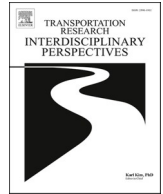


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COVID-19 lockdown as an opportunity to rethink urban freight distribution: Lessons from the Barcelona metropolitan area

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ABSTRACT

The COVID-19 health crisis has had a strong impact on societies around the world, affecting both the health of populations and countries' economies. While lockdowns imposed to stop the spread of infection reduced urban mobility and had a positive impact on air quality, lowering the emission of polluting particles and greenhouse gases, they had the opposite effect on urban freight distribution (UFD). With the population remaining at home, ecommerce-driven shipments surged, and total freight traffic increased. In order to have a better understanding of this phenomenon, the aim of this study was to identify the impact of COVID-19 lockdowns on the daily operation of the region's main logistics agents. Lessons learned from this cyclical scenario could be used to define more sustainable public policies regarding UFD in the post-COVID era. To meet the above objectives, semi-structured interviews were conducted with public administrations and private operators, before being transcribed and encoded for later analysis. The results of our study show that common problems in UFD, such as traffic congestion or problems finding parking in the loading and unloading (L/U) zones, temporarily disappeared during the lockdown phase. Delivery times were consequently reduced, despite an increase in operations due to ecommerce. In addition, the public administrations took advantage of this situation to adapt the urban space and force a transition towards new delivery systems, such as cargo-bikes, to guarantee sustainable last-mile operations in specific zones.

Introduction

The COVID-19 health crisis has represented a challenge for the global supply chain of producers and distributors. In economic terms, it has led to a supply shock which, coupled with a demand crisis (Donnan et al., 2020), may have unpredictable long-term consequences. Distribution channels have quickly become digitalised and increased their presence on the Internet with the sudden change in consumption habits, such as online grocery shopping (Shen et al., 2022). As a result, ecommerce has undergone strong growth, boosted by competitiveness among retailers seeking to position themselves in this market (Heuser & Ashraf, 2019).

In urban terms, COVID-19 has also had significant consequences. Cities and their metropolitan areas have become the epicentre of the pandemic, with 90% of reported cases (UN–United Nation, 2020). Lockdown policies led to an unprecedented decline in urban mobility, affecting all modes of transport (Hiselius and Arnfalk, 2021), and in many countries traffic has been greatly reduced. In the case of Barcelona, this figure is approximately 35% of normal rates (Baldasano, 2020).

Although freight operators were allowed to continue operating during lockdown, they faced a different challenge. The unprecedented increase in ecommerce orders led to a larger number of commercial vehicles circulating in cities, but as a result of the reduced traffic, the number of parcels delivered on each route increased.

With the reopening of cities and a gradual “return to normality”, demand for private car travel is expected to rise, as it is considered a safer form of transport (Anke et al., 2021). This, in turn, will lead to increased traffic flow, which will impact consumers' expectations with regard to receiving their deliveries as soon as possible. In light of this, some cities have begun to implement tough measures on public space and the use of sustainable transport (Joeress et al., 2016). Policymakers are now aware of a potential threat to their sustainable mobility initiatives aimed at minimising externalities (Lai et al., 2020) and boosting infrastructure targeting the movement of private cars (Angiello, 2020). Although such measures are designed to meet the urban resilience and CO2 reduction targets agreed within the EU framework (Clerici Maestosi et al., 2021), some will have a direct impact on UFD processes, a subject little explored by academia during this pandemic period.

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Table 1
Summary of restrictions during the COVID-19 lockdowns in Barcelona.

	1st state of alarm	2nd state of alarm	3rd state of alarm
Periods of restrictions	15/03/20 – 21/06/20	09/10/2020 – 24/10/2020	25/10/2020 – 09/05/21
Measures	<ul style="list-style-type: none"> - Total restriction on citizen movement (only for emergencies or work). - Closure of non-essential shops, hotels, restaurants, and cultural, artistic, sporting and similar venues. - Prioritisation of telecommuting and the suspension of school and university activities. 	<ul style="list-style-type: none"> - Citizens were only allowed to circulate in their municipalities. - Overnight lockdown for citizens from 10 pm to 6am. - Regulation of the opening of hotels, restaurants and cultural, artistic, sporting and similar venues. - Prioritisation of telecommuting and suspension of university activities. 	<ul style="list-style-type: none"> - Citizens were only allowed to circulate in their municipalities. - Overnight lockdown for citizens from 10 pm to 6am. - Regulation of the opening of hotels, restaurants, and cultural, artistic, sporting and similar venues. - Prioritisation of telecommuting and suspension of university activities.
Unrestricted	<ul style="list-style-type: none"> - Free circulation for the supply of food and products necessary for public health. 	<ul style="list-style-type: none"> - Free circulation for the supply of food and products necessary for public health. 	<ul style="list-style-type: none"> - Free circulation for the supply of food and products necessary for public health.

As for research that has addressed the topic, studying the case of Madrid, [Villa & Monzón \(2021\)](#) highlight the need to improve current UFD models, including public–private partnerships for retailers and logistics operators, environmentally-friendly vehicles, and raising e-commerce customer awareness. Other authors emphasise the need to make use of innovative technologies to improve the performance of logistics operations, of which IoT, Big Data, mobile parcel lockers ([Schwerdfeger & Boysen, 2020](#)), mobile warehouses ([Srivatsa Srinivas and Marathe, 2021](#)) and electric vehicles ([Settey et al., 2021](#)) are just a few examples. Furthermore, [Zhang & Zhang \(2021\)](#) note that population distribution and urban structure may also be influenced by the arrival of the post-COVID new normal, and that this will warrant further attention in urban planning. To this end, it will be necessary to explore spatial optimisation strategies and supporting measures for an environmentally resilient, economically prosperous, and sustainable city when moving towards the decarbonisation of the transport sector in the post-COVID world.

The aim of this article is to identify what impacts the COVID-19 crisis has had on the operations of the main logistics agents in the metropolitan area of Barcelona and measures that should be implemented to promote a more sustainable and efficient post-pandemic UFD. The article is divided into six sections: Section one is the Introduction; Section two details the methodology used to carry out the research; Section three then presents the results; Section four the discussion of these results; and Section five recommendations for policymakers. The article ends with the main conclusions in Section six.

Study context

Our research focuses on UFD in the city of Barcelona during the COVID-19 lockdown period. [Table 1](#) summarises which restrictive measures were taken by the public authorities and which activities were granted exceptions from the general rule.

Material and methods

Approach and research design

Qualitative and quantitative approaches can equally provide meaningful insights into the effectiveness of policies on UFD ([Holguin-Veras et al., 2017](#)), and in the specific case of Barcelona, studies can be found using both the former (e.g., [Larrañeta et al., 2001](#); [Ramon, 2001](#); [Navarro et al., 2016](#)) and the latter (e.g., [Domínguez et al., 2012](#); [Nuzzolo et al. 2016](#) [Fernández-Barceló & Campos-Cacheda, 2012](#)). However, these few studies did not analyse the current perceptions of the different logistics agents involved in UFD in any depth. Therefore, and given the exceptional nature of the COVID-19 pandemic, we opted to carry out qualitative research based on individual interviews as our primary method of data collection, this allowing us to explore a little-known field in greater depth and formulate specific propositions in relation to the

object of study ([Silverman, 2016](#)). Thus, the novelty of our study derives from both the specific context and the methods employed.

Sample size

A total of 16 logistics agents were selected for interview following a quota strategy ([Moser, 1952](#)) that consisted of defining the minimum requirements participants must meet to be included in the study. The criteria were as follows: (1) logistics agents such as public administrations, operators, transporters, shipping companies, retailers and associations operating in Barcelona and related to UFD; and for private agents: (2) the representative chosen by the company to conduct the interview must have a good knowledge of its operations, its relationship with UFD and the consequences suffered by the company due to the COVID-19 crisis; and (3) that the selected companies were representative of different sectors, including groceries, HORECA¹, textiles and construction. [Table 2](#) shows the most relevant information regarding the different agents:

The resulting sample size met the criteria established by [Marshall et al. \(2013\)](#), who posited that for qualitative research based on a case, a valid sample size should be between 15 and 30 interviews. Although a total of 16 logistics agents were interviewed, some of them were associations that represented a larger number of companies, so our sample could be considered to be even more representative. Furthermore, the agents interviewed were heterogeneous, since stakeholders can be from very different sectors in UFD. A further aspect that validates our final study sample is the level of saturation obtained during data collection and analysis ([Saunders et al., 2018](#)). This refers to the point at which new interviews do not provide new information. In our case, saturation was reached with Interview 12, when all of the codes used for our research had already been created. Thus, no new codes were added from Interviews 12 to 16, a phenomenon found in similar situations in the literature (e.g., [Sandelowski, 2008](#); [Saumure & Given, 2008](#)). We consider that saturation was probably reached because the most representative agents were selected for the interviews, and the information that best explains UDF activity during the COVID-19 pandemic was therefore obtained immediately.

Method of data collection

It was decided to conduct semi-structured interviews because, despite following a script, it allowed us to ask improvised questions based on the interviewee or change the order of the questions asked ([Rubin & Rubin, 2011](#)). The use of a script was justified by the fact that, although semi-structured interviews do entail some flexibility, not having one could lead to total improvisation and each of the responses being totally different, making it difficult to draw conclusions on the

¹ Acronym for HOTels, REstaurants and CAFés.

Table 2
List of logistics agents interviewed.

Logistics agent	Description	Interviewee
<i>Food sector</i>		
Mercadona	Largest grocery chain in Spain, with 24.5% market share and a turnover of almost €26.7B in 2020.	Joint interview with Logistics Manager and External Relations Manager.
Condis	Grocery chain with a significant presence in the region. Its market share in 2020 was 8% and its turnover €890 M.	Joint interview with Logistics Manager and his team of four people.
<i>Construction, civil engineering and fitters</i>		
Lymet Group	Corporate group representing four companies: Lymet, SA, Lymet Obra Civil SL, UTE MTBT Barcelona and MV Instalaciones. Its turnover in 2020 was €30 M.	Construction Manager
<i>Transport sector</i>		
Catalan Transport Federation of Barcelona (TRANSCALIT)	Organisation comprising nine transport associations, representing a total of 500 companies.	Secretary-General
<i>HORECA sector</i>		
Association of Beverage and Food Distribution and Logistics Companies of Catalonia (ADISCAT)	Organisation comprising eight HORECA associations, representing a total of 115 companies.	Executive Director
<i>Textile sector</i>		
A large fashion company that opted to remain anonymous	–	Logistics Manager
<i>Start-ups specialising in last-mile logistics</i>		
Vanapedal	Company that operates from a micro-platform using cargo-bikes to deliver in the last-mile segment.	CEO and Co-founder
CargoBici	Sole distributors and official technical service for XYZ cargo-bikes in Spain and Portugal.	Technical Consultant
Ecopol	Sustainable transport company with a large presence in Barcelona.	Marketing & Commercial Director
<i>Public companies</i>		
Power stations and Infrastructures for Mobility and Logistic activities (CIMALSA)	Public company owned by the Government of Catalonia, in charge of promoting, developing and managing transport and logistics infrastructures and power stations. Its turnover in 2019 was €7M.	Planning and Intermodality Director
<i>Public administrations</i>		
Government of Catalonia (Generalitat de Catalunya)	Regional government of Catalonia, with exclusive powers over several transport and logistics-related spheres and an enforcement role in others.	Policy Officer for Transport Planning and Logistics
Metropolitan Transport Authority of Barcelona (ATM)	Public consortium in charge of coordinating and planning public transport in the metropolitan area of Barcelona.	Policy Officer for the Transport Management Service
Metropolitan Area of Barcelona (AMB)	Public body that operates as a supramunicipal administration for the metropolitan area of Barcelona, including 37 municipalities. Provincial government institution that promotes	Policy Officer for Sustainable Mobility Services

Table 2 (continued)

Logistics agent	Description	Interviewee
Barcelona Provincial Council (Diputació de Barcelona)	the progress and well-being of citizens in 311 municipalities, providing services predominantly in cooperation with town councils.	Policy Officer for the Mobility and Road Safety Office
Granollers City Council	Local government and administrative body for the municipality of Granollers, which has a population of 62,419 inhabitants (Idescat, 2020) and covers an area of 14.87 km ² .	Urban Mobility Manager
Vic City Council	Local government and administrative body for the municipality of Vic, which has a population of 47,630 inhabitants (Idescat, 2020) and covers an area of 30.58 km ² .	Urban Mobility Manager

Table 3
Codes used to transcribe the interviews in Atlas.ti.

1. No problems with traffic	9. Public space	17. Permissiveness of the authorities
2. Conflict with other sectors	10. HORECA	18. No L/U problems
3. Consequences of COVID	11. Increase in number of users	19. No time problems
4. More dialogue required with the authorities	12. Sales increase	20. Sustainability
5. Economic difficulties	13. Last-mile	21. ICT use
6. UFD difficulties	14. Improved UFD operations	22. Future vision for UFD
7. Cargo-bikes	15. Non-essential services	23. Pedestrian zones
8. Ecommerce	16. New UFD regulation	

research topic (Rubin & Rubin, 2011). The interview script comprised a total of six thematic blocks, which were devised after consulting the relevant literature. The first block addressed the characteristics of the company, aiming to identify its core activity, number of workers, years in operation, etc., among other relevant information that would help us understand its operational context. The second block included a total of six questions on the company’s experience during the pandemic in relation to traffic congestion in the city. As for the third block, it had a total of eight questions addressing the loading and unloading (L/U) process in the city in the context of the pandemic. The fourth block, with five questions, asked about existing restrictions on UFD in the city and how the company coped with the pandemic, including limitations such as hourly windows for L/U and weight restrictions, among others. In the fifth block, there were seven questions on the companies’ use of technology during its distribution operations in the context of the pandemic. And finally, the seven questions in the sixth block asked about the companies’ future vision for the sector, which might have changed after experiencing the exceptional situation of the pandemic. The interviews were conducted via Zoom between October and December 2020 in order to comply with the COVID-19 restrictions imposed by the authorities. All interviews were recorded, and no time limit was set so as to allow all interviewees the time to give the explanations they deemed appropriate.

Data management

A total of 558 min of recordings were obtained from the 16 interviews, with an average of 35 min per interviewee, during which only issues related to the COVID-19 crisis and its implications for UFD were addressed. All interviews were subsequently transcribed and encoded following the recommendations forwarded by Saldaña (2021), which can be summarised in the following five blocks: (1) data layout, (2) pre-

Table 4

Two examples of co-occurrence: codes in the same citation and codes next to each other.

Example of coding	Example of analysed text	Code assignment
Codes in the same citation	“(…) Interviewee 1: Well, certainly, the companies considered as non-essential services during the lockdown stage, well, during lockdown they had difficulties with the urban distribution of goods. This made the whole operation very difficult for us, it was very (…)”	Non-essential services UFD difficulties
Codes next to each other	“(…) for a long time. It was very easy to move around the streets, with no traffic problems because everyone was at home, of course. Because in addition, this situation of low traffic also decongested the loading and unloading zones and this avoided space problems and conflicts with other sectors,… other distributors like… I don’t know… we only need 20 min to unload but other sectors need up to 90 min. During the lockdowns we didn’t have so many problems and didn’t argue with other sectors. (…)”	No problems with traffic Conflict with other sectors No L/U problems

coding, (3) preliminary jottings, (4) questions to consider while coding, and (5) coding contrasting. Table 3 shows the resulting 23 codes used in the analysis (for further information, see Table A.1 in Appendix A).

Codes were defined by using words or short phrases that better described each of the analysed fragments from the collected interviews. We relied on related literature at all times to define the terminology and to unify the language used. As an example of the encoding process, a fragment is provided below, which was encoded as “No L / U problems”:

“(…) during lockdowns the usual problems that occur in the loading and unloading zones, such as lack of space, disappeared (…)”

The code fully describes the information presented by the interviewee. This process provided us with an overview of the concepts mentioned and allowed us to carry out a quantitative analysis of the number of times a code was repeated or the co-occurrence value between codes, for example, thus ensuring objectivity in our analysis. The encodings were analysed using Atlas.ti software, which calculated the co-occurrence value. To do this, Atlas.ti searches for codes that appear in the same citation or close to one another (Friese, 2015). This proximity specifically refers to the spatial relationship between citations in the transcription, which may be embedded in one another, one following the other, etc. Two examples of co-occurrence are shown below, the first with both codes applying to the same citation and the second with proximity between codes (see Table 4).

Thus, Atlas.ti uses different Boolean proximity operators to determine the co-occurrence between codes, following the structure shown in Fig. 1. In this figure, A and B refer to two different codes, while the different Q_i are text extracts linked to those specific codes.

Method of data analysis

This co-occurrence value was measured by the C-coefficient (Equation (1)), which varies between 0 and 1 and determines the correlation between two codes (Friese, 2019). Thus, the closer the C-coefficient is to one, the stronger the correlation between the two codes (Garcia, 2005). Equation (1) shows how Atlas.ti calculates the C-coefficient between two codes, A and B, by taking into account the frequency of occurrence of each of the codes separately in the whole text, (n_A) and (n_B), as well as the frequency of co-occurrence for the combined code pairing (n_{AB}) (Garcia, 2005). Therefore, co-occurrence refers to both those codes that coincide in the same sentence and those close to the same sentence. The closer the two codes are, the higher their co-occurrence will be. It is important to note that calculation of the C-coefficient between two codes is an automatic process performed by the Atlas.ti software. In other words, the researchers encode the interviews according to their content, but it is the software that calculates the C-coefficients. Subsequently, taking into account the specific context of the interviews, the researchers interpret the results of the given C-coefficients between codes.

$$C = \frac{n_{AB}}{(n_A + n_B) - n_{AB}} \tag{1}$$

In our research, with the aim of determining the relationship between UFD and the COVID-19 crisis, the analysis focused on correlations between “Consequences of COVID” and the other codes. To determine the degree of correlation between this code and the rest, the following criteria were established so that the results could be evaluated via the C-coefficient: (1) a correlation of below 0.09 was considered weak; (2) between 0.10 and 0.19 moderate; (3) between 0.20 and 0.49 strong; and (4) between 0.50 and 1 very strong. Following the analysis and a discussion of the results, a series of propositions were developed based on those correlations considered to be strong and very strong.

Results

As a result of encoding and analysing co-occurrences between codes, an array of C-coefficients was obtained between the code “Consequences of COVID” and the rest. Thus, based on the criteria established in our methodology for cataloguing the type of correlation between codes, we obtained the following results:

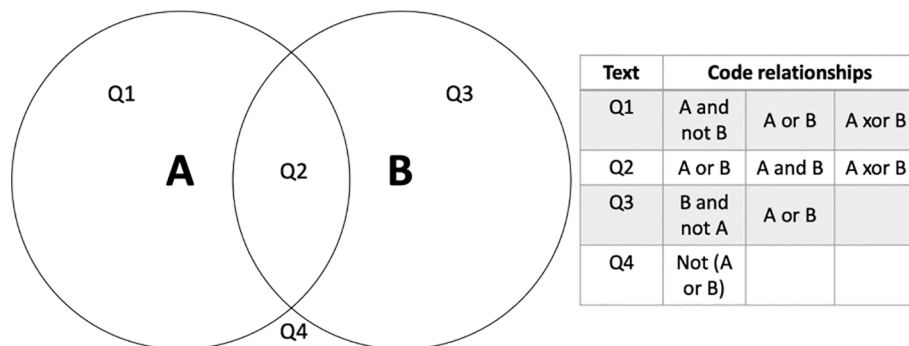


Fig. 1. Boolean queries depicted as Venn diagrams for co-occurrence between two codes, A and B. Source: Authors’ own work, based on Friese 2015.

- **Weak (<0.09):** UFD difficulties (0.01); conflict with other sectors (0.02); increase in number of users (0.04); non-essential services (0.04); ICT use (0.04); and permissiveness of authorities (0.09).
- **Moderate (0.10–0.19):** Improved UFD operations (0.10); new UFD regulation (0.10); sustainability (0.17); and future vision for UFD (0.17).
- **Strong (0.20–0.49):** HORECA (0.25); economic difficulties (0.33); last-mile (0.33); no time problems (0.38); ecommerce (0.40); and pedestrian zones (0.40).
- **Very strong (0.50–1):** Cargo-bikes (0.50); sales increase (0.54); more dialogue required with the authorities (0.50); no L/U problems (0.50); public space (0.63); and no problems with traffic (0.71).

A weak correlation with “Consequences of COVID” indicated that codes were not significant to the logistics agents in this specific period. Codes that displayed a moderate correlation indicated some significance but were not described by the majority of interviewees. However, codes displaying strong and very strong correlations were deemed to truly represent the perceptions of the UFD sector.

Discussion: Lockdown implications and recommendations for policymakers.

Through the analysis of our results, we have reached five propositions that define UFD challenges affecting logistics agents operating in the metropolitan area of Barcelona – challenges that, despite the dramatic nature of the pandemic, allowed us to glimpse certain opportunities. Below, we present five themes with the arguments that led us to each proposition, as well as recommendations for policymakers deriving from them².

Policies for managing the return to a new normality with less road traffic.

During this pandemic, the population stayed at home for months, only able to leave for work in essential sectors or to undertake essential activities. In cities, this lockdown had a positive impact on the environment, with a reduction in urban mobility and airborne particulate pollutants (Qureshi et al., 2020). The reduction in air pollution has been so great that it has confirmed the huge impact of road traffic on the urban environment (Arora et al., 2020). If we focus on data from the city of Barcelona, road traffic decreased by up to 75% compared to pre-lockdown data (Barcelona, 2020a). To quantify this information, the reduction in the main air pollutants during the lockdown period registered levels last reached decades ago; for example, NO₂ (34.35 µg/m³ pre-COVID / 15.7 µg/m³ during lockdown: –43%) and PM₁₀ (26 µg/m³ pre-COVID / 15.9 µg/m³ during lockdown: –21%) (Barcelona, 2020b).

All of the logistics agents interviewed agreed that there was an improvement in road traffic during this period ($C = 0.71$) and acknowledged a large reduction in the time involved in making deliveries (0.38). This operational improvement was aided by the availability of space in the L/U zones (0.50), which is uncommon under normal conditions due to their scarcity and the high incidence of uncivil behaviour reflected by non-commercial vehicles being parked in them (Cherrett et al., 2012; Quak, 2008). Thus, no problems were detected for UFD in the interviews with regard to traffic or the management of L/U zones (0.01), nor conflict with other sectors (0.02), which usually occurs when there are disputes over the few available spaces. Interviewees also noted that they did not observe an increase in the use of these spaces (0.04) and that, for the duration of the pandemic, the use of technologies associated with controlling parking for L/U decreased (0.04), the

authorities being more permissive in their enforcement (0.09).

Proposition 1. The COVID-19 crisis forced the population to be locked down, and delivery companies’ day-to-day operations temporarily benefitted from this.

The reduction in air pollution has been so notable that it must force public administrations to rethink the current model of urban mobility. The most appropriate measures would include encouraging remote working several days a week, promoting sustainable transport modes and discouraging the use of private cars. Specific actions such as Low Emission Zones (LEZ), banning the most polluting cars from the city, urban tolls, increasing the cost of accessing the city and encouraging new forms of shared mobility that can lead to lower rates of car ownership and higher vehicle occupancies may also contribute to achieving this goal. In addition, all of the administration representatives and most logistics companies interviewed agreed that the current UFD model must be transformed to foster the transition to a more sustainable scenario. Thus, regulations to restrict transport and mobility will pose one of the main challenges for the future of cities. An additional challenge to achieve this reduction in road traffic will be the management of ecommerce deliveries, since the urban sustainability measures implemented in recent years could be jeopardised if current growth rates persist.

Policies for differentiating UFD operations according to the specific nature of each business sector.

The coronavirus crisis has had greater economic repercussions than the 2008 financial crisis (Borio, 2020). In cities, the most affected sectors have been those related to leisure and hospitality, including HORECA (0.25). This was confirmed by both our interviewees and the existing literature (Dube et al., 2020). The companies interviewed stated that during lockdown their demand shrank and their logistics operations were drastically reduced, economically affecting their business models (0.33). The same is not true of essential sectors, such as groceries, or those that rely more on the use of ecommerce in their distribution channels (fashion, for instance), which saw sales increase during this period (0.54). Companies operating in these sectors saw stress on their distribution chains at the beginning of the pandemic, with uncontrolled purchase peaks by consumers rising above and beyond the available forecasts. These changes in consumption habits were largely caused by the uncertainty of the situation, which led consumers to increase their spending and store essential supplies in their homes (Aday & Aday, 2020). Whatever the case, there was a notable increase in UFD activity relating to those sectors that were able to continue with their daily operations.

Proposition 2. In those sectors where activity did not cease, operations and UFD increased as a result of the uncertainty generated by the COVID-19 crisis. In contrast, activity was significantly reduced in those sectors most closely linked to leisure and hospitality.

UFD operations depend on the sector to which each company belongs, and public administrations should therefore take into account all the particularities and points of view of each sector when regulating UFD. Some of the comments made by private operators agreed with the challenges facing UFD found in the literature (e.g., Alho et al., 2018; Muñuzuri et al., 2017; Quak, 2008) – challenges that require not only cooperation between all stakeholders, but also an in-depth knowledge of the specifics of each sector. Some of these challenges lie in the physical configuration of L/U zones (Alho et al., 2018) or their time-windows (Quak, 2008). Sectors with increased activity, such as ecommerce, need small spaces with parking times of no more than 20 min, whereas the HORECA sector sometimes requires operating times of over an hour. Additional measures could also include night-time freight logistics or granting special access to high tonnage vehicles at certain periods and under certain conditions.

² Throughout the discussion, we use parentheses to identify the C-coefficients obtained for co-occurrence between codes via Atlas.ti, which serve to support our assertions.

Policies for adapting public spaces to future needs

Local authorities took advantage of the reduced mobility levels during lockdown to implement several measures regarding public spaces. Pavements were widened, new bike lanes were enabled and superblocks were implemented using tactical urbanism. Some interviewees argued that although these actions provided more public space for non-motorised modes of transport (0.63), the needs of the logistics sector were not properly attended to (0.40). These were not the only measures to be implemented, however. HORECA street terraces, for instance, were authorised to spread into parking lanes, reducing the number of spaces available. This meant fewer lanes for the movement or parking of vehicles, and altered some logistics operators' delivery routes, making it difficult for them to manage daily operations in the short term.

Proposition 3. Cities took advantage of the lockdown phase to allocate more public space to non-motorised modes of transport, altering the operations of some logistics agents.

The main public space measures implemented in Barcelona have been: (1) superblocks and green axes, calming traffic on streets where pedestrians and sustainable mobility modes have priority, vegetation is widespread and citizen interaction with local businesses is favoured; (2) more bicycle and pedestrian lanes, meaning fewer lanes for road traffic; and (3) the re-assignment of public space, previously dedicated to street parking, to bar terraces in order to increase distances between tables.

While it is clear that the main focus of these measures is personal mobility, they end up directly affecting UFD, whose operations should be taken into account at the planning stage and in day-to-day management. The most important challenges highlighted by the interviewed agents were ensuring access to delivery points and facilitating the availability of L/U parking.

On the other hand, if a model change is to be encouraged towards more sustainable modes of transport, then public administrations must foster the installation of charging infrastructure for electric and hybrid vehicles, also in L/U zones. The current situation does little to encourage this because: (1) there are not yet any large-tonnage distribution vehicles powered by this kind of energy and (2) the city does not have enough charging facilities to incentivise companies to renew their current fleets.

Lastly, there is the proposal to implement additional public space management measures that decongest the city at peak times. This includes implementing multi-purpose lanes that allow L/U in valley hours and increasing the availability of space, thereby reducing the time spent finding available spaces, or even illegal parking.

A policy to foster consensus and communication between stakeholders

Despite the reduction in congestion levels during lockdown, the private agents interviewed still saw the need for further dialogue with the administration in relation to public space measures (0.50). When implementing these measures, the administration did not take the opinions of the sector into account, even though dialogue between all of the parties involved is essential for the correct management of UFD. A failure to agree on these measures, followed by their unilateral imposition, may result in unexpected outcomes (Viu-Roig and Alvarez-Palau, 2020). In light of this, all parties agreed on the need to transfer recent experiences to the new UFD ordinances (0.17), as well as regulating them (0.10) and being more permissive in facilitating certain operations (0.09). One of the main points taken from the interviews was that public space for UFD was decreased during the pandemic without taking logistics agents into account. Therefore, another of the proposals was to achieve greater dialogue between the two (0.50) in order to better account for the specific characteristics and needs of each sector and draft UFD regulations accordingly.

Proposition 4. To improve UFD efficiency, dialogue must be fostered between public administrations and the different private companies so that newer UFD regulations take into account the specific characteristics of each sector.

One of the most severe criticisms from the private companies interviewed was the lack of communication when authorities implement traffic and parking restrictions. The logistics operators would appreciate greater consensus prior to their implementation due to the impact these measures have on their activity. The creation of a Logistics Focus Group, with the presence of public and private logistics agents operating throughout the metropolitan area, could be a good place to discuss new measures. It may also be advisable to define a strategy to collect and disseminate data on urban logistics. This would allow public administrations to implement data-driven policy-making and unify criteria across municipal borders, while private agents would benefit from being able to use real data to improve their operations.

In relation to dialogue with the administration and the particularities and points of view of each sector, the private agents interviewed also consider it necessary to initiate public awareness campaigns, since policies are needed to make consumers aware of the problems associated with home deliveries of products using an immediate delivery model. This would give the agents more scope to manage deliveries and design optimal delivery routes. Such campaigns could even be included in broader actions that include guidelines for responsible consumption and the circular economy. This proposal was made by those agents who have seen their activity most affected as a result of COVID-19.

Policies to promote more sustainable logistic operations

As already mentioned, another of the consequences most commented on in the interviews was the increase in ecommerce (0.40), forcing private companies to rethink their last-mile delivery model (0.33). Ecommerce-related UFD operations notably differ from those of traditional sectors, involving more and more frequent deliveries of smaller packages. In addition, such operations often require faster deliveries on a lower budget, requiring a larger number of operations to maintain similar profitability. This scenario, combined with the new traffic restrictions in certain areas of the city, and especially the historic centre, forced companies to explore alternative distribution models. For instance, in addition to bringing goods to the hard-to-reach areas, the use of cargo-bikes (0.50) also contributes to the model's sustainability (0.17). The combined use of micro-platforms and cargo-bikes is a powerful alternative for securing deliveries in these districts (Fikar et al., 2018). That being said, private agents did not highlight any element to improve in UFD linked to ecommerce (0.10) during lockdown, when their operations were even more efficient than in the pre-COVID era.

Proposition 5. The increase in ecommerce, along with new restrictions on circulation, resulted in some adjustments to distribution models, such as combining the use of micro-platforms with cargo-bikes to cover the last mile, a change that allows access to areas restricted to road traffic and promotes more sustainable UFD.

The administrations interviewed consider that one of the main policies to consider for the future of UFD, and for ecommerce logistics in particular, would include disincentivising the domestic delivery model. On the one hand, this would mean introducing charges that increase transport costs for users who opt for fast on-site delivery procedures. On the other, users who opt for more sustainable delivery systems that allow load consolidation and route planning could be rewarded. The suggestion here would be to promote a system of micro-platforms spread throughout the city, thereby enabling load consolidation, especially parcels, close to the end user and their distribution in more sustainable modes of transport. All interviewees gave their backing to a greater presence of companies that opt for last-mile cargo-bikes in the distribution model, both in and outside the city of Barcelona. The cargo-bike

distribution model could mitigate the environmental impact of the traditional model by reducing the NO₂ air pollutants in the city by over 30% (Cairns & Sloman, 2019). However, the companies interviewed in this sector considered that more efforts are still needed to strengthen this system, either through direct subsidies or through measures such as the allocation of public spaces to carry out such activities. Secondly, the use and promotion of convenience points, especially proximity trade and lockers, are also envisaged. These measures can help support local business in particularly turbulent times. Some administrations, such as the regional government of Catalonia, have shown themselves to be openly in favour of click-and-collect systems, which allow the combination of online purchases and in-store collection by buyers. Either way, ecommerce platforms should provide users with important information when selecting delivery modes, such as the cost of shipping, delivery time, or the environmental impact of the chosen mode.

Conclusions

The results obtained in this study have enabled us to achieve the objectives set out at the start of our research. The first was to identify the impacts of the COVID-19 health crisis on operations carried out by the main logistics agents in the metropolitan area of Barcelona. The second was to identify measures, derived from interviews with the main stakeholders, for promoting a more efficient and sustainable UFD after the pandemic.

Thus, in relation to the first objective, we can conclude that the pandemic and its containment measures, such as lockdowns, had a cyclical positive effect on UFD. They facilitated the circulation of commercial vehicles throughout the city, reducing delivery times and avoiding unnecessary re-routing due to congestion in L/U zones. The latter are problems that have been widely identified in and studied by the literature (e.g., Figliozzi & Tipagornwong, 2017; Jaller et al., 2013), which were lessened by drastically limiting citizen mobility. On the other hand, public administrations rushed to implement measures that would bring calm to public spaces. Through tactical urbanism, they gave space to non-motorised modes of transport, to the detriment of traffic lanes and parking. Although these policies clearly benefit citizens, their implementation occurred without prior communication or consensus with logistics agents, whose daily operations were directly affected. The agents would have therefore appreciated more dialogue and a prior analysis of the impact of these measures. Moreover, they were carried out at a particularly difficult time due to the rise in ecommerce, which has further complicated such operations. However, in an attempt to respond to the increase in domestic deliveries, a change has been noted in the last-mile model, with a greater use of micro-platforms and cargo-bikes helping to foster the transition to a more sustainable urban model (Sheth et al., 2019).

With regard to our second objective, we can conclude that the logistics agents interviewed consider it vital to remedy the weaknesses inherent in the current UFD model, which were brought to the fore by the COVID-19 crisis. With the aim of improving their operations, the agents propose de-incentivising domestic deliveries, with higher prices for this mode, as well as offering alternatives such as collection points, promoting last-mile delivery with cargo-bikes and providing the city with sufficient infrastructure for recharging commercial electric vehicles. This research has therefore identified the following theoretical and practical implications that will help future researchers and policymakers improve their work.

Theoretical implications

The results of our research are useful for future researchers to understand how the UFD measures implemented by policymakers have a direct impact on the operations of logistics agents. Specifically, our research is among the first to focus on interviewing logistics agents to learn first-hand about the impact of UFD policies. Therefore, our methodology may also open the door to further research of this kind to gather detailed information on UFD practices in cities.

Practical implications

Our results will serve as a basis for policymakers to regulate UFD taking into account the implications that their decisions may have for the operations of logistics agents. More specifically, we have identified the following five considerations that policymakers should refer to when drafting regulations: (1) reducing traffic congestion; (2) taking the different characteristics of UFD operators into account; (3) adapting public spaces to the needs of the future; (4) increasing communication with logistics agents before drafting regulations; and (5) implementing policies to enhance the sustainability of UFD. Thus, our research will help policymakers reach swift solutions in problematic scenarios where administrations are forced to decide on urgent new regulations, such as a new pandemic.

Limitations and future research

As limitations to the results of our study, we must emphasize that they are based on the specific case of the metropolitan area of Barcelona, whose lockdown measures may have differed from those of other administrations. The perceptions of and repercussions for logistics agents in other cities may therefore also vary. This means that the results expressed here must be carefully extrapolated, taking into account the structural differences that exist between different locations. A further limitation to consider is the importance of the context in which each interview was performed and analysed when interpreting the C-coefficient generated by the Atlas.ti software; without context, it is not possible to properly assess the meaning of the relationship between the different codes.

Finally, as future lines of research, we propose similar studies be conducted in other cities of Spain, or even Europe, interviewing recognised logistics agents and checking whether the impact of COVID-19 affected their operations in the same way as in our study. It would also be interesting to use simulation models to prove the effects on UFD of the different interventions on public space identified in our study, as has been done in other similar cases (Nuzzolo et al., 2018).

Declaration of Competing Interest

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

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Appendix A

Table A1

Description of each of the codes used for the interview transcripts in Atlas.ti.

#	Code	Description
1	No problems with <i>traffic</i>	Code used for interview fragments that indicated there were no problems related to traffic congestion in the city.
2	Conflict with other sectors	Code used for interview fragments that indicated conflicts occurred with other sectors during UFD operations. For example, with regard to the use of loading and unloading zones, the ecommerce sector requires a maximum of 20 min to complete operations, while the fitters sector requires between 60 and 90 min. This time difference sometimes leads to conflict between fitters and ecommerce distributors if the former occupy the L / U zones for a longer time.
3	Consequences of COVID	Code used for interview fragments that indicate the consequences of the COVID-19 pandemic in operations related to UFD in the city of Barcelona.
4	More dialogue required with the authorities	Code used for interview fragments in which the interviewees indicated the need for more dialogue about UFD operations with the authorities.
5	Economic difficulties	Code used for interview fragments in which the existence of economic problems or difficulties related to UFD are mentioned.
6	UFD difficulties	Code used for interview fragments in which difficulties encountered by the people interviewed during UFD operations in the city of Barcelona are mentioned.
7	Cargo-bikes	Code used for interview fragments in which mention is made of sustainable modes of transport such as electric bicycles, used most frequently in the city of Barcelona.
8	Ecommerce	Code used for interview fragments mentioning the ecommerce sector and its UFD operations.
9	Public space	Code used for interview fragments that make mention of the public spaces of the city related to UFD, such as spaces assigned to companies to create micro-platforms for managing UFD.
10	HORECA	Code used for interview fragments that relate to the HORECA (Hotels, Restaurants and Cafes) sector of the city.
11	Increase in number of users	Code used for interview fragments that refer to an increase in the number of users who make use of a service or zone, such as L/U zones, for example.
12	Sales increase	Code used for interview fragments referring to sectors that have seen increased sales as a result of the pandemic.
13	Last-mile	Code used for interview fragments that refer to the last section of the route for the delivery of goods, known as the last mile.
14	Improved UFD operations	Code used for interview fragments that refer to processes or situations that improved UFD in the city, always comparing the current situation with that prior to the pandemic.
15	Non-essential services	Code used for interview fragments mentioning those sectors that were not considered essential services during lockdown and therefore suffered mobility restrictions.
16	New UFD regulation	Code used for interview fragments that mention new regulations on post-pandemic UFD.
17	Permissiveness of the authorities	Code used for interview fragments that mention the permissiveness shown by the authorities towards logistics agents during lockdown with regard to UFD. For example, during this difficult period, the authorities unofficially allowed badly parked vehicles to load and unload goods during the day, taking into account urgency due to shortages in some areas.
18	No L/U problems	Code used for interview fragments that indicated there were no problems in the UFD operations carried out in the L / U zones.
19	No time problems	Code used for interview fragments that indicated there was no problem or restriction on time windows for carrying out UFD operations. For example, there are areas of the city that do not allow heavy transport vehicles to circulate at certain times.
20	Sustainability	Code used for interview fragments that mention aspects and measures related to the UFD sustainability in the city.
21	ICT use	Code used for interview fragments that mention the use and application of technology in UFD in the city. This code uses the abbreviation for "Information and Communication Technology".
22	Future vision for UFD	Code used for interview fragments in which the interviewees indicated their vision and prospects for the future of UFD in the post-pandemic era.
23	Pedestrian zones	Code used for interview fragments in which specific mention was made of the city's pedestrian zones. In the case of Barcelona, pedestrian zones had a significant impact during lockdown, since vehicle lanes were reduced to create these spaces, something that also impacted UFD.

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