



Persistent Population Disparities in Algeria (1977–2019): A Lorenz Curve and Gini Coefficient Analysis of Territorial Development

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Abstract:

The geographical distribution of the population is a key indicator for understanding the nature of spatial organization and the degree of balance among regions within a country. In this context, this study aims to analyze the evolution of population distribution in Algeria during the period from 1977 to 2019, using a quantitative approach based on the Lorenz curve and the Gini coefficient to measure the degree of spatial inequality. The study relied on official statistical data at the provincial level, where cumulative percentages of population and area were used as the basis for constructing analytical indicators and representing them graphically. The methodology involves processing the data in ascending order of geographic units, allowing for the identification of patterns of concentration and disparity in population distribution over time and linking them to the characteristics of the national territory. The study also seeks to highlight the multiple dimensions of spatial imbalance by analyzing its demographic, economic, social, and environmental implications within a framework that integrates quantitative measurement with spatial interpretation. This study aims to: measure the degree of spatial imbalance in population distribution using standardized quantitative indicators, analyze the implications of this distribution for spatial development trajectories, and explore the potential for developing a strategic approach to restoring regional balance within the framework of sustainable development. This study derives its significance from its contribution to enhancing the quantitative understanding of spatial imbalances and supporting public policy orientations aimed at achieving greater spatial equity and economic efficiency.

1. Introduction

The geographical distribution of the population is one of the key indicators for understanding the spatial structure of countries, as it reflects the nature of the relationship between people and their environment, and provides insight into the degree of balance or imbalance between regions. This indicator has received widespread attention in geographical and demographic studies, given its close link to the organisation of economic and social activities and the direction of development pathways. The more balanced the distribution of the population, the more it contributes to regional integration and more harmonious development, whereas excessive concentration leads to multidimensional imbalances [1], such as deepening

spatial disparities and creating uneven pressures on resources and infrastructure.

However, reality shows that population distribution is often characterised by uneven patterns, with population density tending to concentrate in areas where natural and economic attractions are present, as opposed to areas with low attractiveness that suffer from environmental constraints or a lack of facilities and services. This issue is particularly evident in Algeria, which covers an area of approximately 2.38 million km², where a highly contrasting spatial structure is evident, combining a densely populated northern coastal strip, transitional inland areas, and a vast, sparsely populated desert region. This pattern of distribution is linked to a complex interplay between natural determinants (such as climate, soil fertility and the availability of

water resources), historical factors (particularly patterns of urbanisation during the colonial period), and more recent economic factors that enhance the attractiveness of coastal regions (concentration of productive and service activities) [2].

In this context, the scope of the study covers the entire Algerian national territory, with the spatial division organised into three main regions: the northern coastal region, the high plateau region, and the desert region. This division reflects clear variations in natural and economic characteristics, making it a suitable framework for analysing and interpreting patterns of population distribution. The aim of incorporating this spatial dimension is to link quantitative indicators to the reality of the territory, thereby allowing for a deeper understanding of the dynamics of population concentration.

To analyse this imbalance scientifically, this study relies on quantitative analytical tools, foremost among which are the Lorenz curve and the Gini coefficient, as they are among the most prominent indicators used to measure the degree of inequality in the distribution of geographical phenomena. On this basis, the study seeks to answer the following questions: To what extent does the distribution of the population in Algeria reflect spatial imbalance? How has this imbalance evolved over time? And what are its implications for spatial development trajectories? This study forms part of an analytical approach that seeks to link quantitative measurement with spatial interpretation, thereby contributing to a deeper understanding of regional imbalances and providing a scientific basis to support regional planning policies and achieve greater spatial balance within the framework of sustainable development.

2. Material and Methods

The study adopts a quantitative-spatial approach that combines theoretical grounding with statistical measurement tools, with the aim of analysing patterns of population distribution and measuring the degree of imbalance between regions. The study relies on the use of the Lorenz curve and the Gini coefficient to measure the degree of inequality in population distribution, both of which are statistical tools used in the analysis of spatial disparities [3] [13]. The conceptual framework is based on the definition of the geographical distribution of the population as a pattern of population distribution within a given area according to specific administrative units, a pattern that is shaped by a and avoiding the issue of statistical series heterogeneity resulting from the 2019 administrative reorganisation, which increased the number of wilayas to 58, making the reconstruction of

complex interaction between natural determinants (climate, topography, water resources) [4] and economic and social factors (employment opportunities, infrastructure, services).

2.1 Courbe Lorenz

Within this framework, the Lorenz curve has been adopted as a key analytical tool for measuring spatial inequality, as it compares the cumulative proportions of geographical units[5] (area) with the cumulative proportions of the population. It is represented graphically by comparing the line of perfect equality (45° angle) [6] with the actual distribution curve, allowing the degree of deviation from the ideal equilibrium to be determined; the closer the curve is to the line of equality, the more balanced the distribution, whilst a greater distance indicates a higher level of inequality. Then, calculate the cumulative percentages for both area and population

2.2 Gini index :

This analysis is linked to a complementary quantitative indicator, the Gini coefficient, which measures the degree of inequality based on the area between the Lorenz curve and the line of equality. Its value ranges from zero (equal distribution) [7] to one (absolute inequality). This index has been calculated using a cumulative formula that utilises the differences between successive values of the cumulative proportions for both area and population, thereby ensuring the accuracy of the measurement and the verifiability of the results.

Finally, the Gini coefficient is estimated based on the values calculated according to the following formula:

$$G = 1 - \sum_{i=1}^n (X_i - X_{i-1})(Y_i + Y_{i-1})$$

where X represents the cumulative percentage of area, Y represents the cumulative percentage of population, and n represents the number of states

2.3 Data sources:

With regard to data sources, the study relied on official statistical data published by the National Statistics Office of Algeria, including the results of the general population and housing censuses for 1977 and 1998, as well as estimates for 2019. The administrative division of 1984 (48 wilayas) [8] was adopted as a standard reference for the analysis, with the aim of ensuring comparability over time historical data according to the new boundaries complex and methodologically inaccurate.

With regard to quantitative processing, Excel was used to organise and analyse the data according to a series of methodological steps, which included

ranking the states in ascending order by area as a reference unit for spatial analysis, [9]

2.4 Thematic maps

Thematic maps (heat maps) were also used to identify population clusters and to enhance the spatial interpretation of the quantitative results.

This methodology allows for the construction of an integrated analytical framework that combines quantitative measurement with geographical interpretation, thereby ensuring the accuracy and verifiability of the results, whilst enhancing understanding of the dynamics of spatial variation in population distribution. [10]

3. Results and Discussions:

This section aims to measure the degree of imbalance in the geographical distribution of the population in Algeria using quantitative analytical tools, in particular the Lorenz curve and the Gini coefficient, through a spatiotemporal approach that enables an assessment of the nature and persistence of this disparity.

3.1 Analysis of the Lorenz Curve

Based on official statistical data for 2019, the states were ranked in ascending order by area, and then cumulative percentages were calculated for both area and population, enabling the construction of a Lorenz curve in accordance with standard methodology. [11]

The graph of these values (Figure 1) shows a sharp deviation of the Lorenz curve from the line of perfect equality (45°), reflecting a very high degree of population concentration.

The results reveal a clear structural imbalance, with a small proportion of the territory (4%) accounting for nearly two-thirds of the population (65%), whilst the desert regions, despite their vast extent (84%), are home to only a marginal proportion (7%).

This pattern is not limited to 2019; it is confirmed by a comparison with the years 1977 and 1998, where the Lorenz curves show a high degree of similarity. This indicates that the shape of the distribution has remained stable and that the same spatial structure has persisted without any fundamental shifts, despite the demographic and economic changes recorded during this period. [12]

3.2 Estimation of the Gini Coefficient

- The Gini coefficient was estimated based on cumulative values for area and population, and the figures were as follows:
 - 1977: 0.90 - 1998: 0.89 - 2019: 0.88

These reflect an extremely high level of spatial inequality, far exceeding internationally recognised reference thresholds (0.40–0.50), which underscores the severity of the imbalance in population distribution. [14] though a slight downward trend has been recorded over time, this improvement remains statistically limited and insufficient to indicate a structural shift in the distribution pattern, reflecting instead a marginal adjustment within the same unbalanced structure.

Table 1 : Spatial distribution of the population

Population growth	Accumulation (area)	Percentage of the population (%)	Percentage of area (%)	Number of provinces	Category
65	4	65	4	27	North (high density)
93	16	28	12	13	High plateaus Average
100	100	7	84	08	The South (low population density)

3.3 Geographical distribution of the population:

3.3.1 2008 census:

Table 02 : Population distribution and density in 2008

Ranking	Province	Population	Density
1	Alger	2231215	3666.4
2	Setif	1067458	229.1
3	Oran	1067015	685.6
4	Tizi-Ouzou	894798	316
5	Batna	791322	91.9
6	Blida	723042	636
7	Chlef	714923	209
8	Bejaia	705900	279.3
9	Tlemcen	702844	104.8
10	Constantine	697479	429.1

11	Djelfa	688171	16.4
12	M'Sila	672526	52.9
13	Skikda	661377	223.2
14	Tiaret	594491	41
15	Medea	593264	92.5
16	Boumerdes	592089	539
17	Mascara	562266	132
18	Mila	551188	81.8
19	Ain Defla	545827	156.6
20	Mostaganem	531564	338.9
21	Relizane	523984	149.1
22	Bouira	515461	156.7
23	Biskra	485301	34.4
24	Jijel	465822	247.2
25	Annaba	465286	423.6

26	<i>Tebessa</i>	<i>459013</i>	45.6
27	<i>Sidi Bel Abbas</i>	<i>448210</i>	66.5
28	<i>B. Bou Arreridj</i>	<i>446701</i>	152.7
29	<i>Oum El Bouaghi</i>	<i>442726</i>	91.6
30	<i>Tipaza</i>	<i>431246</i>	320.2
31	<i>El Oued</i>	<i>410232</i>	11.9
32	<i>Ouargla</i>	<i>364841</i>	2.6
33	<i>Guelma</i>	<i>361160</i>	117.6
34	<i>Souk Ahras</i>	<i>321462</i>	96.5
35	<i>El Tarf</i>	<i>305873</i>	122.3
36	<i>Laghouat</i>	<i>302002</i>	18.2
37	<i>Ain Temouchent</i>	<i>275947</i>	156.1
38	<i>Khenchela</i>	<i>271695</i>	39.4
39	<i>Adrar</i>	<i>262627</i>	0.9
40	<i>Saida</i>	<i>240090</i>	48.9
41	<i>Ghardaia</i>	<i>238687</i>	4.2
42	<i>Tissemilt</i>	<i>211248</i>	93.4
43	<i>Bechar</i>	<i>190985</i>	1.7
44	<i>El Bayadh</i>	<i>154133</i>	2.9
45	<i>Naama</i>	<i>133590</i>	6.4
46	<i>Tamanrasset</i>	<i>110154</i>	0.3
47	<i>Illizi</i>	<i>32992</i>	0.2
48	<i>Tindouf</i>	<i>32762</i>	0.3
Total		24492989	

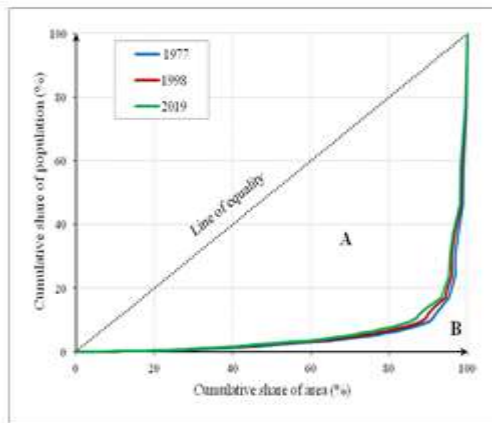


Figure 1: Evolution of the Lorenz Curve for Population Distribution in Algeria (1977-2019)

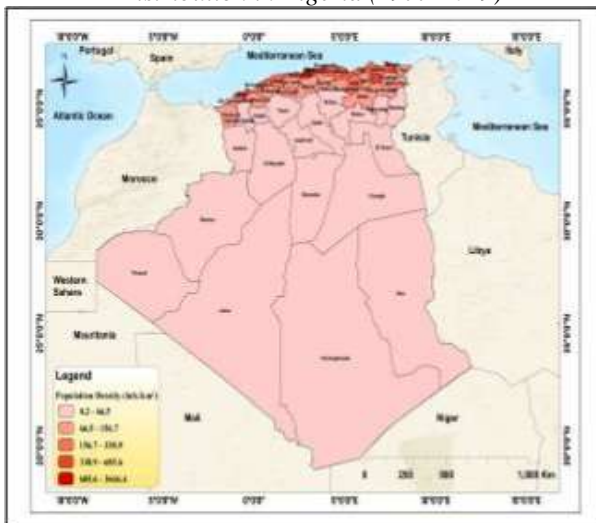


Figure 2: Population density by province in 2008

Table (02) and Figure 2 presents a detailed demographic analysis of Algeria’s 48 wilayas (provinces), ranked by population size. It highlights striking disparities in terms of spatial distribution and population density.

1. The overwhelming dominance of Algiers
The first observation is the dominant position of the capital, Algiers. With over 2.2 million inhabitants, it is the only wilaya to exceed the 2 million mark. Even more impressive is its density (3,666.4 inhabitants per km²), which is incomparable to the rest of the country. This reflects a hyper-centralisation of economic, administrative and social activities.

2. The demographic weight of the North and the High Plateaus

The ‘top 10’ reveals the importance of the urban and agricultural centres in the North:

Sétif (2nd) and Oran (3rd) exceed the one-million-inhabitant mark.

Wilayas such as Tizi-Ouzou, Blida and Constantine have high population densities (between 300 and 640 inhabitants per km²), characteristic of the Algerian coast and the Tell region, where human concentration has a long history.

3. The paradox of the vast expanses (the South and the High Plains).The table perfectly illustrates the ‘diagonal of emptiness’ or, at the very least, the contrast between land area and population density:Djelfa (11th) and M’Sila (12th) have large populations (over 670,000 inhabitants) but relatively low densities (16.4 and 52.9 respectively), indicating vast steppe territories.

4. The desert fringes
The bottom of the ranking (wilayas 46 to 48: Tamanrasset, Illizi, Tindouf) comprises the largest Saharan territories. Although strategic, these areas are characterised by:

Negligible population densities (0.2 to 0.3 inhabitants per km²), highlighting the vastness of the desert where human settlement is essentially limited to oases and industrial or military centres.

land-use planning and the opening up of these areas. The difference in population density between Algiers (3,666.4) and Illizi (0.2) alone sums up the challenge of achieving territorial balance in Algeria.

3.3.2 Estimate for 2019:

Table 3 : Population distribution and density in 2019

Ranking	Province	Population	Area	Density
1	Algeria	3282979	809	4058.1
2	Oran	2118603	2121	998.9
3	Setif	1866845	6504	287.0
4	Djelfa	1508535	66415	22.7
5	Batna	1377000	12192	112.9
6	Chlef	1356151	4791	283.1

7	Blida	1348674	1478	912.5
8	M'Sila	1336958	18718	71.4
9	Constantine	1291579	2187	590.6
10	Tizi Ouzou	1198561	2958	405.2
11	Tlemcen	1101383	9061	121.6
12	Skikda	1095666	4026	272.1
13	Tiaret	1062656	20673	51.4
14	Medea	1062134	8866	119.8
15	Mila	991493	9375	105.8
16	Bejaia	984050	3268	301.1
17	Boumerdes	960315	1591	603.6
18	Relizane	959958	4870	197.1
19	Mascara	955230	5941	160.8
20	Biskra	951981	21510	44.3
21	Ain Defla	912798	4897	186.4
22	El Oued	900000	54573	16.5
23	Mostaganem	892165	2175	410.2
24	Bouira	842207	4439	189.7
25	Annaba	793172	1439	551.2
26	Jijel	789667	2577	306.4
27	Oum El	782188	7638	102.4
28	Tebessa	781247	14227	54.9
29	B.B. Arreridj	730703	4115	177.6
30	Sidi Bel Abbès	713377	9150	78.0
31	Ouargla	708463	211980	3.3
32	Tipaza	706054	2166	326.0
33	Laghouat	686160	25057	27.4
34	Guelma	543552	4101	132.5
35	Souk Ahras	533120	4541	117.4
36	Adrar	528000	427368	1.2
37	El Tarf	481136	3339	144.1
38	Ghardaïa	477953	86105	5.6
39	Khenchela	469510	9811	47.9
40	Aïn	432353	2379	181.7
41	Saïda	406893	6764	60.2
42	Tissemsilt	362229	3152	114.9
43	Béchar	353591	162200	2.2
44	El Bayadh	341665	78870	4.3
45	Naâma	289045	29950	9.7
46	Tamanrasset	245256	557906	0.4
47	Tindouf	97578	159000	0.6
48	Illizi	75770	284618	0.3
Total		42686603	2371891	

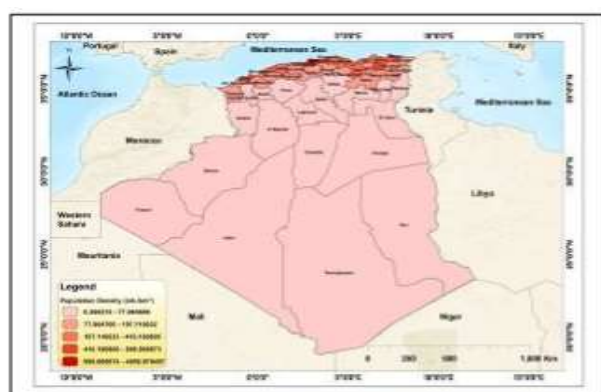


Figure 3: Population density by province 2019

According to Figure 03 and Table 03, we can see that:

1. Algiers is the most populous city, with a population of over 3.2 million, and is situated along the coast, stretching over 809 km². It has a record population density of 4,058.1 inhabitants per km². Secondary centres: Oran (2nd) and Constantine (9th) confirm their role as regional metropolises with high population densities (998.9 and 590.6 respectively), reflecting the attractiveness of coastal and northern urban areas.

2. The significance of the High Plateaus Provinces such as Setif (3rd), Djelfa (4th) and Batna (5th) occupy the top of the rankings. Setif stands out with a massive population of 1.8 million inhabitants. Djelfa is an interesting case: it is the first wilaya in the ranking to have a very large area (66,415 km²), which brings its density down to just 22.7 inhabitants per km² despite a large population. This illustrates the transition towards steppe zones.

3. The vastness of the Sahara: The population/space paradox. The lower half of the table (from 31st to 48th place) reveals the geographical reality of southern Algeria: Enormous areas: Tamanrasset and Adrar cover immense territories, far larger than many European countries. Densities close to zero. Despite this vastness, wilayas such as Ouargla and El Oued maintain significant populations (over 700,000 inhabitants) thanks to the oil industry and Saharan agriculture. Summary The data in the table highlight an Algeria with two faces, characterised by a relative lack of population and populations concentrated in specific centres. 2019 figures, illustrating continuous growth since the last official census in 2008.

From an interpretative perspective, these findings suggest that population distribution in Algeria is not solely determined by circumstantial factors, but is linked to a relatively stable spatial structure, manifested in the concentration of people and economic activities in the northern strip, in contrast to the low demographic attractiveness of the inland and desert regions.

3.4 Discussion

In light of the quantitative findings, it is evident that the geographical distribution of the population in Algeria reflects a structural spatial imbalance rather than merely a circumstantial disparity. The high values of the Gini coefficient, which remained between 0.88 and 0.90 during the period 1977–2019, indicate a high degree of population concentration, a finding further confirmed by the position of the Lorenz curve, which deviates clearly from the line of perfect equality. This conclusion is reinforced by the close convergence of the time series, as well as their consistency with historical data (1987), indicating

the persistence of the same spatial pattern and the difficulty of changing it in the short term [15].

This imbalance is linked to a complex interplay between natural determinants, primarily the concentration of water resources and fertile agricultural land in the north, and historical factors stemming from development patterns during the colonial era that cemented coastal concentration, as well as recent economic dynamics that have enhanced the attractiveness of northern regions through the concentration of investment, infrastructure and services. Despite public policies aimed at achieving regional balance, the study's findings suggest that their impact has remained limited, as they have not led to a structural shift in the distribution pattern, but have merely resulted in a relative alleviation of the imbalance.

An analysis of spatial disparities confirms that this pattern is clearly reflected in the dominance of the coastal strip (Figure 02), which accounts for around 65% of the population within just 4% of the total area, compared with the low population density in the Saharan region, which represents around 84% of the total area but attracts only 7% of the population, whilst the high plateaus occupy an intermediate position in terms of demographic and economic characteristics.

This disparity is reflected in the concentration of economic activities and productive enterprises in the north, in contrast to the limited exploitation of available potential in other regions, despite their abundance of natural resources.

The repercussions of this imbalance are also evident across various dimensions of development, as population concentration leads to increased internal migration towards coastal cities, accelerated unbalanced urban expansion, and rising pressure on infrastructure and services, whilst economic dynamics in the inland and southern regions remain weak. This results in a deepening of social and spatial disparities, alongside increasing environmental pressures on natural resources in the north, particularly water and agricultural land.

3.4.1 Addressing regional imbalances in Algeria:

In this context, the Algerian situation parallels a number of international experiences that have faced similar regional imbalances. Regional balance policies in France have shown that reducing disparities involves developing alternative urban centres with clear productive functions and linking them to efficient transport networks [16], whilst the Brazilian experience has demonstrated the limitations of establishing administrative centres isolated from actual economic dynamics. China's experience also confirms that investment in infrastructure, despite its importance, remains

insufficient in the absence of local production chains capable of creating jobs [17], whilst the experiences of arid-climate countries highlight the importance of employing technology and intensive investment to make desert regions more attractive. (Saudi Arabia) [18]

On this basis, it is clear that addressing regional imbalances in Algeria should not aim to achieve a theoretically equal distribution of the population, but rather requires the reorganisation of economic functions between regions within an integrated approach (Figure 03). This approach is based on the development of specialised regional hubs within an interconnected national network, whereby the north retains its leadership and innovation functions, the high plateaus reinforce their role as a space for agro-industrial production, whilst the south is valued as an energy and logistics hub open to the African hinterland. Supporting this approach by improving multimodal connectivity and channelling investment towards production chains suited to regional specificities will help create sustainable development dynamics and gradually and functionally reorient population distribution.



Figure 3 : Achieving a sustainable spatial balance within the framework of a long-term strategic vision

Consequently, achieving a sustainable spatial balance remains contingent upon the adoption of a long-term strategic vision that is based on inter-regional integration, takes account of environmental and economic specificities, and reconciles the requirements of economic efficiency with the principles of spatial justice.

4. Conclusions

An analysis of the demographic distribution in Algeria over more than four decades highlights a persistent spatial imbalance. Although the country has undergone major socio-economic changes, its territorial structure remains characterised by a profound duality between a hyper-densified

coastline and a steppe and Saharan hinterland in need of revitalisation.

The use of spatial economics tools notably the Lorenz curve and the Gini index has enabled a shift from an empirical observation to a rigorous statistical demonstration. The high Gini index confirms an unequal distribution: the population is concentrated in the northern fringe (around 4% of the territory), reflecting the legacy of natural constraints (climate, terrain) but also of historical economic choices favouring centralisation. The Lorenz curve, by its deviation from the line of equal distribution, graphically illustrates this imbalance, where a tiny portion of the national territory bears almost the entire demographic burden.

The study highlights a major paradox: despite the numerous national spatial development plans [19] and massive public investment aimed at ‘opening up’ the regions, the impact on the underlying structure of population distribution has remained marginal. Regional rebalancing policies have failed to reverse the pull of the urban centres in the North. This observation suggests that population displacement cannot be imposed; it must be the result of genuine and functional attractiveness.

To break this pattern of concentration, the study recommends a paradigm shift in territorial governance:

- Functional redistribution: Relocate not only infrastructure, but above all command functions and high-level services to the Highlands and the South.
- Interregional integration: Move away from the logic of isolated zones to create development corridors that facilitate the flow of goods and people between the country’s different geographical regions.

- Local productive dynamics: Encourage investment based on regional specificities (renewable energy, Saharan agriculture, tourism, mining) to anchor populations through employment.

This work provides a basis for future research that could enhance our understanding of Algeria’s territorial complexity:

- The multi-indicator approach: Cross-referencing demographic data with indicators of health, education and wealth (regional GDP) to provide a multidimensional view of disparities.

- The shift in scale: Moving from a national analysis to a micro-territorial analysis (municipalities) to identify ‘pockets’ of development within disadvantaged regions themselves.

- Prospective simulation: Using Geographic Information Systems (GIS) and artificial intelligence to model future development scenarios and anticipate spatial changes by 2050.

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- **Ethical approval:** The conducted research is not related to either human or animal use.
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