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Original Article

Microsurgery influences breast reconstruction and its timing in patients with breast cancer: A population-based multilevel analysis

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A B S T R A C T

Background: The number of post-mastectomy breast reconstructions performed in patients with breast cancer varies widely. This study aimed to assess geographic and temporal variability and associated factors from 2018 to 2020, including the effect of the COVID-19 pandemic.
Methods: This population-based cohort study was conducted in women who underwent mastectomy for invasive breast cancer from 2018 to 2020 in the Catalan public healthcare system, with follow-up until November 2022. Data were drawn from the Catalan hospital discharge registry. Random-effects logistic regression was performed to identify individual, temporal, and center-based

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variables influencing breast reconstruction and to assess the associations with immediate versus delayed reconstruction.
Results: Among the 4315 included patients, 2173 (50.4%) underwent breast reconstruction (range by center 0% to 79%); 1750 (80.5%) surgeries were immediate and 423 (19.5%) were delayed. Significant, negative associations were older age, heart disease, kidney disease, and metastasis. Microsurgery and the R2 health region showed positive associations (odds ratio [OR] 4.67, 95% credible intervals [CrI] 1.73-13.63). Surgeries were immediate in 0% to 99% of the cases, according to center. Age was unrelated; however, microsurgery (OR 7.15, 95% CrI 1.92-29.34) and belonging to health region R5 (OR 47.88, 95% CrI 1.67-99.0) were related. Compared to 2018, rates of reconstructive surgery were similar to those in 2019 (OR 0.98, 95% CrI 0.81-1.18) and 2020 (OR 0.94, 95% CrI 0.77-1.14), whereas immediate reconstruction was more common (2019: OR 1.72, 95% CrI 1.30-2.27; 2020: OR 4.85, 95% CrI 3.44-6.84).
Conclusions: Age, comorbidities, and microsurgery help explain between-center variability in breast reconstruction, while its timing appeared to be influenced by microsurgery alone. The pandemic may have accelerated the trend toward immediate surgery.

Introduction

In 2023, an estimated 35,001 individuals in Spain were diagnosed with breast cancer,[1] the most common cancer in women. In Catalonia, the incidence of breast cancer in women was 5497 in 2022.[2] Approximately 30% to 40% of women with breast cancer undergo mastectomy,[3,4] entailing partial or total removal of their breast(s); in Catalonia, approximately 1500 mastectomies are performed annually.[5]

Mastectomy negatively affects a patients' appearance and well-being; therefore, post-mastectomy breast reconstruction (BR) is recommended. This oncologically safe procedure aims to restore the volume, shape, and symmetry of the breast, thus promoting post-mastectomy quality of life.[6,7] However, this intervention is implemented unevenly: in a 2013 systematic review of 28 studies (N = 940,678 women), the post-mastectomy BR rate was only 17% (range 4.9% to 81.2%).[8] The authors concluded that non-performance of BR was mainly influenced by individual patient factors and the need for adjuvant treatment. Individual factors associated with BR include younger age, absence of comorbidities, and higher education levels.[9] Studies have also assessed the associations with geographical distance, healthcare financing, and patient preferences. Center-related factors include the existence of a plastic surgery service in the same center, urban location, university affiliation, high volume of breast cancer cases, and private funding.[8,9]

Additionally, within plastic surgery services, microsurgery may be performed to vascularize tissues that are transferred to another part of the body. In some cases of BR, microsurgery is necessary to vascularize the dermofat in the lower abdomen. This involves anastomosing the internal mammary vessels (of the thorax) with the inferior epigastric vessels (of the abdomen)under magnification, as these vessels have a caliber between 0.5 and 2 mm. The technique requires personnel with specific expertise, and in Catalonia, it is available in 11 centers.

Reconstructive surgery can be immediate or delayed, with equivalent oncological outcomes.[7] Although immediate reconstruction (IR) is associated with higher rates of postsurgical complications, it is cost-effective, and patients report greater satisfaction and better body image and self-esteem, making it the preferred choice over delayed reconstruction (DR).[10,11] Moreover, the timing of the intervention also varies with the setting: in a 2017 population-based study in 92 Dutch hospitals, the IR rate in mastectomized women with invasive cancer ranged from 0% to 64% (mean 17%),[12,13] with higher proportions observed in younger patients and in those with certain tumor characteristics. In the UK, Jeevan et al. observed that the 19% IR rate varied regionally (9% to 43%) in the 2008-09 national audit, consistent with the 2006-09 Hospital Episode Statistics data (mean 17%, range 8% to 32%).[14]

Studies based on real-world data are being increasingly used to estimate the burden of disease in patients with cancer, evaluate screening programs and new treatments, and support decision-making around healthcare management.[15,16] In Catalonia, no such population-based studies have examined the implementation of BR in different healthcare centers, its timing, or the individual and center-based factors that influence its application. Moreover, there is scant knowledge on the impact of the pandemic on BR. A better understanding of this reality would allow improvements in the care policy toward patients who are candidates for BR. Thus, this study aimed to assess the geographic and temporal variability of BR and its associated factors in Catalonia from 2018 to 2020, including the effect of the COVID-19 pandemic.

Methods

Study design and population

This cohort study included women diagnosed with invasive breast cancer who underwent mastectomy in the public healthcare system in Catalonia from 2018 to 2020, with follow-up to November 2022.

Cases were identified using the hospital discharge registry, which collects a minimum basic data set from all hospital admissions. Diagnostic codes from the International Classification of Diseases, version 10 (ICD-10) were collected for breast neoplasia and post-mastectomy reconstruction, along with procedure codes associated with mastectomy and BR and data on patient comorbidities. Mastectomy and reconstruction procedures were identified using the Ministry of Health and Equality's publication on mastectomy and BR procedures,[17] together with the Catalan Health Service (CatSalut) working group's consensus paper on defining and coding BR services. Data on center characteristics and the availability of plastic surgery equipment were obtained from CatSalut.

Mastectomy with IR is a procedure in which BR is performed at the same time as mastectomy, even if further procedures, such as in the case of expander placement, are required.

Variables

Individual variables included age and comorbidities (obesity, stroke, heart disease, kidney disease, and metastasis). Center-based data were collected from the hospital where the mastectomy was performed:

- Health region according to CatSalut: R1, R2, R3, R4, R5, R6, and R7;
- Mastectomy center (41 total centers: 7 in the R1 region, 10 in R2, 6 in R3, 7 in R4, 1 in R5, 6 in R6, and 4 in R7);
- Type of center: reference center, regional/intermediate reference center, and county hospital;
- Plastic surgery service onsite;
- Plastic surgery specialist in the breast unit;
- Availability of microsurgery;
- Annual volume of mastectomies, according to the number of patients in the study, by geographical area;
- Annual volume of reconstructions, by geographical area.

Statistical analysis

Following the descriptive analysis, the student's t- and ANOVA tests were used to compare quantitative variables, and the chi-squared test was used for categorical variables. A significance level of

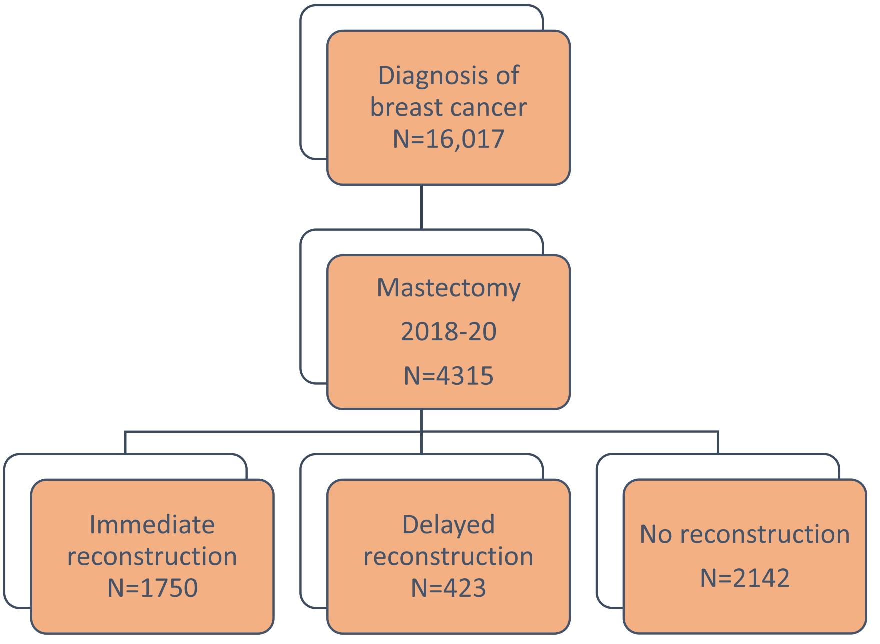

Figure 1. Study flow chart.

$\alpha = 0.05$ was used in all statistical tests. Analyses were performed with SPSS (version 26.0) and R software.[18]

BR performance was assessed dichotomously (yes/no) according to the explanatory variables detailed above. A random-effects Bayesian logistic-regression model was used,[16,17] where the mastectomy center was the random effect. Explanatory variables yielding an odds ratio (OR) of $p < 0.05$ in a logistic model adjusted for age were included in the model.

The impact of the explanatory variables on the timing of BR (immediate vs. delayed) was assessed following the same Bayesian modeling strategy as above and the multivariate OR and their corresponding 95% credible intervals (95% CrI) were computed. Between-center differences were evaluated using random effects. The distribution of the 95% CrI of these random effects to detect differences between hospitals was illustrated using a forest plot. We calculated the median odds ratio (OR_{Me}), a global indicator of the model's residual variability as a function of the between-hospital variability, to assess the impact of the selected covariates in the random-effects model. The OR_{Me} of a baseline model (BM), without covariates, was compared with the OR_{Me} of a model with covariates (MC). The decrease in variability between hospitals was measured in percentage based on a ratio, $(1 - \text{Ratio}) \times 100$, where $\text{Ratio} = OR_{Me}(MC)/OR_{Me}(BM)$. Technical details are presented in Appendix 1. To compare BR rates over the three-year study period with equivalent follow-up, we studied the number of BRs performed at 18 months post-mastectomy.

Results

From 2018 to 2020, 4315 patients with breast cancer underwent mastectomy: 1750 (40.6%) with IR (66.8% in those aged <40 years), 423 (9.8%) with DR, and 2142 (49.6%) with no reconstruction (Figure 1). This last group was followed-up for at least 23 months. Mastectomies were performed in 41 centers, among which 34 performed BR in 2 or more patients during the study period. Seventy-eight percent of women with DR received DR within 2 years of mastectomy (mean interval 18.5 months, 95% confidence interval [CI] 17.6-19.4).

Table 1
Patient characteristics, according to breast reconstruction and timing.

		TOTAL	Number of breast reconstructions performed					Timing of breast reconstruction				
		N	Yes (n=2173)		No (n=2142)		P*	Immediate (n=1750)		Delayed (n=423)		P*
			%row	%col	%row	%col		%row	%col	%row	%col	
Age in years	Mean ± SD	59.9 ± 15.5	51.2 ± 10.5	68.7 ± 14.8	68.7 ± 14.8		<0.001	51.3 ± 10.6		50.8 ± 10.1		0.40
	<40	334	80.8	12.4	19.2	3	<0.001	66.8	12.7	14.1	11.1	0.73
	40-49	996	77.3	35.4	22.7	10.6		61.3	34.9	16	37.6	
	50-69	1703	60.1	47.1	39.9	31.7		48.7	47.4	11.4	45.9	
	70-79	687	14.8	4.7	85.2	27.3		11.8	4.6	3.1	5	
	≥ 80	595	1.2	0.3	98.8	27.5		0.8	0.3	0.3	0.5	
Comorb-idities	No	3892	53.1	95.1	46.9	85.2	<0.001	42.7	95	10.4	95.7	0.51
	Yes	423	25.1	4.9	74.9	14.8		20.8	5	4.3	4.3	
Obesity	No	4101	51.1	96.5	48.9	93.6	<0.001	41.2	96.5	10	96.7	0.82
	Yes	214	35.5	3.5	64.5	6.4		29	3.5	6.5	3.3	
Stroke	No	4312	50.4	0	49.6	99.9	0.22	40.6	100	9.8	100	–
	Yes	3	0	0	100	0.1		0	0	0	0	
Heart disease	No	4253	51	99.9	49	97.2	<0.001	41.1	99.9	9.9	99.5	0.098
	Yes	62	4.8	0.1	95.2	2.8		1.6	0.1	3.2	0.5	
Kidney disease	No	4206	51.5	99.7	48.5	95.2	<0.001	41.5	99.8	10	99.5	0.39
	Yes	109	5.5	0.3	94.5	4.8		3.7	0.2	1.8	0.5	
Metastasis	No	4229	50.8	98.9	49.2	97.1	<0.001	40.8	98.7	10	99.8	0.057
	Yes	86	27.9	1.1	72.1	2.9		26.7	1.3	1.2	0.2	
Final outcome	Survival	3802	55.1	96.5	44.9	79.6	<0.001	44.1	95.8	11	99.1	0.001
	Death	513	15	3.5	85	20.4		14.2	4.2	0.8	0.9	
Follow-up (months), mean ± SD		37.9 ± 12.3	40.0 ± 10.9		35.8 ± 13.3		<0.001	38.8 ± 11.1		44.8 ± 8.8		<0.001

SD: standard deviation.
* Quantitative variables analyzed using ANOVA; categorical variables, using the chi-squared test, continuity correction was applied when needed.

Table 1 shows the individual characteristics of women according to BR outcome. Women who received versus those who did not receive BR differed greatly, but only the presence of heart disease and metastasis could influence the timing of BR, despite their p-value being slightly over 0.05.

Table 2 compares center-based characteristics. More specifically, Table 3 presents the multivariable random-effects model, which shows wide between-center differences in the proportion receiving BR (0% to 79%). Individual variables such as older age, heart disease, kidney disease, and metastasis decreased the odds of BR, while center-based variables such as the availability of microsurgery and belonging to R2 health region increased them (OR 4.67, 95% CrI 1.73-13.63).

Figure 2 shows the crude and adjusted ORs for the number of BR performed in the mastectomy center (sorted by health region) and from centers with the lowest to highest case volume within the regions. The adjustment variables reduced the between-center variability by 15.3% (OR_{Me} 2.35 to 1.99). After adjustment, some centers significantly differed from the median in both directions. In 3 health regions (R3, R6, and R7) the odds of receiving BR increased with case volume.

With regard to the analysis of IR versus DR, the proportion of patients receiving IR ranged from 0% to 99% by center (Table 4). In the multivariable random-effects model, age was not predictive of IR, but the availability of microsurgery (OR 7.15, 95% CrI 1.92-29.34) and belonging to the R5 health region (OR 47.88, 95% CrI 1.67-99.00) were predictive.

Figure 3 shows the distribution of crude and adjusted ORs for the number of IR performed in the mastectomy centers (sorted by health region), and from centers with the lowest to highest case volume within the regions. The adjustment variables reduced the between-center variability by 13.6% (OR_{Me} 3.90 to 3.37). After adjustment, some centers differed significantly from the median in both directions.

Table 2
Distribution of patients by mastectomy center and according to breast reconstruction and timing.

			Number of breast reconstructions performed					Timing of breast reconstruction				
			Yes (n=2173)		No (n=2142)			Immediate (n=1750)		Delayed (n=423)		
		TOTAL N	% row	% col	% row	% col	P*	% row	% col	% row	% col	P*
Geographical health region (centers)	R1 (C10-C16)	1162	49.4	26.4	50.6	27.5	<0.001	37.7	24.8	12	33.1	<0.001
	R2 (C20-C29)	950	54.7	23.9	45.3	20.1		38.4	20.9	16.3	36.6	
	R3 (C30-C35)	771	63.6	22.5	36.4	13.1		60.2	26.5	3.4	6.1	
	R4 (C40-C46)	418	50	9.6	50	9.8		44.7	10.7	5.3	5.2	
	R5 (C50)	335	42.1	6.5	57.9	9.1		40.9	7.8	1.2	0.9	
	R6 (C60-C65)	400	27	5	73	13.6		20	4.6	7	6.6	
	R7 (C70-C73)	279	47	6	53	6.9		29.7	4.7	17.2	11.3	
Breast unit	No	24	4.2	0	95.8	1.1	<0.001	0	0	4.2	0.2	0.042
	Yes	4291	50.6	100	49.4	98.9		40.8	100	9.8	99.8	
Plastic surgery service	No	1255	42	24.3	58	34	<0.001	28.5	20.5	13.5	40	<0.001
	Yes	3060	53.8	75.7	46.2	66		45.5	79.5	8.3	60	
Plastic surgeon in breast unit	No	229	36.2	3.8	63.8	6.9	<0.001	22.7	3	13.5	7.3	<0.001
	Yes	4062	51.4	96.2	48.6	93.1		41.8	97	9.6	92.7	
Microsurgery	No	2048	40.9	38.5	59.1	56.5	<0.001	29.2	34.2	11.6	56.3	<0.001
	Yes	2267	58.9	61.5	41.1	43.5		50.8	65.8	8.2	43.7	
Radiotherapy facilities onsite	No	1789	44.2	36.4	55.8	46.6	<0.001	31.8	32.5	12.4	52.2	<0.001
	Yes	2526	54.8	63.6	45.2	53.4		46.8	67.5	8	47.8	
Type of center	Reference center	2220	55.5	56.7	44.5	46.1	<0.001	46.9	59.5	8.6	45.4	<0.001
	Intermediate (subregional) reference center	1147	50.8	26.8	49.2	26.3		39.2	25.7	11.6	31.4	
	County hospital	948	37.7	16.4	62.3	27.6		27.3	14.8	10.3	23.2	
Mastectomy case volume	Low (<25 procedures/year)	421	28	5.4	72	14.1	<0.001	20.2	4.9	7.8	7.8	0.016
	High (≥25 procedures/year)	3894	52.8	94.6	47.2	85.9		42.8	95.1	10	92.2	

* Chi-squared test.

Table 3
Characteristics of patients and mastectomy centers: multilevel logistic analysis of reconstruction (N=4315).

Explanatory variables		Total	Univariable analysis			Multivariable analysis
			No	Yes	p	OR (95% CrI)
Age (years)	Mean (SD)	59.9 (15.5)	68.7 (14.8)	51.2 (10.5)	<0.001	**0.90 (0.90– 0.91)**
Year of mastectomy, n (%)	2018	1460 (33.8)	715 (33.4)	745 (34.3)	0.427	1.00
	2019	1513 (35.1)	741 (34.6)	772 (35.5)		0.98 (0.81– 1.18)
	2020	1342 (31.1)	686 (32.0)	656 (30.2)		0.94 (0.77– 1.14)
Obesity, n (%)	No	4101 (95.0)	2004 (93.6)	2097 (96.5)	**<0.001**	1.00
	Yes	214 (5.0)	138 (6.4)	76 (3.5)		**0.99 (0.68–1.43)**
Stroke, n (%)	No	4312 (99.9)	2139 (99.9)	2173 (100.0)	0.243	1.00
	Yes	3 (0.1)	3 (0.1)	0 (0.0)		**0.00 (0.00–0.03)**
Heart disease, n (%)	No	4253 (98.6)	2083 (97.2)	2170 (99.9)	**<0.001**	1.00
	Yes	62 (1.4)	59 (2.8)	3 (0.1)		**0.22 (0.06–0.76)**
Kidney disease, n (%)	No	4206 (97.5)	2039 (95.2)	2167 (99.7)	**<0.001**	1.00
	Yes	109 (2.5)	103 (4.8)	6 (0.3)		**0.28 (0.11–0.68)**
Metastasis, n (%)	No	4229 (98.0)	2080 (97.1)	2149 (98.9)	**<0.001**	1.00
	Yes	86 (2.0)	62 (2.9)	24 (1.1)		**0.25 (0.13–0.45)**
Plastic surgery service, n (%)	No	3060 (70.9)	1414 (66.0)	1646 (75.7)	**<0.001**	1.00
	Yes	1255 (29.1)	728 (34.0)	527 (24.3)		0.73 (0.38–1.39)
Plastic surgeon in breast unit, n (%)	No	4062 (94.1)	1973 (92.1)	2089 (96.1)	**<0.001**	1.00
	Yes	253 (5.9)	169 (7.9)	84 (3.9)		0.54 (0.20–1.33)
Microsurgery available in center, n (%)	No	2267 (52.5)	931 (43.5)	1336 (61.5)	**<0.001**	1.00
	Yes	2048 (47.5)	1211 (56.5)	837 (38.5)		**2.76 (1.33–5.94)**
Health region (centers), n (%)	R1 (C10-C16)	1162 (26.9)	588 (27.5)	574 (26.4)	**<0.001**	1.00 (—)
	R2 (C20-C29)	950 (22.0)	430 (20.1)	520 (23.9)		**4.67** (**1.73–13.63)**
	R3 (C30-C35)	771 (17.9)	281 (13.1)	490 (22.5)		1.91 (0.64–5.70)
	R4 (C40-C46)	418 (9.7)	209 (9.8)	209 (9.6)		2.77 (0.97– 8.24)
	R5 (C50)	335 (7.8)	194 (9.1)	141 (6.5)		2.99 (0.51–18.98
	R6 (C60-C65)	400 (9.3)	292 (13.6)	108 (5.0)		1.24 (0.42– 4.04)
	R7 (C70-C73)	279 (6.5)	148 (6.9)	131 (6.0)		2.14 (0.57– 8.05
Mastectomy center, n (%)	C10	457 (10.6)	227 (10.6)	230 (10.6)	**<0.001**	**See** Figure 2
	C11	295 (6.8)	117 (5.5)	178 (8.2)		
	C12	261 (6.0)	165 (7.7)	96 (4.4)		
	C13	141 (3.3)	71 (3.3)	70 (3.2)		
	C14	4 (0.1)	4 (0.2)	0 (0.0)		
	C15	3 (0.1)	3 (0.1)	0 (0.0)		
	C16	1 (0.0)	1 (0.0)	0 (0.0)		
	C20	229 (5.3)	126 (5.9)	103 (4.7)		
	C21	197 (4.6)	64 (3.0)	133 (6.1)		
	C22	147 (3.4)	58 (2.7)	89 (4.1)		
	C23	128 (3.0)	72 (3.4)	56 (2.6)		
	C24	100 (2.3)	48 (2.2)	52 (2.4)		
	C25	75 (1.7)	29 (1.4)	46 (2.1)		
	C26	37 (0.9)	13 (0.6)	24 (1.1)		
	C27	21 (0.5)	10 (0.5)	11 (0.5)		
	C28	15 (0.3)	9 (0.4)	6 (0.3)		
	C29	1 (0.0)	1 (0.0)	0 (0.0)		
	C30	446 (10.3)	94 (4.4)	352 (16.2)		
	C31	138 (3.2)	38 (1.8)	100 (4.6)		
	C32	78 (1.8)	55 (2.6)	23 (1.1)		
	C33	55 (1.3)	43 (2.0)	12 (0.6)		
	C34	29 (0.7)	28 (1.3)	1 (0.0)		
	C35	25 (0.6)	23 (1.1)	2 (0.1)		
	C40	86 (2.0)	31 (1.4)	55 (2.5)		
	C41	79 (1.8)	43 (2.0)	36 (1.7)		
	C42	73 (1.7)	38 (1.8)	35 (1.6)		
	C43	68 (1.6)	25 (1.2)	43 (2.0)		
	C44	54 (1.3)	21 (1.0)	33 (1.5)		
	C45	54 (1.3)	47 (2.2)	7 (0.3)		

(*continued on next page*)

Table 3 (*continued*)

Explanatory variables		Total	Univariable analysis			Multivariable analysis
			No	Yes	p	OR (95% CrI)
	C46	4 (0.1)	4 (0.2)	0 (0.0)		
	C50	335 (7.8)	194 (9.1)	141 (6.5)		
	C60	141 (3.3)	108 (5.0)	33 (1.5)		
	C61	103 (2.4)	70 (3.3)	33 (1.5)		
	C62	84 (1.9)	60 (2.8)	24 (1.1)		
	C63	36 (0.8)	24 (1.1)	12 (0.6)		
	C64	21 (0.5)	16 (0.7)	5 (0.2)		
	C65	15 (0.3)	14 (0.7)	1 (0.0)		
	C70	163 (3.8)	68 (3.2)	95 (4.4)		
	C71	70 (1.6)	38 (1.8)	32 (1.5)		
	C72	25 (0.6)	23 (1.1)	2 (0.1)		
	C73	21 (0.5)	19 (0.9)	2 (0.1)		

95 CrI: 95% Credible Intervals.

There were no significant differences in the proportion of patients who did not undergo reconstruction over the study period (Table 3, Figure 4); however, there was a gradual increase in those receiving IR (Table 4). Taking 2018 as a reference, the odds of receiving IR rose significantly in 2019 (OR 1.72, 95% CrI 1.30–2.27) and 2020 (OR 4.85, 95% CrI 3.44-6.84).

Discussion

This population-based study included over 4000 patients who underwent mastectomy for breast cancer in Catalonia. Over half of them underwent BR, which is significantly more than that reported elsewhere. In their systematic review of 28 studies, Brennan et al. found that just 17% of the 940,678 mastectomy patients benefitted from this procedure.[8] In Jiménez-Puente et al.'s population-based study in Andalusia (Spain) in 2010–2014 (N = 6026), the BR rate was 30.5% in 2010 and 26% in 2014.[19] Moreover, 40% of our sample underwent IR—approximately double the 19% observed by Jeevan et al. in the UK and the 22% by Jiménez et al.[14,19] Furthermore, the rate of IR at the 18-month follow-up increased over the study period, a trend that is consistent with that in other reports.[14] Nevertheless, these high average rates mask wide between-center variation for performing BR (0% to 79%) and the immediate timing of the procedures undertaken (0% to 99%), in keeping with other studies in European countries.[4,12,14]

Brennan et al. found that reconstruction was associated with patient/tumor factors, hospital and/or surgeon, psychological factors, and others.[7] The heterogeneous methods applied in different studies, especially in defining groups according to reconstruction and timing, complicate comparison, but we include the most relevant individual and center-based factors available in the health system's administrative databases. Specifically, our data show that older age decreases the probability of undergoing BR, in consonance with the literature[8,12,20]: over 80% of women under 40 years received BR, and approximately 60% at 50-69 years; however, this proportion dropped dramatically in women over 70 years and was practically null in those aged over 80 years. O'Neill criticized this age discrimination, which was also observed in the UK, as BR has been proven safe and effective in older women.[21,22] Indeed, surgeons in the UK are adhering to the clinical guidelines in increasing the offer of BR—except in older populations.[22] Similar to other studies,[8,23] our results indicated that comorbidities, specifically kidney disease, heart disease, and metastasis, are independently associated with lower BR rates; however, unlike the previous studies, we found no relation with obesity.

Several authors have also studied center-based characteristics, although using different methods and reference populations than ours.[4,8,9,12,19] As with the others, more complex oncological surgeries, where higher case volume is related to better treatment outcomes, studies point to higher BR rates in high-volume hospitals. In 105 German centers, those performing over 200 mastectomies a year were more likely to perform BR than centers with fewer than 100 annual mastectomies.[4] Other

Table 4
Characteristics of patients and mastectomy centers: multilevel logistic analysis of patients receiving immediate breast reconstruction (N=2173).

Explanatory variables		Total	Univariable analysis			Multivariable analysis
			No	Yes	p	OR (95% CrI)
Age (years)	Mean ± SD	51.2 (10.5)	50.8 (10.1)	51.3 (10.6)	0.39	1.00 (0.99–1.02)
Year of mastectomy, n (%)	2018	745 (34.3)	210 (49.6)	535 (30.6)	**<0.001**	1.00
	2019	772 (35.5)	150 (35.5)	622 (35.5)		1.72 (1.30–2.27)
	2020	656 (30.2)	63 (14.9)	593 (33.9)		4.85 (3.44–6.84)
Plastic surgery service, n (%)	No	527 (24.3)	169 (40.0)	358 (20.5)	**<0.001**	1.00
	Yes	1646 (75.7)	254 (60.0)	1392 (79.5)		0.98 (0.29–3.01)
Microsurgery available in center, n (%)	No	837 (38.5)	238 (56.3)	599 (34.2)	**<0.001**	1.00
	Yes	1336 (61.5)	185 (43.7)	1151 (65.8)		**7.15 (1.92–29.34)**
Health region (centers), n (%)	R1 (C10-C16)	574 (26.4)	140 (33.1)	434 (24.8)	**<0.001**	1.00
	R2 (C20-C29)	520 (23.9)	155 (36.6)	365 (20.9)		1.95 (0.28– 13.29)
	R3 (C30-C35)	490 (22.5)	26 (6.1)	464 (26.5)		2.79 (0.32–21.58)
	R4 (C40-C46)	209 (9.6)	22 (5.2)	187 (10.7)		6.49 (0.89– 47.99)
	R5 (C50)	141 (6.5)	4 (0.9)	137 (7.8)		**47.88 (1.67–99.00)**
	R6 (C60-C65)	108 (5.0)	28 (6.6)	80 (4.6)		2.34 (0.29–19.25)
	R7 (C70-C73)	131 (6.0)	48 (11.3)	83 (4.7)		1.57 (0.13–17.93)
Mastectomy center, n (%)	C10	230 (10.6)	76 (18.0)	154 (8.8)	**<0.001**	**See** Figure 3
	C11	178 (8.2)	44 (10.4)	134 (7.7)		
	C12	96 (4.4)	1 (0.2)	95 (5.4)		
	C13	70 (3.2)	19 (4.5)	51 (2.9)		
	C20	103 (4.7)	53 (12.5)	50 (2.9)		
	C21	133 (6.1)	12 (2.8)	121 (6.9)		
	C22	89 (4.1)	7 (1.7)	82 (4.7)		
	C23	56 (2.6)	34 (8.0)	22 (1.3)		
	C24	52 (2.4)	23 (5.4)	29 (1.7)		
	C25	46 (2.1)	17 (4.0)	29 (1.7)		
	C26	24 (1.1)	1 (0.2)	23 (1.3)		
	C27	11 (0.5)	5 (1.2)	6 (0.3)		
	C28	6 (0.3)	3 (0.7)	3 (0.2)		
	C30	352 (16.2)	2 (0.5)	350 (20.0)		
	C32	23 (1.1)	13 (3.1)	10 (0.6)		
	C33	12 (0.6)	8 (1.9)	4 (0.2)		
	C34	1 (0.0)	1 (0.2)	0		
	C35	2 (0.1)	2 (0.5)	0		
	C40	55 (2.5)	3 (0.7)	52 (3.0)		
	C41	36 (1.7)	6 (1.4)	30 (1.7)		
	C42	35 (1.6)	4 (0.9)	31 (1.8)		
	C43	43 (2.0)	5 (1.2)	38 (2.2)		
	C44	33 (1.5)	4 (0.9)	29 (1.7)		
	C50	141 (6.5)	4 (0.9)	137 (7.8)		
	C60	33 (1.5)	11 (2.6)	22 (1.3)		
	C61	33 (1.5)	6 (1.4)	27 (1.5)		
	C62	24 (1.1)	4 (0.9)	20 (1.1)		
	C63	12 (0.6)	6 (1.4)	6 (0.3)		
	C65	1 (0.0)	1 (0.2)	0		
	C70	95 (4.4)	30 (7.1)	65 (3.7)		
	C71	32 (1.5)	16 (3.8)	16 (0.9)		
	C73	2 (0.1)	2 (0.5)	0		
	C31	100 (4.6)	0	100 (5.7)		
	C45	7 (0.3)	0	7 (0.4)		
	C64	5 (0.2)	0	5 (0.3)		
	C72	2 (0.1)	0	2 (0.1)		

95 CrI: 95% Confidence Interval.

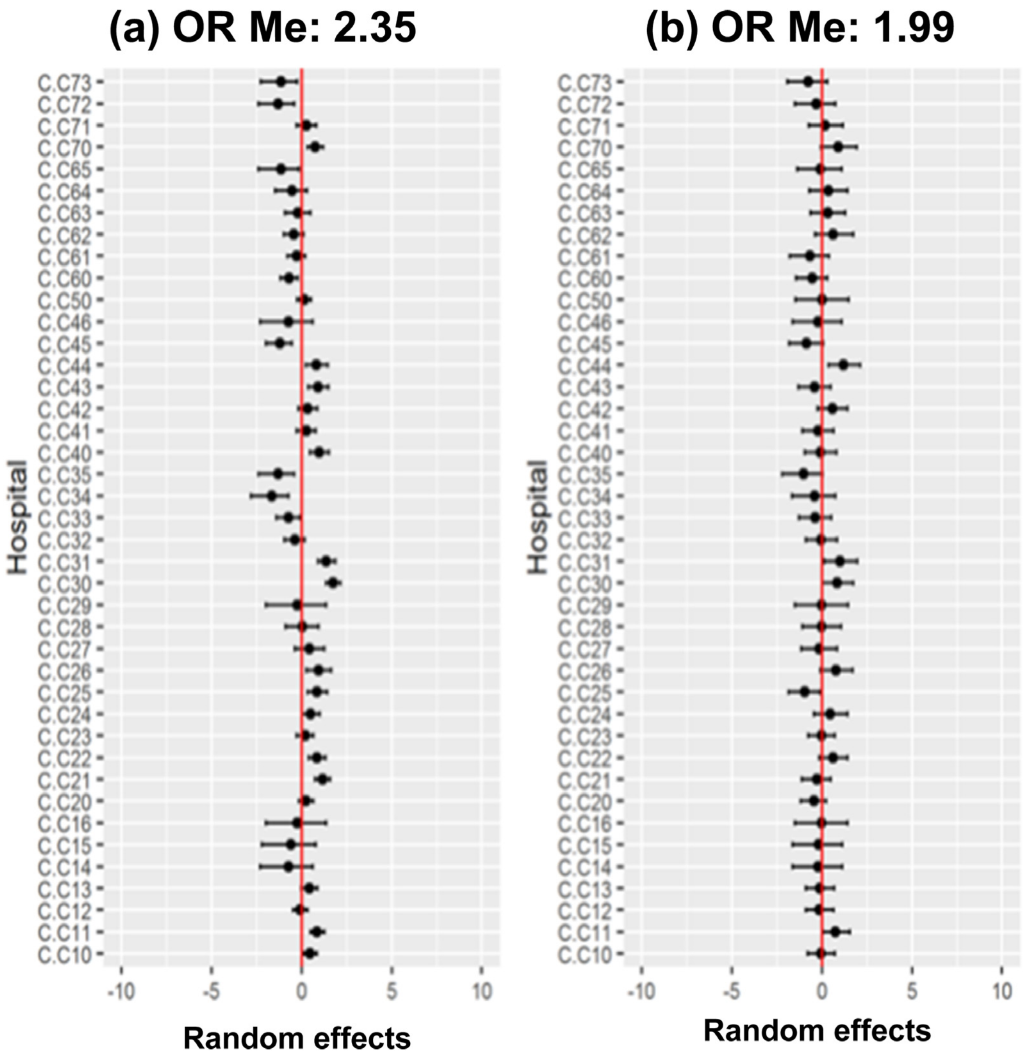

Figure 2. Forest plots of the performance of breast reconstruction in study centers, according to crude (left) and adjusted (right) multilevel analysis.
Hospital: mastectomy center; OR_{Me}: median odds ratio.

studies corroborate this relationship, though no specific threshold of performing mastectomies has been established as being necessary to favor BR. We also observed a higher proportion of BR in high-case volume centers. However, this variable could not be included in the multilevel model because the center variable was also included. Even so, a positive relationship between case volume and the number of BR performed was apparent in 3 of the 7 health regions studied, with one region in particular standing out for its higher BR rates.

Other authors have examined the importance of a plastic surgery service within the hospital.[8] In a Danish study in 13,379 women with mastectomies, higher educational attainment and the woman's affiliation to a hospital with a plastic surgery service increased the probability of receiving IR and to a lesser extent DR.[9] Conversely, our adjusted analyses did not show a statistical association between BR and this service or with the availability of a plastic surgeon in the breast unit. However, the availability

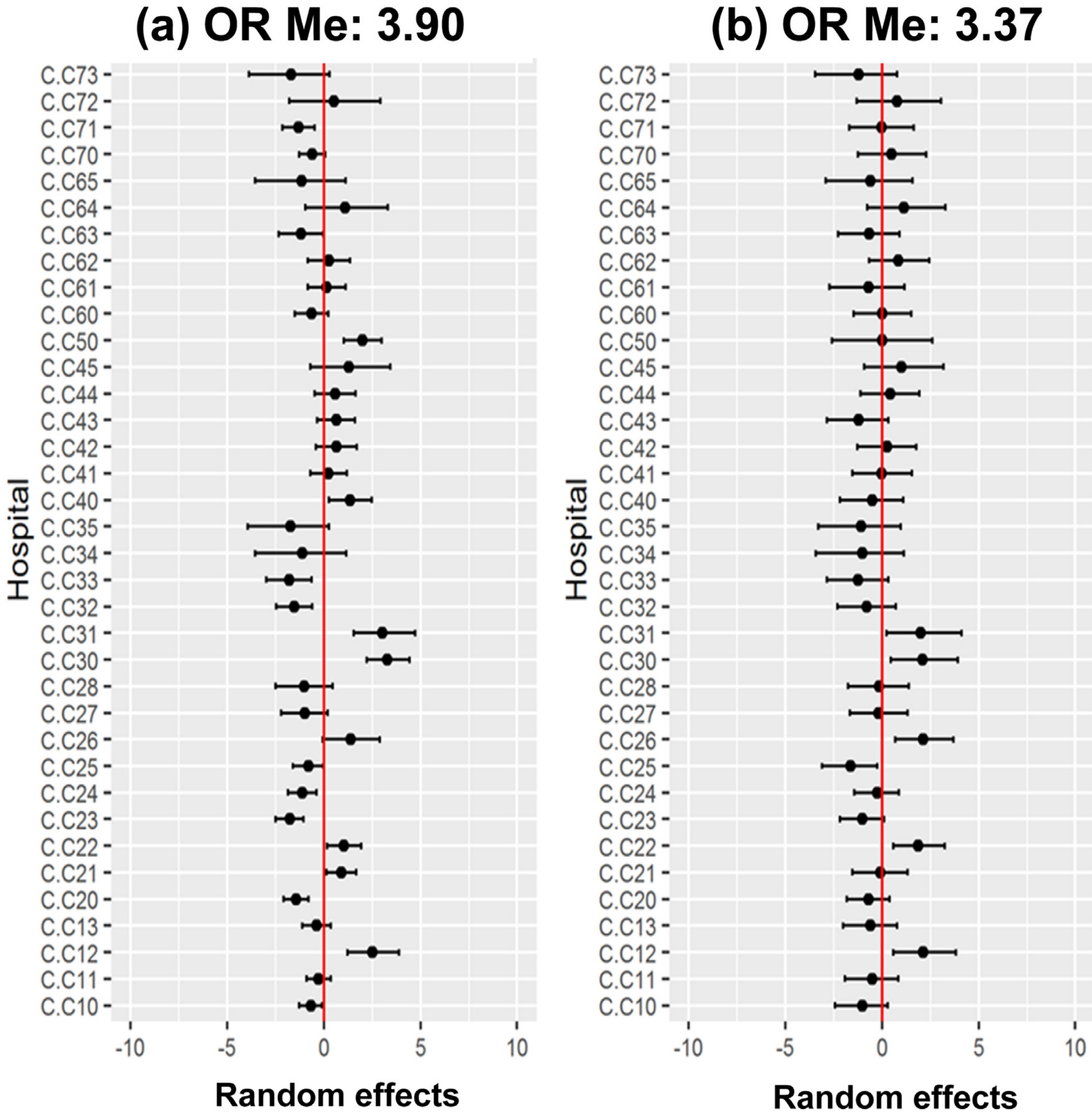

Figure 3. Forest plots of the performance of immediate breast reconstruction in study centers, according to crude (left) and adjusted (right) multilevel analysis. Hospital: mastectomy center; OR_{Me}: median odds ratio.

	2018	2019	2020
Immediate reconstruction	37%	41%	44%
Delayed reconstruction	**8%**	**6%**	**3%**
No reconstruction	55%	53%	53%

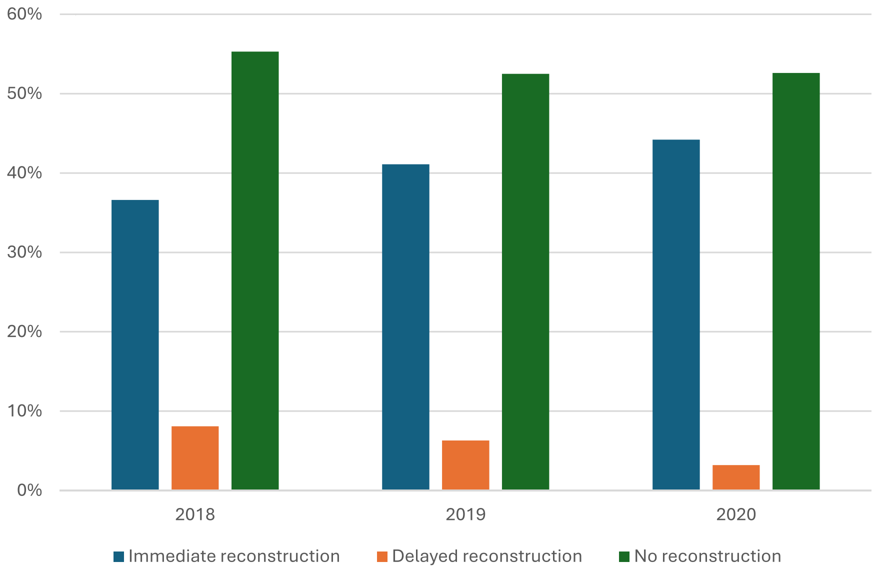

Figure 4. Performance and timing of breast reconstruction at the 18-month follow-up from mastectomy, 2018-2020.
*Chi-squared test with Bonferroni correction: $p < 0.001$.
$N_{2018} = 1460$; $N_{2019} = 1513$; $N_{2020} = 1342$.

of microsurgery was associated with BR in general and IR in particular, suggesting that these centers may be more likely to promote BR as an institutional policy, and in turn have a favorable logistical environment, for example, with reserved operating room time or dedicated personnel. This association may also relate to the possibility of performing radiotherapy-tolerant reconstruction, ensuring that BR is offered to patients regardless of the complementary treatments planned after mastectomy. However, reconstruction with a prosthesis is not recommended in the case of radiotherapy, thereby, limiting the possibilities of IR.

The observed between-center variability is only partially explained by the variables included in the multivariable model. Others that appear in the literature, but unavailable to us, include some that are linked to the surgeon or multidisciplinary team (e.g., reluctance to delay adjuvant treatment), service (availability of additional operating time dedicated to IR), center's policy on BR, and patient preferences. Professional- and service-related factors can influence whether the patients are offered reconstruction. Indeed, Jeevan et al. estimated that less than half of the women undergoing mastectomy in the NHS are informed about the possibility of BR, with this proportion ranging from 24% to 75% by center, even though clinical practice guidelines, including NICE, state that all women should be offered BR unless there is a contraindication. In Australia, a retrospective study found 41% of women underwent BR after being informed about this option, while the national average was approximately 12%[24]; this trend was closely linked to the surgeon's attitude.

Women require accurate and objective information about the options available to them, regardless of their treatment center and the services available there, as the decision to undergo BR can be quite personal.[20] Indeed, a Dutch qualitative study found that the patients' decision-making criteria differed markedly: after being informed of the risks and benefits of the procedure. Different patients used similar arguments to opt for or reject reconstruction.[25] In Catalonia, the Agency for Healthcare Quality and Assessment created a joint decision tool for BR in 2016, aimed at patients considering reconstruction.

The differences rooted in healthcare financing have also been studied: women with private insurance have been shown to receive more BR.[24] In Spain, some patients opt to use private healthcare services for their mastectomy but revert back to the public system for reconstruction intervention(s), which private insurance may not cover. Our study included only patients who underwent mastectomy in the public system.

Our data were drawn from the health system's administrative sources, which may entail some heterogeneity in discharge coding practices, although CatSalut has recently established which codes to use. Another limitation of the database is the absence of variables such as tumor stage, which have been associated with BR or post-mastectomy radiotherapy.[23]

There is an ongoing debate about the best timing for BR.[26] Although oncological outcomes are equivalent, there are differences in complications, the need for reintervention, recovery time, and time for aesthetic and psychological recovery.[6,7,10,26] In our study, the between-center variability of IR in women with reconstruction was wider than that for reconstruction in general. However, neither age nor comorbidities appeared to influence timing, though they influenced its performance. In contrast, in Canada, Matkin et al. reported that significant comorbidities in mastectomized patients explained the non-performance of IR, though this was less important than patient preferences and the likelihood of undergoing post-operative radiotherapy.[23]

Our study period included the year 2020, when COVID-19 was disrupted several cancer diagnostic and treatment services.[1] Our data show that fewer women (11%) underwent mastectomy for breast cancer in the public healthcare system of Catalonia that year. In the pandemic context, several groups recommended postponing reconstruction after mastectomy,[27] whereas other hospital initiatives established protocols to guarantee safe IR.[28] We observed no impact on the reconstruction rate one way or the other, with the trend toward IR continuing.

Altogether, approximately half the women receiving mastectomy in Catalonia also underwent BR—a higher proportion than in most studies published at the national and international level, although with notable between-center variability in BR in general and IR in particular. This variability is partially explained by age, comorbidities, and the availability of microsurgery at the hospital. However, BR should be offered to all eligible patients as an integral part of mastectomy treatment, as all patients have the right to choose BR. To facilitate their decision, women need all relevant information about the reconstruction options available to them, regardless of where they receive care. The variability in IR among women with reconstruction is also partially explained by the availability of microsurgery in the hospital. To guarantee equitable access to all treatment options, centers that perform mastectomy must be able to perform IR or have an established referral pathway if this type of reconstruction is chosen. Monitoring BR rates in treatment centers can also contribute to equity in this regard. Therefore, the factors we studied do not explain every between-center variability, which could be related to institutional policies and/or factors linked to the medical-surgical team. More studies to explore these factors are needed in our setting.

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Conflict of Interest

None.

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Ethical Approval

This study was conducted in accordance with the ethical standards of the Declaration of Helsinki and in compliance with legal regulations on data confidentiality. Evaluation by a clinical ethics committee was not deemed necessary, as the study was based on administrative data fully anonymized provided by the health authority to evaluate the quality of care provided to cancer patients, in accordance with the function of the Catalan Cancer Plan of the Department de Salut (Generalitat de Catalunya, Spain).

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jpra.2025.01.017.

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