

Trends in electroconvulsive therapy use in France from 2017 to 2023: no decline despite new therapeutics

Trends in electroconvulsive therapy use in France

D. Barruel^{a,*}, P. Belnou^a, M. Plaze^{a,b}, V. Dauriac-Le Masson^a

^a GHU Paris Psychiatrie et Neurosciences, Hôpital Sainte Anne, 1, rue Cabanis 75014, Paris

^b Paris University, 75005, France

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ABSTRACT

Objective Underutilization of electroconvulsive therapy (ECT) may have negative consequences for patients' mental health. Public healthcare policies lack longitudinal data on the dynamics of ECT use, which is necessary to inform the development of appropriate strategies. This study aimed to provide a comprehensive overview of ECT use in France over an extended period.

Method We analyzed exhaustive ECT data from the French national database. We conducted statistical analyses of ECT utilization from 2017 to 2023, focusing on variations in age, sex, diagnosis, and geographical use.

Results The French national standardized ECT utilization rate increased from 0.33 patients per 10,000 inhabitants in 2017 to 0.50 in 2023. The significant pre-pandemic trend, indicating a +1.4% increase in ECT use rate per month, remained unaffected by the pandemic, despite a significant drop during COVID-19 period. Notably, the increase in ECT use over this period was more pronounced among younger (≤ 29 years) and older (≥ 70 years) individuals. Two-thirds of ECT recipients were aged 50 years or older, predominantly female and had a mood disorder diagnosis. A key finding was that the increase in ECT use was mainly driven by the private-for-profit hospitals. ECT use and its evolution were geographically heterogeneous in France.

Conclusion Despite the availability of new therapeutics and ongoing stigma, ECT use increased in France, particularly among younger and older populations, from 2017 to 2023, indicating a change in practice. However, uneven access to ECT services across the country and the expansion of private care to the detriment of the public system, represent a major public health concern that must be addressed.

1. Introduction

Electroconvulsive therapy (ECT) was first introduced in Europe (Italy) in 1938 and employed in North America in 1940 (Suleman, 2020). Primarily used to treat psychotic disorders, ECT became a first-line treatment for major depressive episodes in the 1940s and 1950s. Its use declined from the 1960s to the 1980s because of the increase in psychopharmacology and the stigmatization of ECT in the media (M. Swartz, 2009; McCall, 2001). However, the 2000s marked a revival in ECT use (M. Swartz, 2009). With progressive refinements in ECT techniques, it has become a safe and effective therapy for severe mental disorders. Research has focused on reducing side effects while maintaining therapeutic effectiveness (Kirov et al., 2021; Lee et al., 2024; McCall, 2001; Suleman, 2020; Tharyan and Adams, 2002; UK ECT

review group, 2003). Current indications for ECT include (i) treatment-resistant depression or schizophrenia, (ii) major depressive or manic episodes, and (iii) critical clinic conditions with short-term risk to the patient's life (like dehydration, inanition, suicidal ideas, or catatonia symptoms) (Agence Nationale Accréditation Evaluation Santé, 1997; American Psychiatric Association, 2025; Espinoza and Kellner, 2022; McCall, 2001).

Yet some factors might still prevent ECT practice, such as stigma, controversy surrounding the therapy, lack of updated information for psychiatrists reluctant to prescribe it, unequal geographic accessibility, and misperception of costs (Kalisova et al., 2018; Payne and Prudic, 2009). Another source of restraint during the 5 past years was the COVID-19 pandemic: at an international level, most centers delivering ECT care experienced a decrease in activity (Demchenko et al., 2022;

* Corresponding author.

E-mail address: d.barruel@ghu-paris.fr (D. Barruel).

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Luccarelli et al., 2023a; Sarma et al., 2023; Wadoo et al., 2022), which was also observed in France (Amad et al., 2020). However, the under-utilization of ECT can have serious negative consequences for patient health (Amad et al., 2020) and should be a major concern. Thus, there is a strong need for updated and comprehensive data on ECT use during the past years, over a significant period of time, to inform future strategies to its application.

Numerous international studies have explored topics related to contemporary ECT use (Lafreniere, 2023; Lee et al., 2024; Leiknes et al., 2012; Lesage et al., 2016; Patel et al., 2019). They highlighted variations in ECT prevalence rates across countries. Moreover, most of literature relies on survey data (Benson-Martin and Milligan, 2015; Vera et al., 2016), which may not always provide a complete picture. Studies using national databases are needed to account for the contextual complexity of each country. An important feature for France is that it benefits from a distinctive social healthcare system that safeguards patients and makes private clinics accessible to more than just high-income patients.

There is scarce French literature on ECT use. Regional inequalities in access to ECT have been highlighted (Lecarpentier et al., 2022). In addition, the negative impact of the COVID-19 pandemic on ECT use has been documented (Amad et al., 2020). Nevertheless, these studies did not cover more than a single year. This study aimed to give an updated and detailed view of ECT use in France from 2017 to 2023 and to better understand the dynamic of ECT practice. Indeed, this period was marked by major events: the emergence of esketamine use (drug marketing authorization: June 2020), a possible alternative to ECT for treatment-resistant depression (Gastaldon et al., 2019; HAS, 2020), and the COVID-19 pandemic. Thus, the underlying issues that guided our research were (i) What was the trend in ECT use in the recent decade? (ii) What was the impact of COVID-19 on its practice? and (iii) How were these phenomena distributed in the French territory? To assess these questions, we aimed to (i) explore trends in ECT use according to patient characteristics and the type of hospital where ECT was performed and (ii) assess any differences in ECT use among French geographical areas.

2. Methods

2.1. Design and data collection

For this retrospective study, we used data from a national administrative database managed by a French public agency ("Agence technique de l'information sur l'hospitalisation") in charge of the collection of hospital activity in France.

We selected any patient aged ≥ 10 years who received an ECT from 2017 to 2023, with no other exclusion criteria. For each of these patients, we extracted data including:

- Age, sex, geographical area code of the patient's residence
- Type of hospital where the ECT was administered: (i) public, (ii) university, (iii) private-for-profit, (iv) private-non-profit
- Primary or associated psychiatric diagnosis according to International Classification of Diseases, 10th revision (ICD-10) codes. We selected the diagnosis which was the closest in time to the ECT session.
- The timeline of all ECT treatments the patient received. Each ECT procedure was identified according to a common classification for coding medical procedures in France ("Classification commune des actes médicaux" [CCAM]). The code used for ECT definition was AZRP001.

All data extracted from the PMSI ("Programme de médicalisation des systèmes d'information") database were completely anonymous. Originally used by hospitals to report their ECT activity, the PMSI database gathers retrospective data from administrative and medical files. According to French and European laws, informed consent is not required for this category of study; informing the patient of their right to oppose

to the use of their data is sufficient.

See details in **supplementary material**.

2.2. Outcomes definition

Outcomes were first defined on a national level. For the 2017–2023 period, we computed the overall number of (i) patients who received at least one ECT treatment and (ii) ECT sessions received, on a year and month basis. Outcomes were also defined according to patient socio-demographic characteristics and clinical profile and the hospital category where ECT was delivered.

We secondarily assessed the rate of ECT use according to each French geographical area code, at a county level, for each year from 2017 to 2023. We computed the following age- and sex-standardized rates: (i) the number of ECT-treated individuals per 10,000 residents per year and (ii) the number of ECT treatments provided per 10,000 residents per year. We leveraged online data from the "Institut national de la statistique et des études" (INSEE) to compute standardized rates. This dataset provided the estimated number of residents on January 1 of each year, stratified by French county, sex and age category.

See details in supplementary material.

2.3. Statistical analysis

2.3.1. Descriptive analysis

We used the outcomes previously defined in Section 2.1 to perform a descriptive analysis of the evolution of national ECT use 2017–2023, with year as the time unit. Also for each year, we analyzed the ECT receiver cohort by age, sex, diagnosis group, and hospital category. For these categorical variables, we described the characteristics of the related population using frequencies and percentages (%) and assessed how the distribution of these demographic and clinical variables changed over the years. We then mapped the evolution of the ECT use rate at a geographical area level for each year from 2017 to 2023, using the standardized use rate defined in Section 2.1 as the number of ECT-treated individuals per 10,000 residents per year. We additionally assessed for each year the national standardized use rates, defined as the average of the use rates previously computed at the geographical area level. Finally, we checked if there was any correlation between the growth rate of respectively ECT use rate and GDP (Gross Domestic Product) at county level, on our study period. We took per capita median income (derived from INSEE data) as a proxy for GDP. We ran Spearman's rank correlation test.

2.3.2. Time series analysis

We used an interrupted time series (ITS) design, with time unit defined as month, to assess (i) the evolution of ECT use since 2017 and (ii) the effect of the COVID-19 pandemic on ECT use. We analyzed the evolution of the monthly number of ECT receivers with the ITS model based on segmented regressions, using a General Additive Model (Bernal et al., 2017; Leske et al., 2021; Taljaard et al., 2014; Wagner et al., 2002). Interrupt Time Series (ITS) method explicitly estimates the effect of an intervention by modeling level changes (immediate shifts) and slope changes (changes in trend after the COVID-19 event), while accounting for autocorrelation and other time-dependent structures. We relied on clinical experts' advice to define time segmentation as follows: a first pre-pandemic period (T1) from January 1, 2017 to February 29, 2020; a second large pandemic period (T2) from March 1, 2020 to December 31, 2022; and a third post-pandemic period (T3) from January 1, 2023 to December 31, 2023.

We analysed data with software R v4.3.1 and used the mapping tool C&D online®. See **supplementary material** for details.

Table 1

Description by year of people receiving electroconvulsive therapy (ECT) according to demographic and clinical criteria and category of hospital performing the therapy.

| | 2017 n (%) | 2018 n (%) | 2019 n (%) | 2020 n (%) | 2021 n (%) | 2022 n (%) | 2023 n (%) |
|---|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Global | 2562 (100) | 3573 (100) | 3720 (100) | 3200 (100) | 3530 (100) | 3547 (100) | 3972 (100) |
| Sex | | | | | | | |
| Male | 882 (34.5) | 1278 (35.8) | 1349 (36.3) | 1112 (34.8) | 1232 (34.9) | 1282 (36.1) | 1408 (35.4) |
| Female | 1680 (65.5) | 2295 (64.2) | 2371 (63.7) | 2088 (65.2) | 2298 (65.1) | 2265 (63.9) | 2564 (64.6) |
| Age category (yr) | | | | | | | |
| < 18 | 12 (0.5) | 10 (0.3) | 11 (0.3) | 24 (0.8) | 26 (0.7) | 21 (0.6) | 52 (1.3) |
| 18–24 | 63 (2.4) | 98 (2.7) | 116 (3.1) | 105 (3.3) | 152 (4.3) | 170 (4.8) | 195 (4.9) |
| 25–29 | 84 (3.3) | 108 (3.0) | 108 (2.9) | 104 (3.2) | 119 (3.4) | 128 (3.6) | 153 (3.9) |
| 30–39 | 224 (8.7) | 341 (9.6) | 355 (9.5) | 292 (9.1) | 334 (9.4) | 295 (8.3) | 362 (9.1) |
| 40–49 | 392 (15.3) | 534 (14.9) | 515 (13.9) | 410 (12.8) | 475 (13.5) | 473 (13.3) | 519 (13.1) |
| 50–59 | 532 (20.8) | 735 (20.6) | 774 (20.8) | 638 (19.9) | 680 (19.3) | 667 (18.8) | 770 (19.3) |
| 60–69 | 630 (24.6) | 843 (23.6) | 851 (22.9) | 739 (23.1) | 762 (21.6) | 787 (22.2) | 793 (20.0) |
| ≥ 70 | 625 (24.4) | 904 (25.3) | 990 (26.6) | 888 (27.8) | 982 (27.8) | 1006 (28.4) | 1128 (28.4) |
| Diagnosis | | | | | | | |
| At least a mood disorder (F30–39) | 2191 (85.5) | 3095 (86.6) | 3118 (83.8) | 2645 (82.7) | 2957 (83.7) | 2974 (83.8) | 3318 (83.5) |
| At least schizophrenia (F20–29) with no mood disorder | 283 (11.1) | 349 (9.8) | 444 (11.9) | 419 (13.1) | 437 (12.4) | 430 (12.1) | 460 (11.6) |
| Any other diagnosis pattern | 88 (3.4) | 129 (3.6) | 158 (4.2) | 136 (4.2) | 136 (3.9) | 143 (4.1) | 194 (4.9) |
| Hospital category | | | | | | | |
| Public | 773 (30.2) | 975 (27.3) | 1089 (29.3) | 988 (30.9) | 980 (27.8) | 944 (26.6) | 1115 (28.1) |
| University | 805 (31.4) | 958 (26.8) | 929 (25.0) | 817 (25.5) | 819 (23.2) | 862 (24.3) | 896 (22.5) |
| Private-for-profit | 880 (34.3) | 1498 (41.9) | 1623 (43.6) | 1340 (41.9) | 1649 (46.7) | 1697 (47.8) | 1898 (47.7) |
| Private-non-profit | 56 (2.2) | 79 (2.2) | 138 (3.7) | 141 (4.4) | 197 (5.6) | 171 (4.8) | 185 (4.6) |
| Unknown category | 82 (3.2) | 119 (3.3) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |

¹ The sum of percentages for all categories per year might be >100 % because the same patient might have received the therapy in different types of hospital in the same year.

3. Results

3.1. Descriptive analysis

- Evolution of ECT use from 2017 to 2023 at a national level

Table 1 and Fig. 1 report details of the evolution of ECT use (i) at a national level from 2017 to 2023 and (ii) according to socio-demographic and clinical profiles and the type of hospital where ECT was administered. From 2017 to 2023, the national number of ECT users increased globally by 55 % (Table 1). More specifically, the yearly global

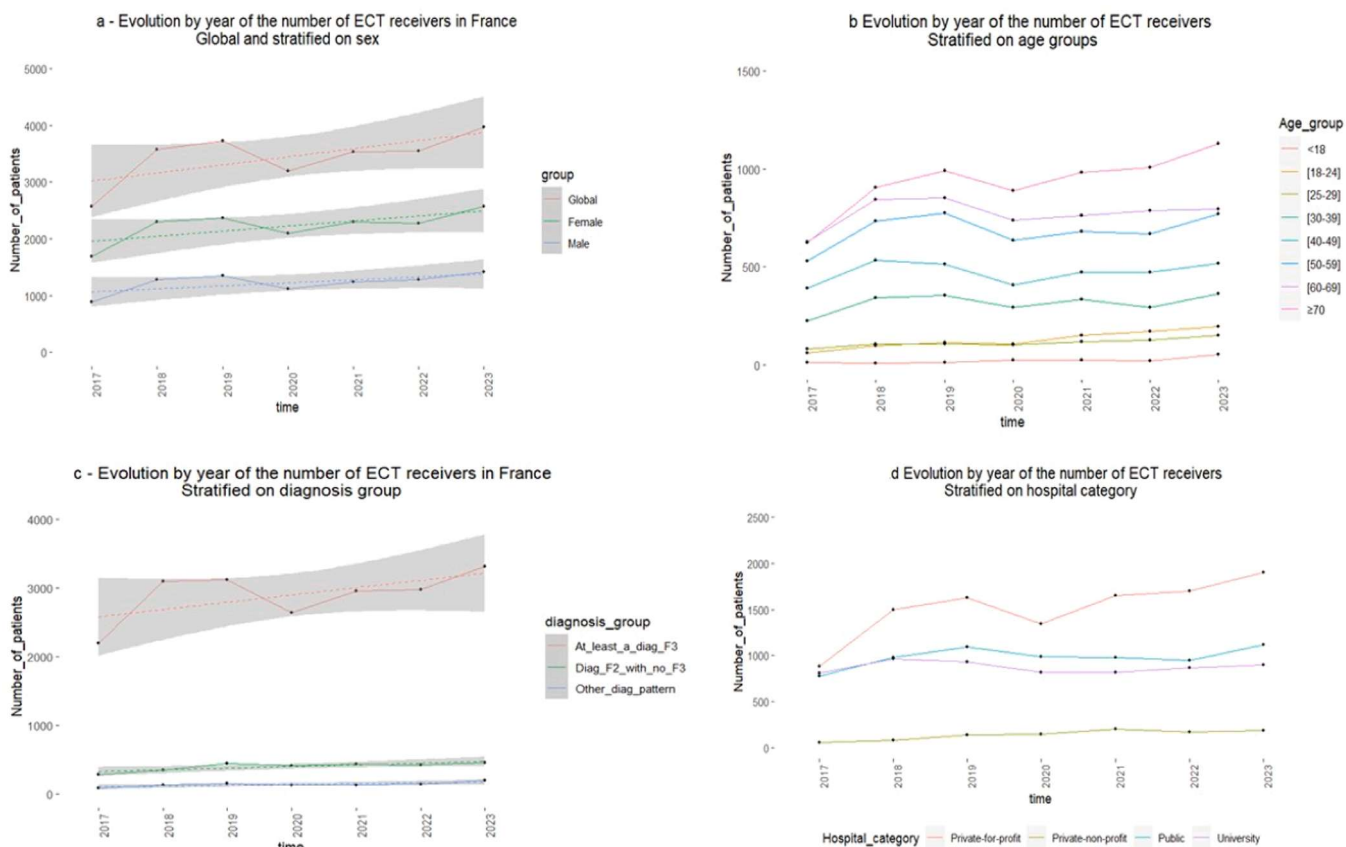


Fig. 1. Evolution by year of the number of electroconvulsive therapy (ECT) receivers in France from 2017 to 2023: Global and stratified analysis.

Table 2
Electroconvulsive therapy (ECT) use by year from 2017 to 2023 on a national level.

| | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|------|------|------|------|------|------|------|
| Average national use rate ¹ (number of ECT receivers per 10,000 inhabitants in France) | 0.33 | 0.47 | 0.49 | 0.41 | 0.45 | 0.44 | 0.50 |
| Average national use rate ¹ (number of ECT sessions received per 10,000 inhabitants in France) | 2.71 | 3.45 | 3.45 | 2.84 | 3.44 | 3.46 | 4.26 |
| Number of ECT sessions received per patient per year in France | 8.61 | 7.76 | 7.85 | 7.39 | 8.14 | 8.25 | 8.80 |

¹ Use rate was standardized according to age and sex.

number of ECT receivers steadily increased by 45 % during the pre-pandemic period 2017–2019. After a 14 % decrease from 2019 to 2020, there was another 24 % increase from 2020 to 2023. Age subgroup analyses revealed the same phenomenon, except for age <18 years, for which there was no decrease from 2019 to 2020 but rather a 118 % increase. In the pre-pandemic period, the age categories 18–24, 30–39 and ≥ 70 showed the highest increase: 84 %, 58 %, and 58 %, respectively. From 2020 to 2023, the age categories <18, 18–24 and 25–29 had the highest increase: 117 %, 86 % and 47 %, respectively.

The private-for-profit hospital subgroup showed a 84 % sustained increase in ECT administration during the pre-pandemic period, followed by a 41 % increase from 2020 to 2023, after the 2020 decrease. This level of increase surpassed results obtained for public and university hospital subgroups.

Additionally, the national use rate, computed as the yearly average national number of ECT receivers per 10,000 inhabitants, increased from 0.33 in 2017 to 0.49 in 2019 (+48 %), decreased to 0.41 in 2020 (–16.3 %), then showed a sustained increase to 0.5 in 2023 (+21.9 %) (Table 2). The same tendency was observed for the national use rate computed as the average number of ECT sessions received per 10,000 inhabitants.

• Evolution of demographic and clinical profile for ECT receivers:

The sex distribution of the total population of the therapy receivers remained globally stable from 2017 to 2023, about an average of 64.5 % females (Table 1). The most represented age group categories were

50–59, 60–69 and ≥70, for an average of 19.5 %, 22.6 % and 26.9 % use, respectively, of the global population for the whole study period. The proportion of patients ≥70 years increased from 24.4 % to 28.4 % over the whole period. A noteworthy change was a steady increase for the albeit very low proportion of individuals aged <18 years: it was multiplied by a factor of 2.6 from 2017 to 2023. Also, the proportion of the 18–24 age category was doubled over the period, from 2.4 % to 4.9 %.

The diagnostic group distribution varied little over the study period. Patients mainly had at least a diagnosis of a mood disorder. The average proportion of patients with at least a diagnosis of schizophrenia (with no mood disorders) was about 12 % over the study period.

• Evolution of the share of ECT activity by hospital category

In 2017, private-for-profit, public and university hospitals were receiving most ECT patients almost in equal share. The private-for-profit hospital share of ECT receivers increased over the global period (except for a slight decrease in 2020), to reach 47.7 % in 2023, versus 28.1 % for public and 22.5 % for university hospitals (Table 1).

• Evolution of ECT use from 2017 to 2023 at a regional level

Fig. 2 highlights the unequal distribution of ECT use across France in 2017 and the uneven development of the practice over the study period, depending on the geographical location. The Paris city, as well some southern, western and central-eastern counties seemed to be privileged ECT receivers over the whole study period, whereas areas from northern

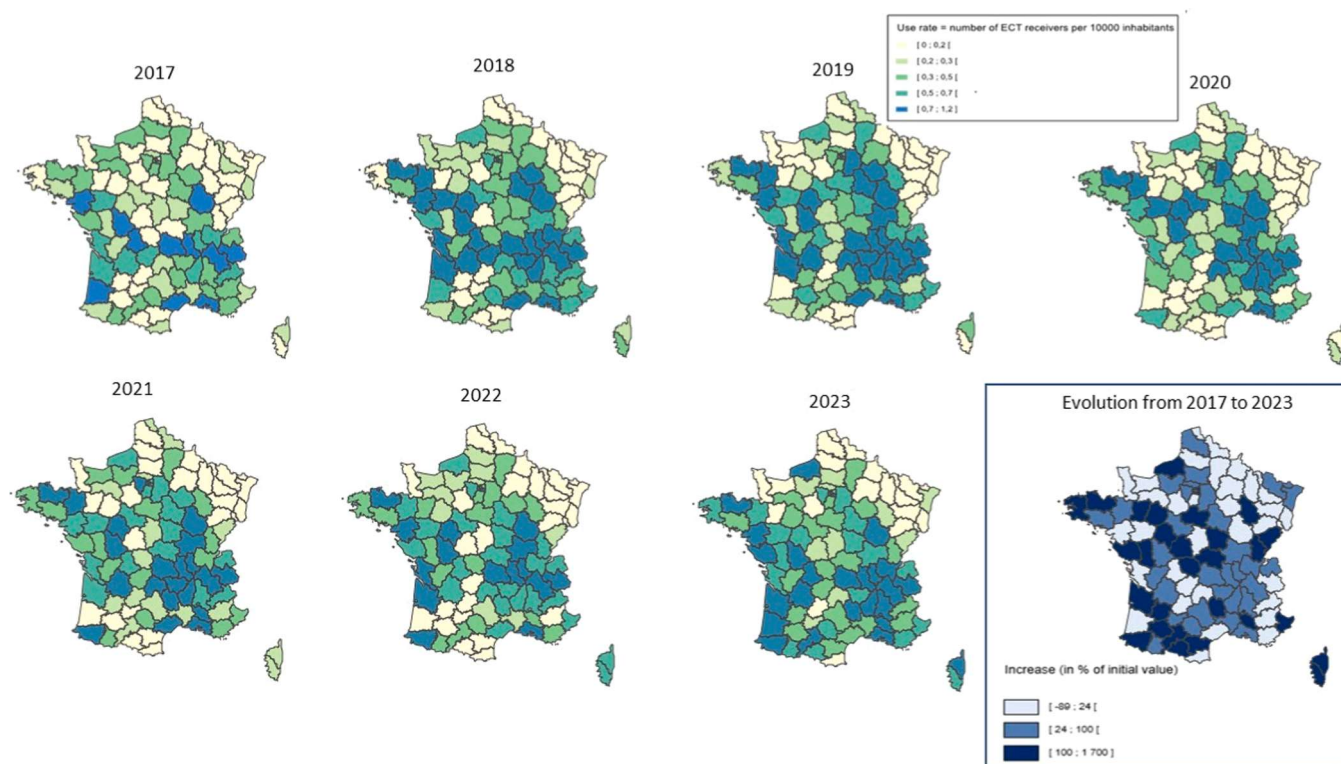


Fig. 2. Electroconvulsive therapy (ECT) use rate by geographical area in France from 2017 to 2023.

and eastern counties always remained low users. We found an uneven evolution of ECT use rate according to regions. Some counties, notably from the south-west, which were low ECT users in 2017, became high users at the end of the period. Other areas progressively increased their ECT practice over the years, either substantially or not. Also, the impact of the COVID-19 pandemic was uneven according to geographic location. Some regions were highly impacted and others, particularly Rhône, were not. The evolution from 2021 to 2023 showed a progressive increase in ECT use but also unevenly across the counties. See supplementary material for details.

We found no significant correlation between the growth rate of respectively ECT use rate and GDP (Gross Domestic Product) at county level on our study period ($p = 0.4$).

3.2. ITS analysis

For the global population, the pre-pandemic trend showed a significant slope of 1.014 [95 % confidence interval 1.010–1.018], indicating a 1.4 % increase in the outcome for a month unit time increase (Table 3). The trend was not significant for the <18 and 25–29 age groups but was significant for all other age categories. Specifically, we found significant trends of +1.3 % (1.013 [1.009–1.017]) for patients with at least a mood disorder diagnosis versus +1.8 % (1.018 [1.014–1.021]) for a schizophrenia diagnosis. Trends were significantly positive for all hospital categories.

At the beginning of the COVID-19 period, the immediate change of level compared to the pre-COVID-19 scenario showed a significant decrease for the global population and all subgroups, except for the <18 age group (+145 % increase). The COVID-19 period did not affect the pre-pandemic trend, except for a few sub-populations, notably patients with at least a mood disorder diagnosis (1.006 [1.000–1.012]), and private-non-profit hospital (1.035 [1.018–1.052]) (we detailed between brackets the value that multiplies the pre-pandemic slope). At the beginning of post-pandemic period, we observed an immediate significant drop of level compared to the pre-COVID-19 scenario for the global population and all subgroups, except for the age categories <18 and 25–29. The post-pandemic and pre-pandemic trends did not significantly differ except for a few subgroups for which we observed a significant change of slope: specifically, the pre-pandemic trend was increased for the <18 age group (1.126 [1.027–1.234]) (we detailed between brackets the value that multiplies the pre-pandemic slope).

4. Discussion

Our research reveals a significant increase in ECT use in France from 2017 to 2023. Over the study period, ECT receivers were more frequently female, with at least a diagnosis of a mood disorder. This status remained stable over time. Although two-thirds of the population were ≥ 50 years old, more specifically over the years, we found an increasing proportion of younger (≤ 29) and older (≥ 70) age categories, to the detriment of the 40–70 age category. Additionally, the share of private-for-profit hospitals among ECT providers increased significantly. We found a significant positive trend for the national number of ECT users during the pre-COVID-19 period. This trend was not significantly affected by pandemic or post-pandemic events. We also observed considerable geographical variability in ECT use and its evolution. Some areas in France seemed to be constant privileged therapy users, whereas some others remained poor users, or conversely progressively increased their use over the years.

The French national number of ECT receivers increased from 2562 in 2017 to 3720 in 2019, finally reaching 3972 in 2023. The ECT use rate also steadily increased (0.33 in 2017, 0.49 in 2019 and 0.50 in 2023). These findings are in line with a previous French study based on 2019 data (Lecarpentier et al., 2022) that calculated a non-standardized rate. Nevertheless, these results should be contextualized in terms of the international literature. The worldwide treated person rate was 2.34 in

2012 (Leiknes et al., 2012), with high variability among countries (from 0.04 to 5.1) (Sanz-Fuentenebro et al., 2017). France was ranking in a lower-to-middle range position. The French level of practice was higher than that of most of Europe eastern countries (from 0.02 to 0.16) (Asztalos et al., 2017; Hranov et al., 2012). It was close to that in Germany (0.7) (Jolivet and Grözinger, 2021), the United Kingdom (0.4) (Kirov et al., 2021), Switzerland (0.48) (Wilhelmy et al., 2023), and Spain (0.66) (Vera et al., 2016). Other countries with higher ECT use (2 to 5) (Wilhelmy et al., 2023) were the United States (2.38 to 5.10) (Wilhelmy et al., 2023), Belgium (4.7) (Nordanskog et al., 2015), Australia (3.7) (Vera et al., 2016), Canada (2.3 to 2.5) (Nordanskog et al., 2015), and Nordic countries (2.4 to 3.7) (Nordanskog et al., 2015; Vera et al., 2016). An increase in use over the years was also confirmed for Germany (Timäus et al., 2021), South Korea (Lee et al., 2024), Spain and Belgium (Asztalos et al., 2017). Conversely, a decrease seemed to occur in the United States (Case et al., 2013; Luccarelli et al., 2023a).

Our results regarding the characteristics of ECT patients, more frequently older and female, with a diagnosis of mood disorders, are consistent with a previous French study (Lecarpentier et al., 2022) and national guidelines (Agence Nationale Accréditation Evaluation Santé, 1997). The high prevalence of patients aged ≥ 70 agrees with older patients more likely showing treatment resistance or intolerance to psychotropic drugs and often having chronic comorbid medical issues (Timäus et al., 2021). Among the different age categories, the highest pre-COVID-19 trend was for the 18–24 age group, and it remained upward for the rest of the study period. This result is consistent with French research, finding an increasing prevalence of depressive episodes during 2017–2021 (Akkaoui et al., 2025; Leon, 2021) or suicidal thoughts during the first year of the pandemic (Bastide et al., 2023). This upward trend for younger and older people was also observed in South Korea (Lee et al., 2024). Apart from age, the French ECT patient profile remained stable over the study period, despite the pandemic. In contextualizing these findings with the international literature, we found a similarly higher proportion of patients >65 years old among ECT receivers in western countries (Leiknes et al., 2012; Timäus et al., 2021) versus a higher share of younger receivers in Africa and Asia (Leiknes et al., 2012; Nordanskog et al., 2015). Female sex was also predominant for ECT patients in North America and Europe (Benson-Martin and Milligan, 2015; Luccarelli et al., 2023a; Nordanskog et al., 2015; Patel et al., 2019; Read et al., 2021) and Australia (Leiknes et al., 2012) but not Africa (Leiknes et al., 2012) or Asia (Nordanskog et al., 2015). The diagnosis was predominantly mood disorders in the United States and other western nations (Lafreniere, 2023; Leiknes et al., 2012; Nordanskog et al., 2015; Olekseev et al., 2014; Payne and Prudic, 2009; Timäus et al., 2021; Vera et al., 2016), but ECT was more often used for psychotic disorders and suicide risk in Asian countries such as Thailand, Japan, and India (Benson-Martin and Milligan, 2015; Lee et al., 2024; Tor et al., 2019). Differences in diagnosis indications for ECT between Western countries and Asia might mirror the differences in gender distribution for ECT use across these regions.

The significant positive trends we observed for French ECT use for each period of our study might reflect a progressive global decline of ECT barriers such as stigma or lack of therapy knowledge and training among psychiatrists. Since therapeutic indications for ECT and ketamine are different (ECT being more suitable for older patients, and conversely ketamine for younger patients), it is understandable that we saw no sign that ECT has been replaced by ketamine. Ketamine might be an emerging option, especially valuable for rapid symptom relief in resistant depression, but ECT remains the go-to when illness is extreme, psychotic, or life-threatening. (Ekstrand et al., 2024, 2022; Lam et al., 2024; National Institute for Health and Care Excellence, 2022). Ketamine may need more time to have an impact on ECT use (Gastaldon et al., 2019). Its cost may also be a barrier to its wider use.

The significant decrease in ECT activity observed at the beginning of COVID-19 and post-COVID-19 periods compared to the pre-COVID-19 scenario was consistent with the French (Amad et al., 2020) and

Table 3
Coefficients of segmented regression: Interrupted time series with three periods.

| Population category | Intercept ¹ | Pre-COVID-19 trend ² | Change of level between pre-COVID-19 and COVID-19 scenario at the beginning of period T2 ² | Change of slope between pre-COVID-19 and COVID-19 scenario for period T2 ² | Change of level between pre-COVID-19 and COVID-19 scenario at the beginning of period T3 ² | Change of slope between pre-COVID-19 and COVID-19 scenario for period T3 ² |
|---|---------------------------------|---------------------------------|---|---|---|---|
| Global | 699.125 [645.403–757.319]**3 | 1.014 [1.010–1.018]** | 0.534 [0.474–0.603]** | 1.004 [0.998–1.010] | 0.542 [0.419–0.700]** | 0.984 [0.963–1.005] |
| Sex | | | | | | |
| Male | 234.455 [217.867–252.307]** | 1.015 [1.012–1.018]** | 0.511 [0.417–0.625]** | 1.005 [0.995–1.015] | 0.563 [0.483–0.656]** | 0.973 [0.957–0.990]* |
| Female | 466.175 [429.472–506.015]** | 1.013 [1.010–1.017]** | 0.557 [0.493–0.630]** | 1.003 [0.997–1.009] | 0.550 [0.423–0.715]** | 0.988 [0.967–1.009] |
| Age category (years) | | | | | | |
| <18 | 2.581 [1.903–3.501]** | 1.002 [0.986–1.019] | 2.447 [1.589–3.767]** | 0.997 [0.977–1.017] | 1.037 [0.347–3.103] | 1.126 [1.027–1.234]* |
| 18–24 | 9.940 [8.001–12.348]** | 1.034 [1.023–1.044]** | 0.465 [0.324–0.668]** | 0.997 [0.984–1.010] | 0.478 [0.299–0.764]* | 0.982 [0.952–1.014] |
| 25–29 | 21.539 [18.719–24.784]** | 1.005 [0.998–1.011] | 0.723 [0.587–0.889]* | 1.010 [1.001–1.019]* | 1.055 [0.694–1.602] | 1.002 [0.969–1.035] |
| 30–39 | 40.785 [35.010–47.512]** | 1.031 [1.022–1.039]** | 0.413 [0.275–0.620]** | 0.979 [0.972–0.986]** | 0.230 [0.165–0.321]** | 1.014 [0.992–1.037] |
| 40–49 | 70.250 [60.303–81.837]** | 1.025 [1.016–1.033]** | 0.465 [0.310–0.699]** | 0.985 [0.978–0.993]** | 0.354 [0.253–0.494]** | 0.995 [0.973–1.017] |
| 50–59 | 107.036 [83.090–137.883]** | 1.025 [1.011–1.038]** | 0.480 [0.275–0.837]* | 0.985 [0.978–0.992]** | 0.336 [0.199–0.567]** | 0.997 [0.974–1.020] |
| 60–69 | 138.485 [107.503–178.395]** | 1.022 [1.008–1.035]* | 0.496 [0.285–0.866]* | 0.991 [0.984–0.998]* | 0.364 [0.215–0.613]** | 0.989 [0.967–1.012] |
| ≥70 | 177.765 [160.367–197.050]** | 1.022 [1.018–1.027]** | 0.492 [0.414–0.584]** | 0.993 [0.986–1.001] | 0.417 [0.324–0.537]** | 0.976 [0.957–0.996]* |
| Diagnosis | | | | | | |
| At least a diagnosis of a mood disorder | 605.057 [557.223–656.997]** | 1.013 [1.009–1.017]** | 0.523 [0.462–0.592]** | 1.006 [1.000–1.012]* | 0.556 [0.427–0.724]** | 0.983 [0.962–1.004] |
| Diagnosis of schizophrenia only | 78.375 [72.189–85.091]** | 1.018 [1.014–1.021]** | 0.626 [0.556–0.706]** | 0.995 [0.990–1.001] | 0.528 [0.411–0.679]** | 0.987 [0.968–1.007] |
| Other diagnosis pattern | 15.650 [14.445–16.956]** | 1.027 [1.023–1.031]** | 0.532 [0.432–0.656]** | 0.981 [0.972–0.991]** | 0.253 [0.186–0.344]** | 1.016 [0.974–1.061] |
| Type of hospital where ECT was performed | | | | | | |
| Public | 207.544 [196.858–218.81]** | 1.013 [1.011–1.016]** | 0.536 [0.437–0.657]** | 1.001 [0.991–1.011] | 0.475 [0.401–0.562]** | 1.003 [0.984–1.022] |
| University | 310.259 [291.801–329.884]** | 1.005 [1.003–1.008]** | 0.617 [0.506–0.753]** | 1.008 [0.999–1.018] | 0.832 [0.722–0.958]* | 0.976 [0.967–0.985]** |
| Private-for-profit | 144.115 [124.002–167.491]** | 1.032 [1.025–1.039]** | 0.426 [0.341–0.533]** | 0.994 [0.984–1.004] | 0.267 [0.166–0.431]** | 0.971 [0.934–1.009] |
| Private-non-profit | 11.494 [8.800–15.011]** | 1.035 [1.022–1.049]** | 0.192 [0.115–0.319]** | 1.035 [1.018–1.052]** | 0.257 [0.132–0.499]** | 0.984 [0.933–1.039] |

¹ Intercept of regression model [95 % Confidence Interval].

² Coefficient of regression model [95 % Confidence Interval].

^{3**} p-value<0.01.

* p-value>0.01 and p-value<0.05.

international research (Demchenko et al., 2022; Luccarelli et al., 2023a; Sarma et al., 2023; Wadoo et al., 2022). As a matter of fact, multiple barriers induced by pandemic hindered the delivery of ECT. In response to the virus, hospitals needed severe control measures in ECT facilities, necessarily affecting productivity. Healthcare facilities were also prioritized for essential treatments. Because of shortages of health professionals or their reassignment to intensive COVID-19 care, hospitals were compelled to decrease allocation of resources for ECT (specifically for anesthesia).

We observed a geographical heterogeneity in ECT use across France, which was previously found (Lecarpentier et al., 2022). In this previous research, the characteristics of the patient care territory mostly accounted for variable ECT use. It specifically identified two factors that increased the odds of receiving the therapy to a greater extent than patient age or diagnosis: being treated (i) in a center close to a technical ECT platform or (ii) in a public hospital with teaching activities, where psychiatrists are likely more familiar with recent clinical guidelines and

neuroscience background. However, this latter result does not match some of our findings. Indeed, we observed a remarkable fact: the increase in ECT use over the study period was mainly driven by the private-for-profit hospitals. In a country with a poorly protective social welfare system, where private-for-profit facilities are primarily accessible to high-income patients, this could reflect that treatment availability is based on socioeconomic status, which might be problematic. But the significance of these results should also be interpreted in light of the highly protective French social health insurance system. France benefits from a distinctive social healthcare system that safeguards patients and makes private clinics accessible to more than just high-income patients. In public institutions, when the admission is related to certain chronic conditions eligible for full reimbursement, hospitalization and ECT costs are fully covered by French public health insurance. Patients receiving ECT are all eligible. As for private-for-profit hospitals, they are run as independent enterprises and largely funded through national health insurance reimbursements. Their ECT patients are covered under

the same system as in the public pathway, except for out-of-pocket costs limited to supplementary room and board charges. These additional expenses can though be covered by complementary private insurance, which a majority of patients have. A noteworthy example is the Paris metropolitan area with a striking social heterogeneity and accounting for over 40 % of the homeless population in metropolitan French urban areas with at least 20,000 inhabitants (Pierre-Marie et al., 2014); among patients present in 2017 in Paris psychiatric hospitals (Perquier et al., 2018), 94,3 % were covered by the general public health insurance system and only 10.6 % had no complementary health insurance. To summarize, for a very large majority of French patients, there should be no financial or socio-economic break in receiving ECT, even in a private-for-profit hospital, due to the specificity of our public health insurance system. Moreover, since we found no significant correlation between the growth rate of respectively ECT use rate and GDP (Gross Domestic Product) at county level on our study period, we found no statistical evidence of a disparity in ECT use based on economic status. Nevertheless, the few patients seeking care in private-for-profit facilities and not covered by a complementary private insurance might have to wait before being allocated a moderately priced hospital bed, the availability of which are limited. They might also be redirected to public facilities if a moderately priced bed cannot be found for them. For these patients, facing prolonged delays in access to ECT care due their socio-economic status, the expansion of private care to the detriment of the public system is a public health issue.

These higher prevalence and trend in private-for-profit facilities might reflect two underlying factors: (i) university hospitals are the source of ECT knowledge and prescription, but private-for-profit ones have more ability to provide technical resources to implement the therapy (specifically in light of the shortage of anesthesiologists in French public hospitals (Assemblée Nationale, 2022)), (ii) Private-for-profit facilities might have found very attractive financial incentive in ECT practice, given its simplicity and the possibility to bring predictable incomes with high-throughput procedures. A noteworthy finding of the mapping was the persistent low use-rate in the northern and eastern regions of France. A university-led study conducted in the North and Pas-de-Calais counties (Dablin, 2022) reported that, as of 2018, only a single ECT facility was operational. Although two additional ECT centers have been established since then, barriers to accessing this treatment persist. As reported in this research, brakes to the development of ECT practice might be linked to a below-average rate of psychiatric infrastructure and regional psychiatrist demographics, insufficient information among professionals concerning ECT and its availability, the unawareness of the existence of new ECT centers or their referral modalities. Thus, a regional North institutional program was launched to enhance awareness of available therapeutic options and support the orientation of patients toward appropriate care structures.

The uneven development of ECT use across French counties was also observed for foreign countries such as Spain (Sanz-Fuentenebro et al., 2017; Vera et al., 2016), the United States (Luccarelli et al., 2023a, 2023c; Patel et al., 2019), England (Read et al., 2021), and Sweden (Nordanskog et al., 2015). So human and material healthcare supply characteristics may be more important than socio-demographic and clinical features of populations (Sanz-Fuentenebro et al., 2017; Vera et al., 2016). Key cited factors were: (i) some heterogeneous psychiatrist schools of thoughts (persistence of the stigma related to ECT, uncertainty of its value (Lee et al., 2024; Leiknes et al., 2012; Mota et al., 2021; Patel et al., 2019; Payne and Prudic, 2009; Sanz-Fuentenebro et al., 2017; Wadoo et al., 2022), regional treatment traditions (Nordanskog et al., 2015), lack of training courses (Gazdag et al., 2017; Mota et al., 2021; Vera et al., 2016)) and (ii) the characteristics of the follow-up hospital (geographical distance to the nearest ECT center, lack of required equipment and limited density of anesthesiologists and psychiatrists (Asztalos et al., 2017; Demchenko et al., 2023; Fisher et al., 2017; Gazdag et al., 2017; Leiknes et al., 2012; Nordanskog et al., 2015; Olekseev et al., 2014; Patel et al., 2019; Payne and Prudic, 2009; Vera

et al., 2016)).

4.1. Strengths and limitations

To the best of our knowledge, this is the first study in the French literature to examine trends of ECT use and the longitudinal profile of patients over a long observation period. The use of a large-scale national medico-administrative database, representative of the French population, should ensure reliable data and minimize reporting bias. We studied the COVID-19 impact on ECT use with robust statistical interrupted time-series models. This method, added to cartography use, allowed us to have detailed insights into ECT use in France over the past 7 years.

Our study has certain limitations. First, a national administrative database can be subjected to miscoding of diagnosis and medical procedures. Nevertheless, the errors would still involve a small proportion of the whole sample. A major challenge and perspective of the work would be to go deeper in the understanding of the geographical variability of ECT use rate.

5. Conclusions

ECT use in France increased from 2017 to 2023, specifically among younger and older patients, with regional variability in the change pattern. ECT supply was also characterized by the increasing share over the years of private-for-profit hospitals versus both public and university ones. This tendency is a public health issue which should be addressed. Our findings suggested that the ECT stigma might be declining, that psychiatrists might be more familiar with this therapy, and that new therapeutics such as esketamine might not yet be ready to supplant ECT use. Further studies are needed to understand the root causes of regional heterogeneous use, but our research underlined the problematic unequal access to ECT care across the French territory. It stressed the importance of adequate national strategies and relevant financial means to (i) provide comprehensive information to patients through the media, (ii) develop ECT centers and a therapy knowledge evenly across the territory, (iii) give hospitals unable to supply the therapy some clear pathways to referral ECT providers. Additionally, some inspiring international studies are advocated to standardize ECT clinical practice (Asztalos et al., 2017; Sanz-Fuentenebro et al., 2017; UK ECT review group, 2003; Vera et al., 2016) and continue to refine its technique to diminish side effects (Rosenquist et al., 2016; Suleman, 2020). Also, ECT must stop being seen as “a treatment of last resort”, and might be considered as a “first line acute treatment” (Kirov et al., 2021; Leiknes et al., 2012).

Data availability

The data used in this study is available from the corresponding author upon reasonable request.

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Patient consent statement

All data extracted from the national database were completely anonymous. According to French and European laws, informed consent is not required for this category of study; informing the patient of their right to oppose to the use of their data is sufficient.

CRediT authorship contribution statement

D. Barruel: Writing – original draft, Software, Methodology,

Investigation, Formal analysis, Data curation, Conceptualization. **P. Belnou:** Writing – review & editing, Validation, Methodology, Investigation, Conceptualization. **M. Plaze:** Writing – review & editing, Validation, Methodology, Investigation, Conceptualization. **V. Dauriac-Le Masson:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary materials

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