STRUCTURAL HEALTH INEQUALITIES
AND TERRITORIAL DISPARITIES:
DRIVERS OF HEALTHCARE MIGRATION

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Abstract. Health-induced mobility is also tied to the distribution and availability of health care resources according to the regions and there is a balance between the supply and demand. Equity in access requires one to know the health profiles and needs of the population, so everyone gets an appropriate level of health treatment. The present study examines regional differences in the use of healthcare in Italy, particularly Medically Assisted Reproduction (MAR). Although, there has been improvement in MAR technologies, there are still inadequate public and private MAR centres in some places, and so many individuals must travel to undertake their treatments abroad as result of inequalities in service provision and regional policies. There is substantial financial burden on couples related to MAR, as travel, lodging and other costs can limit access, especially for those of lower income. To analyse these patterns in patient mobility, we utilise a finite mixture model using clustering techniques, which are widely used to analyse the population data. Results show that locally smooth General Mixture Models together with a normalised spectral cut-off criterion are good for clustering MAR related data. Notably, the migration toward Northern Italy is due to a larger presence of private centres, where generally more patients than public and/or accredited centres are treated. This seems to be shaped by rising demand for higher quality services and a strong preference for services from the private sector. These findings underscore the essential requirement for policy intervention to mitigate health access disparities and strengthen the resilience of health systems. District by district analysis of healthcare infrastructure is also essential in informing efforts to address this inequity in access to MAR services across the nation, and this inequity in the provision of MAR services has profound implications for both the reproductive rights of the individual, and broader demographic and socio-economic stability.

1. Introduction

The flows of health migration in Italy is increasing. Annual shifts remained below 1.2 million until the late 1990s, but since 2004, 1.3 million-plus has become routine. One turning point was in 2012, when the administrative procedures of registration of dwelling changes improved leading internal migration to exceed 1.5 million (Bonifazi et al., 2017; 2020). After a brief fall, migration has continued at well over 1.4 million, except for 2020, a pace that is 30% higher than in the 1990s. Patients

migrate in search of oncological, cardiac, transplant, and health treatment. However, the understanding of the relationship between sexual and reproductive health and migration is still fragmented, even if research has expanded to include rights, gender equality and socio-economic constraints (Alarcão et al., 2019). Needs of different populations have not been easily addressed.

The number of Medically Assisted Reproduction (MAR) enquiries for treatment has increased over the last 40 years. Delayed childbearing has elevated infertility in low-fertility societies and represents a challenge to public health systems as MAR has gained demographic and socio-economic relevance. Fertility rates remain low in Italy, too, yet there are fewer potential parents. MAR treatments have nearly doubled from 2005 and represent 4.25% of births in 2022. Estimated prevalence of using MAR was 3% (as a proportion of all 'births') and 13% amongst women aged 40 years and older from the 2021 SSN publication, reflecting healthcare, financial and social influences (3% for total fertility).

Public health in Italy is increasingly unable to guarantee equal access: the increase in private health out-of-pocket payments affects intentions regarding fertility, reproductive rights as well as public health. Unequal access to healthcare creates demand for migration in the health sector in response to the way in which the LEA is implemented. There are many public and private MAR centres in Lombardia and Toscana whereas few in the South, despite the large demand of health care. The present study analyses the domestic health migration related to MAR, and its goal is to provide an input to regional-based policies on access issues and demographic consequences of post-poned parenthood.

2. Public vs. Private MAR in Italy

A profound multifaceted gap of MAR services in quality and quantity, technological level, and regional coverage is recorded between public or accredited and private centres in Italy. Public and accredited centres are embedded in the Italian National Health System (SSN) in a model regulated by Law No. 40/2004 and by Ministerial Decree on Essential Levels of Assistance (LEA). Differences among regional autonomy lead to substantial differences in the availability of resources, publicly funded cycles, and reimbursement rates. Public centres follow budget limitations and prioritisation rules which are sometimes translated in the existence of waiting lists, in restricted reimbursed cycles and in reimbursement fees. Since the fees often do not cover the effective treatment costs, in turn they are not favourable to investments in high-end technologies and new treatment options.

The private MAR centres are legally and ethically regulated but are not under the direct financial regulation of the SSN and sustained largely by OP or private

insurance coverage. This allows private centres to offer more cycles, to decrease waiting times, to nest cycle types and personal treatment as well as providing technologies not available in public centres and also higher reported pregnancy rates, (although comparison continues to be complex, with variations in patient profiles and selection criteria). Many patients go to private centres looking for alternate therapies or certain high-tech procedures that may not be available in the public sector, so private health market is always increases.

The geography of MAR service provision the spatial coverage of MAR services is extremely uneven. Most high-volume centres are in Northern regions (Lombardia, Emilia-Romagna, Toscana), whereas most southern regions are characterised by scarce availability of certified centres, leading in turn to considerable health-migration. Patients commonly travel north for increased success rates, at a significant financial, emotional and logistical cost – and where socio-economic inequalities only compound access inequalities particularly disadvantaging poorer women. National harmonization Attempts such as the 2019 National Commission for updating the LEA notwithstanding, regional autonomy impedes national harmonization of MAR services. Effective policy interventions should target against the segregation of parallel private funding, the misalignment between tariffs and actual unit costs, the under investment in technology, the insufficiently clear data reporting, and the absence of a national benchmark to be used to constraint the pressure for quality driven solely by the market by avoiding the consolidation of a dual system that endangers equity of access to assisted reproductive technology services and demographic sustainability in Italy.

3. Research hypothesis

This paper explores the dynamics of intra-national mobility due to MAR procedures across Italian regions and focuses also on the role that geographic disparities and socio-economic issues play in influencing such dynamics. In addition to the total volume of MAR centres throughout the country, the inequalities of health-services at the regional level have a significant impact on the migration for healthcare in general and in the case of (non-resident) patients who seek fertility treatment outside their region of residence.

By accessibility data from the Italian National Registry, an unequal distribution of MAR centres is evident, largely concentrated in Northern and Central Italy with a significant decrease in the Southern areas. This geographic inequality generates substantial flows of health-related migration, as couples resident in the South must frequently travel to Northern centres. These movements are not only due to the lack

of the centres, but they also express perceptions of quality and success emphasised by social and economic discrimination that restricts access to poorer people.

Consistent with research objectives, the present analysis intends to: (i) measure socio-economic inequalities related to the territorial distribution of MAR services; (ii) evaluate migration flows for MAR treatments, specifically non-residents who have received procedures away from their home regions; (iii) investigate regional disparities in the supply of the Essential Levels of Assistance (LEA), a set of services aimed at ensuring equal access to reproductive treatment; and (iv) drive political actions to mitigate the consequences of postponed fertility and to assure homogeneous access of MAR treatment throughout the country. To study these 2 specific research questions, the analysis explores 2 primary points: *Q1*) the total, cumulative volume of MAR is much higher in the central and northern regions, due to both higher infrastructural capacity and demand; *Q2*) the mean volume of cycles *per* woman is much higher in the northern regions, due to unequal access and socio-economic status that affects access to the treatments. This evidence can enrich the policy-making process that is required to tackle territorial and social disparities in the reproductive healthcare in Italy.

4. Methodology

One popular clustering method, which is based on a formal statistical methodology for modelling the population distribution, is the finite mixture density model. This model supposes that the population has been divided into several subgroups, or clusters, beyond which the divergence can be considered minimal, and the elements in each cluster are drawn from a multivariate probability density function specific to that cluster. In this context, clustering amounts to estimating the parameters that define the mixture components and then calculating the probabilities that each observation belongs to the clusters.

A finite mixture model is Gaussian Mixture Models (GMMs), where the probability density function of a continuous random variable can be expressed as the sum of weighted Gaussian functions. Applications of GMMs are numerous, including biometric systems and epidemiological and health studies, since they are flexible and powerful tools for modelling complex data distributions. GMM is powerful because it approximates the underlying densities with any arbitrary shape using smooth and continuous functions facilitating the exposure of a wide range of data structures and patterns (Antonicelli et al., 2022; Reynolds, 2009). A GMM is defined as a weighted sum of G Gaussian component densities as in:

$$f(y; \Theta, \tau) = \sum_{k=1}^{G} \tau_k f_k(y_i; \Theta_k) \tag{1}$$

where f_k and θ_k are the density and the parameters of the *k*-th component of Gaussain mixture and τ_k is the probability that the observation y_i belongs to the *k*-th component (Antonicelli et al., 2022; Li and Reynolds, 2020)

$$(\tau_k \geq 0; \sum_{k=1}^{G} \tau_k = 1) \tag{2}$$

and f_k is a multivariate Normal density function, where θ_k is the parameter given by μ_k, Σ_k

$$l(\Theta, \tau, z_i | x) = \sum_{i=1}^{n} \log\left[\sum_{k=1}^{G} z_{ik} \tau_k f_k(y_i | \Theta_k)\right] \tag{3}$$

where z_i means that we have an unobservable vector z for each observation. These values must be estimated together with θ (where θ_k represents in this case the "joint parameter" (μ_k, Σ_k) and τ_k (*k*=1, … G) (Antonicelli et al., 2022).

An EM algorithm is used to estimate unknown parameters and unobservable variables. The criterion used to select the number of components (clusters) of the Gaussian mixture is the Bayesian Information Criterion (BIC):

$$BIC = 2l(\widehat{\Theta}, \widehat{\tau}, \widehat{z_i} | x) - (\# \, parameters)\log(n) \tag{4}$$

in which $(\widehat{\Theta}, \widehat{\tau}, \widehat{z_i} | x)$ is the maximised value of the log-likelihood, *(#parameters)* is the number of parameters estimated, and *n* is the sample size. The BIC index is generally defined with the opposite sign compared to the definition used in this package (and therefore, smaller index => better) (Antonicelli et al., 2022).

To evaluate the performance of the models, is important to measure accuracy (AC) (Cai et al., 2018). Given a point x_i, r_i, and s_i represent the obtained label and the label provided by the data set, respectively. The AC is defined as follows:

$$AC = \frac{\sum_{i=1}^{N}(s_i, map(r_i))}{N} \tag{5}$$

where *N* is the total number of samples, *δ(x, y)* is the delta function that equals 1 if *x = y* and equals 0 otherwise and *map(r$_i$)* is the permutation mapping function that maps the obtained label r_i to the equivalent label from the data set.

5. Data collected

For this research, data were used that were made available in 2023 and referred to 2021, by the National Registry of Medically Assisted Reproduction, developed

through authorization of the Istituto Superiore di Sanità (ISS). The National Registry was established as an operational tool for the application of Law n. 40/2004 and it represents the official database for all information concerning MAR techniques in Italy. It compiles data from all MAR centres recognized by each Regional Health Authority and classifies centres in relation to the complexity of the services they provide, with a distinction between first level activity and second and third level activity. The National Registry aims to provide transparency on MAR practices and to stimulate uniformity in technical and organisational requirements among centres, as well to facilitate central monitoring of treatment efficacy, safety and outcome. The Registry also informs the community to make decisions regarding treatment and authorised activities, fosters scientific scholarship, supports long-term health follow-up studies of those born using MAR, and finally provides data on the number of embryos created and frozen. Consistently with the research goals of the present study, the 2021 data are employed, excluding data of due to the COVID-19 syndemic.

The geographical distribution of MAR centres is the following: 100 are public, 19 are private but affiliated to the National Health Service and 221 are private. Of these, 113 private and 89 public or affiliated centres offer second- and third-level treatments.

About 62% of level II, and III cycles with couples' own gametes are NHS funded as published by the ISS (2023). In 2021, the efficacy of treatments was moderately higher than in 2020. It was reported that pregnancies in fresh cycles had increased by +2.7% (32.6 *vs* 35.2%) and in frozen embryo/thawed oocyte cycles (FER/FO) by 0.6% (25.7 *vs* 26.3%). Furthermore, the use of pre-implantation genetic diagnosis increased, with 5,195 procedures carried out in 66 centres leading to 1,293 live births. It is a deliberate decision to concentrate on 2021 for the analysis. In relation to 2020, which experienced a considerable reduction in activity due to the COVID-19 syndemic and the protocols for containment, the number of treated couples and the total MAR treatment cycles carried out and the number of children born from these techniques in 2021 increased. Summit was excluded from comparisons due to the extraordinary disruption in 2020 and the potential for such a year to distort interpretation of longer-term trends.
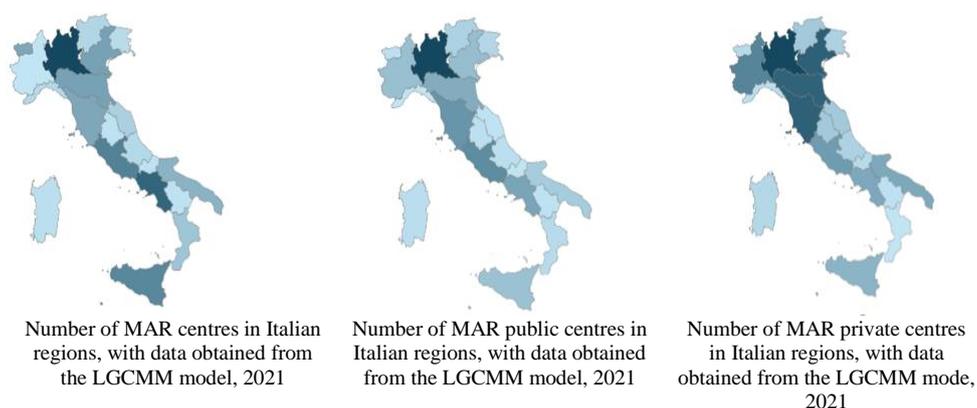
6. Results

Regional discrepancies and healthcare migration related to MAR, are analysed using descriptive statistics and advanced clustering techniques. The aim is to map territorial inequalities in MAR services, to measure inter-regional differences in treatment intensity, and to understand how these disparities influence access to MAR

services. The findings provide nuanced interpretations of 4 cartographic analyses, each highlighting different dimensions of MAR centres and activities.

Descriptive statistics reveal a significant regional variability in MAR centres' distribution, treatment volumes, and the number of cycles *per* couple. The application of clustering methods such as the Locally Coherent Gaussian Mixture Model (LCGMM)[1] and the Spectral Normalised Cut (Ncut)[2] uncover clear spatial patterns in MAR centres' distribution. The measure of accuracy (AC) is employed to assess the best performance between LCGMM and Ncut models. LCGMM is particularly effective in capturing local variations in centres' distribution and treatment intensity, while Ncut in analysing the number of treatments.

The distribution of centres highlights a remarkable territorial heterogeneity. The regions are classified in 4 clusters (Figure 1) by LCGMM.

Figure 1 – *Compared analysis: MAR Centres.*

Number of MAR centres in Italian regions, with data obtained from the LGCMM model, 2021

Number of MAR public centres in Italian regions, with data obtained from the LGCMM model, 2021

Number of MAR private centres in Italian regions, with data obtained from the LGCMM mode, 2021

Lombardia stands out with the highest concentration of MAR centres, further subdivided internally into several sub-clusters (each includes from 4 to 16 centres). Campania also records a relatively high number of centres, showing strong local
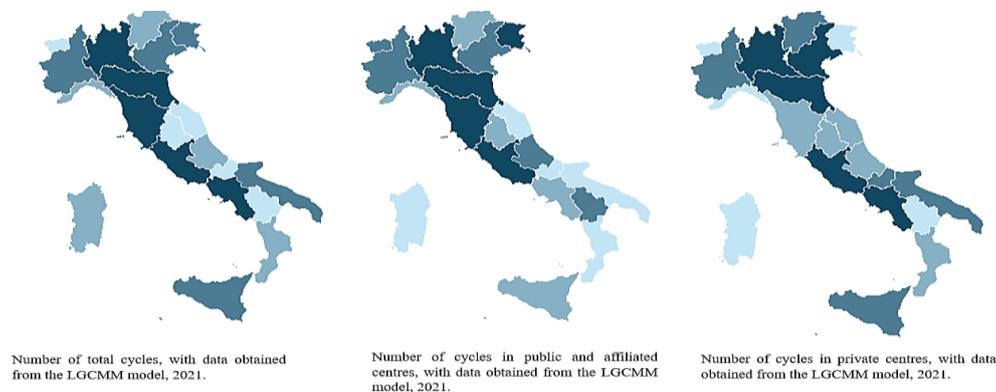
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[1] Latent Class Growth Mixture Model (LCGMM) is a statistical modelling approach designed to capture unobserved heterogeneity in longitudinal data by identifying latent subpopulations that follow distinct developmental trajectories. Unlike traditional growth models, LCGMM allows for variability both within and between latent classes, providing a flexible framework for disentangling complex patterns of change over time.

[2] Normalised Cut (NCut) is a graph-partitioning method for clustering that formulates the segmentation problem as the minimization of a normalized cut criterion. This criterion balances the dissimilarity between clusters (minimizing inter-cluster connections) with the similarity within clusters (maximising intra-cluster coherence), thus avoiding the bias toward small or unbalanced partitions typically observed in standard graph cut methods.

demand and a potential role of attraction for neighbouring flows. Lazio and Sicilia form an intermediate cluster, suggesting a moderate infrastructural development. Veneto, Emilia-Romagna, Toscana, Puglia, and Valle d'Aosta are grouped together in another cluster, showing a balanced provision. Finally, Piemonte, Umbria, Molise, Basilicata, and Sardegna fall into the smallest cluster, suggesting structural limits or regional planning priorities. Overall, the cartogram indicates that, although Northern Italy generally presents better infrastructural endowment, exceptions exist, confirming the complexity of territorial distribution.

The analysis of treatment volumes (Figure 2) using the Ncut model identifies 5 distinct clusters. Lombardia is confirmed as the region with the largest number of cycles, followed by Toscana and Lazio. Piemonte, Veneto, Emilia-Romagna, and Campania form the second cluster, while Trentino-Alto Adige, Friuli Venezia-Giulia, Puglia, and Sicilia appear in an intermediate group. The remaining regions are assigned to the smallest clusters, emphasising once again the persistence of the territorial divide. Considering the number of cycles the LCGMM again classifies the regions into 5 clusters, with Lombardia maintaining its dominance. The territorial pattern changes, however, distinguishing between public and private centres. Lombardia confirms its leadership, combining strong public provision with a very active private sector.

Figure 2 – *Compared analysis: MAR Cycles in public and private centres.*

Number of total cycles, with data obtained from the LGCMM model, 2021.

Number of cycles in public and affiliated centres, with data obtained from the LGCMM model, 2021.

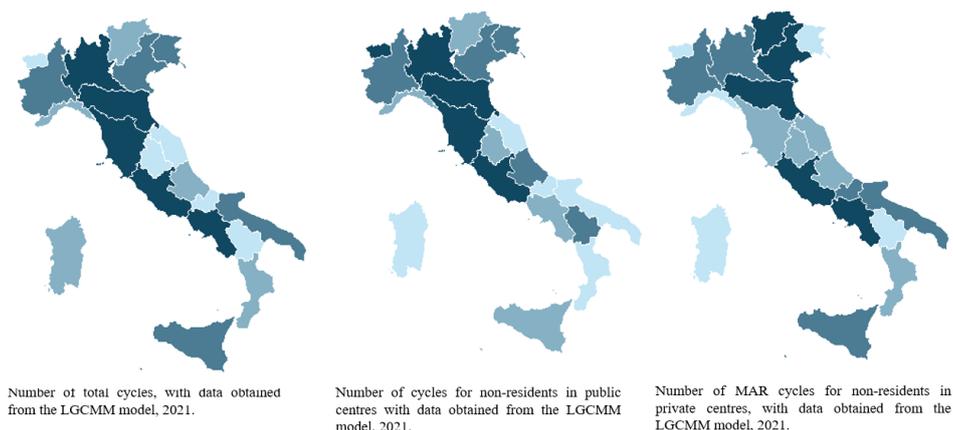Number of cycles in private centres, with data obtained from the LGCMM model, 2021.

Campania, although characterised by a high number of centres, belongs to a cluster with smaller cycle volumes, together with Emilia-Romagna, Toscana, and Lazio. Piemonte, Veneto, Friuli Venezia-Giulia, Puglia, and Sicilia form intermediate groups. Besides Southern regions, such as Calabria and Basilicata, along with Sardegna, Valle d'Aosta, and Trentino-Alto Adige, are placed in the smallest cluster. Lazio constitutes a distinct intermediate cluster, marked by a

relatively balanced ratio between supply and demand. These results highlight that service use is influenced not only by the number of centres but also by organisational efficiency, financial constraints, and patient migration preferences.

The cartogram of MAR cycles performed for non-resident patients with couples' own gametes (Figure 3) confirms Lombardia as the main destination. Its centres combine high success rates, advanced clinical expertise, and a consolidated reputation, elements that strengthen its role as the leading hub for domestic migration. Toscana and Emilia-Romagna also show strong appeal, offering geographically closer alternatives and attracting patients who prefer to limit travel time while maintaining good expectations of quality. Lazio records an intermediate position: although it receives a portion of non-resident patients, it does not achieve the same level of national centrality, reflecting a more balanced but less specialised system.

Figure 3 – *Compared analysis: MAR cycles with couple's own gametes.*

Number of total cycles, with data obtained from the LGCMM model, 2021.

Number of cycles for non-residents in public centres with data obtained from the LGCMM model, 2021.

Number of MAR cycles for non-residents in private centres, with data obtained from the LGCMM model, 2021.
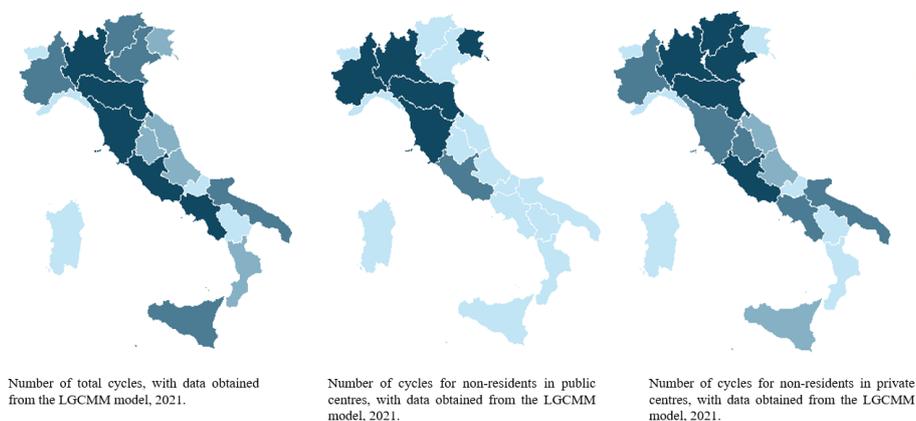
In contrast, the Southern regions appear at the margins of this phenomenon, with consistently low inflows of non-resident patients. Campania is a particularly significant case: despite its relatively high number of centres, it does not emerge as a national destination. This gap suggests that infrastructure alone is insufficient to generate interregional attractiveness if not supported by efficiency, technology, and perceived quality. Overall, the cartogram highlights the strong pulling power of the Northern areas, where both service capacity and patient trust converge in shaping mobility flows.

Finally, the analysis of MAR cycles with donated gametes (Figure 4) shows even stronger disparities. Lombardia confirms its absolute leadership, thanks to centres that combine advanced technology, specialised expertise, and the ability to manage

highly complex procedures. This makes the region the most important destination for couples requiring treatments with higher levels of medical and organisational complexity. Central regions, particularly Toscana and Emilia-Romagna, also attract a considerable share of non-resident patients. Their centres benefit from long-standing investments and a solid reputation for quality, placing them as the first alternatives to Lombardia. Lazio emerges as a moderate attractor: its centres are able to provide these services but their role seems more limited to local or neighbouring demand, without developing a comparable national attractiveness.

Figure 4 – *Compared analysis: MAR cycles with donated gametes.*

Number of total cycles, with data obtained from the LGCMM model, 2021.

Number of cycles for non-residents in public centres, with data obtained from the LGCMM model, 2021.

Number of cycles for non-residents in private centres, with data obtained from the LGCMM model, 2021.

The South, by contrast, remains at the lowest levels of activity. Despite recent infrastructural improvements, centres in these regions struggle to provide complex procedures and compete in terms of patient perception. Campania offers a telling example: although it has a large number of MAR centres, its contribution to donated gametes treatments is limited, showing that the mere presence of infrastructure does not translate into the ability to deliver advanced services.

The evidence suggests that mobility for donated gametes procedures is even more selective than for treatments with couples' gametes. The access is concentrated in a few regions capable of combining advanced technology with patient trust, while the dual public–private system amplifies inequalities: private centres are quicker and more efficient to introduce innovation, whereas public centres often face budget constraints and waiting times. The result is a system where socioeconomic resources affect the access, leaving couples living in disadvantaged contexts with limited opportunities.

These findings underline that donated gametes treatments represent a critical test of the Italian MAR system's equity. The persistence of a clear North–South divide

reflects not only infrastructural shortages but also deeper organisational and socioeconomic disparities. Their overcoming requires both coordinated policies to strengthen public provision, spread high-complexity services beyond the traditional centres of excellence and also to harmonise standards nationwide, so that access is not affected by residence or income.

7. Conclusions

The present study reinforces the known fact that substantial geographical differences persist in the delivery of and access to MAR services in Italy. Using advanced statistical techniques like Locally Coherent Gaussian Mixture Models and Spectral Normalised Cut algorithms we depicted the uneven distribution of centres for MAR, the huge disparities in treatment volumes and the significant North-South gradient of patients mobility for MAR.

These disparities result from infrastructural inadequacies and socioeconomic inequities that restrict more South-based individuals and couples' access. Our results show that MAR institutions hosted in regions such as Lombardia, Emilia-Romagna and Toscana are still appealing not only for local patients but also for a considerable amount of non-resident patients, highlighting their role as national areas of reference for services related to MAR. On the other hand, passing districts are largely found in the south, where as the infrastructure of medical and socio-economic conditions limit access.

Territorial inequalities in MAR services have profound consequences well beyond individual reproductive rights: they shape demographic trajectories and gender relations and impose financial burden on families forced to travel for treatment. Evidence supports the need for policy interventions to equalise the working conditions for MAR services across the country, realigning tariffs with actual costs, investing in new technologies, and strengthening public sector capacity. Addressing these structural health disparities is of paramount importance in ensuring equal access to reproductive health services and in preserving population sustainability more broadly.

Research should seek to track evolving trends, determine the effect of recent policy changes in the Essential Levels of Care, and understand patient decision making at a deeper level. A better understanding of social determinants of health and quality perceptions would contribute to developing more effective strategies to minimize health migration, and to guarantee more adequately comprehensive reproductive healthcare as a benefit for all citizens living in any region irrespective of their economy.

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