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Spatial Analysis of Regional Settlement of Medical Graduates from a School in the Mais Médicos Program: A Pseudo-Longitudinal Study

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Abstract

Objective

to estimate the degree of spatial dispersion of medical graduates from a campus established under the *Mais Médicos* Program.

Methods

An analytical cross-sectional observational study with comparison between independent cohorts, adopting a pseudo-longitudinal approach using secondary data from the Federal Council of Medicine (CFM) and the National Registry of Health Establishments (CNES). The dependent variable was the median distance (km) between the city of professional practice and the city of academic training. Stratification variables included graduating cohort, medical residency enrollment, and employment in SUS services. Data were analyzed through density and heat maps.

Results

A total of 147 graduate physicians were evaluated, with a median distance of 228.8 km. The highest concentration was observed in Pernambuco (n = 63; 43.4%) and Bahia (n = 38; 26.2%). Cohort 5 showed the greatest regional concentration (168.9 km), with 34.8% practicing within 100 km, while Cohort 1 was the most dispersed (292.3 km). Only 15 graduates (10.2%) exceeded the 90th percentile distance. The majority (80.9%) work in SUS services, and those in medical residency programs had a median distance of 267.6 km.

Conclusion

Relevant regional retention was observed, especially in more recent cohorts, suggesting a possible effect of the internalization of medical education. Recent graduating cohorts show greater regional concentration, and enrollment in medical residency programs aligns with the median dispersion distance.

Introduction

The unequal distribution of health professionals drives major inequities in healthcare delivery, particularly in low- and middle-income countries. Communities in rural, remote, or socioeconomically vulnerable areas face substantial barriers to quality healthcare. International evidence shows that rural-based training, regional student selection, and educational incentives are associated with greater physician retention in underserved areas [1 – 3].

In Brazil, despite the rapid increase in the number of physicians over recent decades, inequalities in distribution remain one of the greatest challenges for the Unified Health System (SUS). Most professionals

are concentrated in large urban centers in the South and Southeast, while many areas—especially in the North and Northeast—continue to experience limited medical coverage. This situation particularly affects small and medium-sized municipalities, which often struggle to attract and retain the minimum number of physicians required for effective service delivery .

In response, the Mais Médicos Program (PMM) was implemented in 2013. Beyond emergency physician supply, the program promoted the interiorization of medical education by supporting new undergraduate medical schools and expanding vacancies in existing institutions, particularly in inland regions. This strategy is grounded in evidence that training in regional settings fosters long-term local retention, and that selecting students with ties to the campus territory increases post-graduation settlement. Within this context, the Federal University of the São Francisco Valley (UNIVASF) established its Paulo Afonso campus in Bahia, training physicians immersed in this territorial and social reality [7 – 9].

However, studies indicate that decentralizing medical schools does not, by itself, guarantee that graduates will remain in their training region. Physicians' decisions regarding where to practice are complex and multifactorial. Better working conditions, adequate remuneration, family support, and quality of life often attract professionals to large urban centers. In Brazil, the pursuit of specialist training functions paradoxically both as a temporary anchor and as a major driver of migration, since residency programs remain heavily concentrated in state capitals and in the South-Southeast axis [5,10 – 12].

Evaluating the real effectiveness of interiorization policies requires methods beyond aggregated physician density measures. Longitudinal monitoring of graduate trajectories is necessary, yet no prior study has employed exploratory spatial data analysis to map destinations of cohorts trained under the PMM—a critical gap in the literature. Continuous monitoring of dispersion distances may help determine whether inland medical schools truly function as territorial anchors against local healthcare insecurity. Thus, this study aimed to estimate the degree of spatial dispersion of medical graduates from a campus established under the *Mais Médicos* Program.

Methods

Design

This was an analytical cross-sectional observational study comparing independent cohorts through a pseudo-longitudinal approach, in which time since graduation served as a proxy for temporal dynamics. Individual secondary data were obtained from public information systems, enabling comparison of graduate cohorts across the retrospective period from 2020 to 2025. This was a census study including all graduates from the program; therefore, sample size calculation was unnecessary.

Context

In 2014, the UNIVASF medical program was established in Paulo Afonso, Bahia, under the PMM. The surrounding region includes municipalities of the São Francisco Valley and Northeast Bahia mesoregions. There is no other medical school in Paulo Afonso. The nearest public medical schools are in Lagarto, SE

(247 km), Arapiraca, AL (205 km), Garanhuns, PE (221 km), Serra Talhada, PE (215 km), Petrolina, PE (372 km), and Feira de Santana, BA (367 km), resulting in an average radius of 271 km from the UNIVASF campus.

Data Collection

The unit of analysis consisted of graduates from the first five classes. Data collection was documentary and retrospective, occurring in two stages: professional records were retrieved from the CFM (https://portal.cfm.org.br/busca-medicos) public database, then cross-referenced with microdata from CNES (https://cnes.datasus.gov.br/).

Variables

The outcome variables were the absolute number of graduates registered with the CFM and the distance in kilometers between Paulo Afonso and the municipalities where physicians were working according to CNES. Independent variables included state medical council registration, municipality of professional practice, cohort class, employment in SUS (yes/no), self-employment (yes/no), and participation in medical residency (yes/no).

Data Analysis

Data were analyzed using measures of central tendency and dispersion. The main metric was median distance (50th percentile), robust to extreme values. Distance beyond the 90th percentile was also estimated, as well as the proportion of graduates working within 100 km of Paulo Afonso. Inferential analyses included one-way ANOVA and the Kruskal-Wallis test, with a 5% significance level. Absolute density maps and heat maps were produced to visualize physician concentration by state and municipality.

Ethical Considerations

The study followed Brazilian National Health Council Resolutions No. 466/2012 and No. 510/2016. Because it used only secondary, publicly available data, it was exempt from Research Ethics Committee review under Article II of Resolution No. 510/2016.

Results

The dispersion of 147 graduates from the medical program in Paulo Afonso, Bahia, across five graduating cohorts was analyzed; only 2 (1.4%) had missing CRM data. Spatial distribution showed a greater concentration of graduates in the states of Pernambuco, with 63 (43.4%) physicians, and Bahia, with 38 (26.2%) physicians (Fig. 1).

Among the graduates, 119 (80.9%) were working in SUS services, and 33 (22.4%) were enrolled in medical residency training at the time of the study (Table 1). To better understand the distribution of medical graduates and where they established professional practice, the location of 145 graduates was analyzed (Fig. 2). Half of them were working within 228.8 km of Paulo Afonso, represented by the redder areas in

Fig. 2A. The oldest cohort, class 1 (Fig. 2B), showed the greatest dispersion, with a median distance of 292.3 km, no graduate working within 100 km, and 19.2% among the most distant. In contrast, the most recent cohort, class 5 (Fig. 2E), remained closer to the institution where they trained: 50% were within 168.9 km, and 34.8% were already working within 100 km of Paulo Afonso. Among those undertaking medical residency, 50% were within a distance of 267.7 km (Table 1). However, comparison of mean distance ($F = 0.25$; $df = 4$; $p = 0.91$) and median distance ($\chi2 = 7.5$; $df = 4$; $p = 0.11$) across the cohorts revealed no statistically significant differences (Fig. 3).

Table 1
Frequency distribution of employment characteristics and distance among graduates of the UNIVASF Paulo Afonso medical program.

Class	N (%)	Work in SUS N (%)	Self-employed N (%)	Medical Residency N (%)	Distance (median)	N (%) Distance < 100 km	N (%) 10% More Distance*	Medical Residency Distance (median)
1	26 (17.7)	22 (84.6)	6 (23.1)	5 (19.2)	292.3	0 (0.0)	5 (19.2)	229.1
2	27 (18.4)	25 (92.6)	3 (11.1)	10 (37.0)	228.8	2 (7.4)	2 (7.4)	228.0
3	39 (26.3)	29 (74.3)	4 (10.2)	7 (17.9)	203.4	8 (20.5)	6 (15.4)	1051.9
4	32 (21.8)	27 (84.4)	2 (6.2)	4 (12.5)	227.3	5 (15.6)	1 (3.1)	171.4
5	23 (15.6)	16 (69.6)	1 (4.3)	7 (30.4)	168.9	8 (34.8)	1 (4.3)	292.3
Total	147 (100)	119 (80.9)	16 (10.9)	33 (22.4)	228.8	23 (15.6)	15 (10.2)	267.7
*Percetil 90 = 1171,5 km								

Discussion

The cross-sectional analysis of temporally distinct graduate cohorts showed evidence of regional retention, with 50% of young physicians working within 228 km of the training campus—a distance lower than the average radius separating Paulo Afonso from other nearby public medical schools—and more than 80% providing care in SUS facilities. Older cohorts dispersed more intensely, likely in search of specialization, new labor markets, or renewed family proximity.

This distribution pattern suggests a possible positive effect of the PMM, whose objectives included professional retention in regions distant from major university centers. The marked spatial clustering of graduates in Bahia and Pernambuco reinforces the premise that public institutions may function as regional development anchors. A similar dynamic has been reported in Sobral, Ceará, where implementation of a medical school significantly strengthened local primary, secondary, and tertiary care. No previous study

appears to have mapped graduate dispersion from PMM-origin medical schools in a combined cross-sectional and longitudinal perspective [7,15 – 17].

Regional retention becomes more limited among young professionals seeking residency, among specialists, and among more experienced physicians, who tend to concentrate in economically dynamic hub cities. International studies show that local availability of residency programs is one of the main factors influencing long-term retention, highlighting the tension between strengthening primary care in the inland Northeast and ensuring continued specialized training [6.13.21].

Spatial economics literature indicates there is no natural "trickle-down" effect of the medical workforce toward nearby small municipalities, reinforcing the need for direct supply-side interventions such as the PMM. Possible explanations for graduates remaining in the region include the capacity of local health networks to absorb professionals amid persistent unmet demand, and proximity to residency programs at neighboring institutions such as the Federal University of Sergipe, the Federal University of Alagoas, and the University of Pernambuco [22].

The strong SUS participation among graduates demonstrates the initial success of educational interiorization, aligned with the PMM's objectives. For local health administrations, absorbing newly graduated physicians has been instrumental in staffing teams and ensuring operation of primary care and urgent and emergency services [17].

However, ensuring longer-term retention requires overcoming structural barriers. Studies show that many newly graduated physicians choose inland areas only temporarily, using this stage to earn income before attempting specialty entrance examinations. Public management also faces chronic weaknesses such as precarious employment relationships, heavy workloads, and absence of career plans, causing inland regions to be perceived as transitional workplaces with high physician turnover [6, 23, 24].

In the present study, continuous graduation of new classes appears to offset the dispersion of older cohorts. It is also notable that the UNIVASF Paulo Afonso campus faced difficulties implementing its medical internship locally: Cohorts 1 and 2 completed their entire internship in Petrolina (372 km away), only the first internship year was implemented locally for Cohort 3, and only Cohort 5 completed the full internship in Paulo Afonso. During internship, students develop closer ties with the local healthcare network, which may favor later retention.

Nationally, only 6.5% of medical residents enter Family and Community Medicine. Future implementation of local residency programs and a university hospital could increase physician retention beyond the effect of undergraduate training alone, especially if combined with municipally based primary care residency positions. The data indicate that at least half of resident graduates remain regionally located within a distance below the average radius of neighboring public medical schools [23, 24].

The lack of local specialist training centers, few attractive Family and Community Medicine residency slots, and a shortage of qualified preceptors act as push factors. National regulations from the Ministries of

Education and Health should link the opening of medical schools to the implementation of community-based residency programs in municipal and state services.

Some methodological limitations should be acknowledged. Official secondary databases may be subject to delays in updating professional links to local health services. Information on medical residency reflects only one moment in the cohort panel, identifying who was in postgraduate training at that time rather than specialists who had already completed training. Finally, the impact of regional university admission policies on graduate retention was not assessed.

Conclusion

Medical education offered by an institution established under the PMM was associated with professional retention of graduates in the region surrounding the university campus, especially in SUS services. More recent cohorts were more concentrated in the region, whereas cohorts with longer time since graduation showed greater dispersion across Brazil, likely driven by the search for specialized training.

By providing longitudinal evidence on retention of graduates from PMM-origin medical schools, this study shows that establishing inland medical schools is a promising strategy to improve physician density sustainably and to combat healthcare voids. However, long-term success still depends on well-integrated public policies—especially the creation of medical residency programs—reinforcing the idea that residency availability should be linked to the implementation of new medical schools so that inland regions cease to function merely as places of temporary passage or basic training.

Declarations

Ethics approval: Not applicable**.** The data analyzed are publicly available and accessible through the registration systems of the Federal Council of Medicine of Brazil and the registry of healthcare facilities within Brazil's Unified Health System (SUS). The list of medical graduates is published annually in the official administrative records of the educational institutions.

Consent to participate: As this concerns publicly available data—as mandated by the public transparency law (Law No. 12.527/2011), which grants any Brazilian citizen the right to access such information—formal consent is unnecessary.

Consent for publication: N/A

Availability of data and materials: The data are disponible in links on manuscript.

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Authors' contributions:

WMMS- Formal analysis, Investigation, Methodology, Visualization, Writing - original draft, Writing – review & editing.

DMAP – Validation, Visualization, Writing - original draft, Writing - review & editing

CALB- Validation, Visualization, Writing - original draft, Writing - review & editing

DFL- Validation, Visualization, Writing - original draft, Writing - review & editing

IFC- Validation, Visualization, Writing - original draft, Writing - review & editing

MRL- Investigation, Methodology, Supervision, Validation, Visualization, Writing - original draft,

Writing - review & editing.

JML- Conceptualization, Formal analysis, Investigation, Methodology, Project administration,

Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing.

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Figures

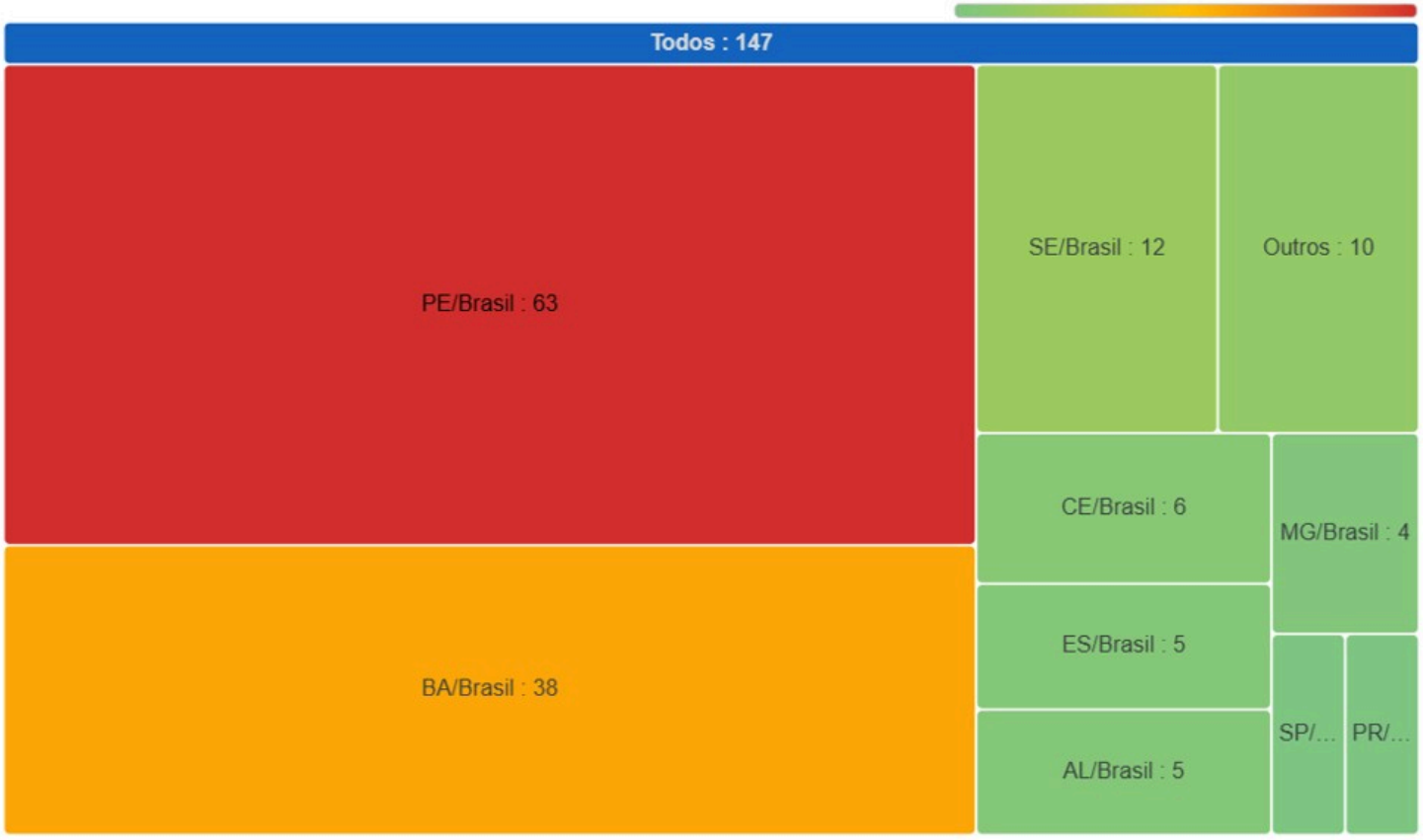

Figure 1

Geographic distribution of medical graduates from UNIVASF's Paulo Afonso Campus across Brazil.

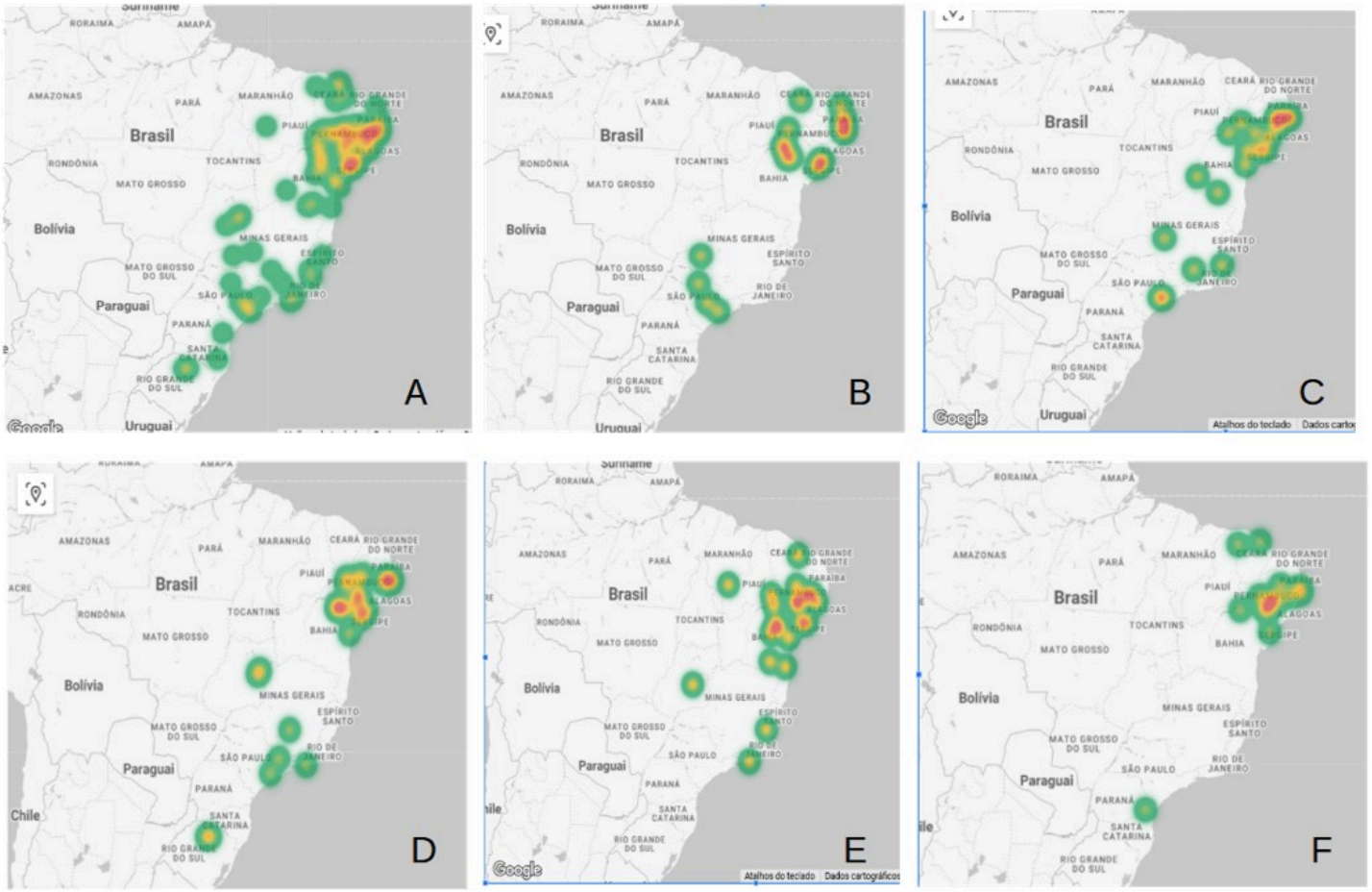

Figure 2

Heat map showing the distribution density of graduate cohorts by cities of professional activity in Brazil. (A) Combined distribution of the five cohorts; (B) cohort 1; (C) cohort 2; (D) cohort 3; (E) cohort 4; (F) cohort 5.

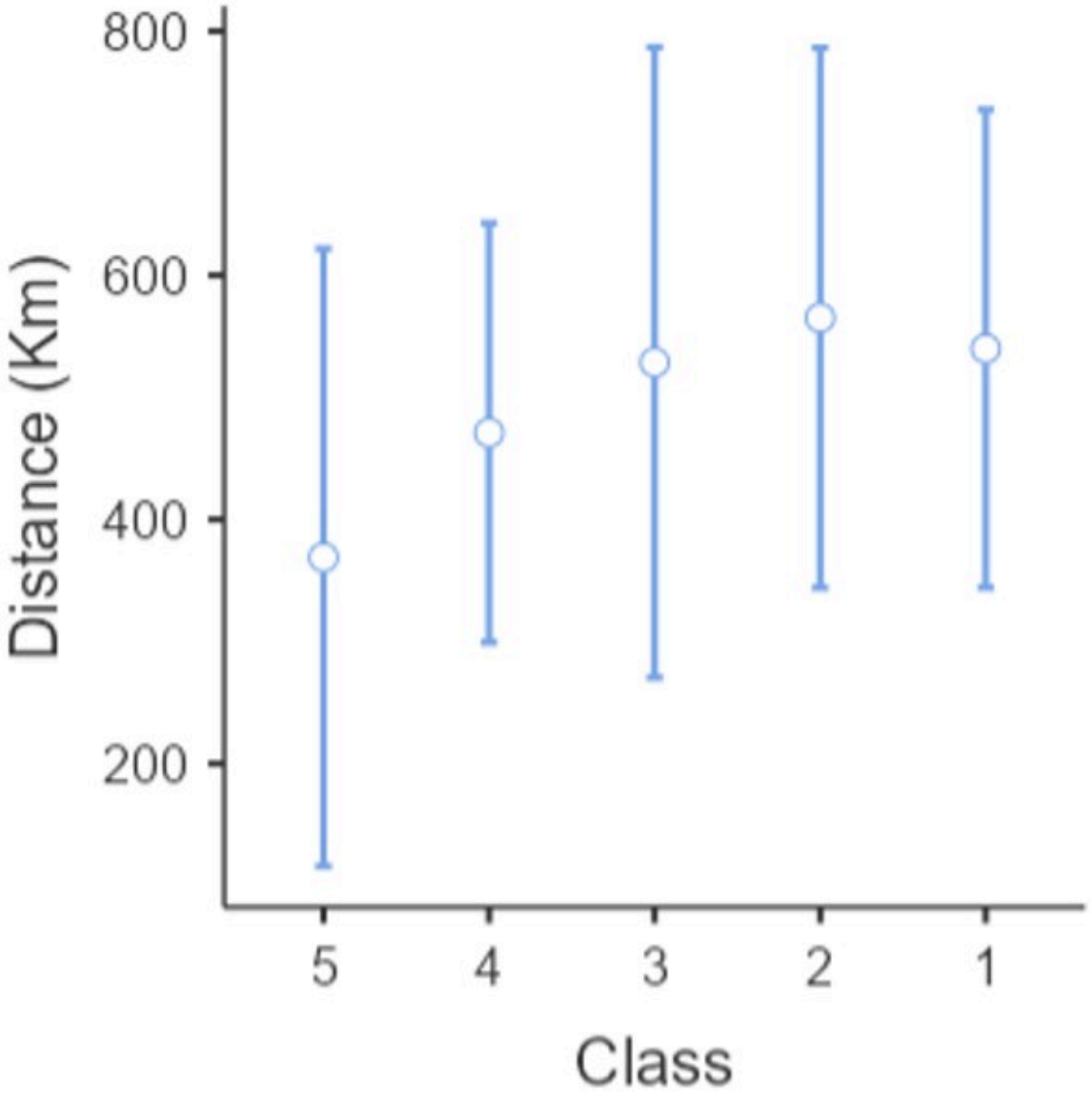

Figure 3

Error bar graph showing the mean and confidence interval (95% CI) of the distance (in km) between the UNIVASF Paulo Afonso campus and the municipality where the graduate works.