



ORIGINAL ARTICLE

From mastectomy to reconstruction: Medical residency programs transforming breast cancer care

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KEYWORDS

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Abstract

Introduction: Specialized training in Mastology may influence surgical practices in breast cancer treatment. With this research, we aim to evaluate the association between the presence of Mastology Residency Programs and the temporal variation in types of breast cancer surgeries in Brazil (2014–2024).

Material and methods: Retrospective ecological study using SIH/SUS data, including surgeries for malignant neoplasms (C50) and carcinoma in situ (D05). Procedures were classified as conservative, mastectomy, or reconstructive. Residency program data were obtained from SISCNRM and CNES. A Generalized Linear Mixed Model (GLMM) with fixed and random hospital effects was used to analyze associations.

Results: A total of 244,538 surgeries from 943 hospitals were analyzed, 48 of which had residency programs. Surgical volume increased from 2014 to 2019, dropped in 2020, and resumed growth until 2024. Hospitals with residency programs had a higher proportion of reconstructive surgeries. The GLMM showed no significant association between residency presence and mastectomy rates (IRR 0.84–1.13; $p > 0.05$). In contrast, residency presence was positively associated with reconstructive surgeries from 2019 onward, with statistically significant IRRs in 2019 (IRR = 1.85; $p = 0.014$), 2021, 2022, 2023, and 2024.

Conclusion: The presence of Mastology Residency Programs is associated with increased access to breast reconstruction, suggesting a positive impact on the quality of oncologic surgical care in Brazil.

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PALABRAS CLAVE

Neoplasias de la
mama;
Ciruga mamaria;
Internado y residencia

De la mastectoma a la reconstruccin: Programas de residencia mdica transformando la atencin del cncer de mama**Resumen**

Introduccin: La formacin especializada en Mastologa puede influir en las prcticas quirrgicas en el tratamiento del cncer de mama. Con esta investigacin pretendemos evaluar la asociacin entre la presencia de Programas de Residencia en Mastologa y la variacin temporal en los tipos de cirugas para cncer de mama en Brasil (2014–2024).

Material y metodos: Estudio ecolgico retrospectivo utilizando datos del SIH/SUS, incluyendo cirugas por neoplasias malignas (C50) y carcinoma in situ (D05). Los procedimientos fueron clasificados como conservadores, mastectomas o reconstructivos. Los datos sobre los programas de residencia se obtuvieron del SISCNRM y del CNES. Se utiliz un Modelo Lineal Generalizado Mixto (GLMM) con efectos fijos y aleatorios por hospital para analizar las asociaciones.

Resultados: Se analizaron un total de 244,538 cirugas en 943 hospitales, 48 de los cuales contaban con programas de residencia. El volumen quirrgico aument de 2014 a 2019, cay en 2020 y volvi a crecer hasta 2024. Los hospitales con programas de residencia presentaron una mayor proporcin de cirugas reconstructivas. El GLMM no mostr una asociacin significativa entre la presencia de residencias y las tasas de mastectoma (RR 0,84–1,13; $p > 0,05$). En cambio, la presencia de residencias se asoci positivamente con las cirugas reconstructivas a partir de 2019, con tasas de razn de incidencia (IRR) estadsticamente significativas en 2019 (IRR = 1,85; $p = 0,014$), 2021, 2022, 2023 y 2024.

Conclusin: La presencia de Programas de Residencia en Mastologa se asocia con un mayor acceso a la reconstruccin mamaria, lo que sugiere un impacto positivo en la calidad de la atencin quirrgica oncolgica en Brasil.

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Introduction

The growing global demand for specialized therapies for breast cancer¹ has driven the evolution of surgical treatment, making it more effective and diverse, with different levels of complexity ranging from conservative procedures to various breast reconstructive strategies.^{2–4} However, breast surgery training is highly heterogeneous worldwide, with distinct training programs and varying levels of proficiency.^{5–8}

In Brazil, Mastology is the recognized medical specialty responsible for managing breast diseases.⁹ Brazilian mastologists undergo a specific two-year medical residency program designed for professionals who have completed training in General Surgery or Obstetrics and Gynecology. Medical residency programs in Brazil are regulated by the Brazilian Ministry of Education. For Mastology residency, the curriculum is comprehensive, encompassing clinical skills, imaging diagnostics, and especially surgical skills at various levels of complexity. These include classic oncological procedures—such as lumpectomies, quadrantectomies, mastectomies, and axillary staging surgeries—as well as breast reconstructive surgeries, such as oncoplastic procedures and breast reconstruction using autologous flaps and implants.^{10,11}

Hospitals with medical residency programs generally offer superior healthcare conditions, which are reflected in better health outcomes for various diseases.^{12,13} In Brazil, the temporal trend of breast cancer surgeries varies by region, with a significant reduction in the number of breast

reconstructions observed in recent years.¹⁴ However, it is still unknown whether this trend occurs similarly in hospitals with and without Mastology residency programs. In this specific Brazilian context, the question arises: does the presence of Mastology residency programs impact the temporal reduction in the number of mastectomies and the increase in national rates of breast reconstructive surgeries?

Methodology**Study type**

This is a retrospective observational ecological study.

Data source

Data related to breast cancer treatments were extracted from the Hospital Information System (SIH) of DATASUS (<http://www2.datasus.gov.br/DATASUS/index.php?area=0901&item=1&acao=25>). DATASUS is the Brazilian Health Informatics Department responsible for collecting, processing, and disseminating health data. It supports the planning, management, and evaluation of public health policies within the Unified Health System (SUS). Data compilation was performed using R Studio version 4.5.0 with the *microdatasus* package.¹⁵ Hospital admissions from 2014 to 2024 were analyzed, in which the primary diagnosis, according to the 10th revision of the International

Table 1 Categorization of breast cancer surgeries in Brazil into mastectomy, conservative, and reconstructive procedures according to SIH/DATASUS codes.

Category	SIH code	Procedure
Conservative surgery	0410010111	Lumpectomy/Quadrantectomy
	0410010120	Lumpectomy/Quadrantectomy with Lymph Node Dissection
	0416120059	Lumpectomy/Quadrantectomy/Sectorectomy in Oncology
	0416120040	Resection of Non-Palpable Lesion in Oncology
Mastectomy	0410010057	Radical Mastectomy with Lymphadenectomy
	0410010065	Simple Mastectomy
	0416120024	Radical Mastectomy with Axillary Lymphadenectomy in Oncology
	0416120032	Simple Mastectomy in Oncology
Breast reconstruction	0410010090	Reconstructive Breast Surgery Post-Mastectomy with Implant
	0410010219	Breast Reconstruction Post-Total Mastectomy
	0416080081	Reconstruction with Myocutaneous Flap (any site) in Oncology
	0410010073	Plastic Non-Esthetic Breast Surgery in Oncology

Classification of Diseases (ICD-10), was either C50 – malignant neoplasm of the breast or D05 – carcinoma in situ of the breast.

Data on breast cancer surgical procedures, uniformly coded across Brazil, were extracted from the SIH database and categorized into three groups based on procedure codes: conservative surgery, mastectomy, and breast reconstruction, as shown in Table 1.

Information on hospitals with medical residency programs that certified specialists in Mastology from 2014 to 2024 was obtained through the National Medical Residency Commission System (SISCNRM – <https://siscnrm.mec.gov.br/>) and the National Registry of Health Establishments (CNES – <https://cnes.datasus.gov.br/>).

Study variables

The explanatory variables were “reference year” (2014–2024); “type of hospital” (with medical residency; without medical residency); and “type of surgery” (conservative surgery; mastectomy; breast reconstruction). The dependent variable was the number of surgeries performed per hospital unit.

Statistical analysis

Initially, data were aggregated by reference year, type of surgery, and hospital type. For each group, absolute counts

and relative proportions of each type of surgery were calculated in relation to the total number of procedures in that group.

Data were visualized using line graphs to assess temporal trends in surgical types, stratified by the presence of a medical residency program.

A Generalized Linear Mixed Model (GLMM) was used to assess the association between the presence of a medical residency program, the type of surgery, and the year of procedure with the number of surgeries performed per hospital unit over time. This model accounts for the hierarchical structure of the data and controls for unobserved variation between hospitals.

The dependent variable was the number of surgeries performed per hospital unit, modeled using a negative binomial distribution with a logarithmic link function.

Fixed effects included: year of the procedure, presence of a residency program in the hospital unit, and type of surgery. An interaction term among these three variables was included to assess how their combined effects varied over time. A random effect for the hospital units (CNES) was also included to capture unexplained variation across hospitals.

The general form of the model can be represented as:

$$\log(E[Y_{ijk}]) = \beta_0 + \beta_1(\text{Year}_i) + \beta_2(\text{Residency}_j) + \beta_3(\text{SurgeryType}_k) + \text{Interactions} + \mu_{\text{CNES}}$$

where

- Y_{ijk} = number of surgeries.
- μ_{CNES} = random intercept for hospitals, assumed to follow a normal distribution with zero mean and constant variance.

The year 2014 and conservative surgery were used as reference categories.

Estimated coefficients were transformed into Incidence Rate Ratios (IRR), and results were presented with point estimates and confidence intervals (CIs). Statistical significance was set at $p < 0.05$. All analyses were conducted using R Studio version 4.5.0.

Ethical aspects

This study used secondary, public, and anonymized data obtained from DATASUS, with no identification of individuals. As it does not involve direct participation of human subjects or the use of sensitive data, the research is exempt from review by a Research Ethics Committee, in accordance with Resolution CNS No. 510/2016. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Results

A total of 244,538 breast cancer surgeries were performed in 943 Brazilian hospitals, 48 of which had medical residency programs in Mastology. Overall, the total number of surgical procedures increased steadily from 2014 to 2019, followed

Table 2 Distribution of breast cancer surgeries performed between 2014 and 2024 in hospitals with and without Mastology residency programs in Brazil.

Variables	Without medical residency N = 180,027	With medical residency N = 64,511
Reference year		
2014	16,688 (9.3%)	6390 (9.9%)
2015	16,837 (9.4%)	6709 (10%)
2016	17,506 (9.7%)	6451 (10.0%)
2017	17,601 (9.8%)	6303 (9.8%)
2018	17,854 (9.9%)	6048 (9.4%)
2019	17,025 (9.5%)	6248 (9.7%)
2020	13,626 (7.6%)	4585 (7.1%)
2021	13,155 (7.3%)	4641 (7.2%)
2022	14,778 (8.2%)	5222 (8.1%)
2023	16,702 (9.3%)	5854 (9.1%)
2024	18,255 (10%)	6060 (9.4%)
Type of surgery		
Reconstructive surgery	25,582 (14%)	10,716 (17%)
Conservative surgery	85,269 (47%)	28,005 (43%)
Mastectomy	69,176 (38%)	25,790 (40%)

by a decline in 2020. From 2021 onward, surgical volumes rose again through 2024. The proportion of different types of surgery varied among Hospitals with and without medical residency (Table 2).

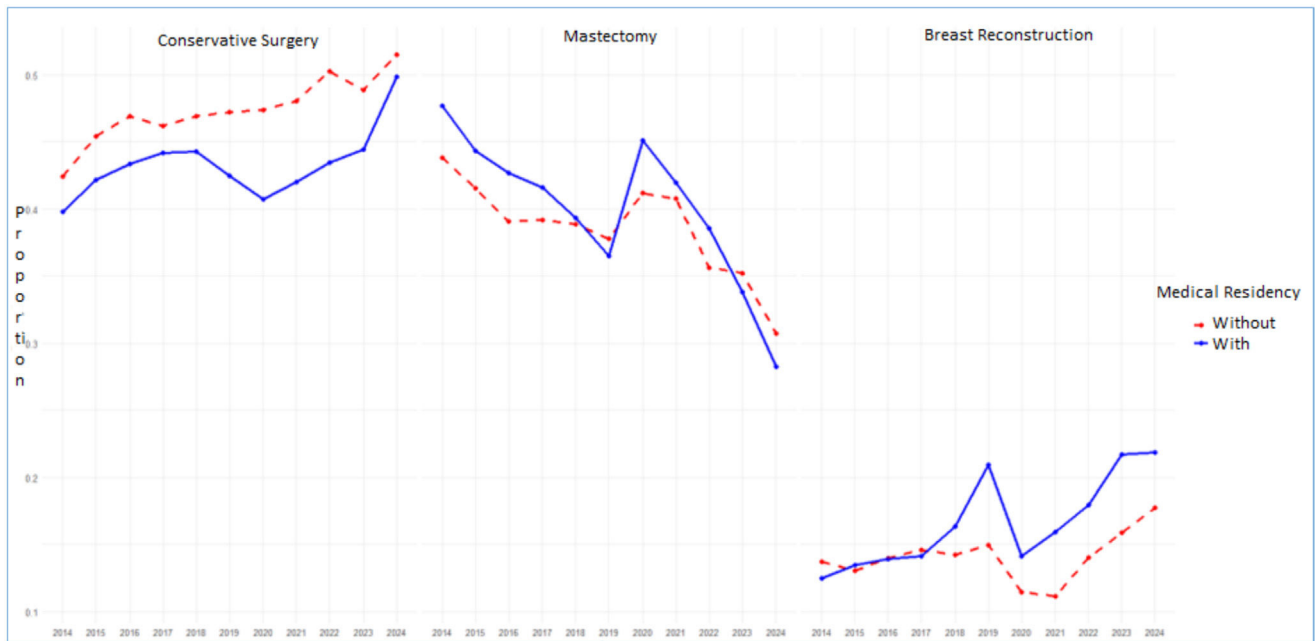
Regarding the trend curves, for conservative surgery, hospitals without residency programs displayed a consistent upward trend throughout the entire period. In contrast,

hospitals with residency programs experienced growth from 2014 to 2018, a decline in 2019 and 2020, and a resumed upward trend from 2021. By the end of the period, the proportion of conservative surgeries was similar between both groups. As for mastectomies, both groups showed a decreasing trend from 2014 to 2018, followed by an increase in 2020 and a subsequent decline. In 2024, hospitals with residency programs had a significantly lower proportion of mastectomies compared to those without. For reconstructive surgeries, proportions were similar between groups from 2014 to 2017. Between 2018 and 2024, both groups exhibited fluctuations, with a persistent higher rate in hospitals with residency programs—reaching nearly double the proportion in 2024 (Fig. 1).

Analysis of the effects of medical residency programs on the types of breast surgery over time, using three-way interaction terms in the Generalized Linear Mixed Model, revealed distinct patterns for mastectomy and breast reconstruction (Fig. 2).

For patients undergoing mastectomy, no statistically significant associations were observed with the presence of a residency program in any of the years from 2015 to 2024 (all $p > 0.05$). Incidence Rate Ratio (IRR) values ranged from 0.84 to 1.13, suggesting non-significant variations in mastectomy rates associated with medical residency presence over time (Table 3).

In contrast, for patients undergoing breast reconstruction, a statistically significant increase in procedure rates was observed in hospitals with residency programs, particularly from 2019 onward. The strongest effects were seen in 2019 (IRR = 1.85; $p = 0.014$), 2021 (IRR = 1.75; $p = 0.032$), 2022 (IRR = 1.73; $p = 0.031$), 2023 (IRR = 1.89; $p = 0.012$), and 2024 (IRR = 1.79; $p = 0.020$). These findings demonstrate a significant increase in the likelihood of breast

**Figure 1** Trend in breast cancer surgeries performed in hospitals with and without medical residency programs in Mastology in Brazil, 2014–2024.

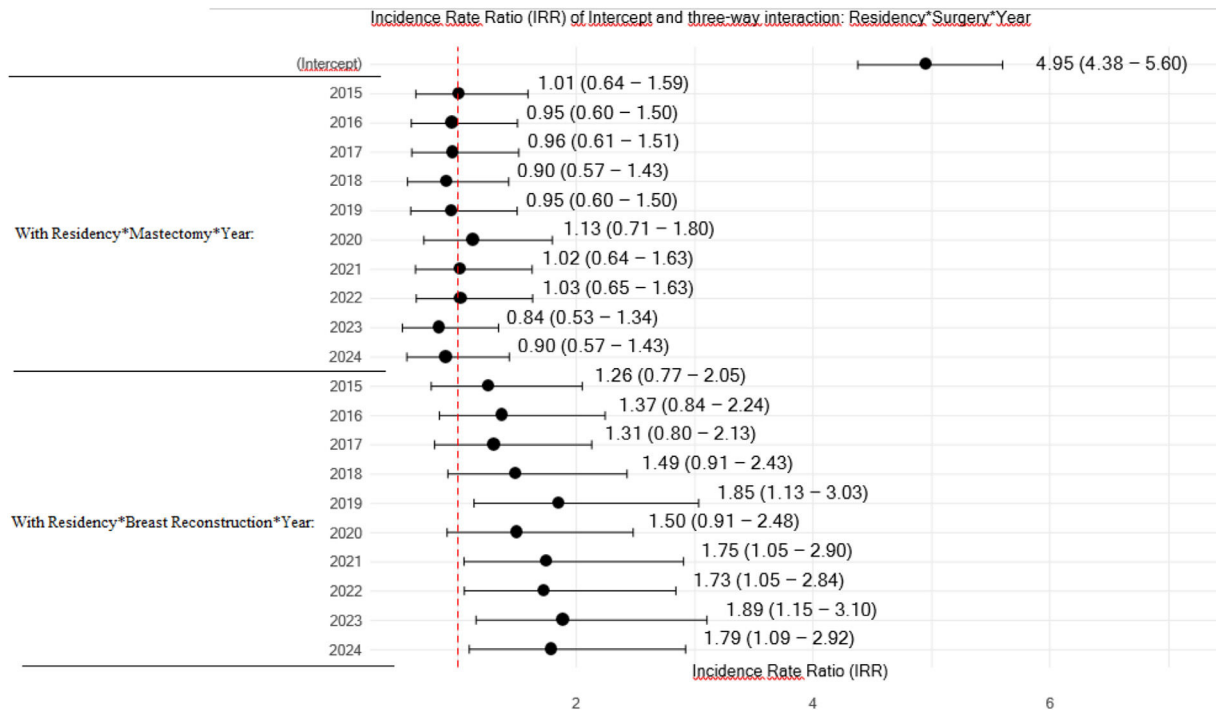


Figure 2 Analysis of the effects of Brazilian Mastology residency programs on the types of breast surgery over time (2014–2025), using three-way interaction terms in the generalized linear mixed model.

Table 3 Temporal impact of medical residency programs in Mastology on the type of breast cancer surgery performed in Brazil (2014–2024): estimated Incidence Rate Ratios (IRRs) from Generalized Linear Mixed Model (GLMM) with three-way interaction terms.

Term	IRR	IC 95% inferior	IC 95% superior	p-value
(Intercept)	4.95101	4.37744	5.59975	0.00000
With residency * mastectomy * year:				
2015	1.01115	0.64322	1.58954	0.96168
2016	0.95291	0.60463	1.50180	0.83536
2017	0.95947	0.60897	1.51170	0.85841
2018	0.90393	0.57253	1.42717	0.66468
2019	0.94773	0.59917	1.49906	0.81849
2020	1.12893	0.70964	1.79596	0.60867
2021	1.02055	0.64064	1.62575	0.93176
2022	1.02577	0.64606	1.62864	0.91411
2023	0.84296	0.52945	1.34213	0.47157
2024	0.90100	0.56683	1.43217	0.65928
With residency * breast reconstruction * year:				
2015	1.25769	0.77230	2.04813	0.35678
2016	1.37406	0.84222	2.24174	0.20323
2017	1.30652	0.80158	2.12953	0.28342
2018	1.48837	0.91292	2.42653	0.11078
2019	1.85456	1.13441	3.03187	0.0137 *
2020	1.49904	0.90658	2.47870	0.11462
2021	1.74681	1.05043	2.90485	0.03159 *
2022	1.72865	1.05250	2.83917	0.0306 *
2023	1.88971	1.15119	3.10201	0.0118 *
2024	1.78826	1.09456	2.92161	0.0203 *

Variable reference: Type of hospital: Without residency; Type of surgery: Conservative; Year: 2014.

* Statistically significant ($p < 0.05$).

reconstruction being performed in hospitals with residency programs in the latter years of the study period (Table 3).

Discussion

Hospitals with Mastology residency programs account for less than 5% of all institutions performing breast surgeries in Brazil. Nonetheless, these hospitals were responsible for at least one-quarter of all breast surgeries nationwide. This significant contribution is likely due to the fact that residency hospitals, given the inherent demands of treating complex conditions, have more robust healthcare infrastructure and greater procedural capacity.^{12,13} The higher proportion of reconstructive surgeries in these hospitals further reinforces this distinction.

In addition to surgical training in reconstruction provided within residency programs, Brazil offers specialized oncoplastic surgery courses that have significantly expanded reconstructive techniques nationwide. Many instructors in these courses are affiliated with Mastology residency programs, which directly contributes to the increased number of reconstructions performed in these hospitals.⁸

This study highlights the variation in surgical trends observed from 2019 onwards—a period marked by the global impact of the COVID-19 pandemic. This health emergency led to a substantial reduction in breast cancer surgeries,^{16,17} with notable repercussions on surgical training within residency programs.¹⁸ Delays in diagnosis and surgical intervention also resulted in an increased incidence of locally advanced cases in subsequent years,^{19–21} reflected in the higher proportion of mastectomies in 2020 and 2021.

Although the pandemic significantly impacted hospitals with residency programs, these institutions demonstrated a faster recovery compared to those without such programs, as evidenced by the rising proportion of reconstructive surgeries in the post-pandemic period. This can be explained by the differentiated funding these public hospitals receive, with additional incentives from the Ministries of Health and Education, including funding for residency stipends, faculty salaries, institutional support, and higher ceilings within the Medium and High Complexity (MAC) funding block. Furthermore, their involvement in strategic SUS (Brazil's Unified Health System) networks and higher care complexity contributes to greater funding allocation and faster post-pandemic recovery.^{22–26}

By the end of the study period, hospitals with residency programs had a significantly higher proportion of reconstructive surgeries, indicating that Mastology residency programs play a decisive role in promoting surgeries that offer better esthetic outcomes for breast cancer patients. These findings affirm the success of Brazil's specialized training model, which supports improved treatment outcomes for breast cancer and may serve as a reference for other countries.

The strengths of this study include its national scope and longitudinal analysis, encompassing both pre- and post-COVID-19 periods.

Conclusion

Surgical practices for the treatment of breast cancer differed between hospitals with and without medical residency programs, with notable variation over time.

Hospitals with Mastology residency programs performed a greater number of reconstructive surgeries, underscoring the positive impact of specialized training on improving surgical quality and patient outcomes in breast cancer care.

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CRedit authorship contribution statement

Jos Pereira Guar: Conceptualization, Methodology, Software, Validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Alcione Miranda dos Santos:** Conceptualization, Methodology, Software, Validation, Formal analysis, Data curation, Visualization. **Rosngela Fernandes Lucena Batista:** Conceptualization, Methodology, Software, Validation, Formal analysis, Writing – review & editing, Visualization, Supervision.

Conflicts of interest

The authors declare no conflict of interest.

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The authors have reviewed and edited the output and took full responsibility for the content of this publication.

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