

RELATIONSHIP BETWEEN THE EVOLUTION OF TERRITORIAL MOBILITY AND VULNERABILITY IN THE CONTEXT OF THE COVID-19 PANDEMIC

EXECUTIVE SUMMARY

1. STUDY OBJECTIVES AND STARTING POINT

The Metropolitan Transport Authority (ATM) commissioned the Study Group on Energy, Territory and Society (Catalan acronym, GURB) of the Autonomous University of Barcelona (Catalan acronym, UAB) to carry out a study analysing the relationship between people's mobility and social vulnerability in the context of the COVID-19 pandemic. The main objective of the study was to assess whether living and income conditions were decisive factors in quantifying the number and origin of commuters on weekdays.

Specifically, the study analysed the patterns in the reduction of mobility in public rail transport in the Barcelona area during the period of health emergency caused by the COVID-19 epidemic, comparing it with previous average mobility levels (validations on average working days from 7 January to 28 February 2020). The analysis paid special attention to the relationship between the evolution of mobility and the average income of the territory. Secondly, mobility was analysed using mobile data, with the aim of comparing the evolution of rail mobility with the absolute mobility of the population.

Thus, the general base hypothesis was that in the context of the COVID-19 pandemic, the most disadvantaged social groups were obliged to maintain higher patterns of mobility on public transport. At the same time, more affluent groups could reduce their mobility and use alternative means of transport.

The study of mobility is of considerable importance in estimating the repercussions of the pandemic on various social groups. Thus, several studies have shown how population density, housing size, as well as the presence of previous pathologies (often linked to income and living conditions) are determining factors in explaining the evolution of contagion among the population. These factors have contributed decisively to the pandemic's greater repercussions on certain social groups and territories. In addition to these factors, the lesser capacity of people in the most vulnerable social groups to reduce their mobility is a key factor in helping to explain the spread of the pandemic.

The lesser capacity of vulnerable social groups to reduce their mobility may be because affluent sectors are more flexible and have more resources when faced with labour difficulties and often

work in sectors where they can more easily adapt to teleworking. On the other hand, the most disadvantaged groups are mostly employed in basic services and low-skilled jobs and have more precarious employment conditions, fewer available savings and less access to private vehicles, and they are more obliged to travel by public transport.

2. METHOD

Regarding the method, sources, temporal coverage and territorial scope of the study, it should be noted first of all that the data correlating mobility and income used were as follows:

- *Access validations to the railway system* of the Integrated Tariff System stations (METRO TMB station network, RENFE Rodalies station network, FGC station network and TRAM Baix and TRAM Besòs station network). The analysis focused exclusively on the trips taken on a working day, and only the trips made in each area in the 04.00-13.00 time slot were analysed to minimize the return trips.

- Mobility data obtained from mobile telephony provided by *Ministry of Transport, Mobility and Urban Agenda* (Spanish acronym, MITMA). These were processed by the ATM in a generic environment in the form of a relational database to analyse mobility globally for the whole of Catalonia and specifically for the scope of the Integrated Metropolitan Mobility System of Barcelona. The ATM has created a dedicated platform called Indicators for Monitoring Mobility using Mobile Data. In this approach, two different dimensions were analysed for all time slots (24 hours) and for a typical weekly day established on Wednesday: for each territorial unit (census district) the total number of trips with origin is shown (Barcelona), destinations and number of trips; and secondly, for each territorial element (census district where the overnight stay took place) it shows the total number of people who did make a journey, made one journey, made two trips or made more than two trips.

- *Gross disposable family income (Catalan acronym, RFDB) 2017 for the city of Barcelona*. The estimate of the income of the neighbourhoods of Barcelona was used. This is drawn up annually by the City Council based on a series of variables.¹ Based on this estimate, the 73 districts of Barcelona were divided by income deciles. For the specific case of mobile telephony, the 10 districts that make up the city of Barcelona were analysed.

- *The classification of the studied census tracts drawn up in the Neighbourhoods and Crisis research study* (Blanco & Nel-lo, 2018).² The classification groups the census tracts into three categories - affluent, intermediate and vulnerable - based on four variables closely related to income (unemployment rate, percentage of foreign population, average cadastral value and average dwelling size).

- *The average household income 2017* at the census section tract of the whole field of study, specifically the georeferenced data on the disposable family income of the population recently published by the INE (Spanish acronym for the National Institute of Statistics) from tax sources of the Tax Agency.³ In this approach, a delimitation of service areas was made by establishing

¹ For more information, please see <https://ajuntament.barcelona.cat/barcelonaeconomia/ca/renda-familiar/renda-familiar/distribucio-territorial-de-la-renda-familiar-disponible-capita>

² Blanco, I., & Nel-lo, O. (Eds.). (2018). *Neighbourhoods and Crisis. Economic crisis, urban segregation and social innovation in Catalonia*. Tirant lo Blanch.

³ For more information, see Experimental Statistics: [Household-income distribution atlas](#).

an area of influence based on the temporary distance of access to the station of a maximum of 10 minutes on foot. Thus, from this isochronous one, a service area of 10 minutes on foot was delimited around the Metro, Tramway, Railway and Renfe stations. These service areas overlap and intersect, with census tracts, neighbourhoods, and other administrative boundaries for which statistical information on population and income is available, which have been classified by income deciles.

Temporarily, the scope of the data includes the situation before confinement (set of working days from Monday to Friday in January and February 2020), from the first week of confinement (from 16 to 20 March 2020) until March 26, 2021. Mobile phone data were analysed on 6 dates: 3 March 2020, 1 April 2020, 27 May 2020, 29 July 2020, 16 September 2020, and 25 November 2020.

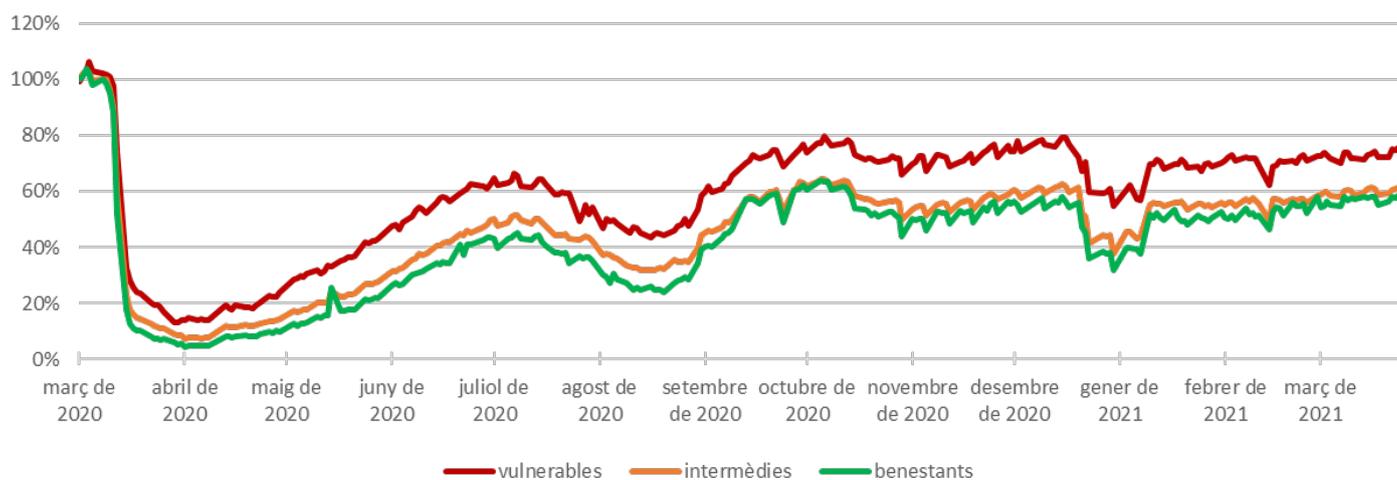
The field of study of this report corresponds to the metropolitan area of Barcelona (zone 1 of the STI including Barcelona), and the cities of Terrassa and Sabadell. The specific study carried out on the basis of mobile telephony data, the territorial scope of the analysis corresponds to that of the municipality of the city of Barcelona and its ten districts.

3. RESULTS

The analysis of the evolution of railway mobility confirms the existence of quite different behaviours according to the social environment in which the stations are located. Throughout the analysed period, the more affluent areas have lower mobility values than the vulnerable areas. This can be seen when the issue is addressed from the classification of the census tracts into the three categories of vulnerability, and when it is studied from the neighbourhoods grouped by income deciles or from the delimitation of the municipal territory into service areas also grouped by income level. In all three cases (with a few exceptions) the level of rail mobility tends to decrease as the area's income increases. However, in the first case the relationship is clearer and more unequivocal.

Across the AMB (Catalan acronym for Barcelona Metropolitan Area) as a whole, average validations in the affluent census tracts not only fell more radically but also more rapidly than in the rest, especially during the first confinement that began on 15 March 2020. As can be seen, the affluent tracts of the AMB had already reduced mobility by 90.9% during the first week of confinement. In contrast, mobility in vulnerable census tracts had only reduced by 76.9%, fourteen percentage points. Since then, mobility in the vulnerable sections has remained significantly higher. The fact that the difference between the two was reduced to 8 percentage points from the third week of confinement, coinciding with the suspension of all non-strategic work activities, may indicate the importance of non-voluntary labour mobility in these census tracts.

Percentage change in validations compared to mobility January-February 2020, according to the vulnerability of the access territory. March 2020-2021, Barcelona Metropolitan Area



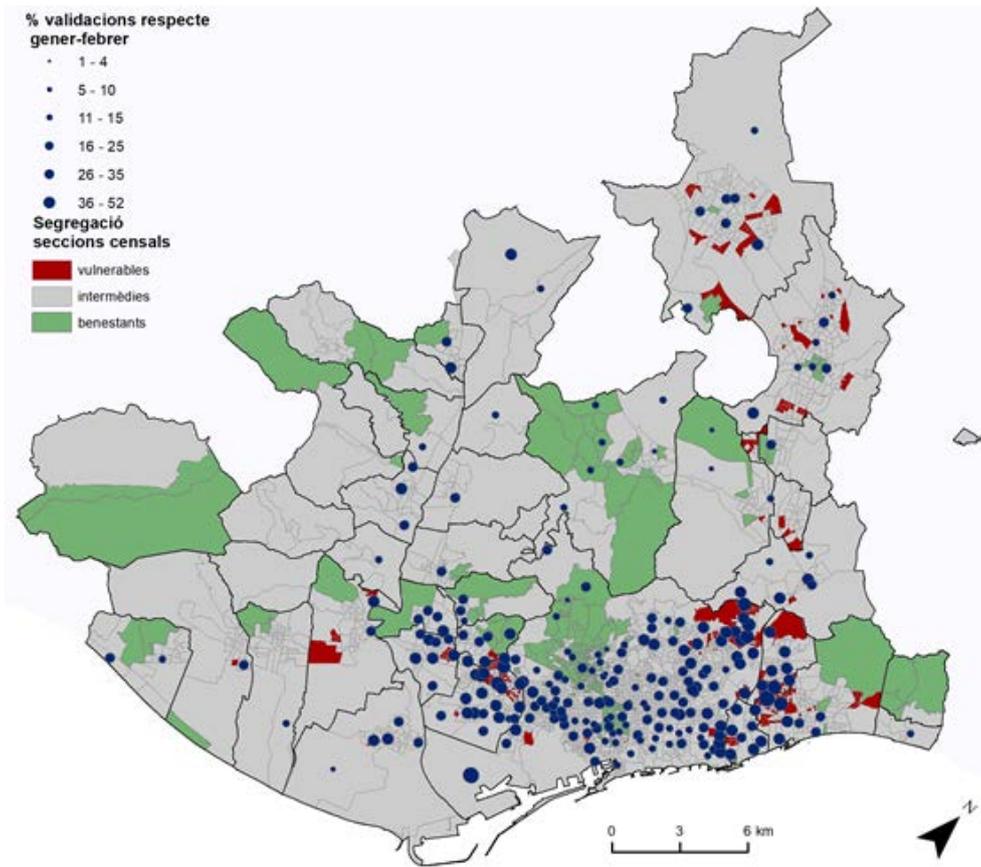
Make: GURB - UAB based on data from the Metropolitan Transport Authority and Neighbourhoods and Crisis

Throughout the period studied, there were significant fluctuations, attributable on the one hand to the evolution of pandemic restrictions, and to a certain extent, the holiday periods. Regarding the recovery of flows, it should be noted that in the last week of March 2021 the validations had already risen again to represent 60.7% of the average for January-February 2020. However, the maximum volume of validations recorded during the pandemic corresponds to the validations for the week of October 5-9, when these were around 64%.

In the territorial distribution of rail mobility in relation to income, similar patterns are maintained throughout the analysed period. Thus, for the whole area studied, it was seen that the relatively higher levels of mobility with respect to the January-February average were located on the axes of the river Besòs and the Collblanc road, in the municipalities of Santa Coloma de Gramenet, Sant Adrià del Besòs and Badalona, and also L'Hospitalet del Llobregat and Esplugues del Llobregat.

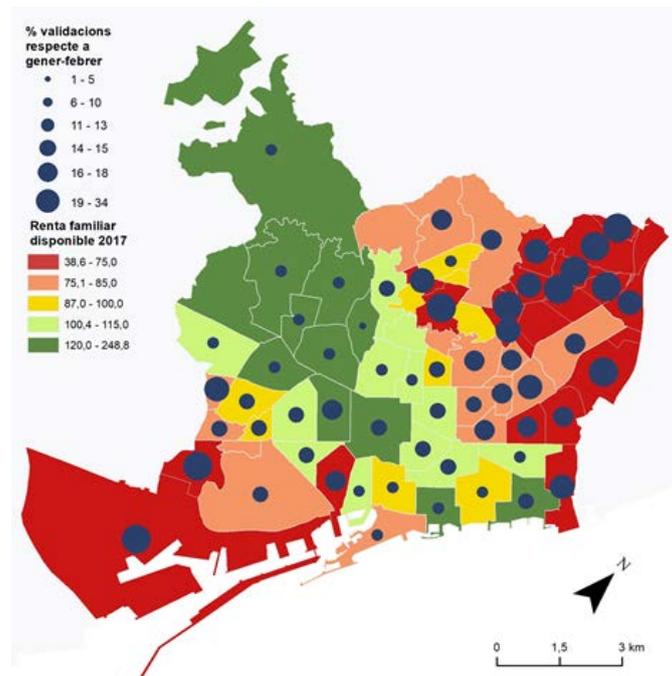
In the case of the city of Barcelona, the spatial behaviour followed very similar patterns. However, it should be noted that the differences between the more and less prosperous stations are particularly pronounced within the city. Mobility was reduced more sharply in the higher-income neighbourhoods (Sarrià, Sant Gervasi, Les Tres Torres, Les Corts) than in the lower-income ones (Torre Baró, Bon Pastor, Ciutat Meridiana, Verdum, La Marina de Port, El Carmel). The Eixample and some central areas maintained relatively higher mobility, which is probably due to the validation of the return of people moving from other parts of the city.

Percentage of validations of transport tickets in the week of 27-30 April compared to the average for January-February 2020. Census tracts, classified according to vulnerability. Barcelona metropolitan area



Source: GURB - UAB based on data from the Metropolitan Transport Authority and Neighbourhoods and Crisis.

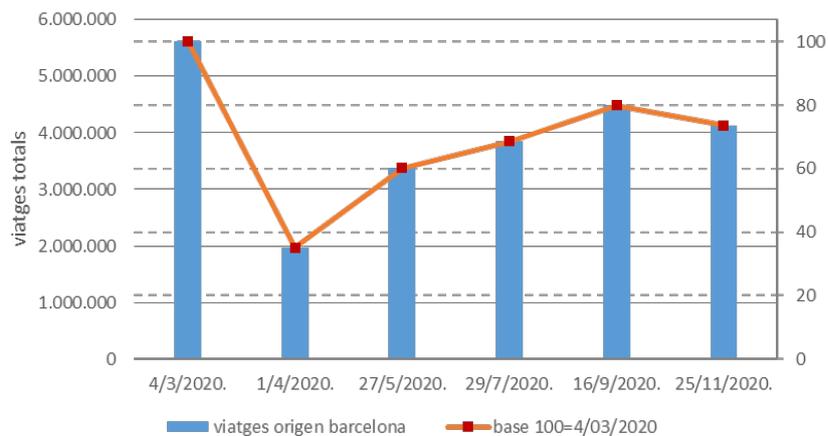
Percentage of validations of transport tickets in the week of 27-30 April compared to the average for January-February 2020. Barcelona Neighbourhoods, by Gross Disposable Family Income.



Source: GURB - UAB based on data from the Metropolitan Transport Authority and Gross Disposable Family Income of Barcelona City Council.

The inverse relationship between mobility and income during the pandemic period was also confirmed by the analysis of absolute mobility based on mobile phone data. Thus, it was detected that once the confinement period began, the number of daily trips made to the city went from slightly over 5.5 million to slightly under 2 million during the confinement period, a decrease of 65%. Subsequently, mobility gradually recovered to reach 4.5 million during September 2020. This decrease in the number of trips was accompanied by an increase in the self-sufficiency of mobility within the city and within the districts. The city went from having a self-contained mobility rate of 77.4% before the pandemic to a maximum self-sufficiency of 81.8% during confinement. Moreover, if before the pandemic an average of 28% of trips originated in the same district during the confinement, this percentage of self-sufficiency reached 48%.

Variation of total trips originating in Barcelona at the different times analysed.

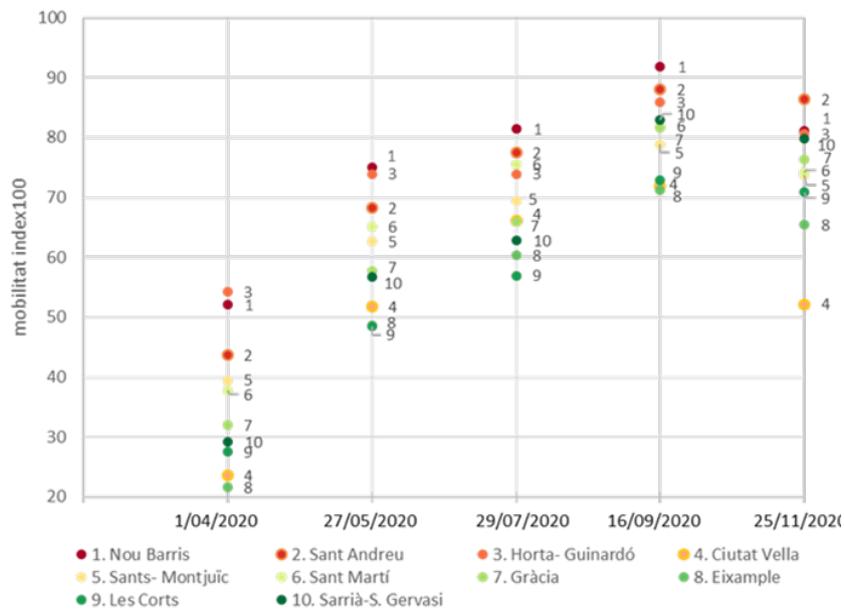


Source: GURB - UAB based on the Indicators for Monitoring Mobility using ATM Mobile Telephony Data, 2020.

Data from mobile devices have also shown that the number of daily trips made by people has been substantially reduced. This was particularly evident for those who made more than two trips a day: 832,867 before the pandemic dropping to 283,105 in confinement, a 66% reduction. In contrast, the number of people travelling only once increased by 35%. These changes were reversed during the return to normal, without recovering the absolute volume of people who made more than two trips a day.

The study of personal mobility in the city of Barcelona showed that on the day of reference before the pandemic, 28% of the population analysed (455,758 people/mobile phones from a total of 1,612,097) did not make any trips along the working day. Subsequently, during the confinement period, the percentage of people remaining at home was 66% of the city as a whole (1,128,806). In higher-income districts, the percentage of people who did not travel was higher than in the rest.

Variation of trips compared to the pre-covid period (index 100) by districts of Barcelona ordered from lowest to highest income (1-10).



Source: GURB - UAB based on the Indicators for Monitoring Mobility using ATM Mobile Telephony Data, 2020 and Disposable Family Income from Barcelona City Council.

As we have seen above, in rail mobility we can see that the highest-income districts are generally the ones that reduced their mobility most compared to the pre-confinement period, with a high correlation between the two variables. It was also seen that rail mobility (number of validations) decreased much more sharply than absolute mobility (mobile data). During the strictest confinement, rail mobility was reduced by up to 93.5% from the reference day before the pandemic; the total number of trips originating in the city of Barcelona were only reduced by 65%. The behaviours analysed at different times between the two types of information follow a very similar pattern in their tendencies to increase or decrease.

However, districts with abnormal mobility and income behaviour were identified. These are Ciutat Vella, which throughout the period had much lower mobility rates than the nearby districts with similar income; Sant Martí, which had slightly more mobility than would be expected due to its income level; and finally, Sarrià-Sant Gervasi and to a lesser extent Les Corts had more mobility than the lower income districts.

Evolution of mobility by district, daily train validations in the city's stations and total daily trips originating in the city of Barcelona, (index 100 = 4/03/2020)

	Nou Barris	St. Andreu	Horta- Guinardó	Ciutat Vella	Sants- Montjuïc	St Martí	Gràcia	Eixample	Les Corts	Sarrià- S.Gervasi	Total
RFDB2017	55	74,6	78	84,3	84,6	88,1	105,3	122,4	137,3	182,8	100
Mobilitat total											
1/4/2020	52,1	43,8	54,2	23,6	39,5	37,8	32,0	21,6	27,5	29,1	35,1
27/5/2020	75,0	68,2	74,0	51,7	62,7	65,2	57,7	48,6	48,5	56,7	60,2
29/7/2020	81,5	77,5	74,0	66,2	69,4	75,5	66,0	60,4	57,0	62,9	68,7
16/9/2020	91,8	88,1	86,0	71,9	78,9	81,9	81,7	71,3	72,9	82,9	80,0
25/11/2020	81,2	86,3	80,6	52,2	73,8	74,2	76,3	65,5	70,9	79,8	73,6
Mobilitat ferroviaria											
1/4/2020	10,9	8,0	10,2	6,2	6,8	6,3	6,6	5,5	4,9	4,2	6,5
27/5/2020	33,2	25,1	29,2	23,1	23,8	22,2	23,7	21,8	17,3	18,8	23,2
29/7/2020	51,1	46,1	44,3	41,1	41,2	40,9	39,5	38,4	32,0	27,6	40,1
16/9/2020	69,3	62,6	61,4	52,2	54,0	50,8	58,0	53,3	50,1	58,7	55,3
25/11/2020	66,5	62,5	60,5	51,7	53,0	50,6	55,7	53,9	48,3	56,6	54,9
Correlación R2	0,875	0,939	0,882	0,711	0,920	0,871	0,954	0,924	0,967	0,919	0,918

Source: GURB - UAB based on the Indicators for Monitoring Mobility using ATM Mobile Telephony Data, 2020 and ATM Rail Validation Data. Income of Barcelona City Council.

4. POSSIBLE FUTURE LINES OF RESEARCH

The study could be developed in the future along various lines of research. Here are some of the potentially most relevant:

1. **Temporal continuity of the analysis, based on validation data and derived from mobile data.** This exercise could be of considerable interest in observing whether the differences in mobility patterns associated with social environments persist in the period following the most acute phase of the health crisis; that is, during the “final” phase of Covid-19. They would also be of interest in measuring the resumption of public transport compared to the absolute evolution of mobility.
2. **Extension of the territorial scope of the analysis.** The scope of the study on the evolution of mobility and its relation to the territorial distribution of income could be extended to the whole of the metropolitan region of Barcelona (164 municipalities, 3,230 km² and 5 million inhabitants) and to the entire Integrated Tariff System (296 municipalities). This extension could address data on the period from the onset of the health crisis to the present, and on the later stages of the resumption of mobility.
3. **Comparison of the parity of the railway service in the ATM with that of other large Spanish cities.** The study of the relationship between mobility and income offers the chance to study the parity of the coverage of the present and planned public transport railway service, comparing the benefits of the metropolitan area of Barcelona with that of other large Spanish cities. The conclusions would be of particular interest in justifying the need for investment not only in functionality but also in social and territorial parity.

Bellaterra, 18 November 2021