# COVID-19 VACCINATION IN ROMANIA. A SPATIAL APPROACH

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**Abstract: -** ***COVID-19 vaccination in Romania. A spatial approach.*** The study analyzes the distribution of settlements which benefit of vaccination centers in Romania and evaluates the influence of the distance as a possible factor impacting the share of the vaccinated population. There have been identified six spatial proximity classes (A to F) to the localities that have at least one vaccination centers; the distribution of the localities in relation to these proximity classes is analyzed. The assessment shows that most of the settlements are located in the spatial proximity class of 10 to 20 km, whereas 82% of the localities are positioned in the range of 0 up to 20 km.

**Key-Words**: COVID-19, vaccination, spatial analysis, network, Romania

## Introduction

The issue of vaccinating the population as a measure to reduce and prevent SARS-CoV2 infection has aroused major global interest. With the approval of vaccines, state governments have sought to ensure the highest possible vaccination rate in order to reach a threshold designed to ensure so-called herd immunity (D'Souza G. and Dowdy D., 2021).

It is known that, in general, the vaccination process is influenced by a number of factors, including accessibility (Thomson et. al, 2016), governments being responsible for ensuring equitable access to the COVID-19 vaccine (Lazarus et al., 2020). As it turned out in the first six months of vaccination, the availability of the population towards vaccination was influenced by a number of both motivating and inhibitory factors. The present study addresses the spatial factor as having a certain potential to influence  the population's decision to vaccinate. This factor is analyzed taking into consideration the spatial distribution of the vaccination centers, aiming at identifying the deficient areas in terms of spatial accessibility to the vaccination centers in relation to the network of localities. Needless to say, the distribution of these centers is influenced by a number of factors that can be divided into several categories: intrinsic factors, specific to the medical system (e.g. those related to ensuring the storage conditions of vaccines according to the technical specifications of the manufacturers; existence of health units in the territory; availability of medical staff) as well as external, more numerous; among them, the capacity of local authorities to ensure adequate spaces for specific technical and epidemiological requirements, meant to compensate the poor distribution of health units in the territory (Bilașco et al, 2015) or the technical inadequacy of medical facilities. In addition to what has been previously stated, there are to be included the characteristics of the network of settlements, understood as a spatial matrix on which the network of vaccination centers was embossed, thus outlining from the beginning a series of conditions with a direct effect on the distribution of vaccination centers.

## Methodology

The data used in the study was obtained from public sources, on account of a good dissemination by the Romanian authorities of the information regarding the locations where the vaccination centers were set up. The website https://vaccinare-covid.gov.ro has been specifically used in order to obtain data regarding the location of the vaccination centers as well as the type of vaccine used. Additionally, this information was compared with that existing on the websites of the county public health

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directorates and the prefectures. The stage of setting up the spatial database led up to the creation of a *shp* file which stores information regarding the 833 vaccination centers, distributed in 441 localities (Fig. 1) (264 cities and 177 villages). It needs to be mentioned the fact that the process of creating this database took place between April and June 2021 and along the way successive verifications of the downloaded data were performed. As a result of these verifications it has been identified that some changes occurred in the mentioned interval, changes that can be grouped into two categories:

- spatial changes, coming from the setting up of additional centers (the most common situation) or the abolition of others (less encountered situations)
- changes in the type of vaccine available at the center (the most common situations regarded the conversion of Astra-Zeneca vaccination centers into centers that make available one of the other vaccines approved by the European Medicines Agency).

Under these circumstances, certain differences between the data shown in this study and the up-to-date information can occur due to the constant adjustments made by the authorities. A special mention should be made in regard to the drive-thru vaccination centers: these were set up during the last monitoring period, generally providing the Pfizer vaccine. In these respects it is also worth mentioning that the centers that had a limited operation in time were also taken into account.

The second stage consisted of the analysis of the spatial distribution of the vaccination centers, in the form of a computerized process based on the use of ArcGIS software and the specific work modules it offers.

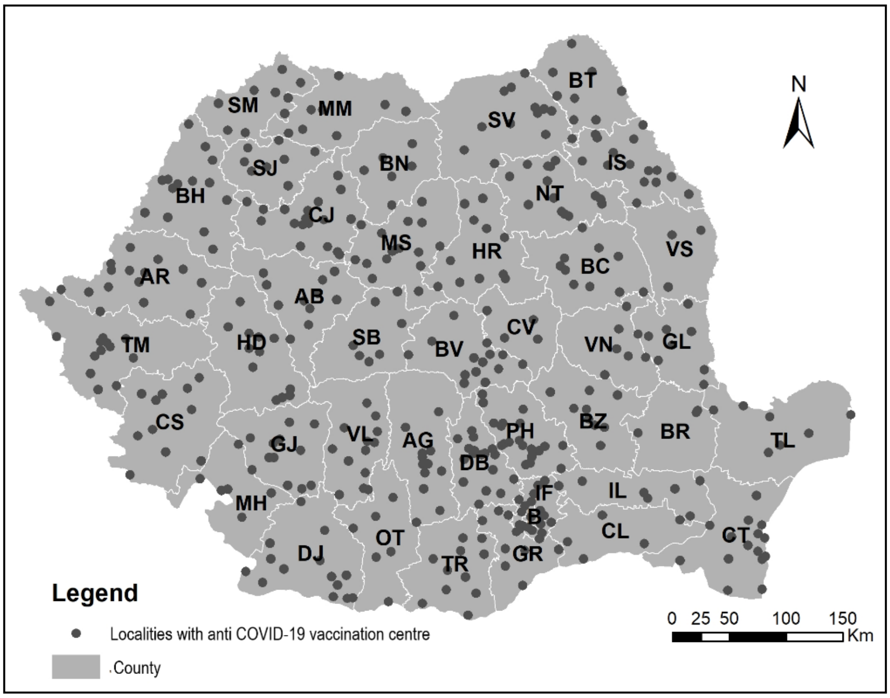


**Fig. 1**. Distribution of localities with COVID-19 vaccination centers in Romania

In particular, the Network Analyst / Service Area tool was used, in which spatial data related to the road network and localities with COVID-19 vaccination centers were integrated. The working procedure also involved the validation of the topology for the road network used in the analysis, in order to ensure compliance with necessary and mandatory conditions for its functionality (there should be no self-overlap situations and no discontinuities of the network) (Bilașco et al., 2017, Imbroane, 2012).

Regarding the problem of network discontinuities, there is a particular situation for the Danube Delta, where portions of the network are partially unintegrated to the national level. In these conditions there was only one point in the specific category *Facilities* (localities with vaccination centers) in the *unlocated* situation - associated with the city of Sulina. The area related to the central and eastern part of the Delta, where the road network is irrelevant both quantitatively but especially functionally, was removed from the overall analysis (Fig. 2), which involved the elimination of a number of 15 settlements (of which 1 city - Sulina) out of a total of 13,750 existing at national level.

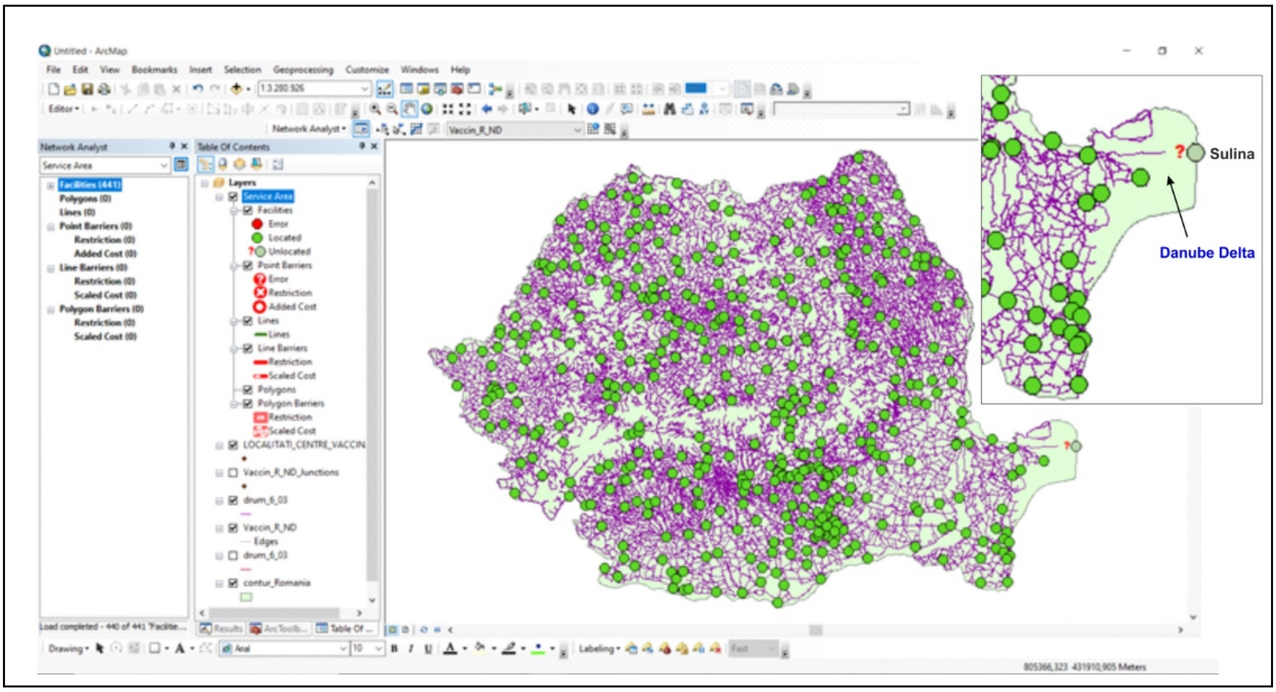


**Fig. 2** Position of the area associated with the *unlocated* point situation (Sulina) within the *Facilities* component related to the road network used in the analysis

The analyzed territory was approached in order to identify the areas located at variable distances from the localities with COVID-19 vaccination centers. For this purpose, six distance threshold values were set in the working algorithm: 5 km, 10 km, 20 km, 30 km, 50 km and 70 km, based on which the spatial proximity classes resulted. The distribution of localities within the spatial proximity classes was assessed by overlaying a point type layer with the localities on the polygon type layer that contains spatial proximity classes.

Additionally, the information obtained in the second stage of the analysis was correlated with the situation of the share of the vaccinated population at the level of LAU on May 26, 2021.

## Results and discussions

Following the spatial analysis, the areas related to the six classes (*A* to *F*) of spatial proximity were identified (fig. 3), for which the characteristic surfaces and their share were calculated (Fig. 4. a).

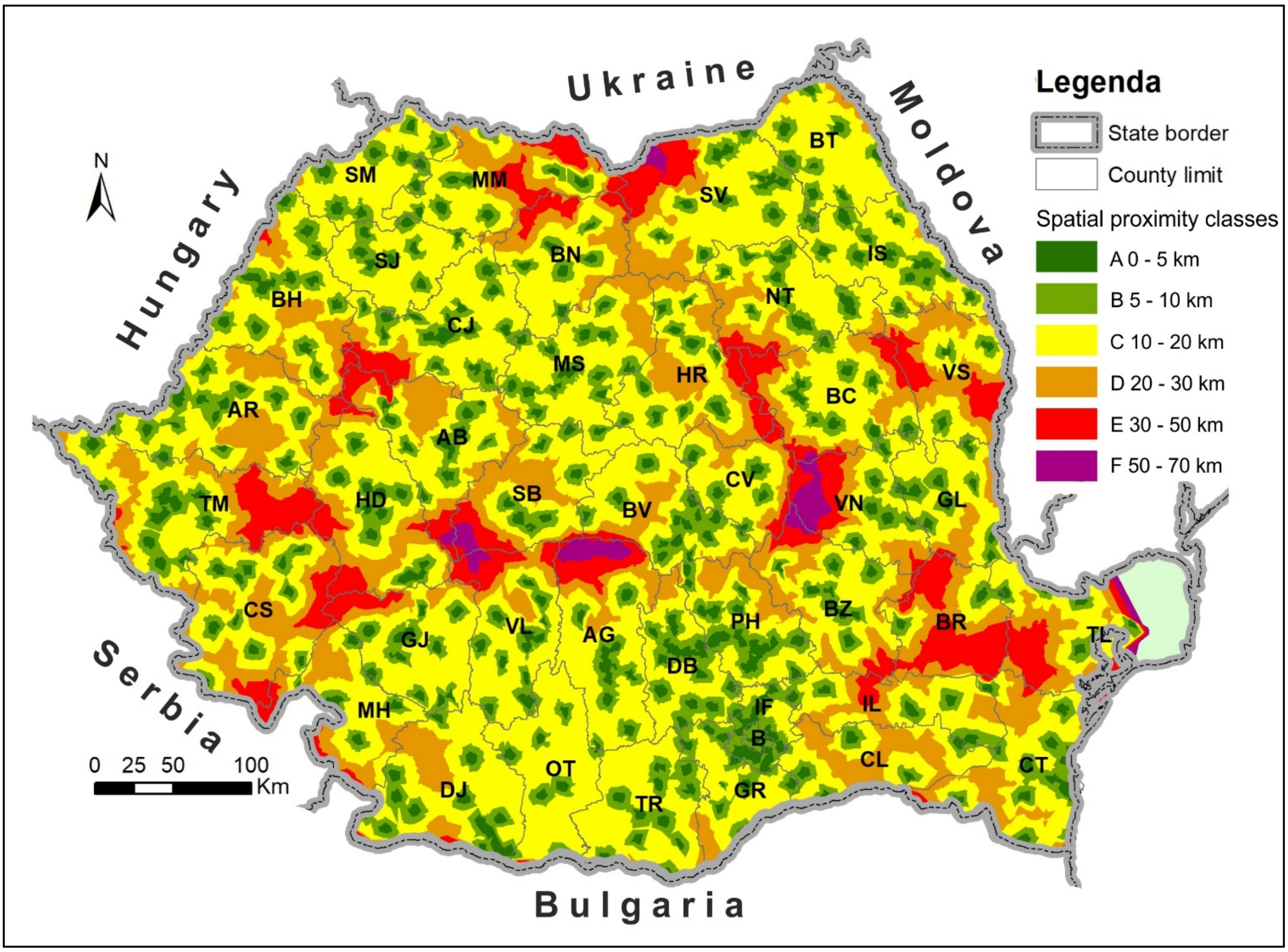


**Fig. 3** Spatial proximity classes related to the settlements with COVID-19 vaccination centers in Romania

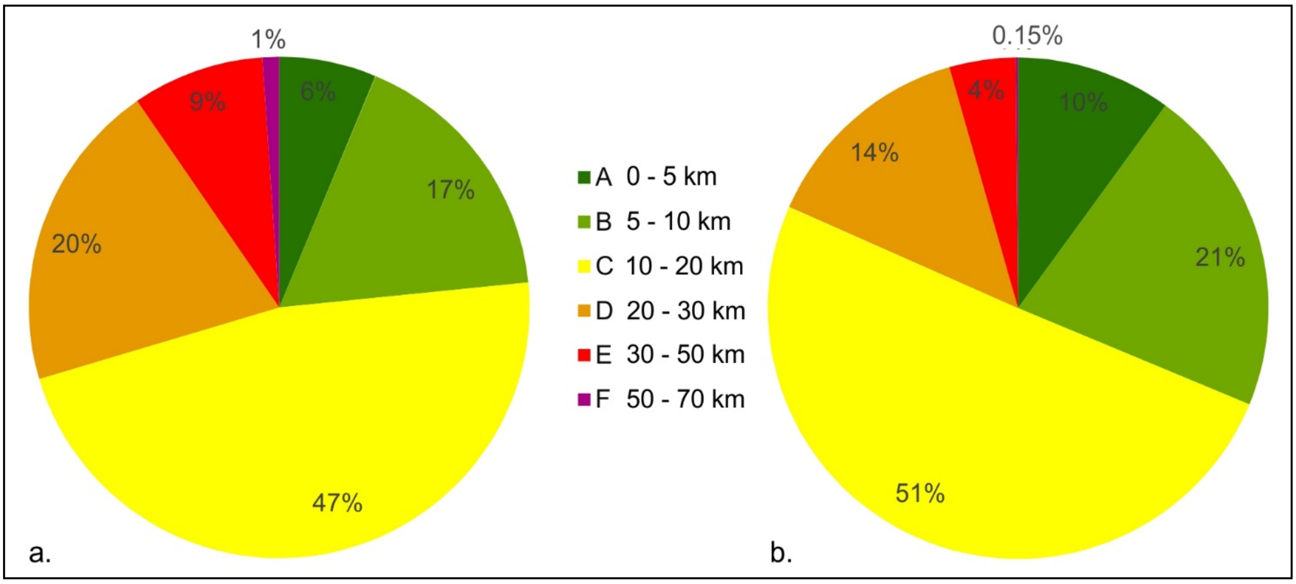


**Fig. 4 a**. The share of the surface of the spatial proximity classes; **b**. The share of the number of settlements positioned in the spatial proximity classes

It was concluded that most of the analyzed territory (47%) is located at a distance between 10 and 20 km from localities with vaccination centers. With approximately equal shares are the areas located at a distance of 20 up to 30 km (20%) and 5 to 10 km (17%), thus generating the situation in which 84% of the analyzed territory is located at a distance of less than 30 km from localities where there is at least one vaccination center.

Areas located at a greater distance have a low share: 9% for the range 30-50 km and 1% for the *F* spatial proximity class (50-70 km). The areas of these last two value classes have an insular location and are usually present in the mountain areas, where the number of localities is smaller. A particular situation is present in several counties (eg. Brăila, Ialomița, Tulcea, Vaslui) as a result of the merging of two main factors: the configuration of the road network and the particular distribution (more distant) of the localities with vaccination centers.

***Tabel 1***.
*Percentage of settlements with a share of the vaccinated population below 5% within the spatial proximity classes*

| Proximity class | The share of localities (%) |
|---|---|
| A (0 – 5 km) | 1,39 |
| B (5-10 km) | 8,52 |
| C (10 – 20 km) | 48,79 |
| D (20 – 30 km) | 25,07 |
| E (30 – 50 km) | 15,27 |
| F (50 – 700 km) | 0,96 |

As far as the distribution of the localities among the proximity classes is concerned, the following observations have been made: 51% of the settlements are positioned in the *C* proximity class (10-20 km) and cumulatively, 96% of the localities present in the analyzed territory (13,127 localities) are located within the first classes (*A-D* / 0-30 km); in the last two proximity classes (*E, F* / 30-70 km) are to be found 4.15%, i.e. 608 localities, of which only 0.15% (i.e. 21) are positioned in the lower proximity class (*F* / 50-70 km ) (fig. 4. b.).

Regarding the share of the vaccinated population at LAU level, the preliminary analysis shows that those with a share of less than 5% have a position that does not suggest a direct influence of the distance from the vaccination centers, given that 60% of them are positioned at distances of less than 20 km from localities with vaccination centers. Thus, on May 26, 2021, out of the 1867 localities included in the LAUs with a vaccinated population share below 5%, almost half were positioned in the class *C* of spatial proximity (10-20 km), about 10% were positioned in *A* and *B* proximity classes (0-10 km), about 40% were positioned in classes *D* and *E* (20-50 km), and less than 1% were positioned in *F* proximity class (50-70 km).

## Conclusions

The analysis shows that the localities with vaccination centers have a fairly good distribution in relation to the localities in the national territory, these being placed at distances that do not pose particular problems of accessibility.

The effort of the authorities to ensure equitable access to COVID-19 vaccination centers can be supported by conducting studies to indicate deficient areas in order to identify the best solutions from the perspective of the epidemiological objective - herd immunity.

Reaching a high percentage of vaccinated people as soon as possible can also be influenced by the accessibility of the population to vaccination centers, further validation studies being appropriate to establish a possible correlation between the spatial factor and the share of the vaccinated population.

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