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COVID-19 and the Papanicolaou test (Pap Smears): A Study of the Municipal Human Development Index in São Paulo 2019-2023

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ABSTRACT

OBJECTIVE

To analyze the impact of the COVID-19 pandemic on cervical oncotic cytology screening performance and the detection of cervical lesions in municipalities of São Paulo, Brazil, considering socioeconomic disparities measured by the Municipal Human Development Index (MHDI).

METHODS

This epidemiological study was based on secondary data from 2019 to 2023, evaluating the total number of tests performed and the diagnoses of Cervical Intraepithelial Neoplasias 1, 2 and 3 (CIN1, CIN2, CIN3), adenocarcinoma, and carcinoma. Analyses were conducted using RStudio software, applying the Shapiro-Wilk normality test and robust regression to explore the relationship between MHDI and test rates.

RESULTS

During the study period, 3.067.345 tests were performed, with a sharp 38,39% decline in 2020, followed by progressive recovery until surpassing pre-pandemic levels in 2023. High- grade lesions (CIN2/3) increased from 1.734 cases in 2019 to 2.497 in 2023, while CIN1 showed only minor variation and a modest decline in the final year. Total of 245 cases of adenocarcinoma and 258 of carcinoma were identified. Regressions did not show statistical significance for the association between MHDI and test rates.

CONCLUSION

The COVID – 19 pandemic had a substantial impact on cervical cancer screening; however, subsequent recovery indicates resilience of the healthcare system. The MHDI alone was insufficient to explain local.in screening performance, highlighting the need for updated indicators and public policies to ensure continuity of preventive care during health crises.

KEYWORDS

Cervical cancer; Pap smear; Covid-19; Human development index; Epidemiology.

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INTRODUCTION

The cervical oncotic colpocytology exam, cervicovaginal smear or simply known popularly as the the Papanicolaou test (Pap smear), is crucial for the early detection and screening of precursor lesions of cervical cancer.[1] This preventive exam plays a fundamental role in reducing mortality from this disease, allowing for adequate treatment before lesions become malignant and significantly impact patients' health.[2] Public health guidelines recommended, until 2025, regular testing for sexually active women over 25 years old, historically contributing to the decrease in cervical cancer cases. [3] During the COVID-19 pandemic, a significant reduction in the search for preventive consultations was noted, including Pap smear exams.[4]

The lack of regular exams brings severe impacts on the survival of the population, since, without performing collections for the diagnosis of lesions, the risk of late diagnoses increases. When performed correctly and with 80% coverage, screening tests for oncology, especially the Pap smear, can reduce serious cases by 60%, reflecting positively on cervical cancer indices and contributing indirectly to the decrease in mortality rates of the disease. [5] It is also emphasized that, precisely because of the importance of this early screening for cervical cancer, a new guideline was implemented in 2025 for this purpose, establishing the DNA-PCR HPV test as the main tool. [6]

The objective of this study was to analyze the impact of the COVID-19 pandemic on the performance of the Pap smear and on the early detection of cervical cancer in the municipalities of São Paulo, considering the socioeconomic disparities measured by the Municipal Human Development Index (MHDI), as it is an indicator of income, education and longevity and, thus, to understand how socioeconomic conditions influenced the maintenance of preventive health care during the health crisis, aiming to provide information that can guide public policies and mitigation strategies for future health emergencies.[7]

METHODS

Study design and location

This research was characterized as a time-series epidemiological study with an ecological and retrospective approach. The unit of analysis comprised data from the municipalities of the State of São Paulo with a time frame from 2019 to 2023, a period that covers the pre, peri and post-pandemic scenario of COVID-19. Sociodemographic information and the MHDI were obtained from the Brazilian Institute of Geography and Statistics (IBGE) and the Human Development Atlas of the United Nations Development Programme (UNDP), composing the necessary context for the interpretation of the findings. Finally, Health Tabulations (TabNet system) was used, a means employed to extract data from the Cancer Information System (SISCAN), using the databases of the Department of Informatics of the Unified Health System (DATASUS).

Data collection

The extracted records were the total quantity of exams, CIN1, CIN2, CIN3, adenocarcinoma and carcinoma. The search was conducted in the "Health Care" category, with filters adjusted for the State of São Paulo considering the place of service. Population data regarding women aged 25 to 64 were obtained from IBGE. Collected files were initially organized in Microsoft Excel.

Statistical analysis

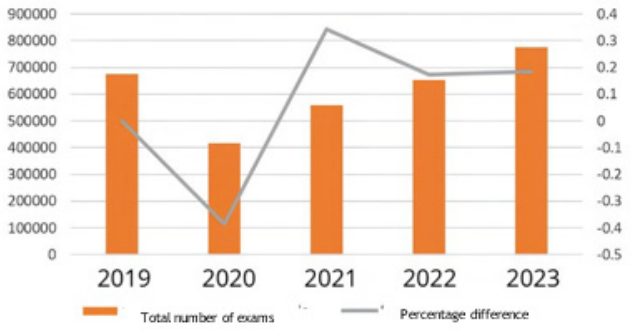
Statistical analysis included the calculation of rates per 100,000 inhabitants, relating the different types of exams to the corresponding female population in the period from 2019 to 2023. Analyses were conducted in RStudio software, using the Shapiro-Wilk test to evaluate the normality of variables and correlation analyses between outcomes and the MHDI. Considering the behavior of the distributions, in which the MHDI presented as a normally distributed variable and the rates of each type of exam result as non-parametric, robust regression was adopted as the main modeling method. QGIS software was used to prepare maps that assisted in the spatial and temporal visualization of the results.

RESULTS

In the period between 2019 and 2023, the State of São Paulo registered a total of 3,067,345 Pap smear exams, presenting the following annual distribution: 672,636 exams in 2019; 414,394 in 2020; 556,101 in 2021; 651,941 in 2022; and 772,273 in 2023. It is noteworthy, as per Figure 1, a significant drop of 38.39% in the volume of exams performed in the year 2020. Regarding the diagnoses of low-grade lesions (CIN 1), the total for the period was 16,369 cases, with 3,080 identified in 2019, 2,546 in 2020, 3,450 in 2021, 3,305 in 2022 and 3,988 in 2023.

As for lesions classified as CIN 2 and CIN 3, a total of 9,362 occurrences were recorded between 2019 and 2023, with annual records of 1,734, 1,350, 1,701, 2,080 and 2,497, respectively. Regarding malignant neoplasms, adenocarcinoma cases totaled 245 records in the five-year period, distributed as 40 cases in 2019, 36 in 2020, 46 in 2021, 69 in 2022 and 54 in 2023. Finally, carcinoma diagnoses totaled 258 exams, presenting 70 occurrences in 2019, 48 in 2020, 40 in 2021, 47 in 2022 and 53 in 2023.

Figure 1: Graph of total number of Pap smear tests and percentage change between 2019-2023



Source: The authors

For the Shapiro-Wilk normality tests,[8] the results showed that, except for the MHDI, the variables did not follow a normal distribution ($p<0.05$). Given this, robust regression is justified,[9] suitable for dealing with non-normal distributions and reducing the influence of outliers. It is emphasized that statistical significance was established by the p-value < 0.05. Although t-values with absolute magnitude equal to or greater than 2 suggest a strong association, the final decision to reject the null hypothesis is strictly conditioned to the adopted level of significance (p).

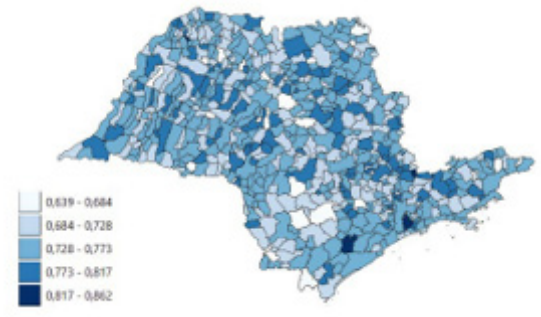
The results of this regression with MHDI and total exams are presented in Table 1 below, including the coefficients for the intercept and MHDI, the standard error for each coefficient, the t-value, and the residual standard error for each analyzed year, observing a t-value without statistical significance. Additionally, gradient graphs A, B, and C can be observed in Figure 2, in which it is visually possible to confirm that there is no direct relationship between MHDI and total exams in 2019 and 2020.

Table 1: Robust Regression between MHDI and total exam rates

Year	Intercept	Coef. MHDI	Standard Error Intercept	Standard Error MHDI	t- value Intercept	t- value MHDI	Residual Standard Error	p-value
2019	4.7124	45.1297	10.2213	15.8919	0.4612	2.8387	18.8461	0.7131554
2020	3.5086	37.321	7.0873	11.9355	0.4941	3.1277	16.2418	0.6609497
2021	4.6017	33.4872	8.6176	14.0015	0.5349	2.3939	19.5177	0.9941927
2022	-48.2181	89.2103	25.1642	33.9946	-1.9161	2.6242	26.3919	0.763032
2023	0.7126	26.5358	28.5177	38.525	0.025	0.6888	30.2147	0.8038977

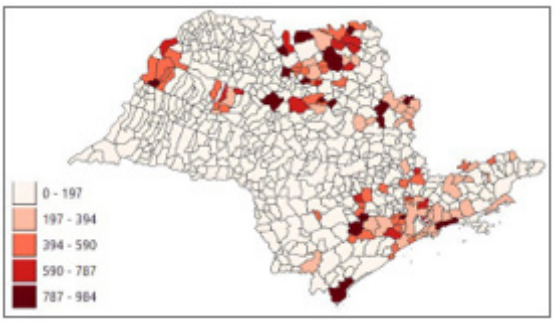
Source: The authors

Figure 2 A: Gradient graph of MHDI in the State of São Paulo



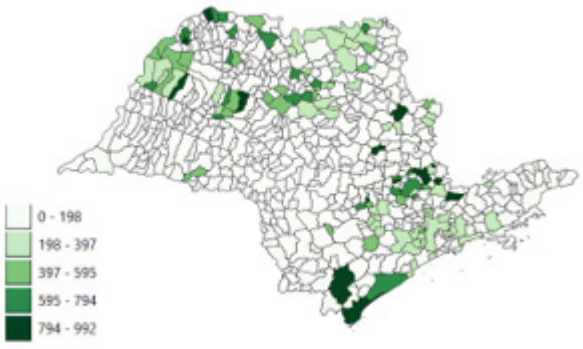
Source: The authors

Figure 2 B: Gradient graph of total Pap smear exam rates in 2019 in the State of São Paulo



Source: The authors

Figure 2 C: Gradient graph of total Pap smear exam rates in 2020 in the State of São Paulo



Source: The authors

In the analysis of CIN 1, the robust regression models did not show statistical significance in any of the years studied. In 2019, the t-value was -0.0642 with a p-value of 0.9528. In subsequent years, although the t-value fluctuated (reaching 1.8924 in 2021 and -1.0368 in 2023), the p-values remained consistently above the 0.05 threshold, recording 0.8960 (2020), 0.1547 (2021), 0.5489 (2022), and 0.3760 (2023), confirming the absence of a strong linear correlation.

Unlike the previous scenario, the data for CIN 2 and CIN 3 present heterogeneous behavior. Statistical significance was observed only at the beginning of the period studied in 2019 and 2020, where t-values were 2.8387 and 3.1277, with p-values of 0.0046 and 0.0018, respectively. However, between 2021 and 2023, significance was lost and remained stable: in 2021, the t-value was 2.3939 (p = 0.0169); in 2022, a t-value of 2.6242 resulted in p = 0.0088; and finally, in 2023, a t-value of 0.6888 also closed with p = 0.0088.

For Adenocarcinoma, the results indicate a low predictive capacity of the model. The recorded t-values were low: 0.7703 (2019), 2.2078 (2020), 0.4900 (2021), 2.5218 (2022), and 0.8686 (2023). Consequently, the p-values did not reach the 5% significance level, ranging from a maximum of 0.6572 in 2021 to a minimum of 0.0860 in 2022, which makes it impossible to reject the null hypothesis.

In the case of Carcinoma, a similar statistical behavior was observed, with an absence of significance. In 2019, the t-value was only 0.0654 (p = 0.9519). In the critical years of the series, such as 2020 and 2021, the t-values were 1.9984 and 1.9322, with p-values of 0.1395 and 0.1193, respectively. In 2022, the t-value fell to 1.2607 (p = 0.2965). The year 2023 presented the highest t-value of the series for this category (2.4108), but the p-value of 0.0949 still remained outside the conventional statistical significance zone.

DISCUSSION

The results reveal a "V-shaped" oscillation in cytological screening in São Paulo, suggesting a compensatory effect to absorb pent-up demand. Although cervical cancer is preventable and detectable early via Pap smear[10], its effectiveness depends on social, cultural, and organizational factors.[11] This study investigated the correlation between human development (MHDI) and the performance of the exam during and after the pandemic.

The absence of statistical significance in the robust regression indicates that the impact of the health crisis was transversal across the different socioeconomic realities of São Paulo. However, the use of the MHDI (2010 base) represents an important limitation[12], as its obsolescence may not capture recent changes in healthcare access. For more precise and representative future analyses, the Firjan Index (IFDM) is recommended, given its annual update.

It is also important to consider that the performance of preventive exams may vary according to awareness campaigns, changes in clinical guidelines, or even high-impact health events, such as the COVID-19 pandemic itself.[13] These contextual elements, which are not covered by the MHDI, help explain the low correlation observed.

The results should be interpreted with caution, as adherence to screening is linked to healthcare determinants that transcend general indicators. The MHDI, for example, may not directly influence the volume of exams, which primarily depends on public policies, access, and local awareness.[14] Thus, future analyses incorporating Family Health Strategy coverage and the density of health units are essential for a more robust view of the subject.[15] In the state of São Paulo, the impact of the pandemic was evident in the 38.39% drop in exams in 2020, with progressive recovery and the surpassing of pre-pandemic levels in 2023. This pattern reflects the international literature on the interruption of preventive services[4], but highlights the resilience of the São Paulo system compared to other countries that still face partial recoveries.[16]

The drop observed in Brazil is similar to that of high-income countries, such as Canada and the United States, where active search strategies only partially recovered screening.[4] In the United Kingdom, 2025 projections indicate that one-third of women remain with overdue exams, highlighting the difficulty of achieving a full recovery.[16] In contrast, the 18.45% growth in São Paulo in 2023 suggests a compensatory effect of pent-up demand. In parallel, the increase in high-grade lesions (CIN 2/3) in the post-pandemic period may reflect both late diagnosis and the reorganization of services, a phenomenon also observed in Sub-Saharan Africa and Europe.[1,17] Such a trend reinforces the urgency of continuous surveillance and the expansion of secondary prevention.

In contrast, low-grade lesions (CIN 1) presented a more stable behavior throughout the period, with a slight decline in 2023. This finding may be associated with two factors: a lower demand for the exam by asymptomatic women, or therapeutic success in cases detected early in previous years. Systematic reviews suggest that the identification of CIN 1 is particularly sensitive to variations in population coverage, being more acutely impacted when there is a reduction in the number of exams among low-risk women.[18] Thus, the decline of CIN 1 in São Paulo should be interpreted with caution, as it may reflect both improvements in clinical management and limitations in capturing this patient profile.

Multivariate analysis with robust regression did not

identify a statistically significant correlation between the MHDI (2010) and the Pap smear test rate. Similar findings were described in studies conducted in Spain and Latin American countries, in which aggregated socioeconomic indicators showed less explanatory power than healthcare variables directly linked to service provision.[19] This reinforces the need to use more updated and specific indicators, such as the IFDM or measures of service access, to evaluate inequalities in screening.

The apparent contradiction found between municipalities with higher MHDI and higher detection of CIN 2/3 also finds an international parallel. In high-income countries, such as the United States and the United Kingdom, it is observed that more developed regions frequently present higher diagnostic rates, not due to higher prevalence, but because of greater access and diagnostic capacity.[20] In the case of São Paulo, it is possible that municipalities with more robust health infrastructure identified lesions accumulated during the interruption period, while cities with lower MHDI remained with underreporting due to a lack of access.

The global comparison reinforces that the impact of the pandemic on cervical cancer screening was a phenomenon transversal to different socioeconomic contexts. While São Paulo demonstrated a capacity for compensation in 2023, countries such as the United Kingdom still face significant delays.[16] In low- and middle-income countries, the impact was even deeper, worsening historical inequalities and hindering access to screening programs that were already weakened before the pandemic.[18]

The analyzed time series (2019-2023) concludes in a scenario of technological transition. Screening, traditionally performed via the Pap smear test, is moving toward an organized model via HPV-DNA testing, a technology recently incorporated into the Unified Health System (SUS) in 2025. Due to its higher sensitivity, this method detects four times more CIN 2+ cases and 1.5 times more cancers.[21] In this new structure, cytology assumes the role of reflex triage. For this transition to be sustainable, the healthcare network must be resilient; thus, understanding the system's vulnerabilities through Pap smear data during the health crisis is essential to guide the implementation of the new guidelines.

CONCLUSION

The study revealed that, although the pandemic interrupted cytological screening globally, the intensity of the drop and the speed of recovery varied according to the organization of health systems. In São Paulo, the time series (2019-2023) presented a “V” pattern, with a recovery in 2023 that exceeded pre-pandemic levels, resembling — and sometimes surpassing — the performance of high-income countries. This scenario reinforces the role of public policies and care reorganization in the resilience of the system.

As a limitation, the use of the MHDI (2010 base) may not reflect recent socioeconomic changes, and the Firjan Index (IFDM) is suggested for future studies due to its regular update. In short, the experience of São Paulo demonstrates that success in resuming screening depends more on the health system's response capacity than only on socioeconomic factors, serving as a reference for future health emergencies.

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