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Research Article

Spatio-Temporal Analysis of the Initial Cases of COVID-19 in the City of Nice and Potential Socio-Economic Determinants

Mariné-Barjoan E, Festraëts J and Chaarana A*

Department of Public Health, Centre Hospitalier Universitaire de Nice, Université Côte d'Azur, France

Abstract

Background: Socio-demographic factors are known to influence epidemic dynamics.

Methods: We describe the SARS-CoV-2 outbreak in Nice, France, between February 28 and March 30, 2020, based on socio-demographic data and the date of lockdown.

Results: Among the 1,161 residents in Nice who underwent a PCR test for SARS CoV-2, 188 were positive, 30 (16%) of whom lived in disadvantaged sector (IRIS units with a poverty rate ≥ 35 %). The positivity rate was higher in disadvantaged sector (24 %) than in the rest of the city (15.3 %); p=0.0012. The population diagnostic rate was also higher in disadvantaged sector (81.6/100,000 inhabitants *vs.* 51.4/100,000; CMF=1.59; [95%CI: 1.45-1.74]).

Before lockdown, the population diagnostic rate was comparable regardless of demographic IRIS unit: 63.4/100,000 inhabitants in disadvantaged sector *vs.* 77.5/100,000 for the rest of the city. However, following lockdown, it was higher in disadvantaged sector: 314.0/100,000 inhabitants *vs.* 255.5/100,000 for the non-disadvantaged sector (p=0.05). We found a significant correlation between the number of cases and the population density (p=0.04), and an accumulation of cases in IRIS units with a higher percentage of apartment residents compared to individual family houses.

Conclusion: If the indicators of density and overcrowding were confirmed on a larger scale, breaking the chain of transmission would require reconsideration of urban planning, allowing for larger living quarters, thus limiting overpopulated households in the most vulnerable areas of the cities.

Keywords: COVID-19; Epidemic spread; Health social inequalities; WHO; SARS CoV-2

Key Points

- The first cases of Covid-19 in Nice were not detected in the most disadvantaged areas of the town.
- The Covid-19 outbreak spread faster among the less affluent population, particularly following the lockdown.
- Living conditions contributed to the spread of the outbreak among the least affluent population.

Introduction

The first five cases of SARS-CoV-2 in the Alpes-Maritimes department of Southeastern France, located near the Italian border, were diagnosed on February 28, 2020. Three of these patients lived in the city of Nice. Five days earlier, the French Minister of Health had triggered the epidemic and biological risk response plan (ORSAN Reb) developed in 2019 [1]. On March 11, COVID-19 was declared a pandemic by the WHO [2] and on March 14, the French government triggered stage three of the ORSAN Reb Plan. This third level of response recommends that all non-severe Covid19 cases stay at home and aims to mobilize, in addition to health institutions, health care professionals, home care services and potentially home help services. Three days later, i.e. two months after the first case had been diagnosed on French territory; the French government announced a nationwide lockdown [3].

On January 1st, 2020, the resident population of Nice numbered 342,979 inhabitants, with significant socio-economic disparities [4]. The National Institute of Statistics (INSEE) divides Nice into 146 sub districts (IRIS: Ilôts Regroupés pour l'Information Statistique, i.e. demographic aggregate units for statistical information), and publishes socio-economic indicators for each of them. Among these indicators, the Poverty Rate (PR) or standard of living corresponds to the share of the population whose income is below 1,026 Euros/month. According to the most recent statistics, in 2018, the average poverty rate among the population of Nice was 20%; for 17 IRIS units it was less than 10% and for 15 IRIS units greater than or equal to 35%, reaching 50% in two IRIS units (https://www.insee.fr/fr/statistiques/2011101?geo=COM-06088).

Socio-demographic factors play a major role in epidemic dynamics [5-10] and have been investigated in the SARS-CoV-2 epidemic context [7,11,12]. Geographical disparities in mortality rates were observed in Italy [11], as well as in France, where the association between social inequalities and Covid-19 mortality was studied in the Ile-de-France region [12]. More recently, the EpiCov study conducted

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***Corresponding author:** Eugènia Marine Barjoan, Department of Public Health, Centre Hospitalier Universitaire de Nice, Université Côte d'Azur, Rte St Antoine de Ginestière, Niveau 1, CS23079, 06202 NICE, France, Tel: +33-492035634; E-mail: marine-barjoan.e@chu-nice.fr

on a representative sample of the French population published initial results on the seroprevalence of SARS-CoV-2 [13], according to living conditions [14].

In France, between February 28 and March 30, 2020, PCR screening for SARS-CoV-2 was conditional upon the presence of symptoms suggestive of Covid-19 and/or the notion of recent travel to a risk area or contact with a person already diagnosed by PCR [15-17]. At that time, only two sites of the Nice University Hospital complex (Nice CHU) could provide a PCR test: the Emergency Department in the East of the city (Pasteur Hospital), and the Infectious Disease Department in the West (Archet Hospital). Between March 28 and 30, two private laboratories in Nice obtained permission to perform PCR tests. For the present study, only data from the virology laboratory of Nice University Hospital was available. All tests were free of charge.

The main objective of our study was to describe the progression of the SARS CoV-2 epidemic between February 28 and March 30, 2020, among the population of the city of Nice, according to socio-demographic characteristics and date of lockdown.

Materials and Methods

This is a descriptive study of the spatial distribution of the first cases of SARS-Cov-2 that occurred in the city of Nice and of the socio-demographic characteristics of the population. We included all patients residing in Nice who underwent a SARS-CoV-2 screening test by PCR at Nice CHU between February 27 and March 30, 2020 [18]. For each case, date of birth, gender, date of first positive PCR test and residence address at the time of the positive PCR test (RT-PCR with prior easyMag® [Biomérieux®] extraction, according to the guidelines of the National Reference Center for Respiratory Viruses of the Pasteur Institute) were recorded. A maximum amplification cycle threshold of 39 is considered as a positive PCR test.

Each address was processed using a geographical information system (ARCGIS 10®) which located each patient within each of the IRIS units.

For each IRIS unit, we collected the following INSEE socio-demographic indicators (18): Poverty Rate (PR), income reported for tax purposes, percentage of households in an individual detached house or an apartment and percentage of main residences occupied by tenants or owners. Each IRIS unit was classified according to its poverty rate: PR ≥ 35% (disadvantaged sector) and PR<35% (non-disadvantaged sector).

We first analyzed trends in positivity rate, then calculated the Diagnostic Rate (DR) per 100,000 inhabitants during two periods, i.e. February 28 to March 16 (pre-lockdown) and March 17 to March 30 (during lockdown), and explored its potential correlation with the poverty rate.

For the statistical analysis, the χ^2-test (chi-squared test) was used to compare qualitative variables, and Student's T-test for quantitative variables. The population DR was compared by a Comparative Morbidity Figure (CMF).

Correlations between two quantitative variables were analysed using Pearson's test. A p threshold of 5% was considered statistically significant. All statistical tests were performed using SAS© and SPSS© software packages.

Results

Between February 28 and March 30, 2020, 3,155 persons underwent a SARS-CoV-2 PCR test performed by the Nice CHU Virology Laboratory (Figure 1). Among them, 1,970 reported residing outside the city of Nice (i.e. in other locations within the Alpes Maritimes department and Monaco); the place of residence could not be identified for 24 persons. Among Nice residents, 1,161 benefited from a PCR test among which 188 were positive (16.2%). These included 100 women (53%) and 88 men (47%); 48 cases (25.5%) were between 40 and 80 years of age and 25 cases (13%) older than 80 years.

Initial cases were diagnosed in Nice in the affluent areas of the Centre-West of the city, progressing slowly until March 19 and reaching the Centre-North on March 20th. Subsequently, the number of cases increased rapidly from March 24 onwards in the North-East of the city which includes several disadvantaged areas. The nationwide population lockdown had begun a week earlier.

Analysis according to IRIS units

Among 188 PCR+ individuals, 30 resided in disadvantaged IRIS units and 158 in non-disadvantaged IRIS units. The positivity rate was significantly higher in the former (24.6%; N=30 cases out of 125 tests) than in the latter(15.3%; N=158 out of 1036 tests) p=0.0012.

The DR in the 15 disadvantaged IRIS units was significantly higher than in the 131 non-disadvantaged IRIS units (81.6/100,000 inhabitants *vs.* 51.4/1000000 inhabitants, CMF: 1.59; IC: 95% [1.45-1.74]) (Figure 2). In all disadvantaged IRIS units, the DR was higher in all age groups, and even more from the age of 69 upwards (Supplementary material).

We observed a greater number of cases in densely populated IRIS units (N=102 in the 69 IRIS with a population density above

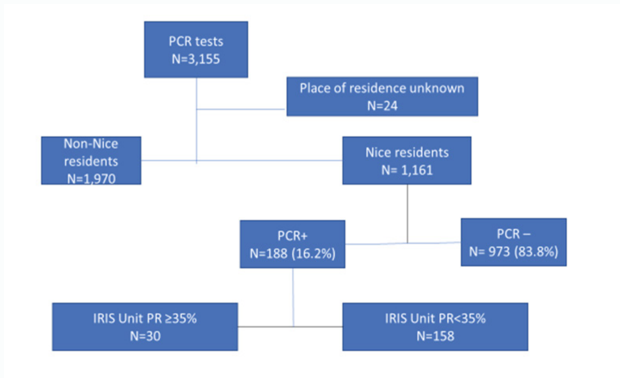

Figure 1: PCR test flowchart.

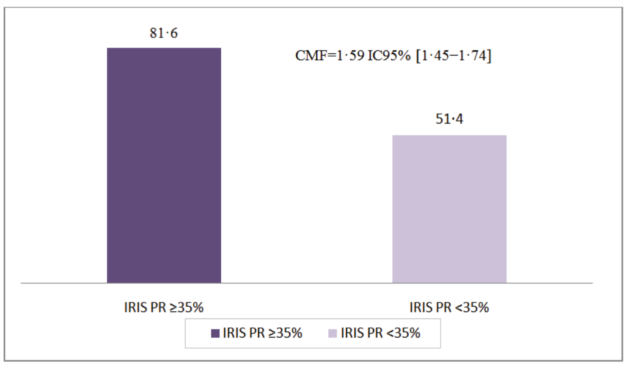

Figure 2: Diagnostic rate by poverty rate.

the median *vs.* N=86 in the 77 IRIS with a population density below the median (p=0.04) (Figure 3)). Most cases were grouped in IRIS units where the proportion of apartments was higher compared to detached houses (Figure 4); 148 cases (78.7%) lived in one of the IRIS units where the percentage of apartments was greater than 89.3%, *vs.* 7 cases (3.7%)who lived in an IRIS unit where more than half of the dwellings were houses (66.8%).

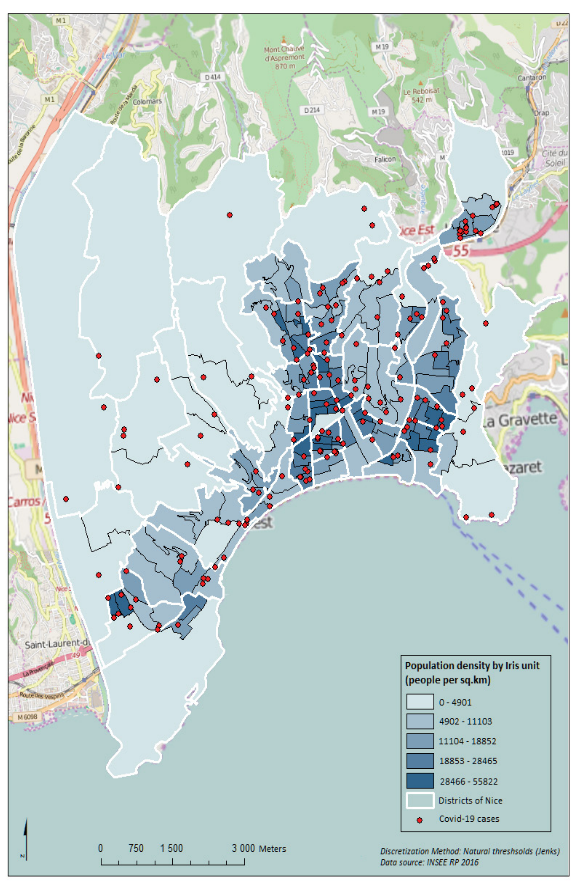

Figure 3: COVID-19 cases and population density.

Analysis according to the date of lockdown

Prior to the lockdown, the DR was comparable in terms of IRIS unit poverty rate (63.4/100,000 in disadvantaged IRIS units versus 77.5/100,000 in non-disadvantaged IRIS units). However, following the lockdown, the DR was significantly higher in disadvantaged IRIS units (314.0/100,000) than in non-disadvantaged IRIS units (255.5/100,000), p=0.05.

In parallel, before March 16th, the positivity rate was identical in disadvantaged and non-disadvantaged IRIS units (9.5% for both), while after March 17th, the positivity rate was greater in disadvantaged IRIS units (26.9% *vs.* 17%), p=0.013. Following the lockdown, it increased in disadvantaged IRIS units, from 10.3 % to 37.9 % over seven days, while in the non-disadvantaged IRIS it rose from 15.2 % to 16.0 %.

Discussion

Our study, conducted over a period when only the Nice CHU performed PCR tests, at the beginning of the epidemic, shows that the number of diagnosed cases of SARS-CoV-2 infection was significantly higher in the most disadvantaged areas of the city of Nice after one week of lockdown. In addition, it confirms the effect of population density on the number of cases. This result is consistent with published studies that highlight low income as a factor accounting for the increase in number of cases at the European level [19] and in France [20]. It is also consistent with studies that have shown the association between population density and the spread of the epidemic [21-23] and with results of the EpiCov survey in France which conclude that the living environment plays a key role in the spread of the virus [20]. A study conducted in Ile-de-France suggests that the geographical distribution of excess mortality due to COVID 19 is closely linked to the social and urban context of the affected population [12]. Finally, the role of the urban environment and housing type has been described in other infectious diseases [7]. Before the lockdown, the DR per 100,000 inhabitants was similar in all the IRIS units of the city. However, between six and thirteen days after the start of the lockdown, the number of tests accelerated in parallel with an increase in positivity rate in disadvantaged IRIS units, from 10.3% to 37.9%.

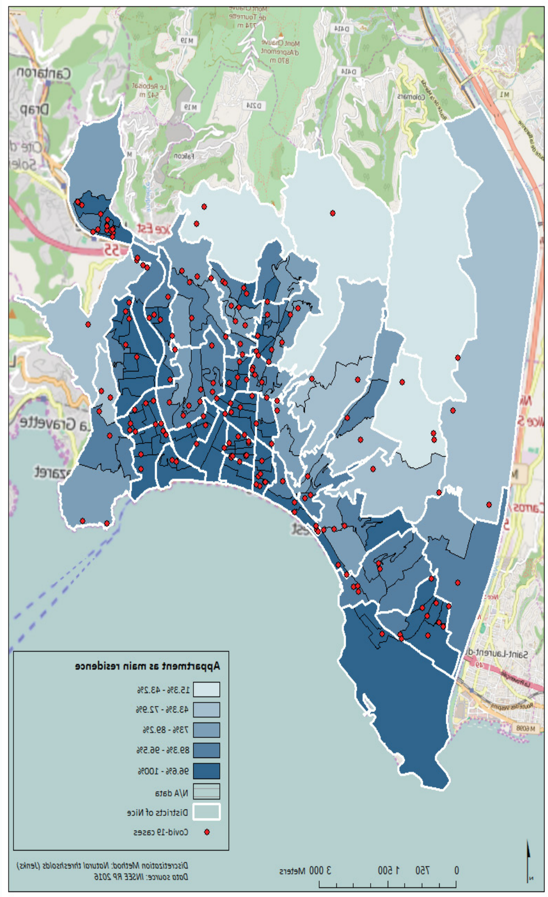

Figure 4: COVID-19 cases and main residence.

These results could suggest that the lockdown has been a vector of contamination in disadvantaged IRIS units. Indeed, they would be consistent with the natural history of SARS CoV-2 infection, its modes of contamination and the delay between contamination and positive PCR test. The average incubation time of SARS-CoV-2 is 5.7 days [15] and the time period between the appearance of the first clinical signs and a positive PCR test varies, depending on the intensity of the symptoms, from one to seven days [16]. However, at that time, the performance of tests was conditioned in part by the presence of clinical signs and/or travel to areas of significant viral circulation. Since the percentage of asymptomatic SARS CoV-2-infected patients is estimated to approach 40%, [24] this assumption appears unlikely. We found that the number of cases was significantly correlated with a high population density and that the DR was higher in IRIS units with a higher percentage of apartments, especially as a main residence, compared to single-detached houses, and this regardless of the poverty rate.

The poverty rate could therefore contribute to the increase in contamination due to crowded housing, with several generations sharing the same dwelling and greater frequency of apartment housing. In our opinion, the lockdown should have been accompanied by additional measures to isolate cases, prioritizing at-risk patients living in crowded lodgings.

In the present study, the age distribution of positive PCR tests showed that 62% of these patients were below 40 years of age, suggesting a possibly higher contamination rate among this age group.

Our results should be interpreted with caution. We were unable to calculate incidence rates and we believe that the incidence data published at the time in France did not reflect the true epidemic situation or the level of viral circulation. During the study period, PCR screening for SARS-CoV-2 was conditioned by the presence of symptoms suggestive of COVID 19 and the notion of recent travel in a risk area or contact with a person already diagnosed by PCR [17]. In addition, in Nice, only two hospital sites could perform nasal swabs, one of which was part of the emergency department. As a result of these screening conditions and poor geographical accessibility, the number of cases has probably been greatly underestimated. That is why we chose to describe DR and not incidence rates.

Our analysis was restricted to patients who performed PCR tests at the Nice CHU until March 30. Indeed, from that date onwards, PCR tests were also offered by private laboratories. As we did not have access to these PCR tests performed in the city, we could no longer guarantee that all diagnosed cases had been collected. In hindsight, we believe that a more targeted, sustained screening approach, focusing on specific geographical units and at-risk populations, would have been more effective.

Conclusion

This descriptive study of the first 32 days of the SARS-CoV-2 epidemic in the city of Nice suggests that populations living in the most disadvantaged areas of the city were the most affected, especially after the beginning of the lockdown, although the first cases were diagnosed in non-disadvantaged areas.

Beyond medical risk factors, these populations are exposed to the additional risks related to overcrowded housing in apartments and lower incomes. In such an urban and demographic context, we think that providing facilities acceptable to the population and aiming to isolate infected individuals would contribute to limit the spread of the virus in family settings where there is no possibility of isolating cases.

If the indicators of density, mobility and overcrowding were confirmed on a larger scale, breaking the chain of transmission would require reconsideration of urban planning, allowing for larger living quarters, thus limiting overpopulated households in the most vulnerable areas of the cities.

Mapping socio-demographic vulnerability indicators and their association with Covid-19 incidence rates could usefully guide and define a suitable public health policy both in terms of social measures and of screening or vaccination campaigns.

Supplementary Data

Supplementary data are available at EURPUB online.

Ethical Approval

The database was registered on June 25, 2020 in the International Clinical Trials Register under the number NCT04449094 and locally in the Data protection Agency (CNIL) Register of the Nice University Hospital as an internal study on July 1, 2020.

Data Availability

Clinical data cannot be made publicly available because of privacy issues. However, additional results and aggregated findings are available on reasonable request.

Acknowledgement

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