et al. (2020) in the first weeks after COVID-19 outbreak, the food reserve extends from 3.37 to 7.37 days, which implied in a dramatically increase in food demand in a short time. In this context, food SCs resilience also involves the ability to meet the changing customer demand.

Lastly, one biggest challenge for SC management is how to achieve SC resilience without aggravating the food waste problem. Especially during uncertain

situations, actors in the food chain cannot exactly predict how much food they will produce and consumers cannot predict how much food they will require. In light of this, two phenomena gain prominence overbuying and/or overproduction (HOBBS, 2021). Generally, the food waste problem involves: a) food loss, in other words, losses earlier in the supply chain, mostly related to production, postharvest, storage and processing, and b) food waste, which is associated losses in distribution, retail and consumption spheres (BAJŽELJ et al., 2020; RUVIARO et al., 2020).

Apart from the environmental aspect, the food waste problem represents a waste of money. For example, in the U.S., the total value of food loss at the retail and consumer levels is about $166 billion (BUZBY; HYMAN, 2012). In the context of agri-food sustainable systems, short food supply chains reduce the number of stages between the farmer and the consumer, and the less handling of perishable products, the lower the chances of food damages and consequently food loss (RICHARDS; HAMILTON, 2018).

1.2.3. Family farming

The traditional vertically integrated agro-food supply chain concentrates the power in the hands of large private enterprises, declining the small farms' share of profit (BERTI; MULLIGAN, 2016). That is actually rather unfair because the smallholder farmers with less than 2 ha produce about 30% of the world's food and with considerer farms with less than 5 ha, the share is about 50% (RICCIARDI et al., 2018). Besides, according to Lowder et al. (2021), from about 608 million farms in the world, more than 90% are family farms.

Brazilian family farms correspond to more than 80% of all the agricultural units in Brazil (BERCHIN et al., 2019). This sector is responsible for US$ 27 billion of the

Brazilian GDP (GRAEUB et al., 2016). However, these values do not reflect an equal income distribution in the countryside. According to Alves and Rocha (2011), less than 10% of the family farmers in Brazil generate 84.89% of family farming production with monthly income of up to 10 national minimum wages; 18.86% family farmers, generate 11.08% of family farming production and live on monthly income between 2 and 10 minimum wages. Lastly, the vast majority of small landowners, around 70% of the total, cannot survive only on agriculture, often depending on government cash transfer policies (e.g. Bolsa Família) to supplement incomes (ALVES; ROCHA, 2011).

The 1990s marked the beginning of the family farming incentive programs in Brazil, with the development of public nationwide policies, such as the National Program for Strengthening Family Farming (PRONAF), Family Farming Insurance (SEAF) and Program of Assurance of Prices in Family Farming (PGPAF) (BERCHIN et al., 2019).

According to the Law N^{o} 11,326, from July 24, 2006, family farming in Brazil is characterized by:

> I - Area smaller than four fiscal modules. Fiscal modules vary according to the Brazilian municipalities. They should be enough for a family to have income, survive, and thrive;
>
> II - predominantly family labor;
>
> III - has a family income predominantly originating from economic activities linked to the establishment itself;
>
> IV - Family-run establishment.

PRONAF was created in 1994 by an agreement between the United Nations Food and Agriculture Organization (FAO) and the National Institute of Colonization and Agrarian Reform (INCRA). PRONAF was the first national policy to strengthening family farming in Brazil and until now the program provides credit to small farms expenses (GUANZIROLI; BASCO, 2010). Furthermore, PRONAF opened doors to the emergence of other national policies aimed at family farming. For example, the PGPAF ensures that family farms products are bought by a price that reflects the average production cost in the region, offering a fair price to the producer (GUANZIROLI; BASCO, 2010). In 2004, the SEAF was created to cover indemnity to family farmers during catastrophic events, such as weather related disasters (FLEXOR; GRISA, 2016).

Since 2009, family farms became part of the Brazilian National School Feeding Program (PNAE). PNAE and the Food Purchase Program (PAA) are the main public instruments for the purchase of products of family farming in Brazil. From 2011 to 2017, 77% of the Brazilian municipalities (288) integrated the PAA, with approximately US$ 754 million invested (BOCCHI et al., 2019). In addition to the benefits of a fresh food diet for students, the inclusion of local family farming as suppliers of PNAE has greatly encouraged the small producers. The program feeds more than 40 million students of basic education in Brazil and 30% of the budget is transferred by the Federal Government for local family farmers (MOSSMANN et al., 2017).

Since 2016, the administrative reformulations of the Brazilian federal legislation promoted a gradual deterioration of the protection mechanisms for family farming (SABOURIN; CRAVIOTTI; MILHORANCE, 2020). The absorption of the Secretariat of Family Agriculture and Cooperatives (SAF) and INCRA by the Ministry of Agriculture, Livestock and Supply (MAPA), in 2019, exemplify the changes at the federal level (IPEA, 2021). In this scenario, limited by an increasingly constrained

budget, specific policies for family farmers, agrarian reform settlers and traditional populations lost strength in the government plan (CORDEIRO; SANTOS; MARUJO, 2021).

In the face of the income inequality in the countryside and the current scenario of uncertainties created by the spread of the SARS-CoV-2 virus, the debate on the resilience of production chains under the farmer's perspective gains fundamental importance (Assunção, Medeiros, Trump, Paiva, & Paes, 2020). According to Futemma *et al.* (2020), up to 70% of Brazilian small farmers interviewed in the states of Amapá, Pará and São Paulo did not have access to special lines of credit during the pandemic. Besides, 84% of these producers did not receive any support from municipal policies to face the crisis and 62% reported losses in sales (FUTEMMA et al., 2020). About this issue, García, Zimmermann and Eleuterio (2020) highlight that robust investment in PAA and PNAE would be of great help for small food SCs resilience during COVID-19. Besides PNAE has contributed greatly to food security, since it served >40 million students (AMORIM et al., 2022).

1.2.4. Food eating demand

A relevant aspect in the consumer choice is income, since unhealthy foods (e.g. crisps) tend to have lower price than the healthy ones (e.g. fruits) conquering individuals with low purchasing power (ANDRADE et al., 2020; SOUSA et al., 2020). According to the Brazilian household budget survey, fruit and vegetable intake felt between the 2008-2009 and 2017-2018, especially for the poorest social stratus (IBGE, 2020). This low-income population that lives in conditions of greater social vulnerability and the global COVID-19 pandemics has worsened the risk of increasing hunger and malnutrition to them (Fan et al., 2020). Furthermore, for many Brazilian

children and young people, access to a balanced diet is done only through school meals. The interruption of this service during the pandemic may exacerbates the risk of hunger in Brazil (LOURENÇO et al., 2021).

Vargas-lopez et al. (2021) point out that the COVID-19 lockdowns may also cause drastic changes in consumers' eating habits, stimulating the increase of food demand and waste. Moreover, with workers spending more time at home, healthier eating habits might be adopted (OLIVEIRA; ABRANCHES; LANA, 2020). For example, the preparation of meals with natural ingredients is expected to increase (HASSEN; BILALI; ALLAHYARI, 2020). In contrast, Arora & Grey (2020) pointed out that COVID-19 quarantines can reduce access to fresh food, encouraging the consume of high-calorie products (fried foods, desserts). Furthermore, the reduction of the purchasing power caused by the pandemic can hinder the access to adequate diet to the poorest ones (ARORA; GREY, 2020). In addition, Mattioli et al. (2020) argued that the quarantine and the isolation measures can induce emotional disturbances (e.g. anxiety and depression), which can unleash overdo eating habits. These unhealthy eating habits associated with the reduction of physical activity can increase the obesity and the cardiovascular risk during COVID-19 curfews (MATTIOLI; NASI; FARINETTI, 2020).

1.2.5. COVID-19 and food eating behavior

The global pandemics constitutes a serious threat to food systems, since it can cause disruption in food supply and changes in demand which can cause move prices (XU et al., 2021). Besides, Song, Goh and Tan (2021) highlight that COVID-19 brought great fear upon food security.

Food security is a central element for the achievement of human development, reason why the global commitment "no hunger" is one of the Sustainable Development Goals – SDGs (CANO; ALBACETE; QUESADA, 2021). According to FAO (2021), food security

> "…exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2021)".

From 2014 to 2017, food security decreased from 51% to 43% in Latin America (LA) (SOUSA et al., 2019). According to Herforth et al. (2020), "energy sufficient" diets meet calorie needs alone, "nutrient adequate" diets provide not only adequate calories but also adequate levels of all essential nutrients (e.g. carbohydrates, protein, fat, vitamins) and "healthy" diets include foods from several food groups and also culturally preferences. In 2017, 3.7% of Latin American and Caribbean (LAC) population could not afford an "energy sufficient" diet, 18.1% could not afford a "nutrient adequate" and 26.5% could not afford a "healthy diet" (HERFORTH et al., 2020). Therefore, food insecurity is often a result of poverty and is not just about hunger, but also about poorer nutritional conditions (CORTÉS, 2020). Adequate and healthy diets include biological (dietary needs) and social (cultural and ethnic) aspects of the individual (LOUZADA et al., 2019).

In 2019, the number of people living with hunger in LA and the Caribbean was 47 million (7.4% of LA population), while more than 190 million people faced moderate or severe food insecurity (FAO, 2020). In times of pandemic, the trend is that the situation gets even worse, since many families had reduced income during this period (CANO; ALBACETE; QUESADA, 2021). Latin American countries adopted

different strategies to deal with the COVID-19 pandemics, in some cases, involving forced social distancing and market access restrictions (CEQUEA et al., 2021).

For example, in Uruguay, despite the lack of mandatory lockdowns (VIDAL et al., 2021), from a sample of 1,643 Uruguayans, more than 50% reported staying home more frequently to contain COVID-19 contagion (ARES et al., 2021). In addition, during the pandemic, from a sample of 891 middle and high-income Uruguayans, 51% of them reported changes in eating habits. From this subgroup, 45% classified the changes as positive, increasing the consumption of fruit, vegetables and decreasing the consumption of unhealthy food contain excessive content of sugars, fat and/or sodium (VIDAL et al., 2021). Regarding low income Uruguayans, 29% (n = 436) reported the lack of sufficient food during the pandemic (ARES et al., 2021).

In Brazil, Carvalho et al. (2020) point out that suspension of many economic activities due to COVID-19 outbreak fostered unemployment, poverty and hunger, and this economic shocks tend to affect more strongly in poorest households (GAITÁN-ROSSI et al., 2021). Burki (2020) argue that 13 million individuals living in Brazilian slums were severe threatened by COVID-19, since they usually work in informal or less flexible jobs. For example, from 909 householders interviewed in two slums located in São Paulo, more than 50% reported moderate or severe food insecurity in the first semester of 2020. These people reported not to have enough money to eat healthy and nutritious food (MANFRINATO et al., 2021). In the Ceará state, the sixth poorest state of Brazil, from 577 families with children, 70% reported food insecurity during the pandemic (15.5% more than in 2017). The main reason was loss of income. About 62% of the mothers reported the loss of business profits during the pandemic (ROCHA et al., 2021).

On the other hand, an online survey with 302 Brazilians revealed that 21.8% of them increased weight during the pandemic. Most of that sample were female with higher education (LOPES et al., 2021). Besides, a study with 45,161 Brazilians found a decrease in regular consumption of greens and vegetables from 37.3% before the pandemic to 33.0% between April 24 and May 24, 2020 (MALTA et al., 2020). At the same time, the ingestion of sugary foods (e.g. chocolate and sweet biscuits) increased from 41.3% to 47.1% and the number of individuals who reported at least 150 minutes a week of physical activity decreased from 30.1% to just 12.0% during COVID-19 outbreak (MALTA et al., 2020). This situation is as dangerous as chronic hunger, since obesity and related diseases such as diabetes have been identified as relevant risk factors that strongly affect the impact of COVID-19 on individuals (CANO; ALBACETE; QUESADA, 2021).

1.3. Research gaps and objectives

Considering the uncertain effects of COVID-19 on SCs explored in previous section and illustrated in Figure 1-1, this study conveys three major research questions:

(I) What are the main critical gaps in scientific literature concerning the effects of pandemic in SCs?

Considering the relevance of food supply chain and food security during COVID-19, the following research questions were:

(II) What are the family farmers' ongoing strategies to adapt to changes in the local food SCs due to COVID-19?

(III) How COVID-19 affect consumers eating demand?

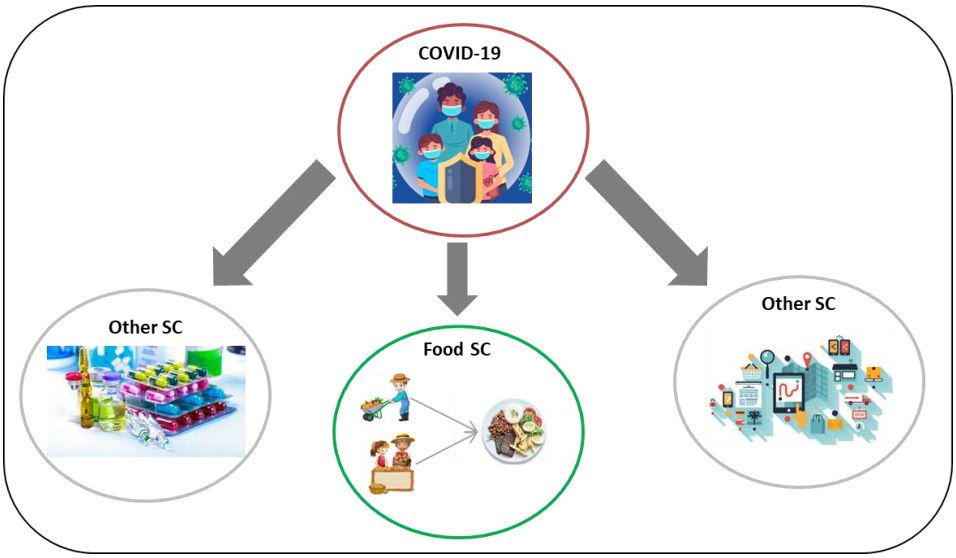


Figure 1-1. COVID-19 effect on supply chains

Based in the research gaps, the specific overarching research objective of this PhD thesis was: To investigate how the food supply chain was affected by COVID-19.

The specific objectives can be listed as:

- To investigate the state of art of promising research lines considering the effects of pandemics in SCs;
- To investigate small farming weakness and resilience strategies (e.g. local suppliers) both in normal and pandemic/epidemics situation;
- To investigate household eating demands in normal and pandemic/epidemics situations.

To address the first objective, a systematic literature review was made to understand the maturity of academic discussions related to the pandemic and supply chains. To achieve the second objective, the next step was to develop a case study considering the reality of the Brazilian family agribusiness in the context of the pandemic, from the producer point of view. Finally, to understand the eating demand of

consumers in situations of social isolation (third objective), a survey was made to investigate food supply chain from the consumer's point of view.

1.4. Originality

The COVID-19 pandemic affected the multiple nodes of a food supply chain, including producers supply and consumer demand (SONG; GOH; TAN, 2021). The research focus is how food supply chain was affected by COVID-19. This focus was defined after the preliminary investigation of the main critical gaps in scientific literature concerning the effects of pandemic in SCs. This preliminary analysis can be justified by the scarcity of scientific literature about the theme. Up to 2020, we could identify only two literature reviews on scientific journals about the impacts of epidemic outbreaks on SCs (DASAKLIS; PAPPIS; RACHANIOTIS, 2012; QUEIROZ et al., 2020).

The second step was investigating small farming resilience during COVID-19, since these local supplies has huge importance for Brazilian food security and economy. Brazilian family farms correspond to more than 80% of all the agricultural units in Brazil (BERCHIN et al., 2019) and the sector is responsible for US$ 27 billion of the Brazilian GDP (GRAEUB et al., 2016). Considering this scenario, a detailed analysis of the ongoing COVID-19 crisis as well as necessary resilience measures needs to be highlighted in small farm context. As pointed by Ali et al. (2021), the scientific literature involving supply chain resilience in food chain is still limited, which can justify the relevance of this work. Besides, it is not possible to achieve food security for consumers, if the links in food chain are unable to respond efficiently to adverse conditions (ALI et al., 2021).

Finally, we investigate food supply chain under the vision of consumers demand. It is important to note that changes in food eating habits directly affect food SCs demand. During COVID-19, food SCs faced several sharp demand (e.g: panic buying behavior) and supply shocks (HOBBS, 2021; WEERSINK et al., 2021). According to Wang et al. (2020) in the first weeks after COVID-19 outbreak, the food reserve extends from 3.37 to 7.37 days, which implied in a dramatically increase in food demand in a short time. In view of these evidences, we can justify the third study.

1.5. Research frontier and limitations

To achieve the first objective a bibliometric analysis and a systematic literature review were performed. Considering the search was done in the beginning of the pandemic, first semester of 2020, and the pandemic sharply increased scientific literature, many papers could not be included.

To achieve the second and third objective, the state Rio de Janeiro was chosen as research location because of the convenience. Besides, in Rio de Janeiro, 75% of rural properties are small farming and they are responsible for about 60% of the state's rural jobs (BURSZTYN; MARTINS, 2018). In addition, the food market in Rio de Janeiro is very expressive. In 2020, the state had about 17 million inhabitants (IBGE, 2021). It is one of the largest metropolitan areas of Brazil (LUCENA et al., 2021).

Considering the second objective, this thesis focuses on small farms point of view and do not included others chain links, such as food retailers, industries and restaurants, for example. Besides, bigger farms were not included in the scope of this research.

CHAPTER 2: WHAT ARE THE MAIN RESEARCH GAPS REGARDING SUPPLY CHAINS AND PANDEMICS?

Chapter 2 is derived from Cordeiro *et al* (2021), titled “Research directions for supply chain management in facing pandemics: an assessment based on bibliometric analysis and systematic literature review”, published in the International Journal of Logistics Research and Applications. This chapter aims to review the current literature in order to understand the state-of-the-art of scientific publications involving supply chain and pandemics. The Chapter also proposes a research agenda for SCs confronting COVID-19 pandemic.

2.1. Bibliometric Procedure and Systematic Literature Review (SLR)

2.1.1. Background

Bibliometric results provide value to academia and practitioners, since it can be used to create a meaningful landscape of a research area using scientific metadata (e.g. authors affiliation and home country) (TSAI et al., 2020). Bibliometric analysis involves a set of statistical techniques that aims to describe and evaluate a scientific field based on bibliographic metadata (GEORGI; DARKOW; KOTZAB, 2013). Bibliometric enables the graphical analysis of a wide range of articles quickly, allowing the simultaneous analysis of multiple aspects such as number of publications across the time, top-cited papers, most productive authors, institutions and countries, besides research patterns (WANG; LIM; LYONS, 2019). Scopus, WoS, and Google Scholar databases are the most used for bibliometrics (BELTER; SEIDEL, 2013; WANG; LIM; LYONS, 2019). However, Google scholar has a more fragile quality control

(CAMARASA et al., 2019). Therefore, to ensure the high quality of metadata, we used only Scopus and WoS databases in our research.

2.1.2. Data collection

A preliminary research was conducted on the topic in order to identify the most appropriate keywords to ensure the search strategy (DURACH; KEMBRO; WIELAND, 2017). We observed several studies with local diseases (epidemics) that could be spread across the world due to globalization, becoming global pandemics (BÜTTNER; KRIETER; TRAULSEN, 2015; MACKENZIE, 2014). Although the term SC involves different concepts and it is associated with terms such as operations management, logistics and value chain (LIM et al., 2017; SOON; UDIN, 2011; TSENG et al., 2018), we observed a scarcity of studies involving the effects of pandemics/epidemics in SCs (GOVINDAN; MINA; ALAVI, 2020). Therefore, boolean operations were used to make the following search strings (SHOAIB; LIM; WANG, 2020): (“pandemic” AND “supply chain”) OR (“epidemic” AND “supply chain”) in Scopus and WoS databases, limited to the English language (XU et al., 2018).

The Bibliometrix R-package was used to investigate metadata (ARIA; CUCCURULLO, 2017). Then, Biblioshiny (KAFFASH; NGUYEN; ZHU, 2021) was used for data analysis (Figure 2-1). The following questions guided bibliometric analysis (WANG; LIM; LYONS, 2019):

- (Q1) What are the distribution of publications and citations across time and space?
- (Q2) Who are the most productive and influential authors, institutions and countries?
- (Q3) What are the publications patterns and main topics?

2.1.3. Refinement of the search results and data analysis

BibText results were imported to RStudio (v. 3.6.3) and merged. Then, duplicates were removed, resulting in 308 records (Figure 2-1), given that Scopus and WoS may map the same documents in different forms, resulting in persistent duplicates (VALDERRAMA-ZURIÁN et al., 2015). Therefore, the records were exported to Excel and manually checked. Three duplicates were removed, resulting in 305 documents. Due to scientific strength and quality of metadata, only articles were considered. Finally, the Excel output was imported into Biblioshiny for data analysis (KAFFASH; NGUYEN; ZHU, 2021).

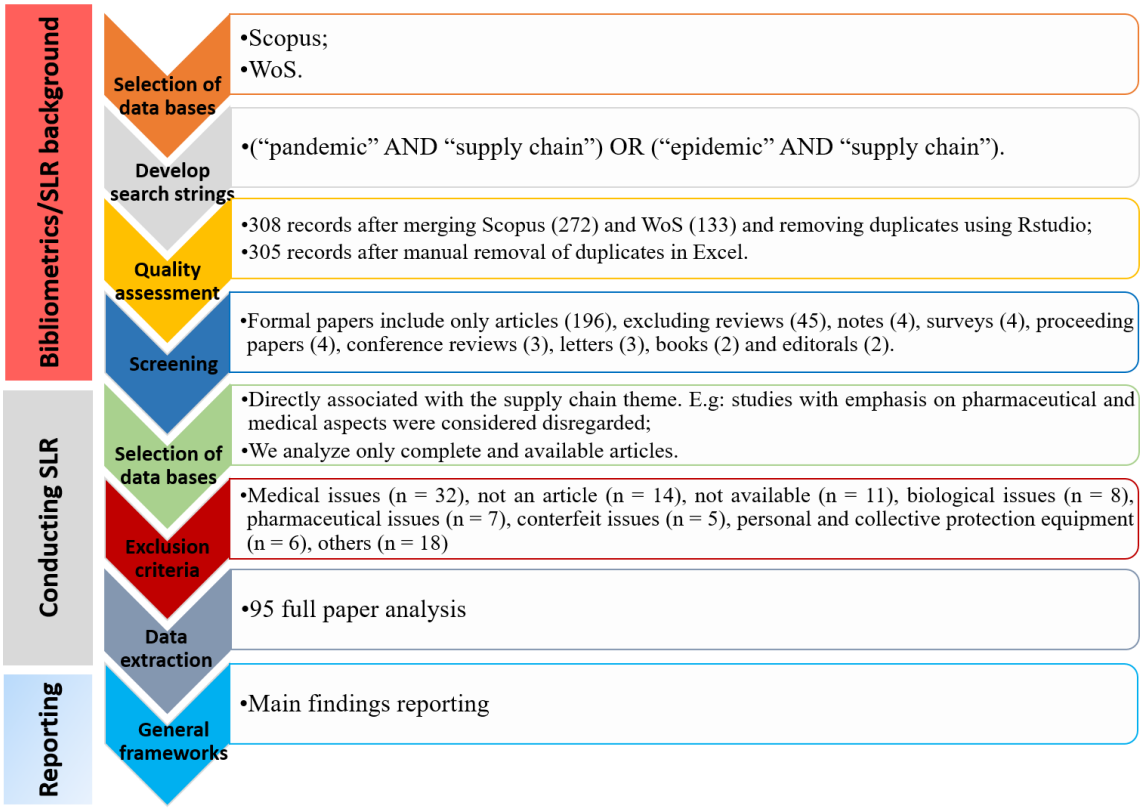


Figure 2-1. Bibliometrics and SLR framework

2.1.4. Systematic Literature Review (SLR)

We conducted a systematic survey (Figure 2-1) based on PRISMA protocol (MOHER et al., 2009) to evaluate the effects of pandemic/epidemic events in the SCs. SLR can collect useful information from published primary studies, helping to create an overview of the current state of the art and to identify research opportunities (SHOAIB; LIM; WANG, 2020). Our approach took into account a large number of studies with different viewpoints in order to identify the main research fields and gaps (DURACH; KEMBRO; WIELAND, 2017). All titles and abstracts were inspected against the following eligibility criteria (HOSSEINI; IVANOV; DOLGUI, 2019) to determine the primary studies sample:

1. Directly associated with the supply chain theme. E.g.: studies with emphasis on pharmaceutical and medical aspects were disregarded;
2. We analyze only complete and available articles.

The software CmapTools, version 4.11, developed by the Institute for Human and Machine Cognition (IHMC) of the University of West Florida (CAÑAS et al., 2004) was used to summarize the main findings in graphical framework, integrating the constructs in a concept map (ALI; MAHFOUZ; ARISHA, 2017).

2.2. Bibliometric results

Table 2-1**Erro! Fonte de referência não encontrada.** summarizes the articles ollection. The analysis period covers twenty-three years of scientific production (1997-2020).

Table 2-1. Main information about the collection

Information	**Description**	**Results**
Period	Years of publication	1997:2020
Articles	Total number of articles	196
Author's keywords (DE)	Total number of keywords	593
Keywords Plus (ID)	Total number of phrases that frequently appear in the title of an articles' references (ZHANG et al., 2016)	1519
Average citations per document	Average number of citation in each article	12.06
Authors	Total number of authors	1032
Authors of single-authored documents	The number of single authors per article	33
Authors of multi-authored documents	The number of authors of multi-authored articles	1001
Authors per document	Average number of authors in each article	5.27

2.2.1. Spatial and temporal distribution

Since 2012, we can observe the increase of the number of published articles (Figure 2-2). Most of them associated to foodborne diseases, especially to Avian Influenza Viruses (BIGGERSTAFF et al., 2020; EKICI; KESKINOCAK; SWANN, 2014; HOVAV; HERBON, 2017; HOVAV; TSADIKOVICH, 2015; KUMAR, 2012; LIN et al., 2012; MACKENZIE, 2014; MORTON et al., 2015; PEPIN et al., 2013; PETROVA et al., 2019; STEELFISHER et al., 2018; STRAMER et al., 2012;

WALKER et al., 2012) and swine illness (BÜTTNER et al., 2013; BÜTTNER; KRIETER, 2018; BÜTTNER; KRIETER; TRAULSEN, 2015; MOSLONKA-LEFEBVRE et al., 2016; PASSAFARO et al., 2020; THAKUR et al., 2016; YAN; LI, 2019). Besides, the number of scientific articles published in 2020.1 is almost 4 times bigger than all publications in 2019 (Figure 2-2), which can be justified by the current COVID-19 pandemic.

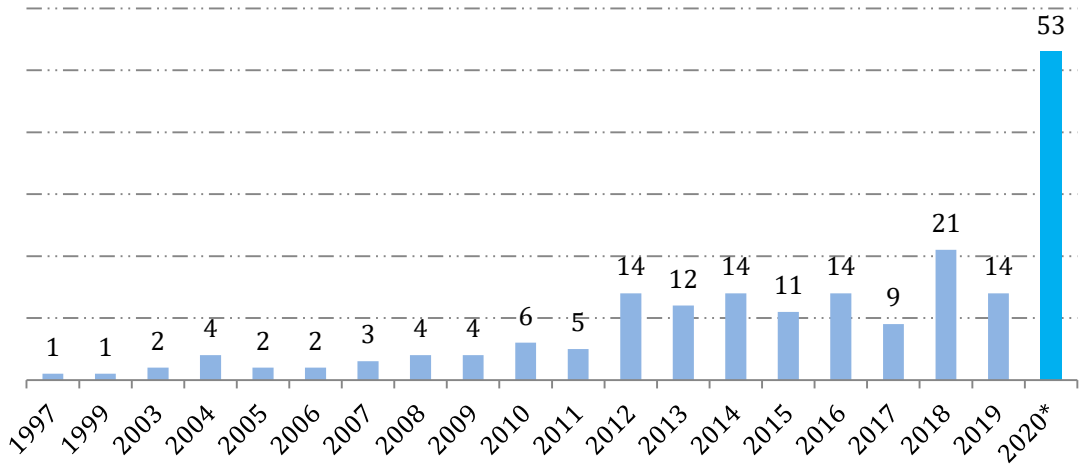


Figure 2-2. Annual scientific production in Scopus and WoS. *up to June 14, 2020

The 196 papers came from 39 countries. Figure 2-3 illustrates that U.S. is the most productive country with 111 publications (38.0%). Another relevant information is the number of citations, it helps to measure the scientific notoriety of a study across the time, being usually adopted in bibliometric studies (WANG; LIM; LYONS, 2019). Although France, Greece, Chile, and South Africa are not among the most productive, they are in the top most cited (Figure 2-4). In Greece, the most cited article is associated to a multistate outbreak of Salmonella, 229 citations (GREENE et al., 2008), in France, to Influenza, 90 citations (CHICK; MAMANI; SIMCHI-LEVI, 2008), in Chile, to Influenza, 39 citations (BIGGERSTAFF et al., 2020) and in South Africa, to crystal metal abuse, 30 citations (NYABADZA; NJAGARAH; SMITH, 2013)

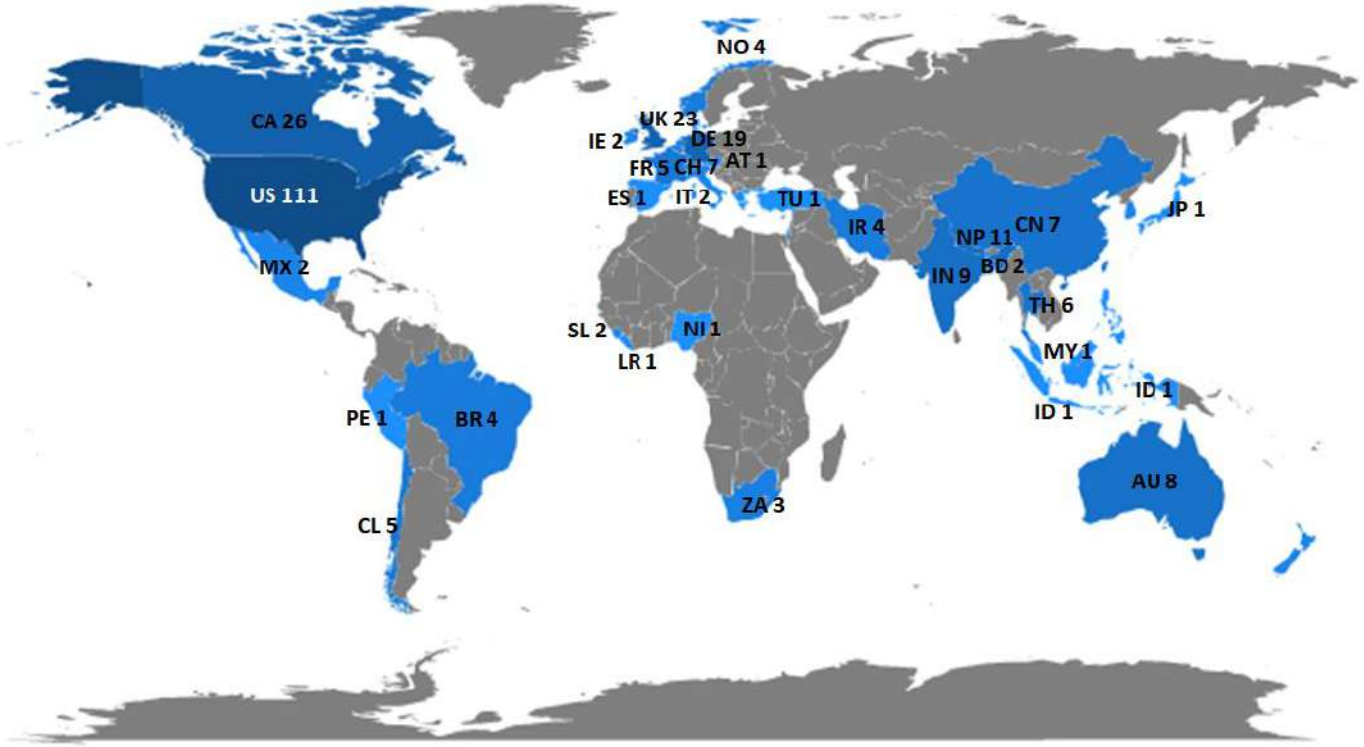


Figure 2-3. Geographical distribution of country scientific production

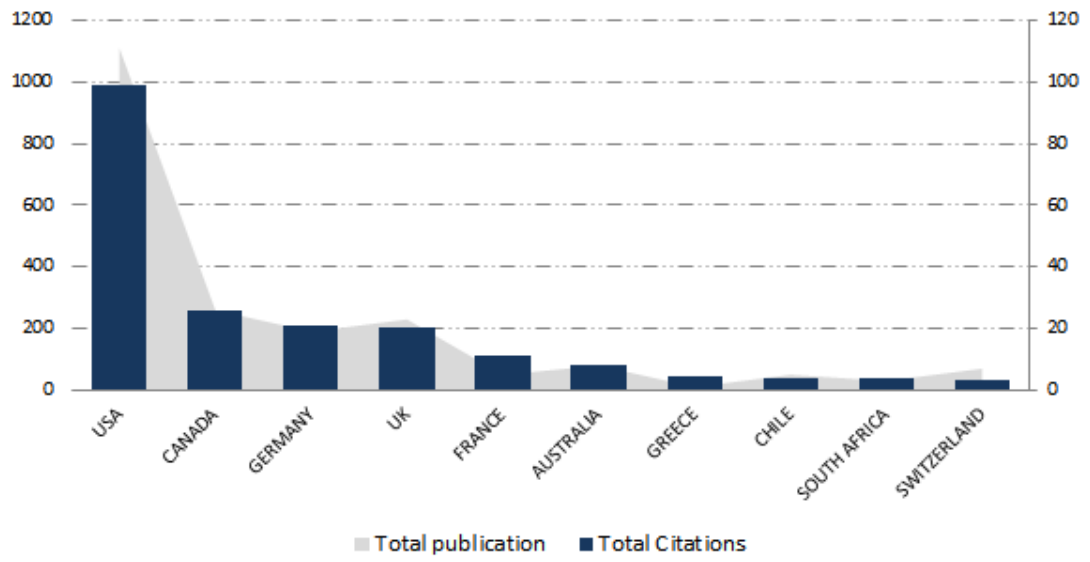


Figure 2-4. Most Cited Countries up to June 14, 2020

2.2.2. Author and institution statistic

In our sample, the most relevant authors are from Germany institutions (Table 2-2). Büttner and Krieter have four publications together about pork's SC outbreaks (BÜTTNER et al., 2013, 2016; BÜTTNER; KRIETER, 2018; BÜTTNER; KRIETER; TRAULSEN, 2015). Appel and Käsbohrer have published together three times, discussing procedures to trace back the origin of foodborne diseases (KAUFMAN et al., 2014; WEISER et al., 2013, 2016). The three publications of Ivanov (IVANOV, 2020b, 2020a; IVANOV; DOLGUI, 2020) are from 2020 (Figure 2-5), and two of them are related to the recent COVID-19 pandemic. This author was one of the first to discuss the impacts of COVID-19 in the global SCs causing the ripple effect (IVANOV, 2020b).

Table 2-2. The most relevant authors

Authors	Affiliation	Country	Articles	h-index	TC
BÜTTNER K	Christian-Albrechts-University	Germany	4	3	43
KRIETER J	Christian-Albrechts-University	Germany	4	3	43
APPEL B	Federal Institute for Risk Assessment	Germany	3	3	45
HAWKER J	University of Birmingham	UK	3	2	134
IVANOV D	Berlin School of Economics and Law	Germany	3	2	24
KIM H	University of Washington	U.S.	3	2	11
KÄSBOHRER A	Federal Institute for Risk Assessment	Germany	3	3	45
KUMAR S	University of St. Thomas	U.S.	3	3	16
LANE C	Centre for Infectious Disease Surveillance and Control	UK	3	2	137
LIN C	National Cheng Kung University	China	3	1	3
SWANN J	Georgia Institute of Technology	U.S.	3	2	24
TRAULSEN I	Christian-Albrechts-University	Germany	3	3	42
WILLIAMS C	Public Health Wales NHS Trust	UK	3	2	12
WU J	The University of Hong Kong	China	3	1	7

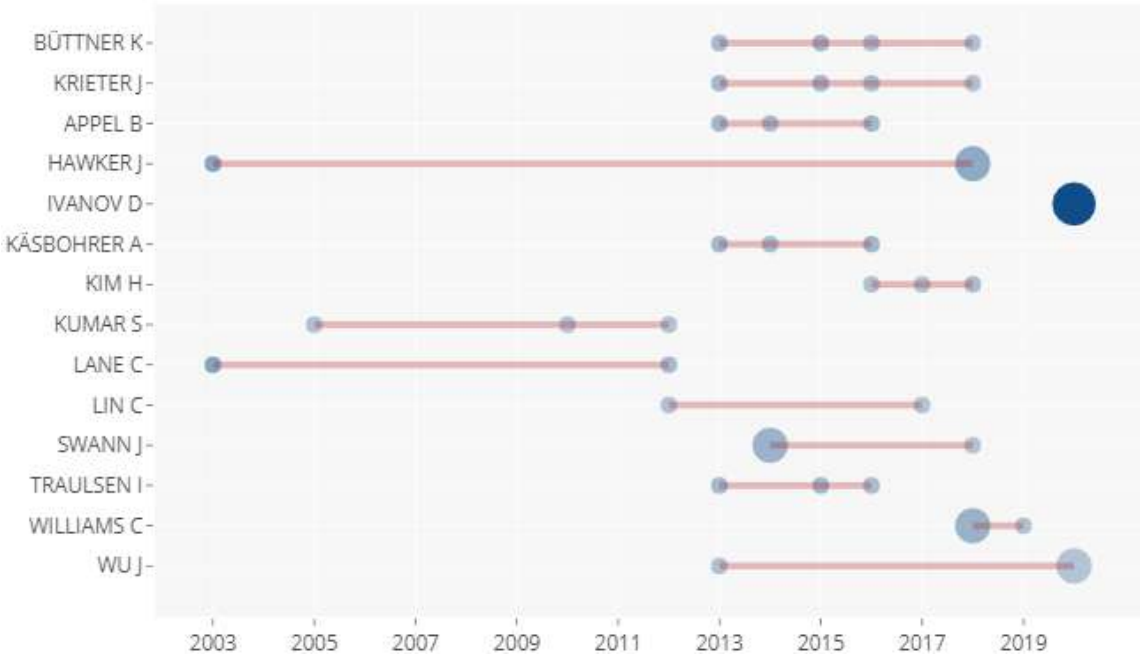


Figure 2-5. Top-authors' production over time

2.2.3. Publications' trends

2.2.3.1. Relevant and frequent words

Keywords are provided by authors to synthesize predominant ideas of the article and keywords plus are extracted from titles of cited reference, providing a conceptual base of the article (ZHANG et al., 2015). The cumulative occurrence of each word over time were determined through local polynomial regression, locally weighted scatterplot smoothing (LOESS) (JACOBY, 2000) for both keyword plus (Figure 2-6) and keyword (Figure 2-7). LOESS was used to fit a smooth curve, taking the frequency of publications as dependent variable and the years as independent variables (KLIEGL; BATES, 2011). The cumulative occurrence of the words "human", "humans" and "epidemics" drastically increase in the last decade in keyword plus, enhancing the upward trend of epidemics diseases. The word "pandemic" also showed higher incidence over time. This finding is in line with Carrasco-Hernandez et al. (2017),

whom highlights the continuous growth of the human population and the intensification of the close contact between people, domestic animals, and wildlife populations increases the risk of new pandemics. The impacts in SCs may be inferred from the growth of the terms “disease outbreak” and “organization management” in Figure 2-6. We can suggest the most affected SCs are food and health care SCs, since “food contamination” has strongly increased over time as well as “heath care delivery”. From 2009 to 2015, Influenza publications quickly growth; however from 2015 to 2020 we can observe a slowdown in the speed of growth.

Despite not been in Figure 2-6, the term “supply chain” has high visibility in keyword loess smoothing over time (Figure 2-7), especially in the last five years. Because of the scarcity of literature involving epidemic outbreaks and SCs (GOVINDAN; MINA; ALAVI, 2020), the authors may have to choose alternative references to put in the papers, which may justify the absence of the term in Figure 2-6. This fact reinforces the relevance of this study. We can also associate the term “supply chain” in Figure 2-7 with the term “organization and management” in Figure 2-6. The fifteen more frequent keyword plus cumulative occurrence over time

Recent papers are highlighting the need of SCs´ resilience and sustainability (Figure 2-7). The terms “avian influenza”, “influenza” and “food security” has shown an upward trend (Figure 2-7), which is in line with the findings in Figure 2-6. We can suggest the “food contamination” highlighted in Figure 2-6, compromise “food security” (Figure 2-7), jeopardizing especially the most vulnerable people to hunger. The growth of the term “vaccine” can be associated to influenza confronting and more recently to COVID-19. Despite COVID-19 emerged only in the end of 2019 (LAI et al., 2020), we can observe the visibility of terms “COVID-19”, “SARS COV 2”, “coronavirus” in Figure 2-7. Although “coronavirus” are a generic term and could also

be associated to SARS epidemic (OVERBY et al., 2004). The growth of the word "epidemiology" indicated that to deal with pandemic/epidemic effects in SCs multidisciplinary approaches might be necessary, merging mathematical models with biological studies.

Cluster tree (Figure 2-8) was based on the frequency of simultaneous occurrence of words in the abstracts, using multiple correspondence analysis (MCA) to simplify the complex network relationship into several relatively small groups. The clusters with highest degree of similarity form a new large cluster in hierarchical approach, forming a tree dendrogram (XIE et al., 2020). We observed three main groups in Figure 2-8. Group 1 is marked by epidemiological terms, probably associated with medical issues. Group 2 has many foodborne outbreaks terms, so these articles should be associated to zoonotic diseases effects in SCs. Group 3 has more SCs management terms, especially health care SCs, which suggests these articles may be associated with medical resources management during outbreaks. The clusters are in line with keyword plus and keyword analysis, strengthen our main findings.

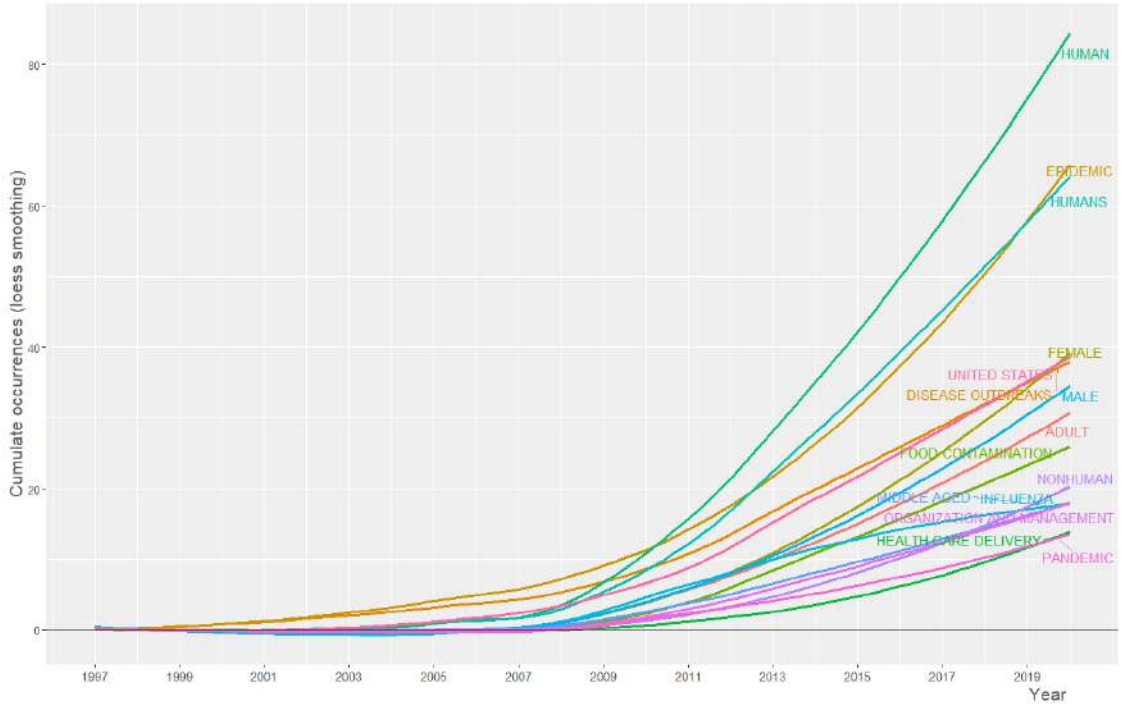


Figure 2-6. The fifteen more frequent keyword plus cumulative occurrence over time

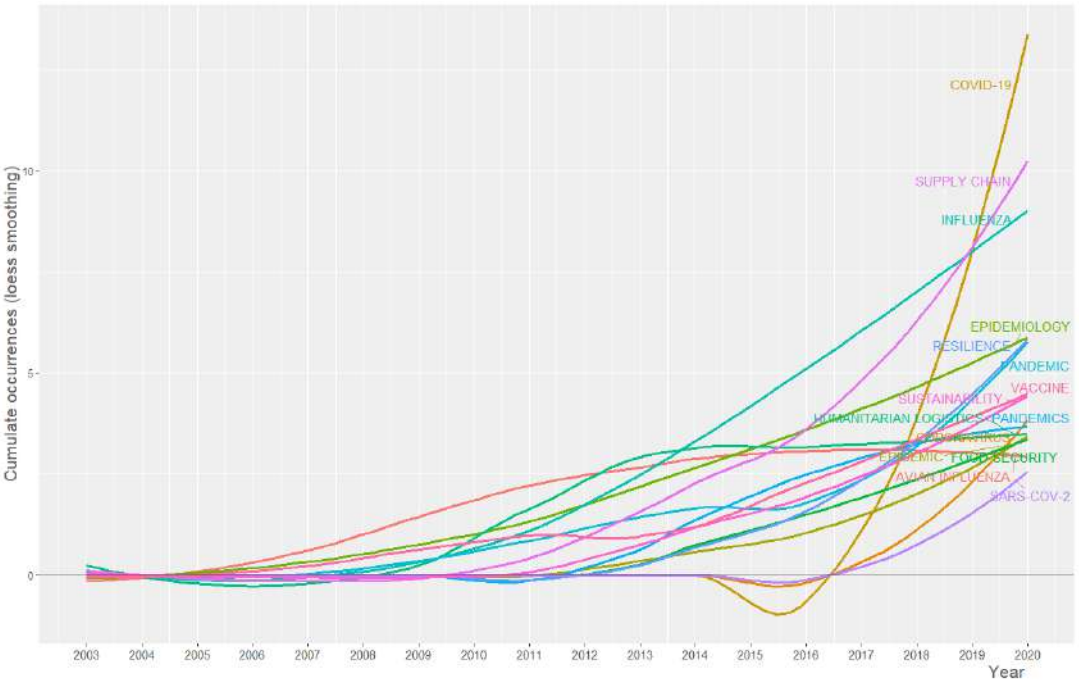


Figure 2-7. The fifteen more frequent keyword cumulative occurrence over time

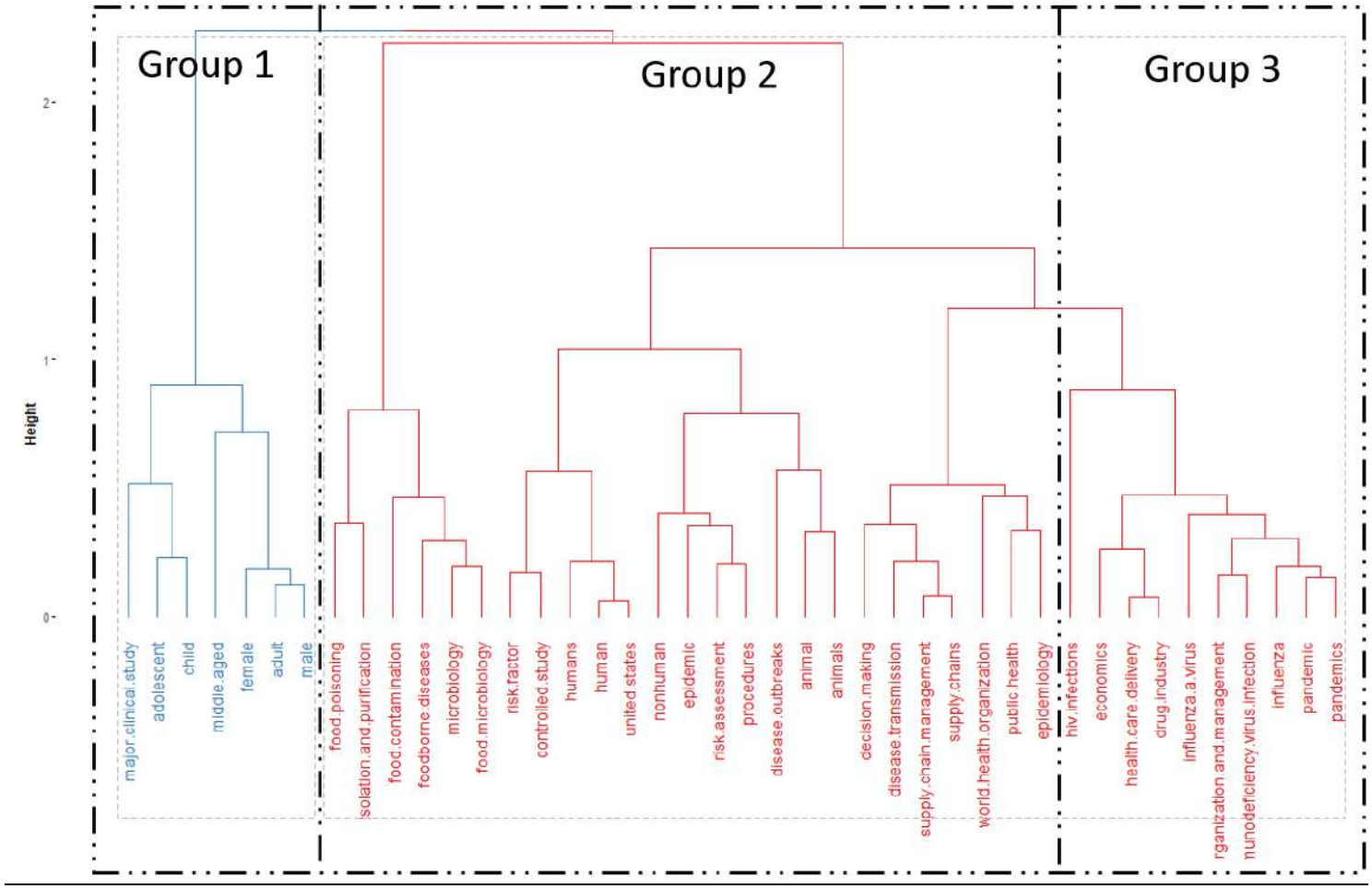


Figure 2-8. Cluster tree using the fifty most common terms in the articles abstract

2.3. Systematic review analysis

Recent SCs disruptions have forced managers to rethink lean strategies, considering some level of redundancy is required for SCs resilience (GRACHT; DARKOW, 2013; IVANOV, 2020a; IVANOV; DOLGUI, 2020; KURNIAWAN; ZAILANI, 2010; NIU et al., 2018). We made a graphical framework from the SLR main findings (Figure 2-9) in order to point out the main supply chains impacted by pandemic/epidemic, including COVID-19 pandemic as well as the consequences and the relationship and hierarchy between keywords in the subject area. Five clusters were identified and the main terms were aggregated qualitatively using different colors.

The pandemic outbreaks effects can be minimized by information sharing (URCIUOLI; HINTSA, 2018) in global SCs (GUAN et al., 2019; IVANOV, 2020b) and small and medium-sized enterprises (LU et al., 2020). For example, the cooperation between health care service and vaccine manufacturers (CHICK; MAMANI; SIMCHI-LEVI, 2008), could help minimize vaccine distribution time (DAVILA-PAYAN; SWANN; WORTLEY, 2014). Vaccination is a critical problem in combating epidemics, as can also be seen from the time evolution of the keyword vaccine in Figure 2-7.

Besides, as consumers spend more time at home during quarantine, SCs may face utility functions changing in pandemic outbreaks (MUGGY; STAMM, 2020), such as the growth of online grocery delivery (HOBBS, 2020; O'LEARY, 2020) and drugs delivery (HOU et al., 2020). Food security is also emphasized during pandemics (as evidenced by Figure 2-7), since food demand is expected to enhance and distribution networks become more complex (EKICI; KESKINOCAK; SWANN, 2014; GRAY, 2020; HUFF et al., 2015; SICHE, 2020).

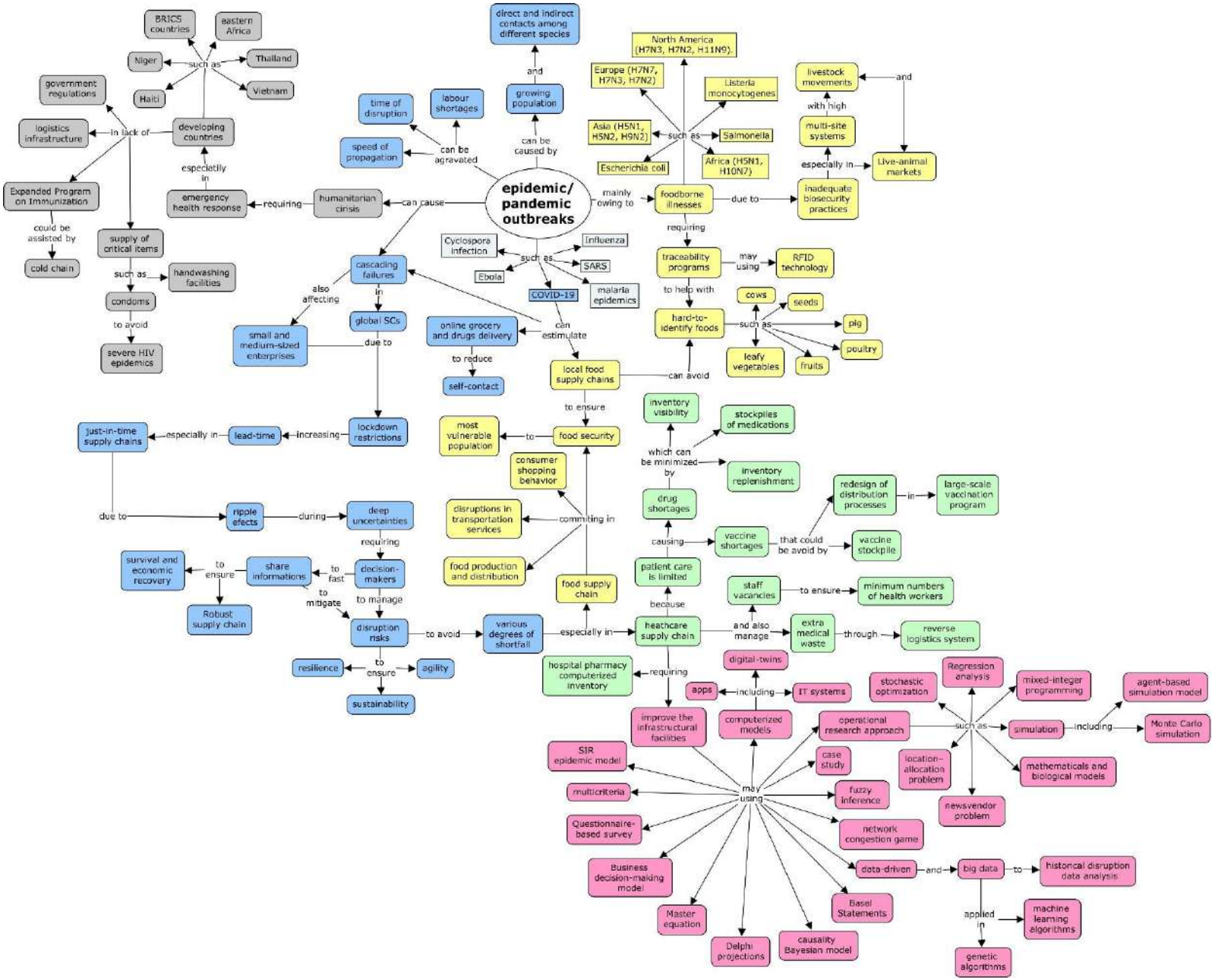

epidemic/ pandemic outbreaks
direct and indirect contacts among different species
and
growing population
can be caused by
time of disruption
labour shortages
speed of propagation
can be agravated
BRICS countries
eastern Africa
Niger
such as
Thailand
Haiti
Vietnam
government regulations
logistics infrastructure
in lack of
developing countries
especially in
Expanded Program on Immunization
could be assisted by
cold chain
supply of critical items
such as
handwashing facilities
condoms
to avoid
severe HIV epidemics
emergency health response
requiring
humanitarian crisis
can cause
North America (H7N3, H7N2, H11N9).
Europe (H7N7, H7N3, H7N2)
Listeria monocytogenes
Asia (H5N1, H5N2, H9N2)
such as
Salmonella
Escherichia coli
Africa (H5N1, H10N7)
livestock movements
and
with high
multi-site systems
especially in
Live-animal markets
mainly owing to
foodborne illnesses
due to
inadequate biosecurity practices
requiring
traceability programs
may using
RFID technology
to help with
hard-to-identify foods
such as
cows
seeds
pig
poultry
leafy vegetables
fruits
can avoid
Cyclospora infection
such as
Influenza
SARS
Ebola
COVID-19
malaria epidemics
cascading failures
also affecting
in
global SCs
small and medium-sized enterprises
due to
lockdown restrictions
increasing
lead-time
especially in
just-in-time supply chains
online grocery and drugs delivery
can estimulate
to reduce
self-contact
local food supply chains
to ensure
most vulnerable population
to
food security
consumer shopping behavior
disruptions in transportation services
committing in
food production and distribution
food supply chain
inventory visibility
stockpiles of medications
which can be minimized by
inventory replenishment
drug shortages
causing
vaccine shortages
that could be avoid by
vaccine stockpile
redesign of distribution processes
in
large-scale vaccination program
patient care is limited
because
staff vacancies
to ensure
minimum numbers of health workers
due to
ripple efects
during
deep uncertainties
requiring
decision-makers
to fast
share informations
to ensure
survival and economic recovery
Robust supply chain
to mitigate
to manage
disruption risks
to avoid
various degrees of shortfall
especially in
heathcare supply chain
and also manage
extra medical waste
through
reverse logistics system
hospital pharmacy computerized inventory
requiring
digital-twins
apps
including
IT systems
resilience
to ensure
agility
sustainability
improve the infrastructural facilities
computerized models
operational research approach
stochastic optimization
Regression analysis
mixed-integer programming
agent-based simulation model
such as
simulation
including
Monte Carlo simulation
location-allocation problem
mathematicals and biological models
newsvendor problem
SIR epidemic model
case study
multicriteria
may using
fuzzy inference
Questionnaire-based survey
network congestion game
Business decision-making model
data-driven
and
big data
to
historical disruption data analysis
Basel Statements
applied in
machine learning algorithms
Master equation
Delphi projections
causality Bayesian model
genetic algorithms

Figure 2-9. Concept framework based on SLR. The ideas marked in blue apply to general consequences pandemic/epidemic, including COVID-19, ideas in yellow to foodborne illness, in green to pharmaceutical and health care SCs, in gray to humanitarian crisis, and the ideas associated with methodological approaches are marked in pink.

2.3.1. Health care services and humanitarian crisis

During epidemics, the health service needs a fast response to minimize the loss of human life (ALEXANDREA; DEWA, 2020; GOVINDAN; MINA; ALAVI, 2020; LOZANO-DIEZ; MARMOLEJO-SAUCEDO; RODRIGUEZ-AGUILAR, 2020). Shortages are usually a critical problem during epidemics (Paul and Venkateswaran 2017; Tosh et al. 2014; Steelfisher et al. 2018). As a result, the use of the keyword healthcare delivery has grown in publications related to the effects of epidemics on SCs in recent years (Figure 2-7). To deal with this, some studies recommend stockpiling drugs and vaccines (SHRESTHA et al., 2018; THOMPSON; TEBBENS, 2016). Others works point out the need of pharmacy computerized inventory (HOLM; RUDIS; WILSON, 2015; LIN et al., 2012) and improved infrastructural facilities in hospitals (VISHNU et al., 2019). It is also necessary to ensure a minimum numbers of health workers to provide high-quality care (TCHIALEU; YAYA; LABONTÉ, 2016). Besides, the number of infected, availability of medicines, urban mobility, economic resources, and disposal of waste should be considered in contingency plans to infectious diseases (HELBING; KÜHNERT, 2003). Yu et al. (2020) underscore the importance of an epidemic reverse logistics network to deal with increased medical wastes.

As vaccine supplies are usually limited, the vaccination during epidemics should be done with self-isolation measures (Andradóttir et al. 2011). Besides, in limited

resources scenarios (HOVAV; HERBON, 2017; HOVAV; TSADIKOVICH, 2015; IZADI; KIMIAGARI, 2014), vaccine allocation models are quite popular (Paul and Venkateswaran 2017; Li, Swann, and Keskinocak 2018; Mehrotra et al. 2020). Recently, they also have been combined with epidemic models to increase the efficiency of the healthcare system (Paul and Venkateswaran 2020). In fact, interdisciplinary approaches can improve mitigation plans (MORTON et al., 2015). Furthermore, Preiss et al. (2016) highlight that the vaccine manufacturing time (10-26 months) should be taken into account to provide vaccine supply in response to uncertain demand (SHAMSI; TORABI; SHAKOURI, 2018). The transportation of vaccines may also require special logistic cares entailing high costs (JUSU et al., 2018; PAGLIUSI; DENNEHY; KIM, 2018), but these costs can be reduced by using thermostable vaccines (MVUNDURA et al., 2017).

Epidemic outbreaks may be even worse in countries with poor health care infrastructure (ANPARASAN; LEJEUNE, 2018; CHEN et al., 2014; SUNYOTO et al., 2019). For example, in Africa, poor logistic infrastructure is one of the main barriers to Malaria large-scale immunization (MIN, 2012). To deal with this challenges, Sun et al. (2014), Sandøy et al. (2012), Rottkemper et al. (2011), Nagurney, Yu, and Qiang (2011), Aviso et al. (2018) and Lawrence et al. (2020) address initiatives and optimization models to provide critical needs under resource-poor settings. Shamsi, Torabi, and Shakouri (2018) argue after natural disasters, unhealthy conditions may favor the proliferation of infectious diseases. In these cases, endogenous supplies for healthy SCs can ensure quick reaction to epidemics (Itiola and Agu 2018; Miller et al. 2018). For example, local markets could identify the demand for cleaning products and provide them (VILLEMINOT, 2018).

2.3.2. Foodborne illness

The increasing number of severe foodborne illnesses has evidenced the need for an interdisciplinary approach to food outbreaks (GRÖHN, 2015; MOSLONKA-LEFEBVRE et al., 2016; SCHÄTTER et al., 2019). Between 1973 and 2010, 700,600 illnesses caused by foodborne diseases were reported (NGUYEN et al., 2015). The quicker contamination source is identified, the less dramatic medical and economic damages will be (KAUFMAN et al., 2014). For example, China's slow response to SARS in 2003 contributed to devastate Asian markets (OVERBY et al., 2004). Then, trust among partners in SCs is essential for quick traceability (MOHAN; VISWANADHAM; TRIKHA, 2009), since consumers may travel between areas for grocery shopping (SCHLAICH et al., 2020).

Influenza was identified as the main cause of epidemic outbreaks in our articles' sample (Figure 2-7). Influenza outbreaks has shown many distribution system fragilities on the poultry SCs around the world (KUMAR, 2012). Most of live bird market (LBM) do not have adequate biosecurity practices (KHOKHAR; MIN; SU, 2015; ROCHE et al., 2014). These outbreaks may be favored by the constant contact between poultry and wild birds in small farms (WALKER et al., 2012; WEBSTER, 1997) and wholesale markets (PEPIN et al., 2013). Furthermore, recurrent livestock transportation between farms may constitute a potential route to infectious diseases (Paul et al. 2013), so traceability programs (WEISER et al., 2016; YAN; LI, 2019), trucks sanitization between successive shipments (THAKUR et al., 2016) and avian vaccination (DUDLEY, 2008) could minimize diseases spread. Pigs are also a huge source of foodborne illness (BRUUN et al., 2009; BÜTTNER et al., 2013, 2016; BÜTTNER; KRIETER, 2018; BÜTTNER; KRIETER; TRAULSEN, 2015; PASSAFARO et al., 2020).

Plant epidemics may also cause severe outbreaks (GREENE et al., 2008; SAVARY et al., 2017) and may be difficult to identify the contamination source (DONNAN et al., 2012; HORBY et al., 2003). In 2013, leaves served at a Food Festival in England caused gastrointestinal illness in 592 people (WALDRAM et al., 2018). In 2016, contaminated salad leaves caused 165 cases of Escherichia coli in UK (GOBIN et al., 2018; INNS et al., 2018). Miller et al. (2012) trace back through the hazelnuts SC to identify the source of Escherichia coli outbreak in the U.S. In 2011, almost 3,000 Escherichia coli infections were reported in Europe, most of them in Germany. The food source was a batch of fenugreek seeds probably imported from Egypt (WEISER et al., 2013). Gibbs et al. (2013) report an outbreak in two cruise ships returning to Australia in 2010, probably caused by contaminated lettuce taken on board at an Asian port; enhancing that global networks can facilitaded deseases to spread. Besides, water used in vegetable disinfection can be a secondary source of cross-contamination (MUNTHER; WU, 2013).

2.4. Research agenda for COVID-19 confronting

This section aims to explore a set of questions that need to be addressed to expand the current SCs research scope to ensure resilience during COVID-19 pandemic. Table 2-3 summarizes the topics for future trends based on scientific literature analysis.

Table 2-3. Research agenda for COVID-19 confronting based on scientific literature analysis

Context	Suggested research topics	Proposed methodologies	References
There is a lack of decision support models to address epidemic outbreak in poor countries compared to their developed ones.	Case studies can improve epidemic models to future diseases.	Case studies papers in developing countries and mathematical models	(ANPARASAN; LEJEUNE, 2018)
The small and medium-sized enterprises (SMEs) play an important role in economic growth and regional development. Despite SMEs are the most vulnerable to COVID-19 lockdown, few studies explore the impact of these firms after epidemics.	Small enterprises find it more difficult to remain resilient in times of crisis.	Case studies.	(JABBOUR; NDUBISI; SELES, 2020); (LU et al., 2020)
During epidemics, the health service needs a fast response to minimize the loss of human life. The forecast of potential infected can help to assist the effectiveness of facility location models, since resources are often scarce, maximum coverage should be prioritized.	Facility location models that optimize accessibility while ensuring equity of resources during pandemics should be explored	Facility location models integrated with epidemiological models.	(MUGGY; STAMM, 2017)
COVID-19 caused a global pandemic with high amounts of medical waste, which may cause a serious risk for both humans and environment if it is not properly managed.	Reverse supply chain for medical waste can be a prominent research field.	Case studies and mathematical models	(KARGAR; PAYDAR; SAFAEI, 2020)
During COVID-19 pandemic, packing waste are expected to grow very quickly, especially plastic waste, due to e-commerce delivery. Besides, masks and gloves large-scale use represents a risk of ocean contamination with microplastic pieces. Furthermore, lockdown policies have complicated recycling efforts.	Studies regarding the effects of COVID-19 in urban waste and carbon footprint of plastics will be needed	Life cicle studies, case studies, mathematical models	(BHAKTA et al., 2020); (PRATA et al., 2020); (SILVA et al., 2020)

Self-isolation measures are essential to contain the spread of the COVID-19 virus. Thus, the drones can assist the transportation of goods.	The use of drones can ensure agility and safety during quarantine periods.	Case studies	(ELAVARASAN; PUGAZHENDHI, 2020)
SCs utility functions may change during COVID-19. Food demand is expected to enhance, and therefore food waste. During the first weeks of COVID-19 lockdown in Spain, household food waste increased in 12%, suggesting changes in an extra-domestic consumption.	Food waste should be included in upcoming research of COVID-19 effects	Case studies and surveys	(O'LEARY, 2020); (GRAY, 2020); (ALDACO et al., 2020)
COVID-19 has aggravated the risk of increasing hunger and malnutrition, the number of people under food insecurity may double from 135 million in January 2020 to 265 million by the end of 2020.	Food security is a relevant theme for future research	Case studies and surveys	(FAN; SI; ZHANG, 2020);(LAL, 2020)
In a post-pandemic scenario, the grocery delivery sector should continue to grow substantially, since many people who were resistant to online shopping ended up surrendering to this convenience during quarantine.	Studies quantifying e-commerce growth due COVID-19 outbreaks and the firms' strategies to deal with this new scenario would be valuable.	Case studies and surveys	(HOBBS, 2020)
Upper-middle-income economies are more susceptible to food insecurity during COVID-19 due to SCs ruptures. For example, farms are the less resilient node in Brazilian sugarcane and orange supply chains.	Food security may have implications for future studies.	Case studies and surveys	(EROKHIN, 2020); (SÁ et al., 2019)
Local sourcing can help SCs to become more resilient, since small suppliers are less exposed to global outbreaks. Therefore, after COVID-19 experience, the interest in locally sourced foods should increase.	Studies focusing on short SCs and self-sustained development deserve further research focus.	Case studies and surveys	(HOEK, 2020); (HOBBS, 2020); (KAHILUOTO; HANNA, 2020)

2.5. Conclusion

The scientific literature discussing the effects of pandemics in the SCs are still scarce. In this study, we review the existing body of knowledge in pandemic/epidemic outbreaks in SCs. It is not easy to be prepared for crises, which one cannot imagine, but some level of redundancy in SC design can mitigate eventualities. These findings are directly contrary to traditional cost obsessive efficiency, based on lean processes, evidencing the need for changes in SCs management.

Our main research were objectives were: (1) identify the papers related to the effects of pandemic outbreaks in SCs, (2) identify the main reasons for these outbreaks, (3) identify SCs resilience strategies and weakness, (4) identify the main effects of COVID-19 in SCs, (5) identify SCs' strategies and difficulties facing COVID-19 pandemic and (5) identify most promising research lines for future work. In literature systematic review, we identified 95 articles related to the effects of pandemic outbreaks in SCs. The main reason for outbreaks is foodborne diseases, especially avian influenza. Most of these illnesses could be avoided with more efficient biosafety protocols in small and medium scale producers, transporters, and retail markets.

Regarding the health care SCs, the disease spread models can help in the contingency plans. In addition, hospital waste management are crucial to avoid infectious diseases spreading. Therefore, reverse logistics is a prominent field of study. COVID-19 pandemic favored online channel supply of medicine and grocery; many people that used to be reluctant with delivery services had to start getting used to this during the quarantine period. Finally, to prevent new global supply disruptions, consumers may also be more interested in local suppliers, which can favor small businesses.

Finally, our graphical framework highlighted the current state of literature addressing the main study fields and most widely used models including optimization research approaches, fuzzy inferences and machine learning algorithms. This framework helps the literature gap in SCs effects of pandemic outbreaks and the main methodological approaches. We also propose a research agenda for COVID-19 confronting, bridging the gap between theory and practice.

CHAPTER 3: WHAT ARE THE MAIN CHALLENGES TO LOCAL PRODUCERS FACING COVID-19?

Chapter 3 is derived from Cordeiro, Santos and Marujo (2021), titled “COVID-19 and the fragility of Brazilian small farming resilience”, published in the Brazilian Journal of Operations & Production Management.

After defining the PhD thesis subject as food security during COVID-19 in Chapter 2, we conducted an investigation of how COVID-19 affected food SC in the viewpoint of the small producers. As pointed in Chapter 2, although local producers can help SC resilience and food security during the pandemic, they are also more vulnerable to market turmoil. In Chapter 3, we use the Grounded Theory principles to formulated hypothesis about Brazilian small farming resilience.

In the article, the method has been identified as case study. Nevertheless, the academic body that approved this PhD Thesis pointed that the methodological procedures would be better conceptually identified as grounded theory than case method and, as main author of the article and author of this thesis, I agreed with the suggestion. As observed by Jacelon and O’Dell (2005) both methods share several of the same strategies for data collection, but while case method is often guided by a previous framework, in grounded theory the framework is created from individuals experience and how they interpreted these experiences. It is important to note that this conceptual change in PhD Thesis methodology does not disqualify the article results and main discussions. Besides, the identification of the methodological procedure as case study in the article does not harm the research replicability, since all the procedures were described systematic.

3.1. Methods

3.1.1. Subject

According to Charmaz (2006) grounded theory methods enable analysis of concepts and build theories based on qualitative data. Aldiabat and Navenec (2018) emphasize that grounded theories are mainly used with unstructured interviews to categorize data in order to build theories. This process are usually followed by data triangulation, which guarantees greater robustness (ALDIABAT; NAVENEC, 2018). Due to the ease in refine and elaborated emerging theoretical categories, Cohen et al. (2021) applied Grounded Theory in the study of the resilience of supply chains. Since COVID-19 outbreak is still ongoing and the uncertainties regarding the spread of the virus are high (CEBALLOS; KANNAN; KRAMER, 2020), we also selected the Grounded Theory approach to investigate insights of how local food chain systems are facing COVID-19 (Figure 3-1), especially perishable food, since they have a shorter shelf life (MATZEMBACHER; VIEIRA; DE BARCELLOS, 2020).

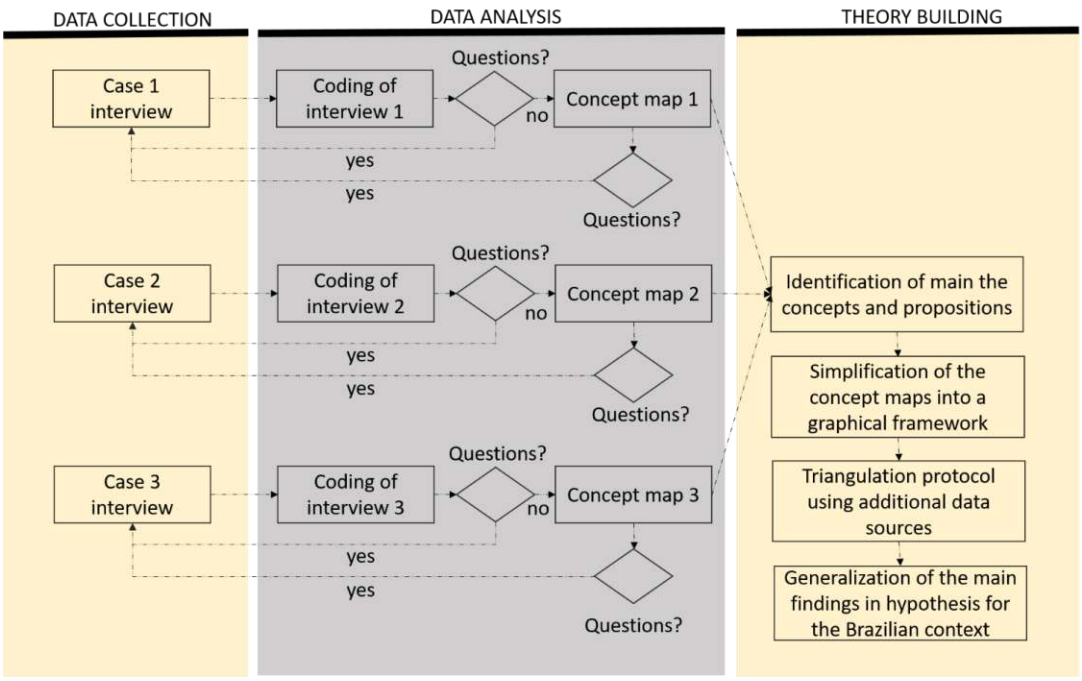


Figure 3-1. Research design. Case 1 is a family farming in Friburgo, Case 2 producers stay in Tanguá city and Case 3 refers to the Association of Citriculturists and Rural Producers of Tanguá (ACIPTA).

3.1.2. Data collection

The research investigation was conducted in two farmers and in a cooperative of family farmers in Rio de Janeiro State, Brazil (Figure 3-2). These locations were chosen due to the ease of access by the authors to the interviewees. The respondents were advised that the interviews would be used to structure their perceptions and experiences about small farms resilience facing COVID-19 (COCHRAN et al., 2011). In order to prevent the risk of contagion by COVID-19, all interviews were done remotely using web conference software.

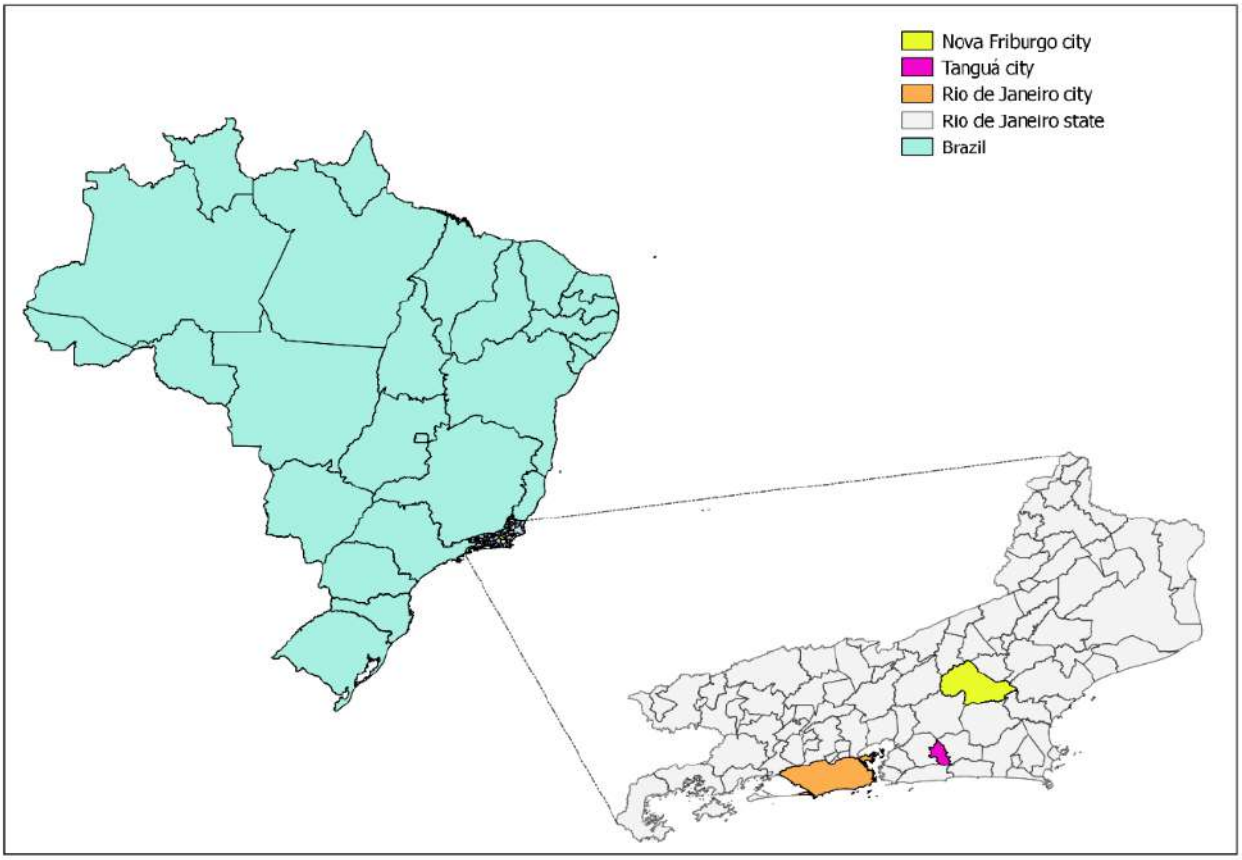


Figure 3-2. Interviewers locations in Brazil, Rio de Janeiro, in the municipalities of Nova Friburgo (Case 1-yellow) and Tanguá (Case 2 and Case 3 - pink). In Blue, Rio de Janeiro city, the main consuming market of the farmers under investigation (Case 1, Case 2 and Case 3).

Source: Designed from (IBGE, 2020c; NERUS, 2020)

We used the Strategic Option Development and Analysis (SODA) to translate the interviews into concept maps. Two interviews were conducted with each respondent, one for the elaboration of the map and another for its validation (COCHRAN et al., 2011). The interviews had an average duration of 01:20 h. Besides, there were also informal talks to clarify eventual questions between the first interview and conceptual map validation. Then, the concept maps were simplified into a graphical framework.

3.1.3. Graphical framework

The following steps guided the graphical framework structure:

1) Developing a focus questions to be answered by the concept map, as opposed to all possible questions (DERBENTSEVA; SAFAYENI; CAÑAS, 2007). Our focus questions was defined as **"What kind of challenges are the small farms facing in COVID-19 context? And how are they responding to these challenges?"**, since our objective is to investigate the insights of the resilience mechanisms of Brazilian small farms facing COVID-19.
2) Transcribing the farms interviews and identification of the pertinent concepts to the focus question (CAÑAS; NOVAK, 2014; LIMA; DA SILVA MÜLLER, 2017).
3) Selection of the best linking words to connect the concepts in good propositions, forming the concept map (CAÑAS; NOVAK, 2014).
4) Validation of the concept maps with the interviewed person, adding extra information when needed (COCHRAN et al., 2011).
5) Simplification of the concept maps into a graphical framework.
6) A triangulation protocol using additional data sources, such as scientific papers and government reports for generalization of concept maps hypotheses in the Brazilian context (DIEFENBACH, 2009).

We used the software CmapTools, version 4.11, developed by the Institute for Human and Machine Cognition (IHMC) of the University of West Florida to represent farms knowledge as concept maps (CAÑAS et al., 2004).

3.2. Interviews

3.2.1. Case 1

Case 1 producers (C1) are located in Nova Friburgo, a municipality in the mountains regions of the state of Rio de Janeiro (RJ), Southern Brazil (Figure 3-2). Nova Friburgo is one of the major agricultural poles in RJ (OLIVEIRA; PRADO; MONTEIRO, 2019). C1 are a family farming company for over 50 years on the market. The farm has five ha, being two ha for fruit and three ha for vegetables. The company's management is currently under the responsibility of the 2 generation of founders. However, there is no prospect of business continuity for the third generation, since according to current managers, the agribusiness sector is devalued.

The administration of the business is concentrated in the hands of two of the brothers of the second generation. While one takes care of agricultural production and harvesting activities, the other takes care of transporting and marketing operations. In addition, three other people from the family work on the farm as sharecroppers, which means that these families receive a plot of land for cultivation and share the result of production with the landowner. There are also three workers with a formal contract. As highlighted during the interviews, landowners would like to hire two more workers with a formal contract to assist in crops, but there is a lack of qualified labor in the region. The farm has only one farm tractor to prepare the fields for planting. Then, most of the planting is done manually, which requires a lot of man-hours and effort. Two trucks owned by the family transport the harvest, and the products are mainly sold in the Rio de Janeiro Supply Center (CEASA-RJ). CEASAS are Brazilian retail and wholesale markets which primarily target fruit and vegetable commercialization (FARIAS; ARAÚJO, 2020).

3.2.2. Case 2

Case 2 producers (C2) stay in Tanguá city, in the metropolitan region of the State of Rio de Janeiro (Figure 3-2). The region has several small farms run by families (CLASS et al., 2020). This case study focuses on the cultivation of tomatoes (1 ha). Increasing awareness of consumers and society about the possible risks from the use of pesticides has incentive agricultural supply chain to improve farming methods (YU; REHMAN KHAN, 2021). In C2, tomatoes are grown using the tomato sustainable production system (Tomatec) developed by the Brazilian Agricultural Research Corporation (Embrapa). The system encompasses a set of good practices on tomato crops (ROSA et al., 2020). For example, the adoption of the Tomatec principles can reduce the use of pesticides by up to 50% in tomato farms (FERREIRA et al., 2014).

According to C2 interview, despite the advantages of the Tomatec system, "Tomatecanas" crops still find it difficult to position themselves in the market, since the product does not fit either as a traditional crop or as an organic crop. The product cannot be identified as organic, as it admits the sustainable use of chemical fertilizers. It also does not fit as a traditional product due to the reduced amount of pesticides in cultivation. (FERREIRA, 2007). As a result, C2 highlights that the monetary value of the product tends to be much lower than an organic product.

During the harvest, part of the production that has small damages in the surface that do not compromise the quality of the product but make it visually less attractive, is destined to produce tomato sauces. This solution helps to reduce losses in the production process, in addition to increasing the product's useful life, since according to our interviewer these tomato sauces can be stored for up to one year.

The farm harvest is transported by their own dump truck with 1.6 ton capacity per trip and driven by members of the owning family. As the exposure to the sun can

accelerate the deterioration of products, the trips are preferably made at night. With regard to tomatoes, the main selling point is the distribution center of a large supermarket chain in city of Rio de Janeiro. Tomatoes are also sold to fairs, municipal schools and individual buyers.

3.2.3. Case 3

Case 3 (C3) refers to the Association of Citriculturists and Rural Producers of Tanguá (ACIPTA). Citrus-fruit has a fundamental relevance in Tanguá, since it is the second largest orange producer in Rio Janeiro (SANTOS; CARLOS, 2020). ACIPTA was created in 2004 and currently has 22 members. As of 2017, ACIPTA's activities have intensified in helping to regularize the documentation of small producers, such as rural land tax, land regulation, property registration certificate, invoice issuance and retirement. Furthermore, ACIPTA assists in the adoption of traceability systems throughout the product life cycle in compliance with the current Brazilian legislation and the large supermarket chains demands.

In December 2020, in order to foster good management practices and add value to oranges produced in Tanguá, the Agriculture Secretariat in partnership with ACIPTA submitted a dossier to the National Institute of Industrial Property (INPI) for registration of the seal of geographical indication (GI) of origin for oranges in the Tanguá Region (PREFEITURA DE TANGUÁ, 2020). GI can be used for market orientation in farming activities, since the seal certifies that the quality of some products from certain regions was better owing to their geographical origin (FAGUNDES et al., 2012).

Besides, during the COVID-19 pandemic, ACIPTA helped to sell members' products intermediating the collective sale of products. In the future, the association intends to act strongly in negotiating collective sales. However, it is necessary that small

producers ensure continuity of supply, in other words, they do not concentrate the entire harvest in a single moment and ensure a high standard of quality.

3.3. Graphical framework

Based on the three interviews, we elaborated a concept map (Figure 3-3) that helped us to identify the typical small farming challenges and the new challenges created by COVID-19. Then, we summarize our main findings in Figure 3-4.

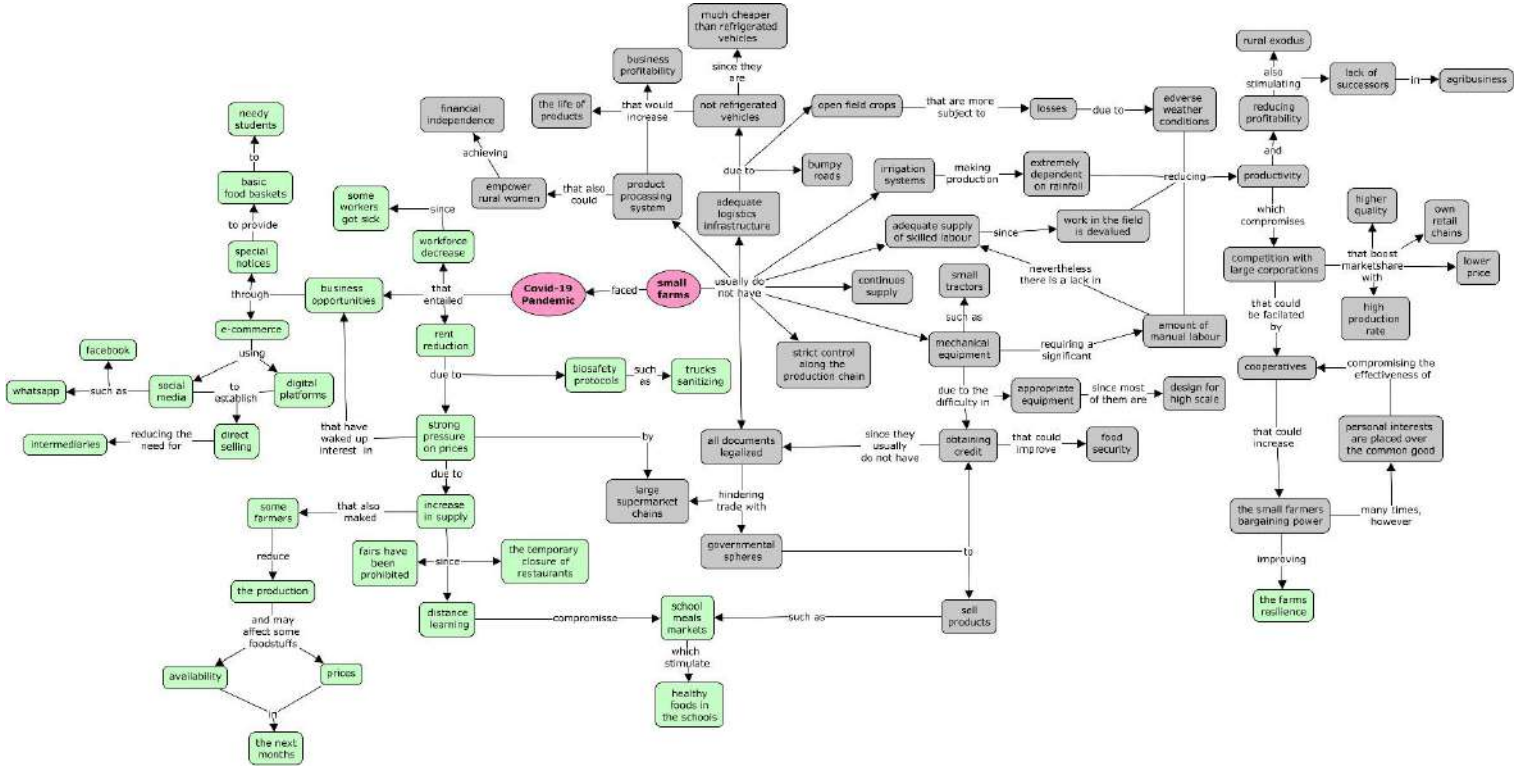


Figure 3-3. Conceptual map based on the three cases (C1, C2 and C3). Green color represents concepts associated to COVID-19 and gray color to general aspects of small farms. In pink, the concepts associated to Covid-19.

Source: Designed from cases studies interviews (2020).

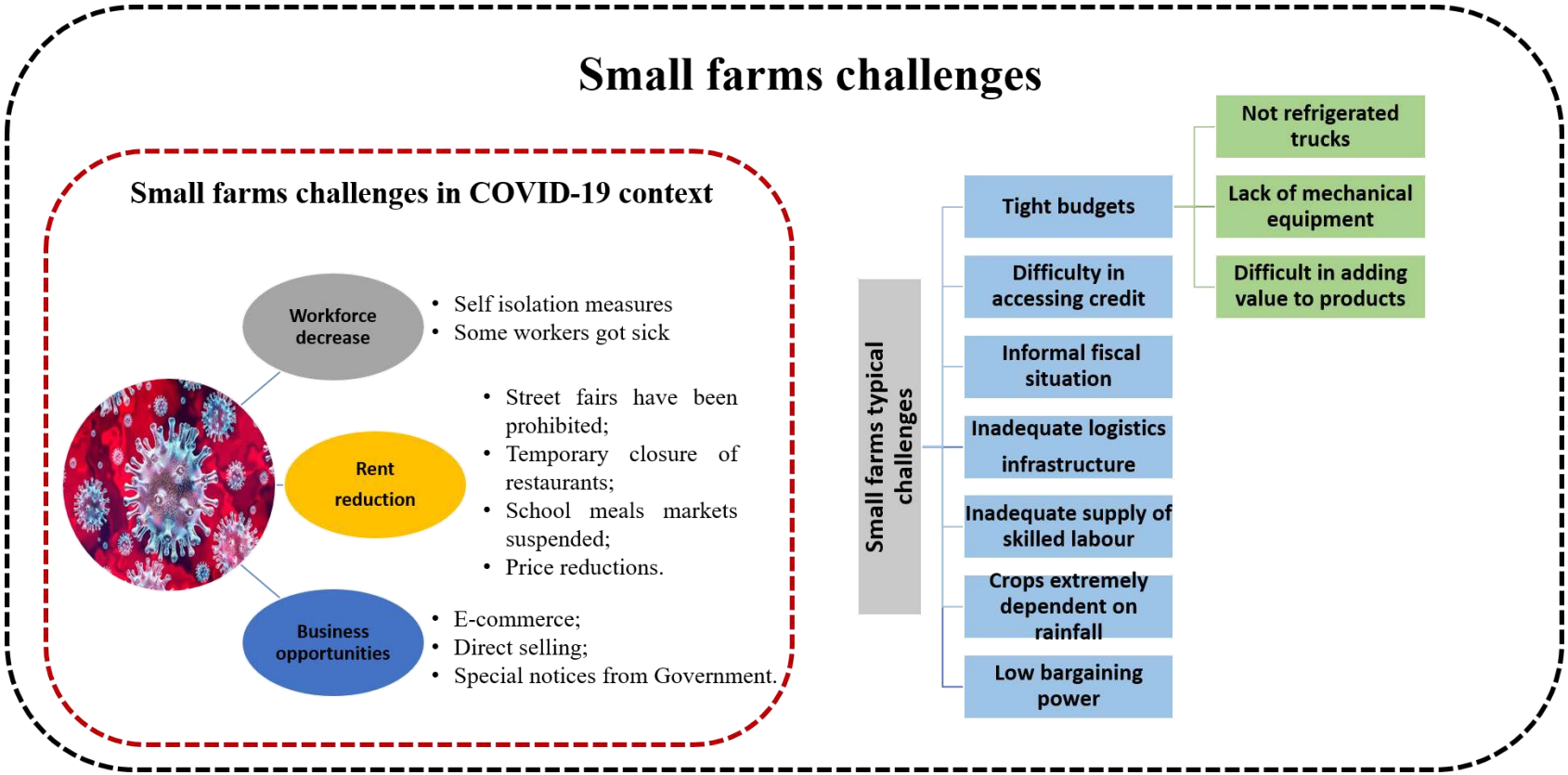


Figure 3-4. Conceptual framework based on the three cases (C1, C2 and C3) main findings.

Source: Designed from cases studies interviews (2020).

3.4. Results and discussion

Based on the main topics of farms concerning mentioned in the interviews (Figure 3-3 and Figure 3-4), we formulated six hypothesis containing the main challenges faced by small farming. Then, we discussed how Covid-19 affected these challenges and how the small farms responded to them during the pandemic. The hypothesis are: 1) Tight budgets and difficulty in accessing credit restrict the adaptability of small business, 2) Many producers are in an informal condition, 3) Digital marketing are still at early stages, 4) Field has lack of human resources, 5) The small crops usually have low-technology production methods, and 6) Difficulty in adding value to the products.

3.4.1. Tight budgets and difficulty in accessing credit restrict the adaptability of small business

Figure 3-4 points out the difficult in regularizing small family business, making the access to credit, and consequently resilience in times of uncertainty, difficult. The pandemic has made financing from the bank even more difficult, since the uncertainties in the market unable most of the small farmers to get through the repayment ability assessment (YU; REHMAN KHAN, 2021). In this context, public policies can play a crucial role supporting investments in family farmers. For example, during COVID-19 pandemic, the European Commission has provided a financial support to the fruit and vegetable sector to compensate for fluctuations in producers' income (HANCE, 2021). Karnali Province, in Nepal, has received about 4 million dollars from federal government to combat food insecurity during COVID-19 (ADHIKARI et al., 2021)

Yamaguchi et al. (2020), based on survey with young rural entrepreneurs in Santa Catarina, Brazil, argue the main difficulties of rural entrepreneurship are

economic, including high production costs and access to credit. In recent years, Brazil has experienced a reduction in family farming incentive programs, leaving the country in a vulnerable situation in the face of the pandemic. For example, the budget target by Federal Government to family farming decreased 24.2% from 2014 to 2017 (SOUZA et al., 2019)

In Brazil, Food Acquisition Program (PAA) ensure direct acquisition by the government of assorted products sold by family farms. Farmers in PAA have 6-month contracts, providing producers with more resilience to market uncertainties (BLESH; WITTMAN, 2015). PAA's already consolidated structure might be used to mitigate the economic and social impacts of COVID-19 in Brazil. However, it should be noted that the amount applied in this program reduced from R$ 1,006.8 million in 2011 to R$ 232.7 in 2018, undermined its benefits (SAMBUICHI et al., 2020).

School nutrition programs are the primary source of food of over 10 million children in Latin America and the Caribbean (ALTIERI; NICHOLLS, 2020). Likewise, Brazil has school food programs that are responsible to provide free meals for over 40 million students using small farmers' products. Many of these students live in extreme poverty (SOARES et al., 2017). During COVID-19 pandemic the schools have been closed and students attended web-based classes, affecting the meals markets for small farms and also food security (BERCHIN et al., 2019; CANABARRO et al., 2020). To deal with this, Brazilian Law 13.987/2020 and Resolution N ° 2, of April 9, 2020 have been launched to send food baskets to low-income students enrolled in public schools through public biddings to farmers (BRASIL, 2020a; RIBEIRO-SILVA et al., 2020).

However, there was no mandatory obligation in the distribution of acquired foodstuffs kits, not even a standardization of the eligibility criteria for the aid, leaving the decision to each municipality (PEREIRA et al., 2020). During the pandemic, the

federal government's denial of the seriousness of the disease made it difficult for public policies to be uniform. In the absence of efficient federal government leadership, municipal leadership have to emerge in the wake of the crisis, often acting in a diffuse manner (ORTEGA; ORSINI, 2020). Therefore, despite creating an alternative to combat food insecurity, Federal Government failed to manage universal access to food.

3.4.2. Many producers are in informal fiscal situation

The public biddings usually require the issuance of invoices (MINAS GERAIS, 2020), which not all small producers are able to do, given that many of them are in an informal fiscal situation. This reinforces the need to regularize small producers to expand their business opportunities. In uncertain times, when traditional routes of commerce such as street fairs are suspended, resilience is linked to the business's ability to diversify (MEUWISSEN et al., 2019). It should be noted that street markets are the second Brazilian favorite place to buy food. Therefore, the temporary close of it, direct affected the farmers budget (PREISS, 2020). In this context, Francesconi *et al.* (2021) points out that rural cooperative organizations can help smallholder-members access new markets. Nevertheless, the success of these cooperatives is directly associated with their level of maturity.

As described on C3 interview, ACIPTA helped associated producers with irregularities in documentation during COVID-19 by issuing invoices through the cooperative. In addition, the cooperative assisted producers by mediating collective bargaining for foodstuffs. As we can see, agricultural cooperatives can improve bargaining power and reduce costs of the members. Nevertheless, coordinate the cooperative is not an easy task and the success is directly affected by the member’s

behavior, in other words, whether cooperation or competition dominates the relationship of them (ZHONG et al., 2018).

In the opposite way of ACIPTA experience, the interviewed farmer in C1 reported an unsuccessful cooperative attempt 15 years ago. According to the reports, the leaders of the cooperative themselves failed to comply with the agreement signed between farmers in the region, lowering the prices of the goods to reach the market. During the pandemic, the existence of this cooperative would facilitate the negotiation of collective sales and the vulnerability to large corporations, one of the biggest problems reported in C1. Community-level trust must be cultivated as a plant that becomes stronger and more resilient over the years. For this reason, unsuccessful experiences as in C1 end up aborting the chances of success of the cooperative system (RILEY et al., 2018).

3.4.3. Digital marketing is still at early stages

Both cases C1 and C2 reported that they leveraged the use of social media as sales channels during the pandemic. In C2, all kaki production, a sweet and extremely perishable species of tomato, was sold using social media. Without this resource, the production would be lost. More recently, it has been evident in the literature that e-commerce is a worldwide trend to deal with the temporary closure of open fairs in order to contain the virus from spreading (LEONE et al., 2020).

For example, agri-food e-commerce platform increased almost 6% in Taiwan, with special emphasis on fresh fruit and vegetables (CHANG; MEYERHOEFER, 2020). Following this line, more quantitative studies dimensioning the impact of e-commerce in small farming would be of great value. The use of digital platforms represents a paradigm shift in the field, giving small producers greater autonomy. The modernization of producer-consumer relations are expected to continue even after the

end of the pandemic, perhaps contributing to increase the attractiveness of agribusiness for young people (HOBBS, 2020).

This new way of organizing the food supply chain, in addition to ensuring greater financial security for the producer, can be very useful in popularizing more sustainable foods, such as organic. For example, the purchase of organic products directly from the producer through digital platforms can make the product cheaper up to 400 times (PREISS, 2020). Nevertheless, in Brazil, supermarkets are still the main distribution channel for organic foods accounting more than 60% of total sales before COVID-19 (MEDAETS; FORNAZIER; THOMÉ, 2020), but this situation can be changed in post pandemic scenario. In this regard, a free e-commerce platform would accelerate the connection between farm and fork (PREISS, 2020).

3.4.4. Lack of human resources in the agro-food chain

Cases C1 and C2 farmers complained about workforce supply in the field. The rural exodus and the low valuation of fieldwork make agribusiness unattractive for younger people. The difficulty in obtaining qualified labor is also pointed by Yamaguchi et al. (2020). According to them, the adoption of technological innovations can avoid rural exodus. In addition, COVID-19 can aggravated the lack of workforce in the field, since the restrictions in the workers mobility decreased the seasonal labor supply (BOCHTIS et al., 2020).

The farmer in C1 also reported that there is no perspective of business continuity for the next generations of the family due to not satisfactory rural income in view of the requirements of the business. This point of view is in line with Foguesatto, Mores, Dalmutt Kruger, & Costa (2020), since they highlight the lack of successors to rural properties in Brazil. According to these authors, the lack of family encouragement and

high opportunity costs are the main reasons for the lack of interest of young people in the countryside.

Because of successors to rural properties problem, the average age of farmers is increasing. This phenomenon compromises the adoption of more sustainable practices and innovations in the field, since older farmers tending to be more averse to changes (FOGUESATTO et al., 2020). Besides, young farmers tend to use information technology to improve the field productivity and resilience, reacting better to situations of uncertainty (MCKILLOP; HEANUE; KINSELLA, 2018).

3.4.5. The small crops usually have low-technology production methods

Another obstacle to innovation smallholders business pointed in Figure 3-4 is the lack of equipment with the appropriate dimensions, since traditional facilities are usually designed for large crops, as also argued by Kornecki & Reyes (2020). The efficiency in the field involves increasing productivity through technological innovation to target higher value-added jobs to field workers. However, unfortunately, small farms usually operate with labor intensive production practices in land preparation, weeding and harvesting, which decreases the attractiveness of field work (MUJAWAMARIYA; KALEMA, 2017). Lastly, during COVID-19, field mechanization would enable the best use of available labor, in addition to reducing the risks of labor shortages and food insecurity (BALWINDER-SINGH et al., 2020).

3.4.6. Difficulty in adding value to the products

Increasing field profitability may also include adding value to products, for example, as described by the farmer from C2, tomatoes with minor blemishes could be made into sauces. The positive impact of adding value to foods goes beyond increasing market price, it also avoids food waste (ALONSO, 2011). In Australia, a survey with 43

horticultural associations identified that over than 10% of production can be rejected by consumers for been partly blemished or small size. Without value-added activities, all that food is simply thrown away (HINGLEY; DUARTE ALONSO; NORTHCOTE, 2013).

Besides, during the pandemic, vegetables and fruits were under great pressure by large retailing companies to reduce prices (HARRIS et al., 2020). In Brazil, one of the reasons for it was that street markets were temporary interrupted (SAMBUICHI et al., 2020). In view of that, the improvement of products could be an alternative to increase the useful life of them and guarantee greater bargaining power to the small producer. Nevertheless, financial constraints are still a big obstacle to the implementation of a system for processing agricultural products (DONKOR et al., 2018).

Another positive point identified in C2 was the adoption of agroecological cultivation practices ("Tomatecanas crops"). The adoption of sustainable practices in supply chains has become an increasingly strong trend in the last years (KHAN et al., 2021). The COVID-19 pandemic has shown that less dependence on external inputs, such as fertilizers and pesticides, makes the agroecological chains more resilient to disruptions. Furthermore, these chains are shown to be more environmentally sustainable, attracting the attention of consumers (ALTIERI; NICHOLLS, 2020). Besides, several empirical cases suggest that agroecological practices are economically efficient ways of adding value to products. For example, family farmers' income can be upward up to 70% with these sustainable practices (PLOEG et al., 2019).

The seal of geographical indication (GI) in process of registration by C3 can be another way to adding value to agro products. GI labeling main economic effects are (1) increased incomes and (2) resilience, since the consumers recognize a real advantage for them when buying the product (VANDECANDELAERE et al., 2020). Therefore,

Malacarne *et al.* (2019) highlights that GI can be used by small farmers to prove the quality of their products against major competitors. In times of uncertainty, this will be an important competitive advantage for small producers in Tanguá.

3.5. Conclusion

Brazilian family farms correspond to more than 80% of all the agricultural units in the country, been responsible to US$ 27 billion of the Brazilian GDP. In Brazil, family farming plays a central role in the food security of children and adolescents, ensuring healthy school meals in public schools for up to 40 million students. Many of these young people live in a vulnerable situation and school meals are the only balanced meal to which they have access. This paper has looked at the insights of how local food systems are facing COVID-19 in Brazil based on two small farms and a cooperative of family farmers located on Rio de Janeiro.

During the pandemic, many businesses were impacted. In the case of small farming, (1) the closure of street fairs and restaurants, and (2) remote classes, with the consequent suspension of school meals were the major challenges. In addition, lockdown measures had a negative impact on product distribution times. In the case of perishable goods, such as fruits and vegetables, the loss can be even greater. There was also an ineffectiveness of public policies to support small products. Despite some promising initiatives such as Brazilian Law 13,987 / 2020 and Resolution N ° 2, of April 9, 2020 for the distribution of basic food baskets to underprivileged students, the implementation failed due to the lack of guidance from the federal government.

At least, the pandemic has generated changes in the way farmers relate to the final consumer, narrowing the bond between them. For example, the use of social media and digital platforms has boosted sales in the field. In addition to allowing the end consumer to trace the origin and history of the food consumed, the tendency is that this

close contact between producers and consumers remain in the post-pandemic, favoring local food production. In this sense, training initiatives for small farmers in digital marketing would be of great use. Agro-entrepreneurship is a promising field both for resilience in the field and for more sustainable relationships with nature and local communities.

However, this advance comes up against the difficulty of accessing credit, depending on effective public policies to become a reality. Unfortunately, in recent years, investment in programs such as PAA and PNAE has been drastically reduced. Seen in these terms, new studies in the post-pandemic scenario would be interesting to measure the evolution of the situation. Perhaps the crisis has attracted attention to the lately neglected family farming in Brazil.

3.6. Appendix: farms' interview main topics

1) Describe your work routine.
2) How many workers are employed in production?
3) How is the division of labor in your business?
4) Describe your supply chain. How many links are involved from production to sale?
5) How big is the crop area on the farm?
6) What products do you crop? Why?
7) What are the biggest problems you encounter in production?
8) What is the seasonality of your products?
9) Who are your customers?
10) How is the transportation for sale?
11) What are the distribution channels used by your company (e.g. wholesale (Ceasa), supermarkets/hypermarkets, street fairs, schools/nursery. digital platform…)?
12) How was each of these channels affected by the pandemic?
13) What are your marketing strategies?
14) Do you use a digital platform to sell your products? Specify the platform name.
15) Did you already use this platform before COVID-19? Was there a decrease/increase in orders via the digital platform during the pandemic?
16) Who are the main competitors?
17) Who are your suppliers (packaging, seeds, pesticides, fertilizer...)?
18) What equipment are used? How were they acquired?
19) How is the price of the products formed?
20) What are the main obstacles for family farming?

21) What could improve the situation of the small producer?
22) In your opinion, where are the biggest sources of food waste in the countryside?
23) In your opinion, where are the biggest sources of wholesale food waste?
24) In your opinion, where are the biggest sources of food waste in retail?
25) Was there a decrease/increase in your business' profitability during the pandemic?
26) What measures were taken to fight COVID-19?
27) List what were the main difficulties of your business in the period from March to May 2020 (more rigid lockdown)
28) Did workers have to be laid off or was there a reduction in wages due to the pandemic?
29) Was there an improvement in the profitability of the business during the relaxation of the lockdown (June to July 2020)?
30) What could be done for small producers to protect themselves in situations of uncertainty?
31) What are your aspirations for the future?

3.7. Appendix: cooperative's interview main topics

1) Describe the cooperative work routine.
2) How does the cooperative help associate members?
3) How many members has currently the cooperative? Has there been any change in the number of members due to COVID-19?
4) What products do the members crop?
5) What are the biggest problems the farmers have?
6) Does the cooperative mediate collective purchases? What are the distribution channels used by the cooperative (e.g. wholesale (Ceasa), supermarkets/hypermarkets, street fairs, schools/nursery. digital platform…)?
7) How was each of these channels affected by the pandemic?
8) Does the cooperative have a marketing strategy or training programs for its members?
9) How is the price of the products formed?
10) What are the main obstacles for family farming?
11) What could improve the situation of the small producer?
12) In your opinion, where are the biggest sources of food waste in the countryside?
13) In your opinion, where are the biggest sources of wholesale food waste?
14) In your opinion, where are the biggest sources of food waste in retail?
15) Was there a decrease/increase in your business' profitability during the pandemic?
16) What measures were taken to fight COVID-19?
17) List what were the main difficulties of your business in the period from March to May 2020 (more rigid lockdown)

18) Did workers have to be laid off or was there a reduction in wages due to the pandemic?
19) Was there an improvement in the profitability of the business during the relaxation of the lockdown (June to July 2020)?
20) What could be done for small producers to protect themselves in situations of uncertainty?
21) What are your aspirations for the future?

CHAPTER 4: HOW COVID-19 AFFECTS CONSUMERS EATING BEHAVIOR?

The COVID-19 lockdowns have changed people routines and may affect eating demand. Considering that, this study aims to: (1) to identify changes in eating habits due to COVID-19 pandemic and the possible effects in food supply chain and (2) to explore factors associated with different perceived eating habits. An online self-report survey was conducted with 431 participants from Rio de Janeiro state. In this study, the convenience sample approach can justify the high education level of most of the respondents (undergraduate or graduate education), since in this method, the participants are selected based on their accessibility and/or proximity to the researchers (JAGER; PUTNICK; BORNSTEIN, 2017). The survey was performed online to avoid physical contact between individuals, respecting the Brazilian sanitary measures of confinement and social distancing during the COVID-19 pandemics (BRAZIL, 2020). Finally, this research may contribute to: (1) practitioners that intend to better understand consumer behavior and improve business strategies; (2) public policy development related to food consumption and food waste; (3) the academy, by improving the knowledge about food habits during COVID-19.

4.1. Materials and methods

The survey was approved by the Brazilian National Commission on Ethics in Research (CONEP) of the Neurology Institute Deolindo Couto of the Federal University of Rio de Janeiro / INDC – UFRJ (Brazil).

4.1.1. Participants

The survey was disseminated through various communication channels, social media (Facebook, Instagram, LinkedIn and WhatsApp groups), and by email, including the personal networks of the authors and specific scientific dissemination groups, as suggested by Espinoza-Ortega et al., 2021. The study population involved residents of Rio de Janeiro state, one of the largest metropolitan areas of Brazil (LUCENA et al., 2021). In 2020, Rio Janeiro state had about 17 million inhabitants (IBGE, 2021).

The authors opted for the use of convenience sampling, since probability samples are usually cost prohibitive for independent studies (FAOUR-KLINGBEIL et al., 2021; JAGER; PUTNICK; BORNSTEIN, 2017). Sampling convenience is a not random selection strategy where the participants are selected based on their accessibility and/or proximity to the researchers (JAGER; PUTNICK; BORNSTEIN, 2017). In this study, the convenience sample approach can justify the high education level of the respondents (undergraduate or graduate education).

The questionnaire was administered in Portuguese language in two moments from January 24 until April 11, 2021 and from July 02 until August 31, 2021. The questionnaire was based on the research performed by Hassen et al. (2020) regarding consumer behavior in Qatar during the pandemic, Jribi et al. (2020) about the impact of COVID-19 on food waste in Tunisia and Casotti (2002) about the eating habits of Rio de Janeiro's families at the table.

In the first online survey, 502 participants answered the questionnaire. Nevertheless, despite the authors having yielded a pretest with 10 respondents to refine the scales and correct potential problems with the interpretation of questions, during data analysis they have identified a need for further subdivide the household income classes in order to further investigate the impact of COVID-19 pandemic in different

yield classes (IBGE, 2019). Considering that at the time this article was wrote, US$ 1 U.S. dollar was worth R$ 5.64 (BCB, 2021) and Brazilian minimum wage was R$ 1045 (BRASIL, 2020b).

The original question *"What is your family income bracket?"* with the options:

"a) 0 - R$ 1254

b) R$ 1255 - R$ 2004

c) R$ 2005 - R$ 8640

d) R$ 8641 - R$ 11261

e) > R$11261"

It had the options replaced by

"a) until 2 minimum wages (R$ 2.090,00)

b) between 2 and 4 minimum wages (R$ 2.090,01 - R$ 4.180,00)

c) between 4 and 10 minimum wages (R$ 4.180,01 - R$ 10.450,00)

d) between 10 and 20 minimum wages (R$ 10.450,01 - R$ 20.900,00)

e) Above 20 minimum wages (R$ 20.900,01 or more)".

Furthermore, two more questions were included in the study considering that prior studies have already highlighted the positive impact of physical activity in prevent overdo eating and weight gain in Latin American during the COVID-19 outbreaks (MARTÍNEZ-RODRÍGUEZ et al., 2021; RUIZ et al., 2021). The questions were:

i) *"how often did you workout during the pandemic?"*, and

ii) *"did your weight change during social isolation?"*

For the second online survey, the first respondents were contacted by email to answer these three additional questions, the response rate was 62% (n=311). At the same time, a complete questionnaire was disclosed to new respondents, receiving 120 answerers. Unifying the two surveys, there was 431 respondents.

4.1.2. Questionnaire

The questionnaire was implemented using online forms and participants answered it by mobile or computer with internet access. Respondents provided informed consent in an online form at the beginning of the questionnaire. No compensation was given to participants. The survey asks a number of questions related to socio-demographics profile, food consumption changes during the pandemic and food waste concerning. First, the questions were translated from English to Portuguese by the authors (CEQUEA et al., 2021). Then, some questions were adapted considering local reality, such as the question about the family's social class by minimum wage.

4.1.3. Data Analysis

A descriptive analysis was performed to explain the sociodemographic profile of the sample, and then frequency was used for each category variables (MALTA et al., 2020). Then, specific statistical tests were performed in order to identify significant patterns. Statistical analyses were performed using Jamovi 2.2.5 and statistical significance was assessed at the 0.05 level (ŞAHIN; AYBEK, 2019).

The following tests were applied:

- Qui-square was applied when the variables were qualitative nominal. Then, for Statistically Significant Chi-Square Test, the residuals were calculated in order to investigate further the source of a statistically significant result (SHARPE, 2015).
- For non-paired ordinal variables, Comparisons between three or more groups were made using one-way analysis of variance or Kruskal–Walis tests (SAWILOWSKY; FAHOOME, 2014). Then, Dwass-Steel-Critchlow-Fligner pairwise comparisons were used to Post-hoc multiple comparisons (SHINNICK et al., 2016).

- Wilcoxon Test was applied for paired ordinal data with two analysis groups: before and after pandemic (DIVINE et al., 2013)

4.2. Results

4.2.1. Demographic characteristics

Table 4-1 shows the sociodemographic data of the respondents of this study (n = 431). Most of the respondents have completed graduation (61.3%, n =264) and 93.3% (n = 402) of the respondents are in working age, between 18 and 60 years old (IBGE, 2020). Most interviewees (66.4%, n = 286) receive more than four Brazilian minimum wages (R$ 4180, about U$ 770.92). About 68.7% (n = 296) of the respondents live in Rio de Janeiro city.

Table 4-1. Sociodemographic characteristics of the participants (n=431)

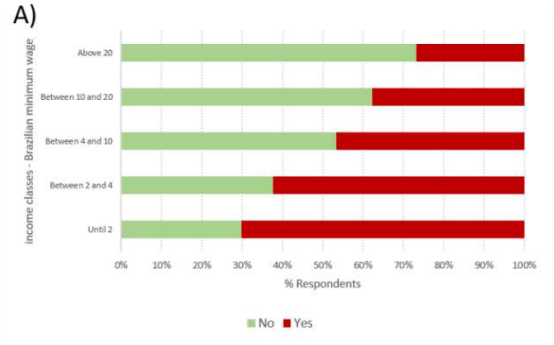
Characteristics		**% of respondents**
Gender	Male	43,4%
	Female	56,6%
Age (years old)	< 18	0,7%
	18-25	25,8%
	26-40	49,9%
	41-60	17,6%
	> 60	6,0%
City	Rio de Janeiro	68,7%
	Belford Roxo	6,5%
	Niterói	4,9%
	São Gonçalo	3,2%
	Nova Iguaçu	2,8%
	Others	13,9%
Number of persons in the household	1	11,1%
	2	27,1%
	3	30,9%
	4	24,1%
	≥ 5	6,7%
Level of education	Incompleted Elementary School	0,5%
	Completed Elementary School	0,2%

	Incomplete secondary education	1,4%
	Complete secondary education	3,5%
	Incomplete university degree	33,2%
	University degree	61,3%
Occupation	Not exert paid activity	11,6%
	Student	19,5%
	Informal worker	6,0%
	Employed	51,7%
	Manager or trader	7,9%
	Retired	3,2%
Household income	Until 2 minimum wages	10,9%
	Between 2 and 4 minimum wages	22,7%
	Between 4 and 10 minimum wages	35,3%
	Between 10 and 20 minimum wages	21,6%
	Above 20 minimum wages	9,5%

4.2.2. Purchasing and consumption behaviors

We used qui-square test to investigate the statistical significance of the answers patterns in the questions with nominal dependent variable (questions 14, 15 and 16 in 5.5 Appendix). Qui-square test found evidences of significant statistical difference (p-valor < 0.001) between income levels for the question “15. Did you have difficulty buying fresh fruits and vegetables during the pandemic?”. Then, for that case, we calculated the adjusted standardized residual. Figure 4.1 shows an evidences that the poorest had more difficult in buying fruits and vegetables during the pandemic. The residuals analysis (Figure 4.1B) highlights that most of the poorest classes (receiving until 2 minimum wages and receiving between 2 and 4 minimum wages) had difficult to buy fruits and vegetables, while the richest (between 10 and 20 minimum wages and above 20 minimum wages) did not.

A)



B)

	No	Yes
Until 2	- 3,09	3,09
Between 2 and 4	- 2,99	2,99
Between 4 and 10	0,69	- 0,69
Between 10 and 20	2,47	- 2,47
Above 20	2,98	- 2,98

Figure 4-1. Difficulty in buying fruits and vegetables during the pandemic: A) percent of respondents by income class and B) adjusted standardized residual analysis. The significant residuals are marked in red cells (p-valor < -1.96) and green cells (p-valor > 1.96).

We observed that women have greater self-perception of healthier eating habits than men do, especially in the poorest classes (Figure 4-2). We also observed that women declared eating more fruits and vegetables than men do. (Figure 4-3).

We used Kruskal-walis test to investigate the statistical significance of the non-paired answers in the questions with three or more ordinal dependent variable (questions 12, 13, 19 and 20 in 5.5 Appendix). Then, for the cases with p-valor < 0.05, we performed Dwass-Steel-Critchlow-Fligner pairwise comparisons. Kruskal-walis test showed a statically significant difference between male income groups for: a) balanced diet ($p < .001$) and b) daily fruit eating ($p < .001$). Dwass-Steel-Critchlow-Fligner pairwise comparisons showed that men in the poorest classes has weaker diet and eat less fruits than men do in the richest classes (Table 4-2 and Table 4-3).

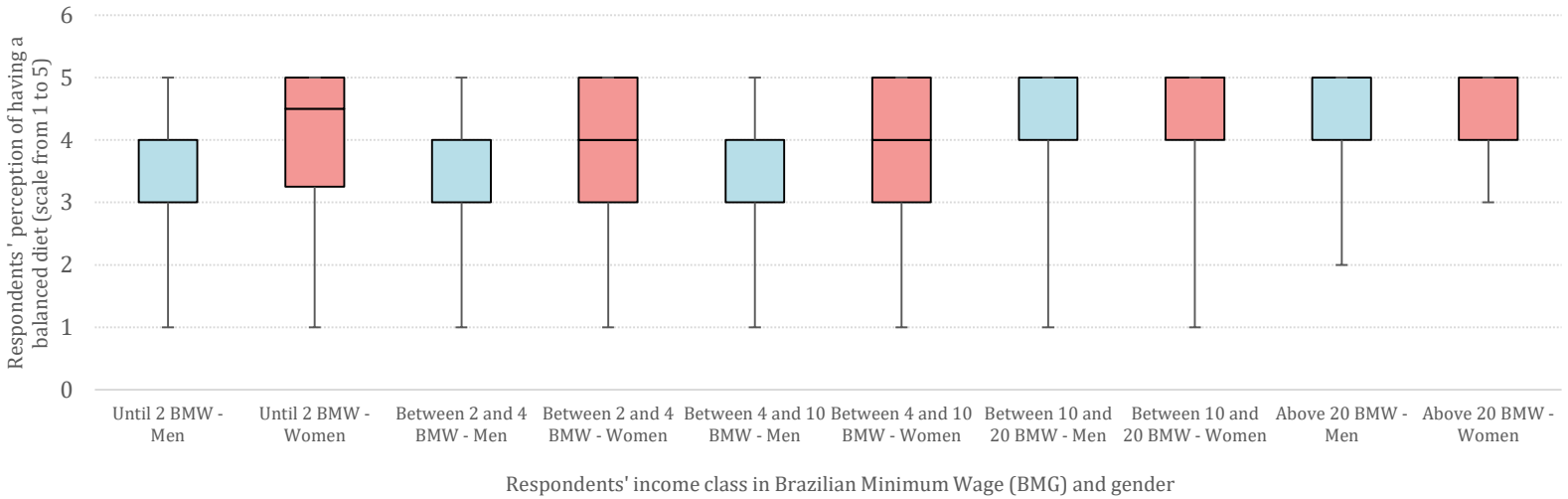


Figure 4-2. Respondents' self-perception of having a balanced diet grouped by income class and gender. Scale from 1 ("I totally disagree. My diet is not balanced at all") to 5 ("I totally agree").

Figure 4-3. Respondents' self-perception of daily eating fruits and vegetables grouped by income class and gender. Scale from 1 ("I totally disagree" to 5 ("I totally agree").

Table 4-2. Dwass-Steel-Critchlow-Fligner pairwise comparisons for the answers of the question "12. Do you believe you have a balanced diet (healthy and balanced should contain several nutrients: Carbohydrates, Proteins, and Fats)?" In blue, the income wages with statistical difference ($p < 0.05$).

		Men		Women	
Brazilian minimum wages		**W**	**p**	**W**	**p**
Above 20	Until 2	-4.26	0.022	-1.051	0.946
Above 20	Between 10 and 20	1.64	0.776	-1.285	0.894
Above 20	Between 2 and 4	-2.47	0.406	-3.156	0.168
Above 20	Between 4 and 10	-4.30	0.020	-2.876	0.250
Until 2	Between 10 and 20	5.49	< .001	-0.166	1.000
Until 2	Between 2 and 4	2.41	0.431	-2.402	0.435
Until 2	Between 4 and 10	1.01	0.954	-2.057	0.592
Between 10 and 20	Between 2 and 4	-4.28	0.021	-2.766	0.288
Between 10 and 20	Between 4 and 10	-6.33	< .001	-2.446	0.416
Between 2 and 4	Between 4 and 10	-1.92	0.655	0.423	0.998

Table 4-3. Dwass-Steel-Critchlow-Fligner pairwise comparisons for the answers of the question "13. Do you eat fruits and vegetables daily?". In blue, the income wages with statistical difference ($p < 0.05$).

		Men		Women	
		W	**p**	**W**	**p**
Above 20	Until 2	-4.40	0.016	-35.164	0.094
Above 20	Between 10 and 20	-2.55	0.371	-21.307	0.558
Above 20	Between 2 and 4	-4.56	0.011	-37.914	0.057
Above 20	Between 4 and 10	-4.22	0.024	-35.358	0.091
Until 2	Between 10 and 20	3.56	0.087	26.386	0.336
Until 2	Between 2 and 4	1.12	0.933	0.0556	1.000
Until 2	Between 4 and 10	2.05	0.594	13.192	0.884
Between 10 and 20	Between 2 and 4	-3.24	0.148	-30.146	0.207
Between 10 and 20	Between 4 and 10	-2.40	0.437	-21.525	0.548
Between 2 and 4	Between 4 and 10	1.17	0.922	14.205	0.854

Then, we investigated food consumption change by gender and income class using Kruskal-walis test (Table 4-4). We find statistical evidence (p-valor < 0.05) of fruit and vegetables consumption change during the pandemic for men. Dwass-Steel-Critchlow-Fligner pairwise comparisons showed a statistical difference between income

classes above 20 Brazilian minimum wages and between 10 and 20 Brazilian minimum wages (p-valor < 0.05).

Table 4-4. Kruskal-walis test for changing consumption in food groups during the pandemic.

	Men			Women		
	χ^2	**df**	**p**	**χ^2**	**df**	**p**
19. How was the consumption of the following food groups during the pandemic? [Fruits/Vegetables]	13.0	4	0.011	6.08	4	0.193
19. How was the consumption of the following food groups during the pandemic? [meat]	6.30	4	0.178	6.43	4	0.169
19. How was the consumption of the following food groups during the pandemic? [Candy, cookies and cakes]	2.78	4	0.595	7.51	4	0.111
19. How was the consumption of the following food groups during the pandemic? [Unhealth snaks]	4.02	4	0.403	3.18	4	0.528
19. How was the consumption of the following food groups during the pandemic? [Packaged frozen foods]	2.01	4	0.733	4.29	4	0.368
19. How was the consumption of the following food groups during the pandemic? [Pasta and bread]	4.85	4	0.303	5.47	4	0.242
19. How was the consumption of the following food groups during the pandemic? [Canned food]	6.45	4	0.168	2.54	4	0.638

We also investigated changes in eating habits during the pandemic by gender and income class using Kruskal-walis test (Table 4-5). We identified a statistical difference (p < 0.05) in the habits cooking and preparing food, eating between meals and ordering take-away or fast food meals with deliveries for male respondents. Using Dwass-Steel-Critchlow-Fligner pairwise comparisons (Table 4-6), we could not identify statistical difference between specific income levels for the habit “cooking and preparing food”. Besides, the same pairwise comparison method showed significant difference (p-valor = 0.006 < 0.05) in the habit “eating between meals” for de income levels above 20 Brazilian minimum wages and the level until two minimum wages.

Considering the habit "ordering take-away or fast food meals with deliveries", Dwass-Steel-Critchlow-Fligner pairwise comparisons showed significant difference between the income level until two minimum Brazilian wages and the others (Table 4-6). As we can we observe in Figure 4-4, with the exception of the poorest income group, all the others income classes for male respondents strongly increased the habit of "ordering food".

Table 4-5. Kruskal-walis test for changing eating habits during the pandemic

	Men			Women		
	χ^2	df	p	χ^2	df	p
20. During the pandemic, there was a change in the following eating habits? [Cooking and preparing food]	10.14	4	0.038	8.04	4	0.090
20. During the pandemic, there was a change in the following eating habits? [Eating between meals]	11.76	4	0.019	4.47	4	0.346
20. During the pandemic, there was a change in the following eating habits? [Eating instant foods]	6.85	4	0.144	2.75	4	0.600
20. During the pandemic, there was a change in the following eating habits? [Ordering take-away or fast food meals with deliveries]	21.86	4	< .001	7.27	4	0.122
20. During the pandemic, there was a change in the following eating habits? [Eating at someone else's place]	3.07	4	0.545	9.43	4	0.051
20. During the pandemic, there was a change in the following eating habits? [Eating out]	6.31	4	0.177	8.63	4	0.071

Table 4-6. Dwass-Steel-Critchlow-Fligner pairwise comparisons between income levels for male respondents considering the habit "Ordering take-away or fast food meals with deliveries".

Brazilian minimum wages		W	p
Above 20	Until 2	5.354	0.001
Above 20	Between 10 and 20	-0.194	1.000
Above 20	Between 2 and 4	-0.634	0.992
Above 20	Between 4 and 10	0.151	1.000
Until 2	Between 10 and 20	-4.977	0.004
Until 2	Between 2 and 4	-5.380	0.001
Until 2	Between 4 and 10	-6.055	< .001
Between 10 and 20	Between 2 and 4	-0.568	0.995
Between 10 and 20	Between 4 and 10	0.279	1.000
Between 2 and 4	Between 4 and 10	0.819	0.978

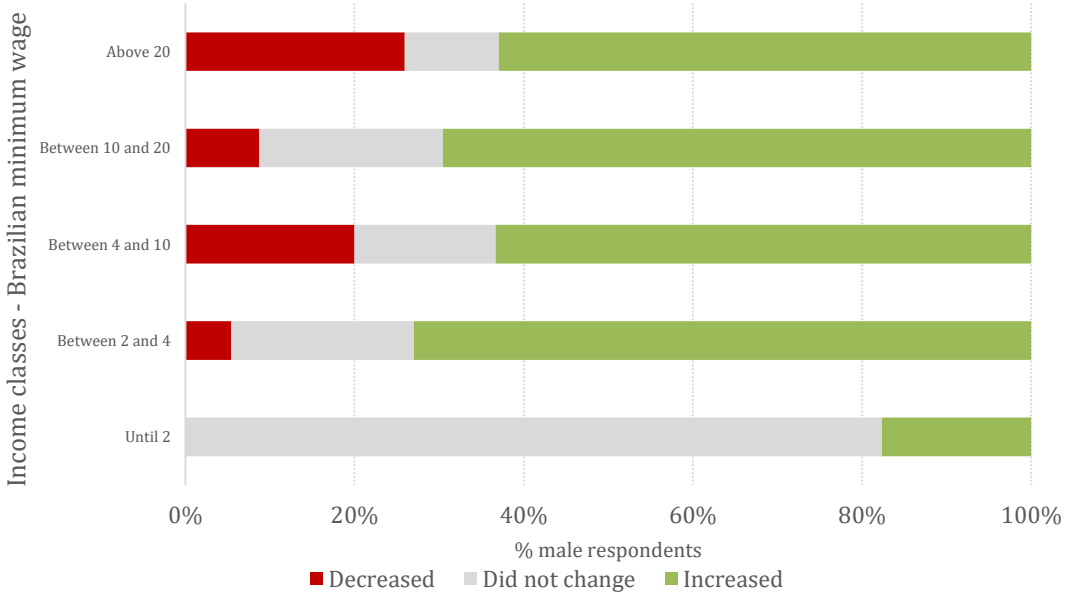


Figure 4-4. Changing in the habit "ordering take-away or fast food meals with deliveries" for male respondents.

The changes in food buying channels were investigated by Wilcoxon test (Table 4-7), since we have paired samples (before and after pandemic answers). To use the test we have to convert the answers in scale data (never = 1, rarely = 2 and often = 3). Then, we investigated the cases with statistical difference by income class (Figure 4-5). Results showed a decreased in the number of respondents that never used digital platforms (Figure 4-5A), we also observed a decreased in the number of respondents that used street fairs during the pandemic (Figure 4.5C).

Table 4-7. Wilcoxon test for food buying channels before and during the COVID-19 pandemic (paired samples). The significant changes (p < valor) are highlighted in blue.

	p
Digital platforms	< .001
Ceasas	0.005
Supermarket / Hypermarket	< .001
Street fairs	< .001
Hortifrutis	< .001
Small producers	0.235

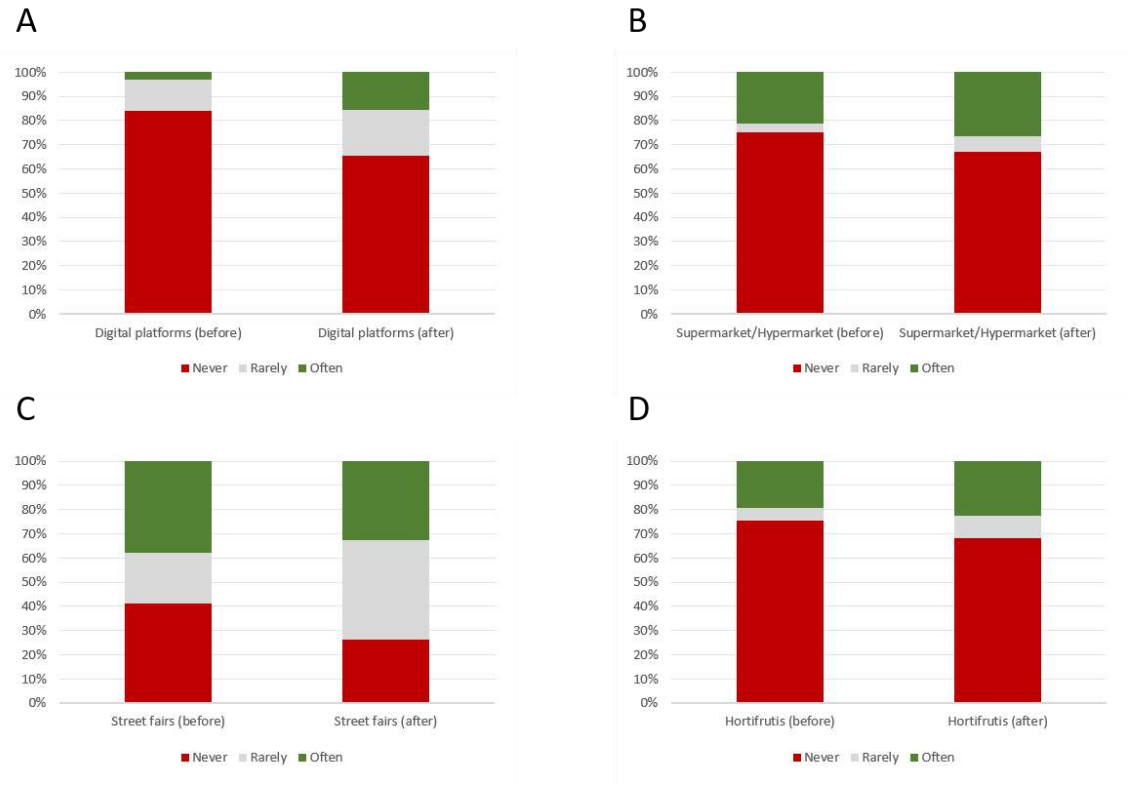


Figure 4-5. Food buying channels before and during the COVID-19 pandemic

4.2.3. Physical health

As we can observe in Figure 4-6, during the pandemic, there was a tendency to reduce physical activity. At the same period, as we can see in Figures 4.7 and 4.8, most respondents reported weigh gain

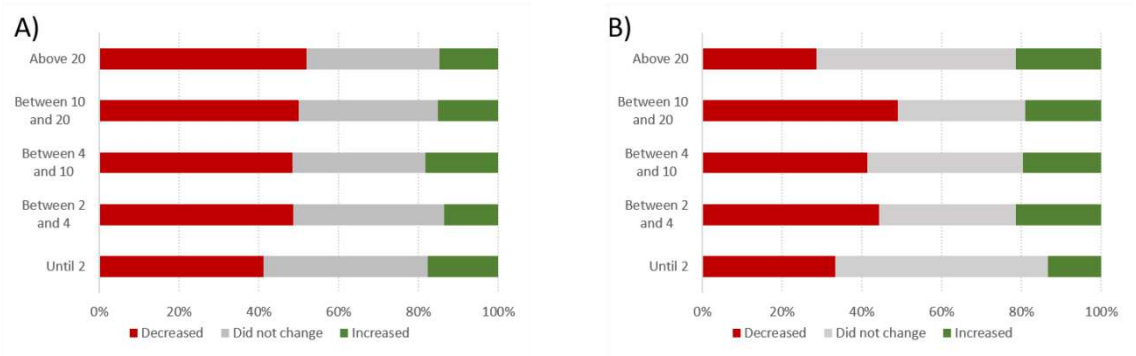


Figure 4-6. The exercise practice during social isolation by income class for : (A) Men and (B) Women.

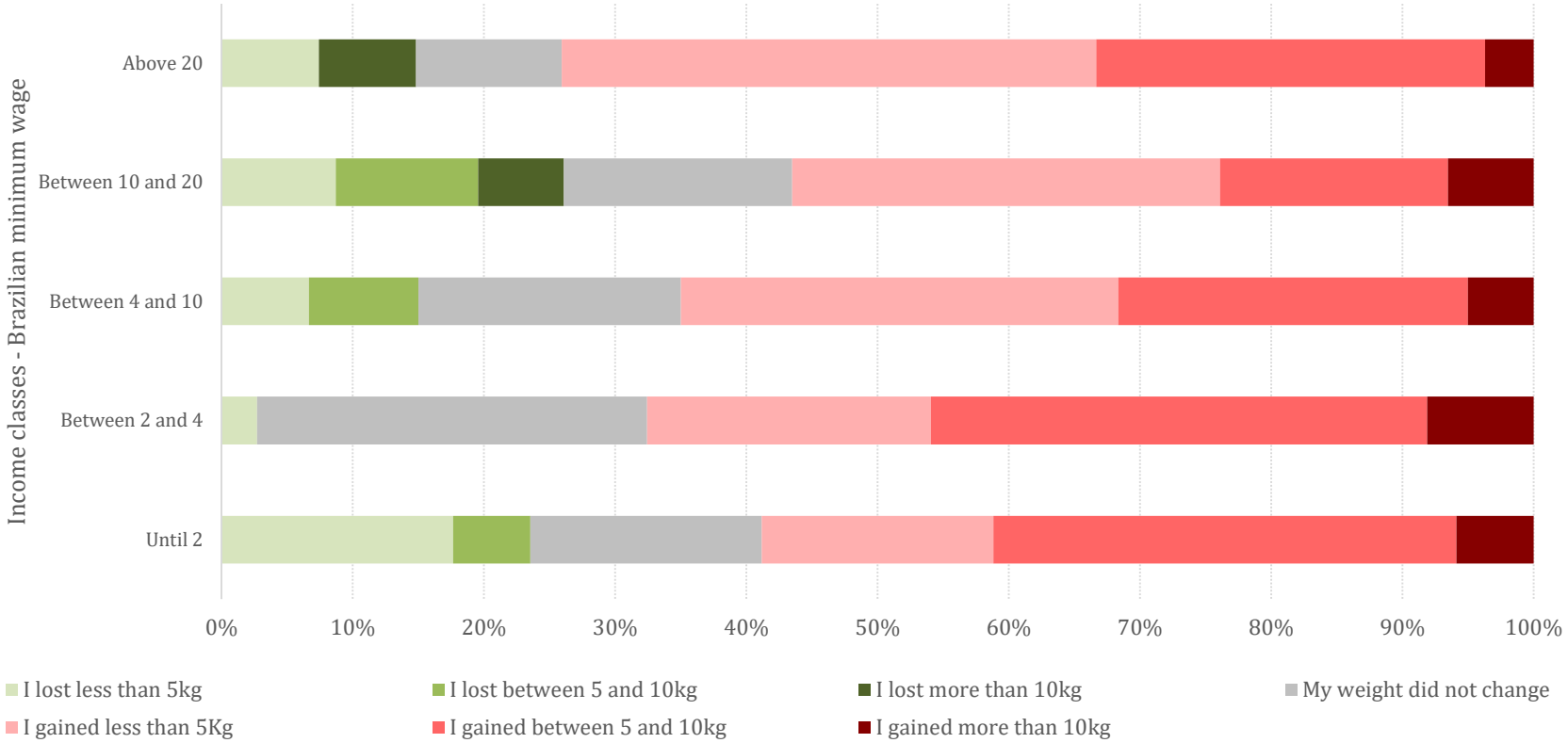


Figure 4-7. Men weight change during the pandemic by income classes

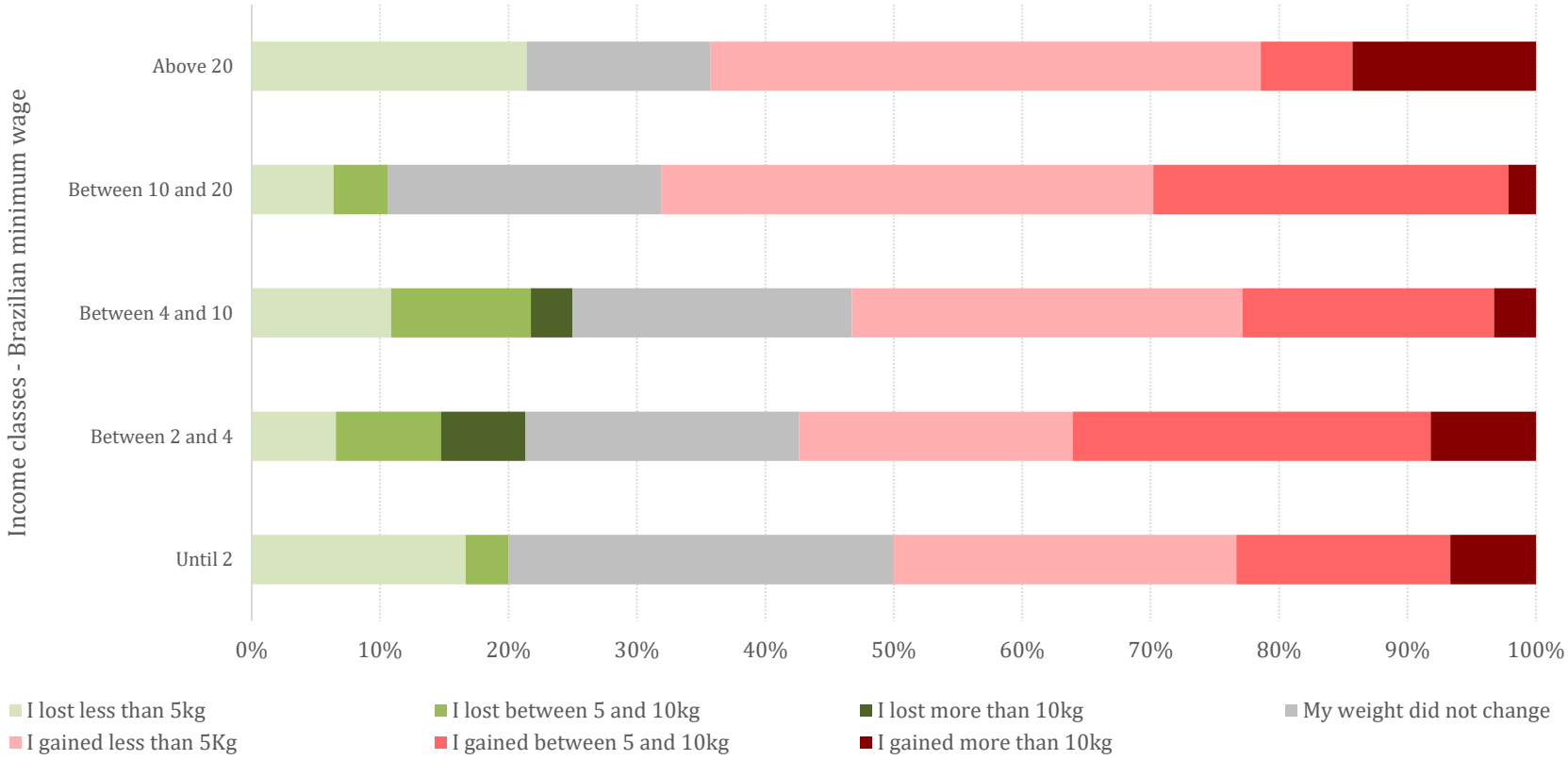


Figure 4-8. Women weight change during the pandemic by income classes

4.2.4. Food waste

The most of the respondents (91%) affirmed that they worry about food waste when planning food purchase and consumption (Figure 4-9A). Besides, 75% of them declared usually making shopping list (Figure 4.9B) Nevertheless, qui-square test identified a significant difference between income classes considering the habit of "usually buy more food than eat" (p-valor < 0.001). The residuals analysis (Figure 4.10B) highlights that most of the poorest classes (receiving until 2 minimum wages and receiving between 2 and 4 minimum wages) declared not buy more food than eat, while the richest (between 10 and 20 minimum wages and above 20 minimum wages) have greater food waste propensity (Figure 4-10A).

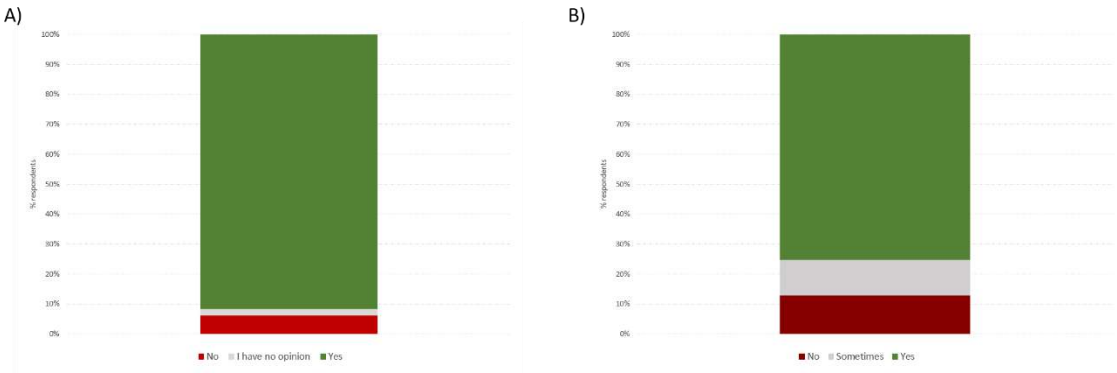
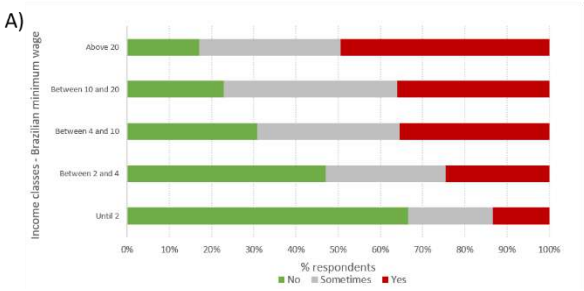


Figure 4-9. Awareness toward food wastage. Respondents' answers to the questions: A) "Do you worry about food waste when planning food purchase and consumption?" and B) "Do you usually make a shopping list?"

A)



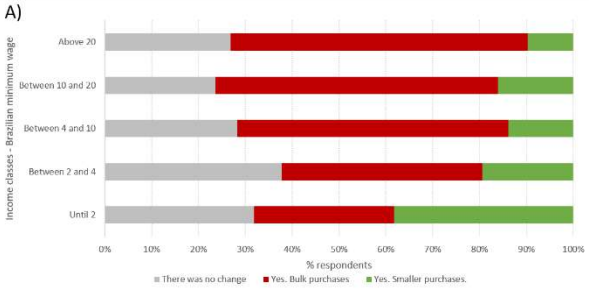
B)

	No	Sometimes	Yes
Above 20	- 2,72	1,12	2,39
Between 10 and 20	- 2,99	2,59	0,87
Between 4 and 10	- 0,82	0,43	0,61
Between 2 and 4	2,90	- 1,88	- 1,67
Until 2	3,86	- 2,60	- 2,10

Figure 4-10. Respondents' answers to question: "Do you usually buy more food than eat?". A) Percent of respondents by income class and B) adjusted standardized residual analysis. The significant residuals are marked in red cells (p-valor < -1.96) and green cells (p-valor > 1.96).

We identified significant change in food purchases by income class during the pandemic (p-valor < 0.001). The residuals analysis (Figure 4.11B) highlights that the income class receiving until two minimum wages made smaller purchases during the pandemic, while the income class between 2 and 4 wages did not change the purchasing volume (Figure 4-11A). Despite this, our results did not identified a significant increase in food waste perceptions by income during the pandemic (p-valor = 0.053).

A)



B)

	There was no change	Yes. Bulk purchases	Yes. Smaller purchases.
Above 20	- 0,42	1,48	- 1,42
Between 10 and 20	- 1,44	1,70	- 0,49
Between 4 and 10	- 0,47	1,67	- 1,62
Between 2 and 4	1,99	- 2,16	0,45
Until 2	0,35	- 3,29	3,87

Figure 4-11. Respondents' answers to the question: "Was there a change for purchases at your home during the pandemic?". A) Percent of respondents by income class and B) adjusted standardized residual analysis. The significant residuals are marked in red cells (p-valor < -1.96) and green cells (p-valor > 1.96).

The main reason to stockpiling food during the pandemic was reduce the frequency of purchases (Figure 4-12). Most of the respondents believe that they already do as much as possible to reduce food waste (Figure 4-13). Besides, the respondents indicated that the main reason for food waste is too long fridge-storage (Figure 4-14).

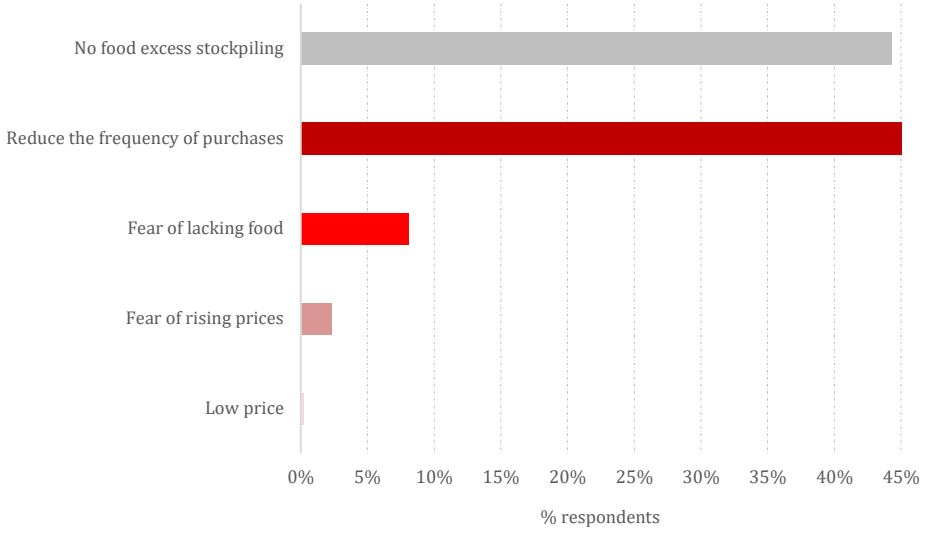


Figure 4-12. Respondents' answers to the question "If you have stockpiled food during the pandemic, what was the main reason for this behavior?"

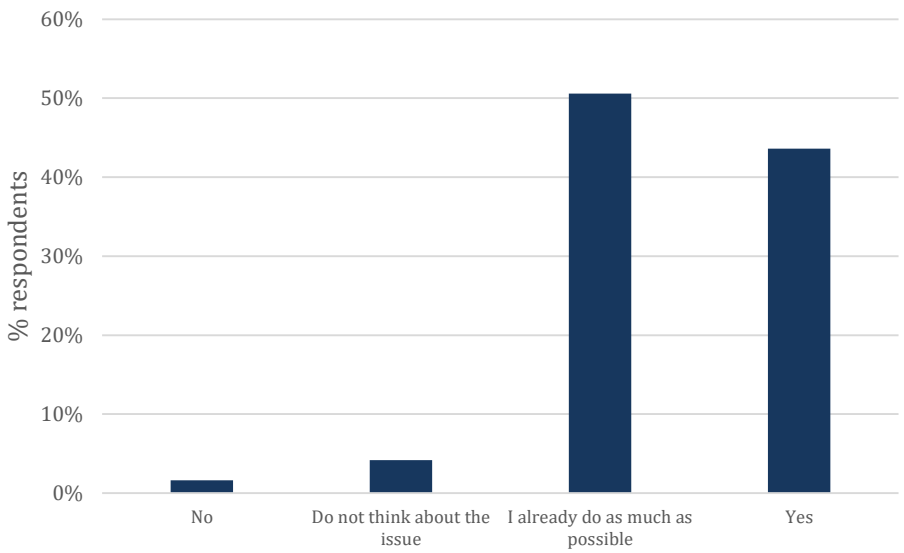


Figure 4-13. Respondents' answers to the question "Do you intend to reduce food waste in your home?"

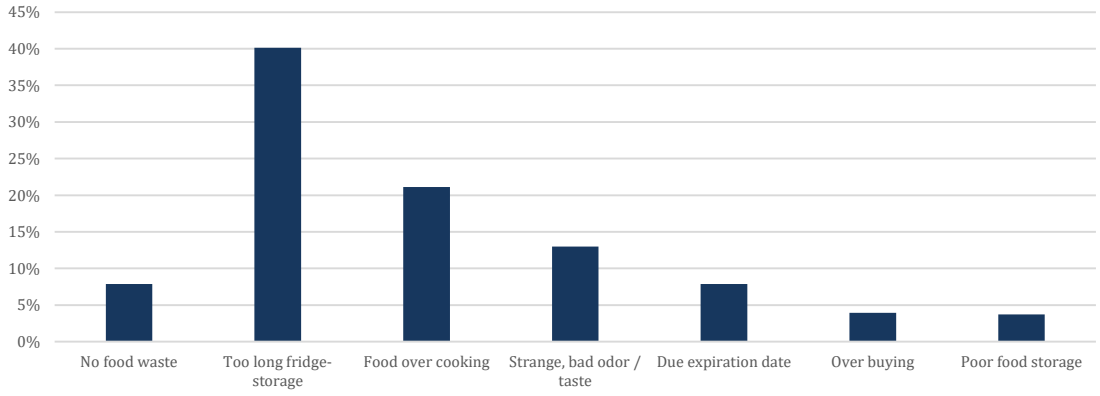


Figure 4-14. Respondents' answers to the question "What is the main reason for food waste in your home?"

4.3. Discussion

4.3.1. Purchasing and consumption behaviors

The results about healthy eating habits show that, in general, women declared a healthier diet than men did (Figure 4-2). We also observed that women declared eating more fruits and vegetables than men do. (Figure 4-3). According to our survey, this difference between men and women diets are bigger in the low-income classes. These gender inequalities were also found in Barros et al. (2016) and in Brasil (2020).

Besides, we identified that the evidences that the poorest had more difficult in buying fruits and vegetables during the pandemic. This situation requires particular attention, since according to ECLAC (2020) the number of people living in poverty in Brazil was expected to rise from about 19.4% in 2019 to 25.4% in 2020, while the forecasted number of living in extreme poverty from about 5.4% in 2019 to 7.9% in 2020. Furthermore, income inequality in all countries of LA will increase (ECLAC-PAHO, 2020). In Brazil, the Gini coefficient, which measure the income concentration, is expected to grow more than 3% during the pandemic, reflecting this tendency (ECLAC, 2020).

Results showed a decreased in the number of respondents that never used digital platforms (Figure 4-5A). Regarding to food delivery apps, the social contact restrictions may have stimulated the capturing of new clients (KUMAR; SHAH, 2021). For example, Belarmino et al. (2021) identified that the searches for delivery apps (DoorDash, Uber Eats, GrubHub, and Postmates) increased in the U.S. during the quarantine and consumers became more sensitive to time-speed service. In Brazil, unhealthy meals (e.g. ultra-processed beverages and pizza) prevailed in food delivery platforms and they usually are cheaper and offer more discounts than the healthier options (e.g. natural juices and sandwiches) (HORTA; MATOS; MENDES, 2021).

Therefore, food delivery apps growth may stimulate unhealthy eating habits if the marketing strategies did not change.

We also observed a decreased in the number of respondents that used street fairs during the pandemic (Figure 4.5C). Our results are in line with the survey conducted in May 2020 by the Embrapa that identified that before the pandemics 21% of Brazilians usually bought greens and fruits in street markets, and after the pandemic, this number changed to 11% (NASCIMENTO; CARVALHO; SIQUEIRA, 2020). Besides, street fares are usually cheaper to buy fresh food than supermarkets, since they favor the direct contact between the producer and the consumer, which can justify the poorest complain about rising in prices (PREISS, 2020). Furthermore, pricing strategies adopted by the supermarkets usually encourage the ultra-processed foods instead of fresh food (MACHADO et al., 2017, 2018). In Brazil, the high consumption ultra-processed foods is associated with high consumption of free sugars, and of total, saturated and trans fats (Louzada et al., 2018).

4.3.2. Physical health

As we can observe in Figure 4-6, during the pandemic, there was a tendency to reduce physical activity. In 2019, about 45% of the habitants of Rio de Janeiro did not practiced sufficient physical activity (BRASIL, 2020c), and our results evidence that this situation may have getting worse during the pandemic. Werneck et al. (2021) argue that the quarantine measures have stimulated the reduction of physical activity and the increase in sedentary behavior, such as increased hours watching TV. Guimarães et al. (2020) highlight that about 14% of Brazilian advertises of free-to-air TV channels were food-related, and more than 90% of them were of ultra-processed food, stimulating poor dietary habits.

At the same period, as we can see in Figures 4.7 and 4.8, most respondents reported weigh gain. The high consumption of sugar and soft drinks are associated with obesity, especially in women (LOBATO; COSTA; SICHIERI, 2009). In 2019, almost 60% of the habitants of Rio de Janeiro were overweight and about 20% were obese (BRASIL, 2020c). The gain of weight and reduction of physical activities may also be warning sign for possible mental disorders, such as depression. Poor diet habits could be an escape route for bad feelings, which can be extremely dangerous (WERNECK et al., 2020). According to Mazzolani et al. (2021), bad psychological symptoms were associated with food choice, possibly including eating in front of the TV, replacing main meals with snacks and snacking,

4.3.3. Food waste

As pointed out by Falasconi et al. (2019), although most food waste is generated in households, the perceived quantity of food waste by consumers tends to underestimated. One of the reasons is that people usually see as food waste only what they consider edible, excluding parts that they normally do not eat and could be eaten, such as plant stems (ASCHEMANN-WITZEL; DE HOOGE; ALMLI, 2021).

The qui-square test identified a significant difference between income classes considering the habit of "usually buy more food than eat" (p-valor < 0.001). The residuals analysis (Figure 4.10B) highlights that most of the poorest classes (receiving until 2 minimum wages and receiving between 2 and 4 minimum wages) declared not buy more food than eat, while the richest (between 10 and 20 minimum wages and above 20 minimum wages) have greater food waste propensity (Figure 4-10A).

The same was observed in survey with Uruguayan (ASCHEMANN-WITZEL; GIMÉNEZ; ARES, 2019). This findings are also in line with Falasconi et al. (2019), which argue that food waste concerning are more associated with the perception of food

waste as a “waste of money” than with social and environmental awareness. For example, people hardly waste expensive items, as fish and meat, and they usually waste fruit, vegetables and bread (AYDIN; YILDIRIM, 2021). According to Aschemann-Witzel et al. (2018), food waste increases with the level of a country’s income, because the relative importance of food budget is lower compared with the income.

The main reason for food waste during the pandemic was too long fridge-storage (indicated by 40% of the respondents, Figure 4-14). This result is in line with Cequea et al. (2021) that argue that Brazilian households leave prepared food sitting in the refrigerator for a long time. Consumers also usually have difficulty in judging the quality of stored food, specially fruits and vegetables. Just because the food that not seems externally so beautiful that not necessary means it is rotten (BARONE; GRAPPI; ROMANI, 2019).

4.3.4. Implications for practice

4.3.4.1. Public policies

Based in our main findings we elaborated a research agenda with recommended public policies to deal with food security and food demand.

I. Policy interventions encouraging healthy eating habits and physical activities, such as sugar taxes in sweetened beverages and junk food. Besides, subsidies to reduce the price of healthier products (e.g. organic) (MOZAFFARIAN et al., 2018) and taxes on high caloric junk foods (ESPINOZA-ORTEGA et al., 2021).

II. Given that childhood is a critical period to establish lifelong eating habits, the government should limit marketing to children of unhealthy food (FLEMING-MILICI; HARRIS, 2018) and school meals should met high quality dietary standards (MICHA et al., 2018).

III. Making the people aware about the importance of healthy diet.

IV. According to Rezende et al. (2019), in Brazil, 26.5% (114,497 cases) of all cancer cases and 33.6% (63,371 deaths) of all cancer deaths could be avoided by changing social habits, including a healthier diet . For example, the excess body weight is strong positive associated with endometrial cancer, esophageal adenocarcinoma and kidney cancer (FANG et al., 2018). Therefore, more campaigns disclosing the association between bad eating habits and increased risks for developing cancer, cardiovascular diseases, and diabetes are needed. We also highlight the positive effects of a balanced dietary in the reinforcement of the immune system (WALLACE et al., 2020).

V. Ensuring that the poorest social stratus get safe, quality food at affordable prices. In our research, 70% of the poorest population complained about rising in fruit and vegetables prices. Although food price is an important constrain of food choice (DARMON; DREWNOWSKI, 2008), Verly-Jr et al. (2019) argue that it is possible to improve low-income Brazilian diet quality without increasing the current diet cost. For example, cooking campaigns on social media and mobile applications could help families to prepare affordable and healthy meals at home (GARVIN et al., 2019). Besides, subsidy policy to improve the access of low-income people to fruits and vegetables can minimize the price restriction (CLARO et al., 2007).

VI. Campaigns teaching people how to storage and get the most of all parts of food are needed. From 52 Kg of fruits purchased per year, a European consumed about 38 kg, 9kg become unavoidable waste (inedible fraction,

e.g. pits) and 5kg become avoidable waste (Laurentiis et al., 2018). According to Aschemann-Witzel et al. (2019), fresh vegetable and fruits are usually prolonged storage.

VII. Raise the awareness of the population about the economic, social and environmental impacts of food waste. In Brazil, household food waste accounts for more than 12 million ton per year (PNUMA, 2021). To deal with this, we recommend a national program to reduce food waste, especially at the household level (ASCHEMANN-WITZEL; GIMÉNEZ; ARES, 2019).

4.3.4.2. Business opportunities

We also highlighted some markets opportunities to promote healthier habits.

I. In relation to business management in food marketplace, we highlight the great opportunity to healthy food apps, since most of the food apps in Brazil are associated with unhealthy food (HORTA; MATOS; MENDES, 2021). Apps combing meal planners, shopping lists and simple recipes can help improving people healthy and decrease food waste (MAUCH et al., 2018).

II. Short food supply chains with direct contact between the farmer and the consumer, could improve the market resilience against pandemics and reduce the costs of food (FARIAS; ARAÚJO, 2020). During the pandemic, many farmers started to use digital marketing to promote and sell their products. The results of these sells confirmed that social media can be a highly promising field to stimulate healthier habits and the access to affordable safe food (CORDEIRO; SANTOS; MARUJO, 2021).

4.3.5. Limitations of the study

First, the results found in this research do not provide a comprehensive overview of the changes in Brazilian eating habits caused by COVID-19 given that the study recevied major proportion of responses from residents fromRio de Janeiro state. Most of the respondents have undergraduate and graduate level and it is important to note that low ingestion of greens, vegetables, and fruits and sedentary lifestyle is expected to be higher in the lower educational levels (BRASIL, 2020c; DE AZEVEDO BARROS et al., 2016). Besides, self-reported answers in food habits and life style could be potentially affected by social desirability bias (VIDAL et al., 2021). Therefore, our results should be interpreted carefully. We strongly recommend that future research also include representative samples of lower educational groups. Studies focusing on poorest areas of Rio de Janeiro would also be promising, since most of our respondents were from the Rio de Janeiro capital.

4.4. Conclusion

This study aimed to identify the changes in perceived eating habits due to the COVID-19 pandemic and explore factors underlying the different perceived eating habits. Results showed that the poorest individuals in Brazil faced more difficult in buying fruits and vegetables due to rising prices and they wasted much less food than the richest, suggesting that food waste is more associated with the perception of food waste as a “waste of money”, than with socio-environmental awareness. These rates are usually cheaper when buying fresh food than in supermarkets, as they favor the direct contact between the producer and the consumer, which can justify the poorest’ complains about rising in prices. Besides, the increased time spending at home stimulated the capturing of new clients for food delivery apps. Unfortunately, the

unhealthy options prevailed in these apps. We also found an increased consumption of candy, cookies and unhealthy snacks, reduction of physical activity and weigh gain during the pandemic. Another major point is that the meat consumption declined sharply, in line with the fall in purchasing power, evidencing the positive income elasticity of meat for Brazilian consumers.

4.5. Appendix: Brazilian National Commission on Ethics in Research approval

UFRJ - INSTITUTO DE NEUROLOGIA DEOLINDO COUTO DA UNIVERSIDADE FEDERAL DO RIO DE JANEIRO / INDC - UFRJ

Plataforma Brasil

Continuação do Parecer: 4.688.279

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1693936.pdf	13/04/2021 13:41:47		Aceito
Recurso Anexado pelo Pesquisador	Respostas_v2.pdf	13/04/2021 13:41:06	MARCELLE CANDIDO CORDEIRO	Aceito
Parecer Anterior	PB_PARECER_CONSUBSTANCIADO_CEP_4644824.pdf	13/04/2021 13:21:51	MARCELLE CANDIDO CORDEIRO	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_v2.pdf	13/04/2021 13:21:22	MARCELLE CANDIDO CORDEIRO	Aceito
Projeto Detalhado / Brochura Investigador	Projeto_alimento.pdf	29/01/2021 20:54:16	MARCELLE CANDIDO CORDEIRO	Aceito
Folha de Rosto	folhaDeRosto_digitalizada.pdf	29/01/2021 10:51:32	MARCELLE CANDIDO CORDEIRO	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

RIO DE JANEIRO, 03 de Maio de 2021

Assinado por:
Cláudia Márcia Nacif Drummond da Fonseca
(Coordenador(a))

Endereço: Av. Venceslau Brás 95
Bairro: Botafogo **CEP:** 22.290-140
UF: RJ **Município:** RIO DE JANEIRO
Telefone: (21)2295-9794 **Fax:** (21)2295-9794 **E-mail:** cep@indc.ufrj.br

4.6. Appendix: Questionnaire

4.6.1. ***Informed Consent Form***

1. Was the TCLE information clear enough for you?

a) Yes

b) No

2. If, in view of these explanations, you think you are sufficiently informed about the research and you agree of your own free to participate just tick "yes". If you do not agree to participate, please tick "no". In this case, the questionnaire will be closed and your information will not be computed.

a. Yes

b. No

4.6.2. ***Food: Consumer behavior towards COVID-19***

3. Would you like to receive the results of this survey by email?

a. Yes

b. No

4. Do you live in Rio de Janeiro state?

a. Yes

b. No

4.6.3. ***Profile of respondents***

5. What is your gender?

a. Female

b. Male

c. Other

6. What is your age bracket?

a. Under 18

b. 18-25 years

c. 26-40 years

d. 41-60 years

e. Over 60 years

7. In which city do you live?

a. Angra dos Reis

b. Barra Mansa

c. Belford Roxo

d. Cabo Frio

e. Campos dos Goytacazes

f. Duque de Caxias

g. Itaboraí

h. Macaé

i. Magé

j. Mesquita

k. Niterói

l. Nova Friburgo

m. Nova Iguaçu

n. Petrópolis

o. Rio de Janeiro

p. São Gonçalo

q. São João de Meriti

r. Teresópolis

s. Volta Redonda

t. Other

8. How many people live in your household (including yourself)?

a. 1

b. 2

c. 3

d. 4

e. 5 or more

9. What is your education level?

a. Incomplete primary school

b. Primary school

c. Incomplete high school

d. High school

e. Incomplete university education

f. University degree

10. What is your occupation?

a. Agricultural producer
b. Manager
c. Salaried worker
d. Informal worker
e. Student
f. Retired
g. At the moment, I do not perform a paid job

11. What is your family's income bracket (including the income of all household members)?

a. Above 20 minimum wages (BRL 20,900.01 or more, U$ 3,854.60 or more)
b. From 10 to 20 minimum wages (BRL 10,450.01 - BRL 20,900.00; U$ 1,927.30 – U$ 3,854.60)
c. From 4 to 10 minimum wages (BRL 4,180.01 - BRL 10,450.00; U$ 770.92 - U$ 1,927.30)
d. From 2 to 4 minimum wages (BRL 2,090.01 - BRL 4,180.00; U$ 385,46 – U$ 770.92)
e. Up to 2 minimum wages (BRL 2,090.00; U$ 385.46)

4.6.4. ***Healthy food and habits***

12. Do you believe you have a balanced diet (healthy and balanced should contain several nutrients: Carbohydrates, Proteins, and Fats)?

	1	2	3	4	5	
I totally disagree. My diet is not balanced at all						I totally agree

13. Do you eat fruits and vegetables daily?

	1	2	3	4	5	
I totally disagree						I totally agree

14. Were you afraid of consuming fruits and vegetables during the pandemic?

a. Yes

b. No

15. Did you have difficulty buying fresh fruits and vegetables during the pandemic?

a. Yes, there was a decrease in supply

b. Yes, there was an increase in prices

c. Yes, there was an increase in prices and a decrease in supply

d. No

16. Did you have to change the place you used to buy fruits and vegetables during the pandemic?

a. Yes

b. No

17. Where did you use to buy your fruits and vegetables before the pandemic?

	Often	*Rarely*	*Never*
Digital platforms (ex.: ifood)/Orders via social media (ex: whatsapp)			
Ceasas			
Supermarket/Hypermarket			
Street fairs			
Hortifrutis			
Small producers			

18. How often did you buy fruits and vegetables in the following ways during the pandemic?

	Often	*Rarely*	*Never*
Digital platforms (ex.: ifood)/Orders via social media (ex: whatsapp)			
Ceasas			
Supermarket/Hypermarket			
Street fairs			
Hortifrutis			
Small producers			

19. How was the consumption of the following food groups during the pandemic?

	Decreased	Did not change	Increased
Fruits/Vegetables			
Meat			
Candy, cookies and cakes			
Unhealthy snacks			
Packaged frozen foods			
Pasta and bread			
Canned food			

20. During the pandemic, there was a change in the following eating habits?

	Decreased	Did not change	Increased
Cooking and preparing food			
Eating between meals			
Eating instant foods			
Ordering take-away or fast food meals with deliveries			
Eating at someone else's place			
Eating out			

21. How was the exercise practice during social isolation?

a. Decreased
b. Did not change
c. Increased

22. Did your weight change during the pandemic?

a. I lost less than 5kg
b. I lost between 5 and 10kg
c. I lost more than 10kg
d. My weight did not change
e. I gained less than 5Kg
f. I gained between 5 and 10kg
g. I gained more than 10kg

4.6.5. ***Food waste***

23. Do you worry about food waste when planning food purchase and consumption?

a. Yes
b. No
c. I have no opinion

24. Do you usually buy more food than eat?

a. Yes
b. Sometimes
c. No

25. Do you usually make a shopping list?

a. Yes
b. Sometimes
c. No

26. Did food waste increase in your home during the pandemic?

a. Yes
b. There was no change
c. No

27. Was there a change for purchases at your home during the pandemic?

a. Yes. Bulk purchases.
b. Yes. Smaller purchases.
c. There was no change

28. If you have stockpiled food during the pandemic, what was the main reason for this behavior?

a. Reduce the frequency of purchases
b. Fear of rising prices
c. Fear of lacking food
d. No food excess stockpiling
e. Others

29. Do you intend to reduce food waste in your home?

a. Yes
b. I already do as much as possible
c. Do not think about the issue
d. No

30. What is the main reason for food waste in your home?

a. Too long fridge-storage
b. Food over cooking
c. Strange, bad odor / taste
d. Due expiration date
e. No food waste
f. Over buying
g. Poor food storage
h. Too large food packages
i. Others

CHAPTER 5: CONCLUDING REMARKS

As previously pointed, the first objective achieved by this thesis was "*To investigate the state of art of promising research lines considering the effects of pandemics in SCs?*". This preliminary analysis could be justified by the scarcity of scientific literature about the theme. Up to 2020, we could identify only two literature reviews on scientific journals about the impacts of epidemic outbreaks on SCs.

To address the first objective, an investigation was made to understand the maturity of academic discussions related to the pandemic and supply chains (chapter 2 of the PhD thesis). This first study highlighted the literature gap in SCs effects of pandemic outbreaks and the main methodological approaches. It also proposes a research agenda for COVID-19 confronting, bridging the gap between theory and practice. This study can be used by academics to quickly identify research lines. Managers can also use this research to identify the fragilities of SCs in the context of pandemics, which can reduce the response time in similar situations (CORDEIRO et al., 2021). This analysis also helped in the delineation of the thesis main objective *"To investigate how the food supply chain was affected by COVID-19"*. In this context, the following studies investigate food supply chain from the producer (supply) and the consumer (demand) points of view.

The scientific literature involving supply chain resilience in food chain is still limited, which can justify the relevance of the second study that aimed "*To investigate small farming weakness and resilience strategies (e.g., local suppliers) both in normal and pandemic/epidemics situation*". Besides, it is not possible to achieve food security

for consumers, if the links in food chain are unable to respond efficiently to adverse conditions.

Therefore, the second study (chapter 3) investigated evidences of how small farming responded to COVID-19. The main findings pointed that the use of social media and digital platforms has boosted sales in the field. In addition to allowing the end consumer to trace the origin and history of the food consumed, the tendency is that this close contact between producers and consumers remain in the post-pandemic, favoring local food production. This study can be considered by government authorities to plan public policies to small producers; can also be used to small producers to identify efficient strategies of resilience. Finally, academics can consider this research to study small farms vulnerabilities and resilience strategies (CORDEIRO; SANTOS; MARUJO, 2021).

Finally, the third study (chapter 4) focuses on consumers food demand and can be used to identify eating patterns induced by stressful situations. This information can be explored in public polices to avoid medical expenses associated with lifestyle risk factors. Supply chains managers can also adopt this study to identify consumers' food preferences. Besides, researchers can also use this study as baseline in advanced researches in food eating habits.

Figure 5.1 summarizes the connections between the three studies in the supply chain perspective, considering the main objective "*To investigate how the food supply chain was affected by COVID-19*". The first study investigated the effects of pandemics in supply chains and achieved the first specific objective "*To investigate the state of art of promising research lines considering the effects of pandemics in SCs*". It results pointed food supply chain as a matter of concern for food security during COVID-19 outbreaks and can be used to justify the second (effects of COVID-19 in food

producers) and third (effects of COVID-19 in eating demand) studies. Besides, the second study is related to the specific objective "*To investigate small farming weakness and resilience strategies (e.g. local suppliers) both in normal and pandemic/epidemics situation*" and the third study to the specific objective *"To investigate household eating demands in normal and pandemic/epidemics situations"*.

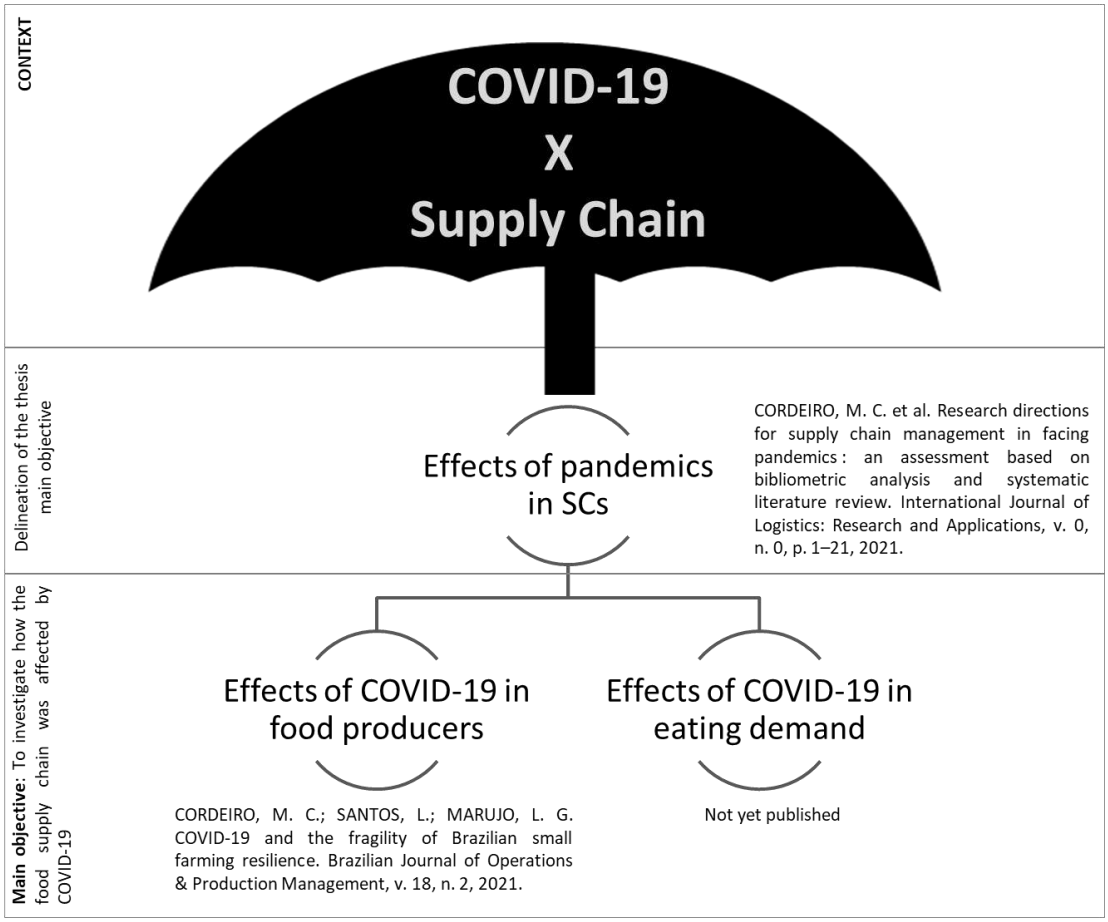


Figure 5-1. PhD thesis studies' connections

Regarding the PhD thesis limitations, the first study is limited by the temporal coverage, since it was performed in beginning of the quarantine and many studies related with supply chain were published after it. Besides, we consider the databases Scopus ans WoS, including other databases and admitting non-article scientific documents (eg., reviews and book chapters) the analysis sample could be greater. Therefore, we recommend new studies updating the scientific sources of the first study.

The second study considers two small farms and a food cooperative in Rio de Janeiro. Including other farms sizes and other supply chain networks (e.g. supermarkets and restaurants), would provide a broader view of food supply chain during COVID-19. Finally, the third study was performed with a convenience sample, but a random sample would provide a greater statistical inference. Besides, the survey received response predominantly from people living on Rio de Janeiro; to more robust analysis, we recommend new studies with a national coverage.

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