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Factors associated with surgeons' dual practice in mixed health systems. A hierarchical modelling study from Brazil

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Abstract

Background

Physician dual practice, whereby public doctors engage concomitantly with private healthcare services, is widespread in mixed and fragmented health systems. For surgical services, dual practice may be particularly important because surgeons depend on hospital infrastructure, operating facilities and multidisciplinary teams, while their distribution across sectors can influence the availability, organisation and geographical accessibility of specialist care. Brazil combines a tax-funded universal health system with a large private healthcare sector, creating substantial opportunities for surgeons to work across multiple organisations. We examined employment arrangements among Brazilian surgeons and factors associated with dual practice.

Methods

We conducted a national cross-sectional survey of 1,544 practising surgeons affiliated with the *Colégio Brasileiro de Cirurgiões* between September 2024 and February 2025. Respondents were classified as public-only, private-only or dual practitioners. Two hierarchical binary logistic regression models compared private-only and public-only surgeons with dual practitioners, sequentially incorporating personal characteristics, labour-market factors, organisation and characteristics of surgical practice, and psychosocial variables.

Results

Dual practice was the predominant employment arrangement, reported by 1,092 (70.7%) surgeons, compared with 332 (21.5%) working exclusively in the private sector and 120 (7.8%) exclusively in the public sector.

1 INTRODUCTION

Surgeons are a critical component of health systems, providing essential and often life-saving interventions for conditions ranging from trauma and obstetric emergencies to non-communicable diseases.[1] Surgical care is increasingly recognised as indispensable to achieving universal health coverage because of its effects on mortality, disability, and economic productivity.[2] At the same time, surgeons occupy a distinctive position within national medical workforces, as they undergo lengthier and highly specialised training, command relatively higher incomes, and often enjoy greater professional autonomy than other physicians.[3, 4] These characteristics shape how surgeons engage with labour markets and healthcare systems, particularly in contexts where public and private provision coexist.

Across most low- and middle-income countries (LMICs), health systems remain fragmented, with public, social security, and private sectors operating in parallel and often with limited coordination. This fragmentation contributes to persistent inequities in access, financing, and quality of health care, particularly for rural and socioeconomically vulnerable populations.[5] In this context, dual practice, doctors' simultaneous engagement in public and private healthcare sectors,[6] has become a defining feature of mixed health systems.[7]

Although many suggest dual practice might help topping up salaries and retain highly skilled professionals in underfunded public systems,[8] concerns also have been raised that surgeons, operating time, and other scarce resources may increasingly shift toward more lucrative private practice, thereby exacerbating inequalities in population access to surgical services.[9, 10] The literature on dual practice conceptualises it largely as a response to income differentials, labour market conditions, and institutional constraints.[11] Empirical studies across low- and middle-

income countries show that doctors are more likely to engage in dual practice where private-sector remuneration is higher and public-sector oversight is weaker.[12]

Such dynamics are especially relevant in Brazil, South America's largest country and health market, where the tax-funded universal health system, *Sistema Único de Saúde* (SUS), coexists with a large and heterogeneous private sector.[13] Recent evidence has suggested that dual practice is widespread in the country's mixed health system, particularly among specialised and experienced physicians.[14, 15] The country's surgeons have been found to be particularly likely to engage in dual practice because surgical work is hospital-based, procedure-intensive, and often compatible with employment across multiple institutions.[16]

Little evidence exists on the effects of dual practice on population access to services, quality of care, and on effectiveness of regulatory options.[17] Although it has been observed that public sector specialists enjoy greater access to private sector employment than their general practice peers, [18] the literature has not looked yet into how different medical specialties are affected by dual practice.

This paper addresses two key gaps in the literature. First, it examines whether surgeons' patterns of dual practice differ systematically from those of other physicians, thereby assessing the extent to which specialty-specific factors shape labour allocation across sectors. Second, it investigates the main determinants of surgeons' engagement in public and private practice, focusing on individual, institutional, and market factors. By analysing surgeons within the Brazilian health system, this study contributes to a more differentiated understanding of dual practice and its implications for equity, efficiency, and workforce policy in Latin America.

2 METHODS

2.1 Study design and data sources

This cross-sectional study used data from a national survey conducted among practicing surgeons affiliated with the *Colégio Brasileiro de Cirurgiões (CBC)*, the largest professional surgical association in Brazil. The survey aimed to investigate demographic characteristics, professional trajectories, employment arrangements, and patterns of engagement across public and private healthcare sectors among Brazilian surgeons. The study was conceptually designed to examine the correlates of different forms of labour-market participation among surgeons, with particular emphasis on dual practice, defined as simultaneous engagement in both public and private healthcare sectors. The study questionnaire was administered to surgeons as part of the 2025 Medical Demography exercise, and available online [19].

The analytical framework was structured around four interconnected domains of factors potentially associated with surgeons' employment arrangements: (i) personal characteristics; (ii) labour-market features; (iii) characteristics related to the type of work, organization of shifts, and working arrangements; and (iv) surgeons' responses to questions considered proxies for professional attitudes, perceptions, and satisfaction. This conceptual organization was intended to capture the multidimensional nature of surgical work in Brazil and to explore how individual trajectories, labour-market insertion, organization of professional practice, and subjective evaluations of work interact with patterns of public-private engagement.

Given the centrality of dual practice in the Brazilian medical labour market, dual practitioners were adopted as the reference category for the analytical models. This decision was both empirical and conceptual: dual practice represented the predominant employment arrangement among surgeons and constituted the principal phenomenon under investigation. The analytical strategy therefore focused on identifying factors associated with exclusive participation in either the private or public sector in comparison with surgeons engaged simultaneously in both sectors.

For this reason, the study employed two separate analytical comparisons: private-sector only surgeons versus dual practitioners, and public-sector only surgeons versus dual practitioners. Separate models were preferred because the three employment groups presented substantially different demographic, professional, and organizational profiles. Modelling all categories simultaneously within a single hierarchical framework could have weakened model performance and obscured distinct correlational patterns associated with exclusive sector participation. The adopted approach therefore enabled more consistent estimation of factors differentiating exclusive private and exclusive public practice from dual engagement.

2.2 Sampling and study population

The sampling frame was derived from the CBC registry, which initially included 8,278 active members. After excluding duplicate records, incomplete registrations, and invalid contact information, 6,869 surgeons constituted the eligible survey population.

A stratified probabilistic sampling strategy was employed to ensure geographic representation across Brazil's five major regions (North, Northeast, Southeast, South, and Central-West). Within each stratum, eligible surgeons were randomly selected from the CBC registry.

A total of 1,630 surgeons completed the interview, corresponding to a response rate of 23.7%. Respondents who reported not having performed surgical procedures during the 12 months preceding the survey were excluded (n = 86), resulting in a final analytical sample of 1,544 actively practicing surgeons. The study population should be interpreted as a nationally distributed sample of practicing surgeons drawn from the eligible CBC membership registry, rather than from the entire population of surgeons practicing in Brazil. Nevertheless, the CBC constitutes the largest professional surgical association in the country and includes surgeons from all Brazilian regions and states.

Data collection was conducted between September 16, 2024, and February 18, 2025, using structured computer-assisted telephone interviews administered by trained interviewers. The questionnaire included 35 items covering sociodemographic characteristics, medical training, labour-market participation, surgical workload, income, employment arrangements, and perceptions regarding work and wellbeing. Interviews lasted approximately 20 minutes on average.

The study received ethics clearance by the Brazilian Research Ethics Committee (CAAE:35140914.7.0000.0065). All participants provided informed consent prior to participation. Data were anonymized before analysis and handled in accordance with national ethical guidelines for research involving human participants.

2.3 Variables and statistical analysis

The outcome of interest was surgeons' professional practice arrangement, classified into three mutually exclusive categories according to self-reported engagement in the public and private healthcare sectors. Because dual practice represented both the predominant employment arrangement among surveyed surgeons and the central phenomenon of interest, it was adopted as the reference category in multivariable analyses.

Based on previous literature on physician labour markets and dual practice, explanatory variables were organized into four conceptual domains reflecting progressively proximal determinants of professional practice arrangements, including (1) Personal characteristics, including sex, age group, race/ethnicity, and geographic region; (2) Labour-market characteristics, including educational qualifications, surgical training, income, number of employment relationships, and mobility between residence and workplace locations; (3) Work organization and surgical practice characteristics, including surgical volume, procedure duration, scope of practice, and type of surgical activity; (4) Attitudinal and satisfaction-related factors, including perceptions of professional future, work-life balance, leisure time adequacy, and self-perceived mental health.

Descriptive analyses were performed to characterize surgeons according to practice arrangement. Categorical variables were summarized using absolute and relative frequencies with corresponding 95% confidence intervals (95% CI). Group differences were assessed using Pearson's chi-square test or Fisher's exact test, as appropriate.

To investigate factors associated with professional practice arrangements, two separate hierarchical binary logistic regression models were estimated. The first compared surgeons engaged exclusively in private practice with those involved in dual practice, while the second compared surgeons engaged exclusively in public practice with dual practitioners.

Variables associated with the outcome at $p \leq 0.20$ in the corresponding bivariate analysis, together with variables considered conceptually relevant, were eligible for inclusion in multivariable modelling. Variable selection was performed independently for each comparison (private-only versus dual practice and public-only versus dual practice); therefore, the set of eligible variables differed between models according to the results of the respective bivariate analyses.

Hierarchical logistic regression models were constructed by sequentially entering eligible variables according to the predefined conceptual framework: Model 1 included personal characteristics; Model 2 added labour-market characteristics; Model 3 incorporated work organization and surgical practice variables; and Model 4 included attitudinal and satisfaction-related factors. Consequently, not all variables presented in the descriptive analyses were retained in the final multivariable models, and the composition of the final models differed between the two comparisons.

Adjusted odds ratios (ORs) and 95% confidence intervals were estimated. Model fit was evaluated using likelihood-ratio tests and Akaike's Information Criterion (AIC), while multicollinearity was assessed using variance inflation factors (VIF). Statistical significance was defined as $p < 0.05$. All analyses were conducted using R statistical software (R Foundation for Statistical Computing, Vienna, Austria).

3 FINDINGS

We analysed a sample of 1,527 surgeons in 2024, representing a total surgical workforce of 6,869 in Brazil. Table 1 below presents the descriptive characteristics of the study sample, stratified by employment sector (public only, private only, and dual practice).

Table 1
Descriptive statistics for the study's sample of surgeons

Variable/ Categories	Employment sector						p-value
	Public only		Private only		Dual Practice		
n	% (95% CI)	n	% (95% CI)	n	% (95% CI)		
Sex							
Female	35	29,17 (21,6–37,7)	59	17,99 (14,1–22,4)	219	20,3 (18–22,8)	0.033
Male	85	70,83 (62,3–78,4)	269	82,01 (77,6–85,9)	860	79,7 (77,2–82)	
Race/ Ethnicity							
White	84	68,85 (60,3–76,6)	287	86,45 (82,5–89,8)	862	79,08 (76,6–81,4)	< 0,001
Black	4	3,28 (1,1–7,6)	3	0,9 (0,3 – 2,4)	20	1,83 (1,2–2,8)	
Asian	5	4,1 (1,6–8,7)	8	2,41 (1,1–4,5)	29	2,66 (1,8 – 3,7)	
Brown (Mixed race)	29	23,77 (16,9–31,9)	26	7,83 (5,3–11,1)	168	15,41 (13,4–17,6)	
Indigenous	0	0 (0–0)	1	0,3 (0–1,4)	4	0,37 (0,1 – 0,9)	
Prefer not to answer	0	0 (0–0)	7	2,11 (0,9 – 4,1)	7	0,64 (0,3 – 1,3)	
Age group							
< 35 years	61	50,83 (42–59,7)	65	19,82 (15,8–24,4)	305	28,27 (25,6–31)	< 0,001
35–50 years	30	25 (17,9–33,3)	132	40,24 (35–45,6)	448	41,52 (38,6–44,5)	
> 50 years	29	24,17 (17,2–32,4)	131	39,94 (34,7–45,3)	326	30,21 (27,5–33)	
Brazilian region of medical registration							
North	4	4,76 (1,6–10,9)	2	0,75 (0,2–2,4)	49	5,25 (4–6,8)	0.002
Northeast	11	13,1 (7,2–21,5)	18	6,74 (4,2–10,2)	101	10,83 (9–12,9)	
Southeast	49	58,33 (47,7–68,4)	209	78,28 (73–82,9)	616	66,02 (62,9–69)	
South	14	16,67 (9,9–25,7)	25	9,36 (6,3–13,3)	102	10,93 (9,1–13,1)	
Central-West	6	7,14 (3–14,1)	13	4,87 (2,8–8)	65	6,97 (5,5–8,7)	

Note: Data are presented as absolute frequency (n), relative frequency (%), and 95% confidence interval (95% CI).

Variable/ Categories	Employment sector						p-value
	Public only		Private only		Dual Practice		
n	% (95% CI)	n	% (95% CI)	n	% (95% CI)		
Highest level of education (lato sensu, Master's, PhD)							
No postgraduate degree	82	68,33 (59,7–76,1)	147	44,41 (39,1–49,8)	468	43,09 (40,2–46,1)	< 0,001
Lato sensu (without Master's or PhD)	20	16,67 (10,8–24,1)	92	27,79 (23,2–32,8)	265	24,4 (21,9–27)	
Master's degree (may include lato sensu)	7	5,83 (2,6–11,1)	40	12,08 (8,9–15,9)	152	14 (12–16,2)	
PhD (may include lato sensu and Master's)	11	9,17 (5–15,3)	52	15,71 (12,1–19,9)	201	18,51 (16,3–20,9)	
Complete a Medical Residency in General Surgery?							
Yes	99	81,15 (73,5–87,3)	305	91,87 (88,6–94,4)	981	90 (88,1–91,7)	0.003
No	23	18,85 (12,7–26,5)	27	8,13 (5,6–11,4)	109	10 (8,3–11,9)	
Complete a Medical Residency in another surgical specialty?							
Yes	41	33,61 (25,7–42,3)	235	70,78 (65,7–75,5)	730	66,97 (64,1–69,7)	< 0,001
No	81	66,39 (57,7–74,3)	97	29,22 (24,5–34,3)	360	33,03 (30,3–35,9)	

Note: Data are presented as absolute frequency (n), relative frequency (%), and 95% confidence interval (95% CI).

Most surgeons (70.7%) declared engaging in dual practice, with 21.5% dedicating to private work only, and just 7.8% working exclusively for the public sector. The distribution revealed a predominance of male surgeons across all sectors, although the proportion of women is significantly higher in the public-only group compared with private and dual practice ($p = 0.033$). Statistically significant differences were also observed in racial and ethnic composition ($p < 0.001$), with White surgeons comprising the majority in all sectors, particularly in private practice, while mixed-race ("Brown") surgeons more represented in public and dual practice settings.

<*Insert* Table 1 *here*>

Age distribution differed markedly by sector ($p < 0.001$), with younger surgeons (< 35 years) disproportionately concentrated in the public-only group, whereas private-only and dual practitioners are more commonly in the 35–50 and > 50 age categories. Regional variation in medical registration is also significant ($p = 0.002$), with the Southeast region accounting for the largest share across all groups (57.2%), especially among private-only practitioners (63.7%). Public-only surgeons show relatively greater representation in the North and Northeast regions.

3.1 Multivariate correlates for dual practice and private sector-only surgeons

Hierarchical multilevel modelling identified important demographic, geographic, and professional correlates associated with surgeons working exclusively in the private sector, as opposed to those engaging in dual practice. Across models, explanatory power improved progressively with the addition of employment and surgical practice variables, with Model 3 (M3) providing the best overall fit to the data (Table 2 below).

Table 2
Hierarchical models explaining surgeons' decisions to engage exclusively in private sector Vs engaging with dual practice

Variables/categories	M0	p	M1 OR (95% CI)	p	M2 OR (95% CI)	p	M3 OR (95% CI)	p	M4 OR (95% CI)	p
Employment sector										
Dual practice	1.0		-	-	-	-	-	-	-	-
Private only	0.22 (0.19–0.26)	< 0.001	-	-	-	-	-	-	-	-
Race/ethnicity										
White	-		1.0	-	1.0	-	1.0	-	1.0	-
Non-white	-		0.65 (0.40–1.09)	0.100	0.70 (0.40–1.24)	0.224	0.74 (0.41–1.33)	0.310	0.68 (0.35–1.34)	0.268
Age group										
<35 years	-		1.0	-	1.0	-	1.0	-	1.0	-
35–50 years	-		2.09 (1.27–3.46)	0.004	2.74 (1.55–4.84)	< 0.001	2.75 (1.52–4.98)	< 0.001	2.83 (1.55–5.17)	< 0.001
>50 years	-		2.79 (1.68–4.63)	< 0.001	2.17 (1.22–3.85)	0.008	2.04 (1.12–3.73)	0.020	2.11 (1.14–3.90)	0.017
Brazilian region										
Southeast	-		1.0	-	1.0	-	1.0	-	1.0	-
Central-West	-		0.26 (0.09–0.72)	0.010	0.29 (0.10–0.89)	0.030	0.29 (0.09–0.94)	0.039	0.32 (0.10–1.00)	0.050
Northeast	-		0.61 (0.33–1.13)	0.116	0.63 (0.31–1.25)	0.186	0.63 (0.31–1.28)	0.199	0.64 (0.32–1.31)	0.225
North	-		0.10 (0.01–0.74)	0.024	0.10 (0.01–0.79)	0.030	0.11 (0.01–0.95)	0.045	0.11 (0.01–0.95)	0.045
South	-		0.54 (0.30–0.98)	0.042	0.64 (0.33–1.24)	0.184	0.67 (0.34–1.33)	0.250	0.68 (0.34–1.35)	0.273
Residence–work municipality relationship										
Outside	-		-	-	1.0	-	1.0	-	1.0	-
Same municipality	-		-	-	0.65 (0.22–1.93)	0.442	0.56 (0.18–1.71)	0.308	0.56 (0.18–1.73)	0.314

Variables/categories	M0	p	M1 OR (95% CI)	p	M2 OR (95% CI)	p	M3 OR (95% CI)	p	M4 OR (95% CI)	p
Employment sector										
Multiple	-		-	-	0.50 (0.16–1.52)	0.220	0.42 (0.14–1.32)	0.138	0.42 (0.13–1.32)	0.136
Employment ties										
Up to 3					1.0	-	1.0	-	1.0	-
More than 3	-		-	-	0.07 (0.05–0.11)	< 0.001	0.07 (0.05–0.11)	< 0.001	0.07 (0.05–0.11)	< 0.001
Surgical procedures per month										
>80	-		-	-	-	-	1.0	-	1.0	-
21–80	-		-	-	-	-	1.16 (0.30–4.52)	0.836	1.26 (0.32–4.98)	0.742
≤20	-		-	-	-	-	1.13 (0.29–4.46)	0.862	1.24 (0.31–4.97)	0.759
Surgical procedure duration										
>6h (Grade IV)	-		-	-	-	-	1.0	-	1.0	-
4–6h (Grade III)	-		-	-	-	-	0.41 (0.09–1.89)	0.254	0.42 (0.09–1.94)	0.265
2–4h (Grade II)	-		-	-	-	-	0.23 (0.06–0.88)	0.032	0.23 (0.06–0.90)	0.035
≤2h (Grade I)	-		-	-	-	-	0.42 (0.12–1.52)	0.185	0.43 (0.12–1.58)	0.204
Types of surgical procedures										
Mostly emergency	-		-	-	-	-	1.0	-	1.0	-
Mostly elective	-		-	-	-	-	4.07 (1.34–12.37)	0.013	4.44 (1.43–13.82)	0.010
Emergency only	-		-	-	-	-	2.00 (0.26–15.27)	0.505	2.06 (0.26–16.30)	0.493
Elective only	-		-	-	-	-	6.13 (1.97–19.12)	0.002	6.89 (2.14–22.14)	0.001
Mixed	-		-	-	-	-	1.07 (0.27–4.19)	0.920	1.13 (0.29–4.50)	0.859

Variables/categories	M0	p	M1 OR (95% CI)	p	M2 OR (95% CI)	p	M3 OR (95% CI)	p	M4 OR (95% CI)	p
Employment sector										
General or specialized surgery										
Specialized only	-		-	-	-	-	1.0	-	1.0	-
General surgery only	-		-	-	-	-	0.76 (0.40–1.43)	0.393	0.77 (0.41–1.45)	0.411
Both	-		-	-	-	-	0.92 (0.60–1.42)	0.711	0.93 (0.60–1.43)	0.727
Confidence in future as a surgeon										
Agree	-		-	-	-	-	-	-	1.0	-
Disagree	-		-	-	-	-	-	-	0.69 (0.39–1.21)	0.198
Satisfaction with time dedicated to work										
Agree	-		-	-	-	-	-	-	1.0	-
Disagree	-		-	-	-	-	-	-	1.23 (0.72–2.11)	0.445
Mental health (self-perceived good)										
Good	-		-	-	-	-	-	-	1.0	-
Not good	-		-	-	-	-	-	-	0.87 (0.41–1.84)	0.714
Leisure time sufficient										
Yes	-		-	-	-	-	-	-	1.0	-
No	-		-	-	-	-	-	-	1.08 (0.67–1.75)	0.748
Model fit statistics										
Residual deviance	995.74		945.08		743.90		706.50		704.14	
AIC	997.74		961.08		765.90		750.50		756.14	
p	-		< 0.001		< 0.001		< 0.001		0.669	
Reference	-		M1 vs M0		M2 vs M1		M3 vs M2		M4 vs M3	

The first adjusted model (M1), which included sociodemographic and regional characteristics, demonstrated that age was strongly associated with exclusive private-sector practice. Compared with surgeons younger than 35 years, those aged 35–50 years had more than twice the odds of working exclusively in the private sector (OR 2.09, 95% CI 1.27–3.46), while surgeons older than 50 years had almost threefold higher odds (OR 2.79, 1.68–4.63). Regional disparities

were also evident. Relative to the Southeast region, surgeons in the Central-West (OR 0.26, 0.09–0.72), North (OR 0.10, 0.01–0.74), and South (OR 0.54, 0.30–0.98) were significantly less likely to engage exclusively in private practice. Race/ethnicity was not independently associated with practice arrangement.

Model 2 (M2) incorporated employment organisation characteristics, including municipality of practice and number of employment ties, and substantially improved model fit compared with M1 (AIC reduction from 961.08 to 765.90; $p < 0.001$). The most influential variable introduced at this stage was number of employment ties. Surgeons holding more than three employment positions were markedly less likely to work exclusively in the private sector (OR 0.07, 95% CI 0.05–0.11), indicating that extensive multi-post employment was strongly characteristic of dual practitioners. Age and regional effects remained robust after adjustment, suggesting that career stage and regional labour-market dynamics independently influenced employment arrangements.

The addition of surgical workload and procedural characteristics in Model 3 (M3) produced the best explanatory model overall, achieving the lowest Akaike Information Criterion (AIC 750.50) and a further significant improvement in fit relative to M2 ($p < 0.001$). The superior performance of M3 suggests that the nature of surgical practice itself, particularly procedural profile and case mix, plays a central role in distinguishing surgeons who transition to exclusive private-sector work from those who maintain dual practice arrangements.

Within M3, the strongest associations were observed for type of surgical activity. Compared with surgeons performing mostly emergency procedures, those undertaking mostly elective surgery had approximately fourfold higher odds of exclusive private-sector practice (OR 4.07, 1.34–12.37), while surgeons performing elective procedures only had more than sixfold higher odds (OR 6.13, 1.97–19.12). These findings indicate that exclusive private-sector practice is strongly concentrated among surgeons whose work is organised around elective care delivery.

Procedure duration was also independently associated with practice arrangement. Surgeons predominantly performing intermediate-duration operations (2–4 hours; Grade II) were less likely to work exclusively in the private sector than those undertaking very long procedures (> 6 hours; Grade IV) (OR 0.23, 0.06–0.88). By contrast, surgical volume and degree of specialisation were not significantly associated with exclusive private practice after adjustment.

Importantly, the major correlates identified in earlier models remained stable in M3. Surgeons aged 35–50 years (OR 2.75, 1.52–4.98) and those older than 50 years (OR 2.04, 1.12–3.73) continued to show substantially greater odds of exclusive private-sector practice compared with younger surgeons. Similarly, surgeons with more than three employment ties remained substantially less likely to work exclusively in the private sector (OR 0.07, 0.05–0.11), reinforcing the central role of employment fragmentation in sustaining dual practice. Regional inequalities also persisted, particularly for surgeons in the North and Central-West regions, who consistently demonstrated lower odds of exclusive private-sector engagement.

The final model (M4), which added indicators of wellbeing and professional satisfaction, did not improve model performance relative to M3 ($p = 0.669$), and none of the psychosocial variables were independently associated with practice arrangement.

<Insert Table 2 *here>*

3.2 Correlates for dual practice Vs public sector-only surgeons

Multilevel modelling showed important differences between surgeons working exclusively in the public sector and those engaged in dual practice across successive model specifications (see Table 3 below). In the initial adjusted model (M1), which included demographic characteristics, non-white surgeons had significantly higher odds of working exclusively in the public sector than white surgeons (OR 1·61, 95% CI 1·02–2·56), whereas surgeons aged 35–50 years and older than

50 years were substantially less likely to remain public only compared with those younger than 35 years. Sex was not independently associated with employment arrangement.

Table 3
Hierarchical models with correlates for public-only surgeons Vs dual practitioners

Category	M0 OR (95% CI)	p	M1 OR (95% CI)	p	M2 OR (95% CI)	p	M3 OR (95% CI)	p	M4 OR (95% CI)	p
Employment sector										
Dual practice	1.0		-	-	-	-	-	-	-	-
Public only	0.11 (0.09–0.13)	< 0.001	-	-	-	-	-	-	-	-
Sex										
Female	-		1.0	-	1.0	-	1.0	-	1.0	-
Male	-		0.79 (0.49–1.28)	0.347	1.65 (0.87–3.11)	0.125	1.63 (0.84–3.15)	0.145	1.57 (0.83–2.98)	0.165
Race/ethnicity										
White	-		1.0	-	1.0	-	1.0	-	1.0	-
Non-white	-		1.61 (1.02–2.56)	0.043	1.99 (1.06–3.74)	0.032	2.02 (1.05–3.89)	0.035	2.04 (1.08–3.86)	0.028
Age group										
<35 years	-		1.0	-	1.0	-	1.0	-	1.0	-
35–50 years	-		0.33 (0.20–0.55)	< 0.001	1.01 (0.49–2.07)	0.980	1.09 (0.51–2.32)	0.830	1.04 (0.50–2.15)	0.919
>50 years	-		0.48 (0.29–0.82)	0.007	0.85 (0.41–1.76)	0.662	1.00 (0.46–2.18)	0.999	0.91 (0.43–1.90)	0.798
Residence–work municipality relationship										
Outside	-		-	-	1.0	-	1.0	-	1.0	-
Same municipality	-		-	-	0.22 (0.07–0.70)	0.010	0.23 (0.07–0.73)	0.013	0.23 (0.07–0.73)	0.012
Multiple	-		-	-	0.27 (0.08–0.88)	0.030	0.23 (0.07–0.78)	0.018	0.28 (0.09–0.94)	0.038
Monthly income range										
≤ BRL 23,000	-		-	-	1.0	-	1.0	-	1.0	-
BRL 23,001–38,000	-		-	-	0.55 (0.29–1.08)	0.083	0.45 (0.22–0.93)	0.030	0.57 (0.29–1.12)	0.101
> BRL 38,000	-		-	-	0.23 (0.10–0.50)	< 0.001	0.18 (0.08–0.43)	< 0.001	0.22 (0.10–0.48)	< 0.001

Category	M0 OR (95% CI)	p	M1 OR (95% CI)	p	M2 OR (95% CI)	p	M3 OR (95% CI)	p	M4 OR (95% CI)	p
Number of employment ties										
Up to 3					1.0	-	1.0	-	1.0	-
More than 3	-		-	-	0.01 (0.00–0.02)	< 0.001	0.01 (0.00–0.02)	< 0.001	0.01 (0.00–0.02)	< 0.001
Surgical procedures per month										
>80	-		-	-	-	-	1.0	-	-	-
21–80	-		-	-	-	-	0.53 (0.15–1.86)	0.321	-	-
≤20	-		-	-	-	-	0.36 (0.10–1.28)	0.114	-	-
Types of surgical procedures										
Mostly emergency	-		-	-	-	-	1.0	-	-	-
Mostly elective	-		-	-	-	-	0.74 (0.32–1.74)	0.493	-	-
Emergency only	-		-	-	-	-	1.05 (0.31–3.53)	0.938	-	-
Elective only	-		-	-	-	-	0.98 (0.39–2.48)	0.967	-	-
Mixed	-		-	-	-	-	0.40 (0.14–1.12)	0.081	-	-
General or specialized surgery										
Specialized surgery only	-		-	-	-	-	1.0	-	-	-
General surgery only	-		-	-	-	-	1.58 (0.69–3.60)	0.277	-	-
Both general and specialized surgery	-		-	-	-	-	1.73 (0.80–3.71)	0.163	-	-
Confidence in future as a surgeon										
Totally or partially agree	-		-	-	-	-	-	-	1.0	-
Totally or partially disagree	-		-	-	-	-	-	-	0.48 (0.22–1.05)	0.065

Category	M0 OR (95% CI)	p	M1 OR (95% CI)	p	M2 OR (95% CI)	p	M3 OR (95% CI)	p	M4 OR (95% CI)	p
Model fit statistics										
Residual deviance	674.67		646.19		353.30		339.56		349.66	
AIC	676.7		656.19		373.30		381.56		371.66	
p	-		< 0.001		< 0.001		0.248		0.056	
Reference	-		M1 vs M0		M2 vs M1		M3 vs M2		M4 vs M2	

Model 2 (M2), which additionally incorporated geographical and labour-market variables, provided the best overall explanatory performance. The marked reduction in residual deviance (646·19 to 353·30) and AIC (656·19 to 373·30), together with the highly significant improvement relative to M1 ($p < 0·001$), indicated substantially better model fit. The strongest correlates in M2 were related to work organisation and earnings. Surgeons with more than three employment ties had dramatically lower odds of being public-only practitioners (OR 0·01, 95% CI 0·00–0·02), suggesting that multiple concurrent posts are strongly associated with dual practice. Higher income was also inversely associated with exclusive public-sector work, particularly among surgeons earning more than BRL 38,000 monthly (OR 0·23, 95% CI 0·10–0·50). In addition, surgeons living and working in the same municipality, or across multiple municipalities, were less likely to work exclusively in the public sector than those commuting from outside municipalities.

Further expansion of the model (M3 and M4) to include surgical workload, procedural profile, and confidence in the future profession did not materially improve model fit, and most additional covariates were not statistically significant.

<Insert Table 3 *here>*

4 DISCUSSION

Our analysis indicates that dual practice is by far the predominant employment arrangement among surgeons in Brazil. Only a small proportion work exclusively in the private sector, and an even smaller proportion work exclusively in the public sector. Surgeons are heavily concentrated in the Southeast, the country's most economically developed region, with this concentration particularly pronounced among those working exclusively in private practice. Marked differences across employment arrangements were also observed by career stage: younger surgeons were disproportionately represented among public-sector-only practitioners, whereas older surgeons were more likely to work exclusively in the private sector. Differences between dual practitioners and surgeons working exclusively in one sector were primarily related to employment structure and patterns of clinical activity. Compared with dual practitioners, private-sector-only surgeons typically reported fewer employment ties and were more likely to perform specific surgical procedures, while public-sector-only surgeons were characterised by fewer concurrent positions and lower income levels.

Taken together, these findings suggest that surgeons' distribution across public-only, private-only, and dual practice arrangements is shaped less by individual characteristics or subjective measures of wellbeing and job satisfaction than by broader structural factors. Labour market organisation, the regional availability of private-sector opportunities, employment arrangements, career stage, and the nature of surgical work itself appear to play central roles in determining patterns of practice across sectors.

Our results show that, in a mixed health system such as Brazil's, simultaneous employment in both the public and private sectors is the dominant mode of practice among surgeons. This finding is consistent with evidence from other

South American countries with similarly fragmented health systems, including Peru, Colombia, Argentina, and Ecuador. [20–22] Several factors may help explain this pattern. Unlike many office-based physicians, surgeons depend on access to hospitals equipped with sophisticated and costly infrastructure, which may limit opportunities for fully independent private practice. [23] In addition, maintaining surgical competence requires continuous clinical exposure and lifelong learning to prevent skill decay - the deterioration of critical technical and psychomotor abilities.[24] These professional demands may encourage surgeons to seek additional opportunities to operate beyond their primary employment setting, whether in the public or private sector.

Our work from Brazil also suggest that dual practice among surgeons exhibits several distinctive features compared with other medical specialties. First, although previous studies have shown that dual practice is the predominant employment arrangement among physicians in general,[25] [14, 15] our results indicate that it may be even more prevalent among surgeons. Within this specialty, exclusive employment in either the public or private sector appears to be the exception rather than the norm.

Second, surgeons were highly concentrated in Brazil's economically prosperous Southeast region, a pattern that was particularly pronounced among private-only and dual-practice surgeons. This geographic concentration challenges the argument that dual practice increases the availability, volume, and diversity of surgical services in underserved areas. [26, 27] Instead, dual practice appears to reinforce existing patterns of service concentration rather than expand access. Given that geographical inequalities in surgical care are already recognised as a major weakness of Brazil's surgical workforce,[28] policies aimed at improving workforce distribution should consider private-sector engagement as a potentially important determinant of success. As argued by Massenburg and colleagues, strengthening surgical systems requires not only increasing workforce capacity but also improving the organisation and distribution of services across sectors, particularly in underserved regions.[23]

Third, male sex was not strongly associated with the likelihood of engaging in dual practice. Although the gender composition of the surgical workforce differs substantially from that of many other medical specialties, this finding contrasts with the broader dual-practice literature, which generally reports lower participation among female physicians. [18] Finally, self-reported income did not differ substantially across public-only, private-only, and dual-practice surgeons. Although salaries for specialist surgeons in Brazil's public sector are reportedly relatively high, this finding challenges the assumption that income maximisation is the primary motivation for maintaining multiple employment arrangements.[29]

Our study highlights the importance of examining dual practice at the level of individual medical specialties. The distinctive organisational and professional characteristics of surgical practice suggest that the longstanding tendency to analyse dual practice across all physicians as a single occupational group [30, 31] may obscure important specialty-specific dynamics. Future research should therefore move beyond aggregate analyses and investigate dual practice within individual specialties to generate more nuanced and policy-relevant evidence.

This study has several limitations. First, the sample consisted exclusively of surgeons who were members of the *Colégio Brasileiro de Cirurgiões* and who agreed to participate in the survey; consequently, the findings may not be fully representative of all surgeons in Brazil. Second, the analysis relied on self-reported survey data rather than direct observation, introducing the possibility of reporting and social desirability biases. Subgroup analyses by specialty were not conducted; as the study included surgeons from multiple specialties, specialty-specific differences in labour-market dynamics and dual-practice patterns could not be explored. As such, future studies with larger samples within individual specialties should investigate whether the correlates of dual practice differ across surgical fields. Finally, the study focused primarily on surgeons' experiences and employment arrangements and did not assess the effects of dual practice on patient outcomes, service delivery, or broader population health indicators.

CONCLUSIONS

Dual practice is the predominant employment arrangement among Brazilian surgeons and represents a key challenge for health policy because it influences workforce distribution, service delivery, and access to specialist surgical care across public and private sectors. Using survey data from more than 1,500 practicing surgeons, we examined the determinants of surgeons' employment arrangements through a hierarchical modelling approach that incorporated personal characteristics, labour-market conditions, surgical practice patterns, and psychosocial factors.

Labour-market and employment-structure variables were the strongest correlates of practice arrangements, whereas wellbeing, job satisfaction, and professional outlook contributed little independent explanatory power. These findings suggest that dual practice is driven primarily by the structural organisation of mixed health systems rather than by individual preferences or dissatisfaction with work.

Accordingly, policies focused solely on changing physician behaviour through salary supplements, incentives, or restrictions on dual practice are unlikely to address the underlying drivers of the phenomenon. Greater emphasis should instead be placed on strengthening coordination between public and private surgical services, reducing regional disparities in access to specialist care, and improving workforce planning where both sectors coexist.

Abbreviations

AIC: Akaike Information Criterion

BRL: Brazilian real

CAAE Certificate of Presentation for Ethical Appreciation (*Certificado de Apresentação de Apreciação Ética*)

CBC: Colégio Brasileiro de Cirurgiões (Brazilian College of Surgeons)

CI: Confidence interval

FAPESP: São Paulo Research Foundation (*Fundação de Amparo à Pesquisa do Estado de São Paulo*)

LMICs: Low- and middle-income countries

NIHR: National Institute for Health and Care Research

OR: Odds ratio

SUS: Sistema Único de Saúde (Brazilian Unified Health System)

VIF: Variance inflation factor

Declarations

Ethics approval and consent to participate

Ethical approval for the study was obtained from the Research Ethics Committee of the University of São Paulo (CAAE: 35140914.7.0000.0065). All participants provided informed consent prior to participation in the study. Survey data were anonymised before analysis and handled in accordance with applicable national ethical guidelines for research involving

human participants. The study was performed in accordance with the relevant guidelines and regulations of the Declaration of Helsinki.

Consent for publication.

Not applicable. The manuscript does not contain any identifiable individual participant data, images, videos, or other material requiring consent for publication.

Availability of data and materials.

The datasets generated and analysed during the current study are not publicly available but deidentified participant data, aggregate data supporting the analyses, and the study data dictionary are available from the corresponding author on reasonable request.

Competing interests.

None declared.

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Authors' contributions.

MS participated in the design of the study, analysis of data, and management of the project. AC in the design of the study, analysis of data. SB in the design of the study, analysis of data. GAP in the design of the study, analysis of data. RC in the design of the study and reviewing the manuscript. LB in the design of the study and reviewing the manuscript. GR in the design of the study, analysis of data, drafting the manuscript, and funds acquisition.

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