Medical Research Archives

European Society of Medicine

OPEN ACCESS

Published: March 31, 2024

Citation: Douet-Vannucci V, Chebli M, et al., 2024. French National Trends in Neurodevelopmental and Mental Health-Related Healthcare Center Visits among Youth, 2014-2022: Towards Sex Specificities in the Care Pathway, Medical Research Archives, [online] 12(3). https://doi.org/10.18103/mra.v12i3.5286

DOI
https://doi.org/10.18103/mra.v12i3.5286

ISSN: 2375-1924

RESEARCH ARTICLE

French National Trends in Neurodevelopmental and Mental Health-Related Healthcare Center Visits among Youth, 2014-2022: Towards Sex Specificities in the Care Pathway

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What is already known on this topic.

- World widely, neurodevelopmental disorders (NDD) and mental health (MH) related conditions among children and adolescent represent a wide public health burden, that has been worsened by the COVID-19 pandemic.
- However, few studies have examined NDD and MH-related diagnoses and care pathway in youth attending public healthcare center (HCC) services in France.
- Furthermore, the influence of sex and age on NDD and MH-related conditions is still understudied, particularly in youth.

What this study adds.

- While the total number of pediatric HCC visits related to NDD and MH has remained relatively stable from 2014 to 2022, strong age- and sex-specificities were observed across visits and diagnosis's types. The number of visits doubled for adolescent girls with internalizing disorders (anxiety and mood) while a 5-fold decrease in the proportion of visits was observed for boys aged 0 to 12 years with NDD diagnoses.
- The mainstreams for HCC admissions were the emergency department for internalizing disorders and home for the NDD. The HCC discharge accounted only for 9% of patient being hospitalized, and most of them were sent home or to socio-medical center.

How this study might affect research, practice, or policy

- Understanding the prevalence and type of NDD and MH-related concerns in youth attending healthcare services is crucial for helping healthcare providers and public health institutions identify and provide integrated responses and care pathway to these concerns in a proper and timely manner.

ABSTRACT

Background: Neurodevelopmental disorders (NDD) and mental health (MH)-related conditions among children and adolescents, represent a global public health burden, that was worsened by the COVID-19 pandemic due to disruptions in access to healthcare, support services, and increased stressors exacerbating symptoms and challenges. However, few studies have examined in France, NDD and MH's diagnoses and care pathway in youth attending public healthcare center (HCC) services.

Methods: An annual cross-sectional analysis was performed in youth aged 0 to 17 years on health information, that were extracted from the French PMSI database (DIAMANT database) between January 1, 2014, and December 31, 2022, using the MH-related ICD-10 diagnosis codes, including NDD, mood-, behavior-, anxiety-, and other-disorders (sleep and eating). Trends in healthcare center visits for NDD and MH-related conditions, were evaluated according to age, sex, diagnoses, and care pathway over the 10-year period using ANOVAs.

Findings: Out of the 17,707,806 total HCC-visits across a 10-year period, 289,382 visits (1,6%) were related to youth with diagnoses for NDD or MH disorders of the study interest. Among them, 57% were girls and 43% boys. The total number of pediatric HCC-visits related to NDD and MH has remained stable from 2014 to 2022. However, the proportion of visits has doubled for adolescent girls with internalizing disorders (anxiety and mood) while a 5-fold decrease in the proportion of visits for NDD, was observed for boys aged 0 to 12 years. The HCC-admission mainstream for internalizing disorders was the emergency department and was "home" for the NDD. While the HCC-discharge accounted for 9% of patients being hospitalized, most of them were sent home (90.7%) with a strong age- and sex-specificities.

Interpretation: Over the last 10 years, the proportion of HCC visits for NDD and MH remained stable, but strong age- and sex-effects were found on diagnoses visits and care pathway. These findings are essential to improve emergency and outpatient service capacity dedicated to youth. They could help European and national policies to patient-tailor care pathway depending on sex and diagnosis from screening, interventions, and monitoring during this sensitive period of development.

Introduction

Neurodevelopmental disorders (NDD) and related mental health (MH) are the most frequent disabilities among young people. More than 9 million youth aged 7-17 in Europe are affected by such disorders as stated by Organisation for Economic Cooperation and Development (OECD, 2022), leading to a significant social and economic burden [1,2]. These conditions impact emotional, social, and cognitive development from the first years of life (0 to 5 years of life)[3], and persist across the lifespan. Many pediatric health organizations and institutions have alerted about the public health emergency and challenges of NDD and MH concerns among youth [4–6]. The COVID-19 pandemic has caused drastic disruption in youth's daily lives, whose consequences have highlighted mental health concerns to the general population.

NDD and MH-related are defined as any structural or/and brain functioning anomaly that occurs during neurodevelopment. They encompass intellectual handicaps (intellectual disabilities), attentional deficit/hyperactivity disorder (ADHD), communication disorders (language, speech, or communication deficits), specific learning disabilities (SLD, difficulty reading, or with written expression, or with numbers and mathematical reasoning etc.), developmental coordination disorder (DCD or dyspraxia), autism spectrum disorder (ASD)[7,8].

Firstly, the pathophysiology of NDD is complex with somatic or psychiatric diagnoses (comorbid, concomitant or in continuum) [9–12]. Up to 80% of children with NDD exhibit co-occurring mental health symptoms [13,14] that contribute to poorer functional outcomes [15,16] and quality of life [17,18].

Most studies on care specifics for NDD have focused on children and adolescents attending psychiatric clinics [19], research-based clinics [20,21], or specific disorder dedicated clinics.[22] Children with NDD represent about 25% of all pediatric mental health presentations in emergency departments (ED) [23]. Several US national studies showed an increase up to 60% in the MH–related pediatric ED visits [24–26] with a raise in the proportion of pediatric ED visits for MH concerns associated with the COVID-19 pandemic [6,27–29]. However, little has examined public healthcare center visits related to NDD and MH among French children, adolescents, and youth.

Girls with NDD are more likely to be diagnosed with internalizing disorders, such as anxiety, than boys [30,31], however the evidence is inconsistent.[21] A recent large scale meta-analysis showed that no significant difference emerged by sex, or age of onset. [32] Overall, sex and age are important contributors to the biological and behavioral variability among on NDD and mental health conditions, but they are still understudied, particularly in youth[33].

Understanding the prevalence and type of NDD and MH concerns in youth attending healthcare center (HCC) services is crucial for helping healthcare providers and public health institutions identify and provide integrated responses and care pathway to these concerns in a proper and timely manner.

To our knowledge, no French national nor European annual trends in pediatric neurodevelopmental disorders and mental health-related (NDD & MH-related) HCC-visits and care pathway, was reported. Since those would provide critical

opportunities to identify population wide unmet NDD and MH health needs and inform national policies. For the first time, French national data from the 2014-2022 from the public PMSI database were examined to evaluate recent trends, characteristics, and care pathway of NDD & MH-related HCC visits among children and adolescents aged 0 to 17 years, as follow:

- What are national annual trends in pediatric NDD & MH–related HCC visits from 2014-2022, including trends during the COVID-19 pandemic?
- How do trends vary by age, sex, diagnoses?
- Which sociodemographic (age and sex) and diagnostic characteristics are most strongly associated with NDD & MH-related HCC care pathway?

Considering how age and sex may impact the presentation and care pathway of children and adolescents with NDD and MH, may unravel national unmet medical needs and give insights on efforts to reduce the burden of NDD and MH on children, adolescents, their family, and ultimately the entire society.

Methods

DATA SOURCE AND SAMPLE

This study is based on data extracted between January 1st, 2014 and December 31st, 2022 from the comprehensive retrospective PMSI database (Décisionnel Inter-ARS pour la Maîtrise et l'ANTicipation: the DIAMANT database), that includes visits of patients comprising admission and discharge, visit types, diagnoses and procedures in French public and private healthcare centers (HCC). HCC include (i) private and public hospitals encompassing medicine, surgery, obstetrics, (ii) hospitalized homecare, and (iii) care/rehabilitation centers. Out of the 289,383 HCC visits from the PMSI database, one visit was excluded for the healthcare center visit since data was missing. Among the final sample of 289,382 visits, three periods of age were categorized: early childhood (0-6 years old, n= 43,251), children (7-12 years old, n=82,722), and adolescents (13-17 years old, n= 163,409).

For the analysis of effect of the care pathway on HCC visits, seven admission visits related to birth were excluded. Seven discharges for deaths with diagnosis of NDD (n=4), mood disorders (n=1), behavioral disorders (n=1), and other disorders (n=3) were also excluded from the care pathway analysis.

The study was covered by the common rule exemption and did not require institutional review board review as data are deidentified. The use of data from the PMSI was authorized by the National Commission for Data Processing and Civil Liberties (CNIL; authorization n°1419102 v6) and captured through the Technical agency for information on hospital care (ATIH: accreditation 2015-111111-56-18/orders M14N056).

MEASURES

NDD & MH–related diagnosis were identified by either 1) International Classification of Diseases-Ninth Revision, Clinical Modification (ICD-9-CM; 2011-2015) or ICD-10-CM (2016-2020) using 5 diagnosis code groups (eTable1): (1) NDD disorders (attention-deficit/hyperactivity disorders, autism spectrum disorders, specific learning disorders, intellectual deficiency, dyslexia); (2) behavioral disorders (eg, conduct disorders, hyperkinetic disorders, disruptive, impulse control, emotional control); (3) mood disorders (eg, depression- and stress-related); (4) anxiety (eg, anxiety, phobia, panic, obsession compulsion, trauma and neurotic disorders); and (5) other disorders (eg, eating disorders, and sleep disorders). Sociodemographic characteristics included age (0 to 17 years) and Sex (girls or boys). Using primary diagnosis, HCC admissions that were categorized as follow: 1) Home; 2) Emergency department (ED); 3) Socio-medical centers; 4) Inpatient services (Assisted home hospitalization, follow-up care and rehabilitation, long-term care, intensive care unit (ICU), psychiatry department, and obstetrics/surgery/medicine department) while HCC discharges include 1) Home, 2) Socio-medical centers, and 3) Inpatient services as previously defined.

DATA ANALYSIS

Descriptive data presented the total HCC visits over the 10 years period (2014-2022) among children and adolescents, and the proportion of visits related to NDD and mental health conditions. Using the R-Statistical package (v4.1.2; R Core Team 2021) and SAS version 9.4 (SAS Institute Inc), group estimates of admissions or discharges were examined across the age-, sex-, diagnosis-, and care pathway groups, and with age-by-sex-by-diagnosis or age-by-sex-by-care pathway interaction terms. A P value less than 0.05 is considered statistically significant.

PATIENT AND PUBLIC INVOLVEMENT

Patients were not involved in setting research questions or outcome measures, nor were they involved in design of the study. National parents' associations will assist with the dissemination of results through the O-Kidia and RETINES' las website.

Table 1. French National Trends in Neurodevelopmental And Mental Health-Related Healthcare Center Visits Per Age, Sex And Diagnosis Among Children And Adolescents, 2014-2022.

	2014	2015	2016	2017	2018	2019	2020	2021	2022	TOTAL	P-value
TOTAL VISITS	2,083,293	2,058,747	2,058,838	2,027,205	2,006,221	1,989,512	1,704,627	1,880,502	1,898,861	17,707,806 (100)	$p_{(years)}$= 0.15
Annual % change	NA	-1,19%	0,00%	-1,56%	-1,05%	-0,84%	**-16,71%**	9,35%	0,97%		
NDD & MH -related admission (% of total HCC visits)	31,351 (1.5)	31,357 (1.5)	31,483 (1.5)	32,730 (1.6)	32,503 (1.6)	33,705 (1.7)	28,871 (1.7)	35,442 (1.9)	31,940 (1.7)	289,382 (1.6)	$p_{(years)}$= 0.89
Annual % change	NA	0.02%	0,40%	3.81%	-0.7%	3.57%	**-16,74%**	18.54%	-10.96%		
AGE PERIOD (%NDD&MH-related visits, n=289,382)											$p_{(age)}$<0.0001
Early childhood	5,361 (1,85)	5,058 (1.75)	5,037 (1.7)	5,291 (1.8)	5,111 (1.8)	5,199 (1.8)	**3,752 (1.3)**	4,393 (1.5)	4,049 (1.4)	43,251 (15)	
Annual % change	NA	-5,99%	-0,42%	4,80%	-3,52%	1,69%	**-38,6%**	14,68%	-8,50%		
Childhood	9,232 (3.2)	9,378 (3.2)	9,335 (3.2)	9,484 (3.3)	9,547 (3.3)	10,277 (3.5)	**8,481 (2.9)**	9,242 (3.2)	7,746 (2.7)	82,722 (29)	
Annual % change	NA	1,56%	-0,46%	1,57%	0,66%	7,10%	**-21,2%**	8,23%	-19,31%		
Adolescence	16,758 (5.8)	16,921 (5.8)	17,111 (5.9)	17,955 (6.2)	17,845 (6.2)	18,229 (6.3)	16,638 (5.7)	**21,807 (7.5)**	**20,145 (7)**	163,409 (56)	
Annual % change	NA	0.96%	1.11%	4.7%	-0.62%	2.1%	-9.56%	**23.7%**	**8.25%**		
DIAGNOSES TYPE (% NDD&MH-related visits, n=289,382)											$p_{(diagnosis)}$<0.0001
NDD	7,225 (2,5)	7,060 (2,4)	6,928 (2,4)	7,261 (2,5)	7,063 (2,4)	7,310 (2,5)	**5,490 (1.9)**	6,590 (2.3)	**6,030 (2.1)**	60,958 (21)	
Annual % change	NA	-2,34%	-1,91%	4,59%	-2,80%	3,37%	**-33,15%**	16,69%	**-9,29%**		
Behavior	10,596 (3,7)	10,539 (3,6)	10,226 (3,5)	10,731 (3,7)	9,694 (3,35)	10,695 (3,7)	8,941 (3,1)	9,951 (3,4)	**8,212 (2,84)**	89,585 (31)	
Annual % change	NA	-0,54%	-3,06%	4,71%	-10,70%	9,36%	-19,62%	10,15%	**-21,18%**		
Anxiety	6,555 (2,3)	6,568 (2,3)	7,026 (2,4)	7,342 (2,5)	7,888 (2,5)	6,863 (2,7)	8,654 (2,4)	7,789 (3)	7,176 (8.5)	65,861 (23)	
Annual % change	NA	0,20%	6,52%	2,09%	2,26%	6,92%	-14,94%	20,70%	-11,11%		
Mood	4,605 (1,6)	4,727 (1,6)	4,808 (1,6)	5,135 (1,8)	5,642 (1,9)	5,312 (1,8)	4,722 (1,6)	**6,582 (2,3)**	**5,804 (2)**	47,337 (16)	
Annual % change	NA	2,58%	1,68%	6,37%	8,99%	-6,21%	-12,49%	**28,26%**	**-13,40%**		
Others	2,370 (0,8)	2,463 (0,85)	2,495 (0,9)	2,427 (0,8)	2,762 (1)	2,500 (0,9)	2,855 (1)	**3,665 (1,3)**	**4,105 (1,4)**	25,642 (9)	
Annual % change	NA	3,78%	1,28%	-2,80%	12,13%	-10,48%	12,43%	**22,10%**	**10,72%**		
SEX (%NDD&MH-related visits, n=289,382)											$p_{(sex)}$=0.009
Girls	17,041 (5,9)	16,816 (5,8)	16,790 (5,8)	17,680 (6,1)	18,245 (6,3)	18,655 (6,5)	16,799 (5,8)	22,335 (7,7)	20,522 (7,1)	**164,883 (57)**	
Annual % change	NA	-1,34%	-0,15%	5,03%	3,10%	2,20%	-11,05%	24,79%	-8,83%		
Boys	14,310 (4,95)	14,541 (5)	14,693 (5,1)	15,050 (5,2)	14,258 (4,9)	15,050 (5,2)	12,072 (4,2)	13,107 (4,5)	11,418 (4)	124,499 (43)	
Annual % change	NA	1,59%	1,03%	2,37%	-5,55%	5,26%	-24,67%	7,90%	-14,79%		

Data were reported as percent values of total admission for NDD and MH related unless otherwise specified. Disorders included within 5 MH diagnoses categories among children and adolescents , were for (1) NDD (attention-deficit/hyperactivity disorders, autism spectrum disorders, specific learning disorders, intellectual deficiency, dyslexia); (2) behavioral disorders (eg, conduct disorders, hyperkinetic disorders, disruptive, impulse control, emotional control); (3) mood disorders (eg, depression- and stress-related); (4) anxiety (eg, anxiety, phobia, panic, obsession compulsion, trauma and neurotic disorders); and (5) other disorders (eg, eating disorders, and sleep disorders).
Age groups were predefined based on the EU census data. Interaction terms were tests to assess whether trends.
HCC : HealthCare Center; NDD : NeuroDevelopment Disorders; MH : Mental Health

Results

OVERALL TRENDS IN THE TOTAL STUDY SAMPLE

From 2014 to 2022, the total national number of HCC visits among children and adolescents aged 0 to 17 years tended to decline from 2.08 million to 1.9 million patients (p=0.15). HCC visits related to neurodevelopmental disorders (NDD) and mental health (MH) conditions represented about 1.6% of the total national number of HCC visits, and remained stable over the 10 years (p=0.89).

These NDD & MH-related visits were more likely among adolescents (56.47%) than in children (28.5%) or early childhood (14.95%) ($p_{(age)}$<0.0001); Table 1). Among diagnosis, behavior disorders (31%) were more likely represented than anxiety- (23%), NDD (21%), mood- (16%), and finally others-disorders (9%) ($p_{(diagnosis)}$<0.0001, Table 1).

An age-by-diagnosis interaction (p<0.0001, Table 2) showed that NDD disorders were more likely in early childhood (9.6%) and childhood (9.6%) than during adolescence (1.9%) while anxiety- (17.9%), behavior- (14.9%), mood- (14.3%) and other- (7.5%) disorders were more represented in the adolescence period than during both early- and childhood.

During the COVID-19 pandemic period from 2019 to 2020, the total HCC visits and the NDD & MH-related visit among children and adolescents declined with an annual per cent change about 16.7%, although this change was not found statistically significant across years ($p_{(years)}$= 0.15-0.89, Table 1). Among the NDD & MH-related visits, the early childhood and childhood periods exhibited the more drastic decline between 2019 and 2020 with an annual per cent change at 38.6%, and 21.2%, respectively.

While the total number of HCC visits prior the COVID-19 pandemic period (2019) was restored in 2022, a decline was observed in the number of visits for NDD and behavior disorders between 2019 and 2022 (Table 1).

Table 2. Sex-by-Age Period-by-Diagnosis Specificities On The French National Trends In Neurodevelopmental And Mental Health-Related Healthcare Center Visits Among Children And Adolescents , 2014-2022.

N, % NDD&MH-related visits (n=289,382)	Early Childhood	Childhood	Adolescence
NDD	27,872 (9.6)	27,538 (9.6)	5,548 (1.9)
Girls (6.5)	8,240 (2.8)	8,868 (3.1)	1,834 (0.6)
Boys (14.6)	**19,632 (6.8)**	**18,670 (6.5)**	**3,714 (1.3)**
BEHAVIOR	13,315 (4.6)	33,086 (11.4)	43,177 (14.9)
Girls (14.6)	5,564 (1.9)	10,708 (3.7)	**26,088 (9)**
Boys (16.3)	**7,751 (2.7)**	**22,378 (7.7)**	17,089 (5.9)
ANXIETY	974 (0.4)	13,113 (4.6)	51,774 (17.9)
Girls (15.9)	454 (0.2)	**7,406 (2.6)**	**37,898 (13.1)**
Boys (7)	520 (0.2)	5,707 (2)	13,876 (4.8)
MOOD	99 (0.02)	5,906 (2)	41,332 (14.3)
Girls (12.1)	29 (0.01)	3,427 (1.1)	**31,724 (11)**
Boys (4.3)	70 (0.01)	2,479 (0.9)	9,608 (3.3)
OTHER	985 (0.3)	3,079 (1.1)	21,578 (7.5)
Girls (7.8)	448 (0.1)	**2,303 (0.8)**	**19,889 (6.9)**
Boys (1.1)	537 (0.2)	776 (0.3)	1,689 (0.6)

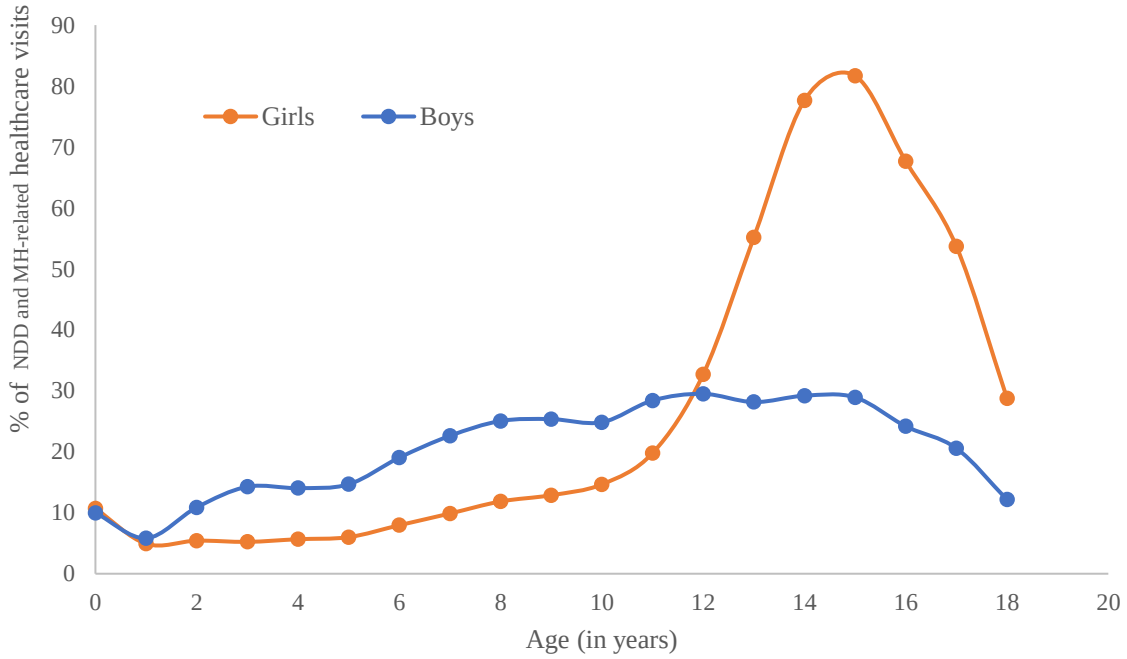
Data were reported as percent values of total admission for NDD and MH related (n=288,382).
HCC : HealthCare Center; NDD : NeuroDevelopment Disorders; MH : Mental Health

SEX SPECIFICITIES FOR NDD-RELATED VISITS

Overall, the proportion of all types of MH-related visits was higher in girls (57%) than boys (43%) ($p_{(Sex)}$=0.009, Table 1). A trend for an age-by-study period interaction ($p_{(Sexxyears)}$ =0.04) was found and suggests that a higher number of NDD & MH-related visits was more likely for girls across the 10 years while a slight decrease was observed for boys over the same period (Table 1).

A strong age-by-sex interaction (p<0.0001, Figure 1) was also observed with a percentage for NDD & MH-related visits peaking at 82% at age 15 for girls while a peak at 29.5% at 12 years old was observed for boys.

Figure 1. French National Trends n Neurodevelopmental And Mental Health-Related Healthcare Center Visits Per Age And Sex, 2014-2022.



Data were reported as percent values of total admission for NDD and MH related. No significant changes in the total admissions in NDD & MH-related healthcare were observed over the 10 years-period. However, girls (in red) exhibited a higher percentage of NDD & MH-related healthcare visits peaking at age 15 years compared to boys (in blue) across 2014-2022.
HCC : HealthCare Center; NDD : NeuroDevelopment Disorders; MH : Mental Health

In addition, a diagnosis-by-Sex interaction ($p<0.0001$, Table 2) was found showing that visits for girls were more likely related to anxiety- (15.9%), mood- (12.1%) and other-(7.8%) disorders than those for boys while visits for NDD were about twice more likely for boys (14.6%) than girls (6.5%). No Sex-specificity was observed for visits related to behavior disorders (girls, 14.6%; boys, 16.3%, $p>0.5$).

Finally, an age-by-sex-by-diagnosis interaction ($p<0.0001$) was observed and mainly driven by the pattern of visits for behavior disorders (Table 2). The higher proportion of NDD & MH-related visits was found for behavior disorders in girls, peaking during adolescence (9%) while it was observed during both early- and childhood periods in boys. Higher percentages of NDD & MH-related visits for anxiety-, mood, and other-disorders were exhibited in girls than boys during childhood and adolescence with a drastically increased proportion of these visits across these 2 periods of age (Table 2).

NDD AND MH-RELATED CARE PATHWAY OVER THE 10-YEARS PERIOD

Over the 10-years period, no statistically significant changes overtime were found on the care pathway of the NDD & MH-related HCC visits ($p=0.51$, Table 3). Independently of age, children and adolescents were admitted to HCC more often from home (49%) and from emergency department (ED, 50%) than from inpatient services (socio-medical center and hospitalized) (Table 3). Across care pathway, the proportion of NDD&MH-related discharges were for 90% towards home, and at lower extent, towards inpatient services (hospital, 9%) with twice more discharges in girls than boys, and towards outpatient care (0.3%).

Table 3. French National Trends In Neurodevelopmental and Mental Health-Related Healthcare Center Visits among Children And Adolescents , 2014-2022 by care pathways

	ADMISSION			DISCHARGE				
	Girls	**Boys**	**Sub-Total**	**Girls**	**Boys**	**Sub-Total**	**Total**	**P-value**
TOTAL NDD & MH-related visits, (in %)	164,880 (57)	124,496 (43)	289,376 (100)	164,875 (57)	124,498 (43)	289,373 (100)	578,749 (100)	$p_{(sex)}<0.0001$ $p_{(statutxsex)}= 0.78$
CARE PATHWAY (% NDD&MH-related visit type)								$p_{(carepathway)}<0.0001$, $p_{(carepathway\ x\ sex)}<0.0001$
Hospital	2,649 (1)	935 (0.3)	3,584 (1)	**16,756 (6)**	8,308 (3)	**25,064 (9)**	28,648 (5)	
Psychiatry	582 (0.2)	212 (0.07)	794 (0.3)	**12,160 (4)**	6,368 (2)	**18,528 (6)**	19,322 (3)	
Other inpatient systems	2,058 (1)	717 (0.2)	2,775 (0.6)	4,556 (2)	1,924 (0.7)	6,480 (2)	9,255 (2)	
Hospitalized Homecare	9 (0.003)	6 (0.002)	15 (0,01)	40 (0.01)	16 (0.01)	56 (0.02)	71 (0.01)	
Socio-Medical Center	26 (0.01)	20 (0)	46 (0.01)	**535 (0.2)**	**382 (0.1)**	**917 (0.3)**	963 (0.2)	
Emergency Department	96,197 (33)	49,016 (17)	**14,5213 (50)**	NA	NA	NA	145,213 (25)	
Home	66,008 (23)	74,525 (26)	**140,533 (49)**	147,584 (51)	115,808 (40)	**263,392 (90.7)**	**403,925 (70)**	
AGE PERIOD (% NDD&MH-related visit type)								$p_{(carepathway\ x\ age)}<0.0001$
Early childhood	14,735 (5)	28,510 (10)	43,245 (15)	14,736 (5)	28,513 (10)	43,249 (15)	86,494 (15)	
Childhood	32,712 (11)	50,010 (17)	82,722 (29)	32,711 (11)	50,009 (17)	82,720 (29)	165,442 (29)	
Adolescence	**117,433 (41)**	45,976 (16)	**163,409 (56)**	117,428 (41)	45,976 (16)	163,404 (56)	**326,813 (56)**	
DIAGNOSES TYPE (% NDD&MH-related visit type)								$p_{(carepathway\ x\ diagnostic)}<0.0001$
NDD	18,942 (7)	**42,016 (15)**	60,958 (21)	18,939 (7)	**42,014 (15)**	60,953 (21)	121,911 (21)	
Behavior	42,360 (15)	47,218 (16)	89,578 (31)	42,362 (15)	47,222 (16)	**89,584 (31)**	**179,162 (31)**	
Anxiety	**45,758 (16)**	20,103 (7)	65,861 (23)	**45,758 (16)**	20,103 (7)	65,861 (23)	131,722 (23)	
Mood	**35,180 (12)**	12,157 (4)	47,337 (16)	**35,179 (12)**	12,157 (4)	47,336 (16)	94,673 (16)	
Others	**22,640 (8)**	3,002 (1)	25,642 (9)	**22,637 (8)**	3,002 (1)	25,639 (9)	51,281 (9)	

HCC visits labeled for birth (n=7) and death (n=9) were excluded from this analysis.
Status represented the grouping between admission and discharges.
Data were reported as percent values of either total admission (n=289,376) or discharge (n=289,373) for NDD and MH related HHC visits.
ED: Emergency Department; HCC : HealthCare Center ; NDD : NeuroDevelopment Disorders; MH : Mental Health

A care pathway-by-age interaction showed that admissions among the youngest patients (0-6 years) and children (7-12 years) were mainly from home or through ED while admissions for most of the adolescents were through the ED (38%, Table 4).

A care pathway-by-sex-by-diagnosis interaction showed that admissions of girls were more likely through the ED (16.6%) than those of boys ($p_{(carepathway\ x\ Sex)}$ <0.0001, Table 3), and those were mainly for anxiety-, mood-, and other-disorders compared to those of boys.

Admissions in adolescents were mostly from home with diagnosis of anxiety-, mood-, and others-disorders while children aged 7 to 12 years old were mainly admitted for behavior-disorders (Table 4). Most of the children and adolescents were discharged to home for behavior- and, then anxiety and mood-disorders (Table 4). Finally, admissions for behavioral disorders were mainly from home with adolescent girls being mostly discharged to home while boys were discharged with this diagnosis during childhood (Table 4).

Psychiatry's care pathway specificities

Out of the total inpatient admissions (n=3,584, Table 3), one-fourth (n= 794,) were from psychiatry departments. Discharges to inpatient services represented 9% of the total discharges (n=25, 064) where discharges were mainly to psychiatry services accounting for 6% of the total discharges (Table 3). Those inpatients discharged to psychiatry services were mostly adolescents (Table 4), twice more girls than boys (Table 3), and diagnosed for behavior-, anxiety-, mood- and other disorders (Table 4).

NDD's care pathway specificities

Patients with NDD represented 21% of the total HCC visits across the 10-years period (Table 3), and were twice more likely to be boys than girls across all age periods. At adolescence, a drastic drop-down occurred in the proportion of HCC visits for both boys and girls (Table 3). Younger NDD patients (0 to 12 years) were admitted in HCC through home (3.5%, $p_{(age\ group\ x\ diagnosis)}= 0.04$, Table 4) while no age group effect was found on NDD patients admitted though the ED ($p_{(age\ group\ x\ diagnosis)} = 0.99$, Table 4).

Discussion

To our knowledge, our study presents the first nationally representative estimates of children and adolescents' neurodevelopmental (NDD) and mental health (MH)-related healthcare center (HCC) visits in France.

Despite a drastic decrease (-16.7%) during the COVID-19 pandemic, the total number of children and adolescents' HCC visits, has remained stable from 2014 to 2022 and the proportion of NDD & MH-related HCC visits was about 1.6% of the total nation number of HCC visits. These finding extent prior studies mainly done on the US national trends showing an increase rate for children and adolescents' MH-related visits over the last decades [3,34].

Table 4. Sex-By-Age Period-By-Diagnosis Specificities On The French National Care Pathway Of The Neurodevelopmental And Mental Health-Related Disorders Among Children And Adolescents, 2014-2022.

	ADMISSION			DISCHARGE		
% NDD&MH-related visit type	Early childhood	Childhood	Adolescence	Early childhood	Childhood	Adolescence
HOSPITAL, (in %)	(0.05)	(0.2)	(1)	(0.08)	(1)	(8)
NDD						
Girls	13 (0)	9 (0)	10 (0)	22 (0.01)	29 (0.01)	76 (0.03)
Boys	20 (0.01)	17 (0.01)	16 (0.01)	37 (0.01)	74 (0.03)	185 (0.06)
Behavior						
Girls	54 (0.02)	90 (0.03)	378 (0.13)	70 (0.02)	505 (0.2)	**2,979 (1)**
Boys	43 (0.01)	126 (0.04)	206 (0.07)	67 (0.02)	905 (0.3)	**2,255 (0.8)**
Anxiety						
Girls	9 (0)	85 (0.03)	613 (0.21)	7 (0)	238 (0.08)	**4,269 (1.5)**
Boys	6 (0)	59 (0.02)	177 (0.06)	5 (0)	161 (0.06)	1,996 (0.7)
Mood						
Girls	0 (0)	47 (0.02)	508 (0.18)	0 (0)	308 (0.1)	**5,712 (2)**
Boys	0 (0)	22 (0.01)	166 (0.06)	5 (0)	196 (0.07)	2,217 (0.8)
Others						
Girls	6 (0)	87 (0.03)	740 (0.26)	14 (0)	335 (0.1)	**2,192 (0.8)**
Boys	7 (0)	15 (0.01)	55 (0.02)	6 (0)	46 (0.02)	153 (0.05)
SOCIO-MEDICAL	(0)	(0)	(0)	(0.02)	(0.07)	(0.22)
NDD						
Girls	3 (0)	3 (0)	0 (0)	4 (0)	0 (0)	2 (0)
Boys	4 (0)	4 (0)	0 (0)	6 (0)	2 (0)	2 (0)
Behavior						
Girls	0 (0)	4 (0)	6 (0)	10 (0)	59 (0.02)	**203 (0.07)**
Boys	0 (0)	2 (0)	4 (0)	30 (0.01)	102 (0.04)	**124 (0.04)**
Anxiety						
Girls		1 (0)	5 (0)	2 (0)	12 (0)	**91 (0.03)**
Boys	1 (0)	1 (0)	4 (0)	3 (0)	16 (0.01)	**48 (0.02)**
Mood						
Girls	0 (0)	0 (0)	3 (0)	0 (0)	11 (0)	**108 (0.04)**
Boys	0 (0)	1 (0)	1 (0)	0 (0)	6 (0)	**42 (0.01)**
Others						
Girls	0 (0)	0 (0)	3 (0)	0 (0)	3 (0)	30 (0.01)
Boys	0 (0)	0 (0)	1 (0)	0 (0)	1 (0)	0 (0)
EMERGENCY DPT	(2)	(10)	(38)			
NDD						
Girls	193 (0.07)	227 (0.08)	319 (0.1)	NA	NA	NA
Boys	**341 (0.1)**	**439 (0.2)**	**659 (0.2)**	NA	NA	NA
Behavior						
Girls	1,515 (0.5)	5,832 (2)	19,752 (6.8)	NA	NA	NA
Boys	1,823 (0.6)	9,070 (3)	11,703 (4)	NA	NA	NA
Anxiety						
Girls	286 (0.1)	5,298 (1.8)	**28,843 (10)**	NA	NA	NA
Boys	306 (0.1)	3,711 (1.3)	10,295 (4)	NA	NA	NA
Mood						
Girls	19 (0.01)	2,658 (0.9)	**24,634 (8.5)**	NA	NA	NA
Boys	46 (0.02)	1,790 (0.6)	7,681 (2.7)	NA	NA	NA
Others						
Girls	239 (0.08)	971 (0.3)	**5,411 (2)**	NA	NA	NA
Boys	**271 (0.09)**	**342 (0.1)**	**539 (0.2)**	NA	NA	NA
HOME	(13)	(18)	(18)	(15)	(28)	(49)
NDD						
Girls	8,031 (2.8)	8,631 (3)	1,505 (0.5)	8,212 (3)	8,838 (3)	1,756 (0.5)
Boys	**19,267 (6.7)**	**18,213 (6.3)**	3,039 (1)	**19,588 (7)**	**18,593 (6)**	3,527 (1)
Behavior						
Girls	3,995 (1.4)	4,782 (1.7)	5,952 (2)	5,487 (2)	**10,144 (3.5)**	**22,905 (8)**
Boys	5,885 (2)	**13,180 (4.6)**	5,176 (1.8)	7,658 (3)	**21,371 (7)**	**14,710 (5)**
Anxiety						
Girls	159 (0.05)	2,022 (0.7)	**8,437 (3)**	445 (0.1)	**7,156 (2.5)**	**33,538 (11.6)**
Boys	207 (0.07)	1,936 (0.7)	3,400 (1.2)	512 (0.2)	**5,530 (2)**	**11,832 (4)**
Mood						
Girls	10 (0)	722 (0.25)	**6,579 (2.3)**	29 (0.01)	**3,108 (1)**	**25,903 (9)**
Boys	24 (0.01)	666 (0.2)	1,760 (0.6)	65 (0.02)	**2,277 (0.8)**	**7,349 (2.5)**
Others						
Girls	203 (0.07)	1,245 (0.4)	**13,735 (4.8)**	434 (0.1)	**1,965 (0.7)**	**17,664 (6)**
Boys	259 (0.09)	419 (0.1)	1,094 (0.4)	531 (0.2)	**729 (0.25)**	**1,536 (0.5)**

Data were reported as percent values of either total admission or discharge for NDD and MH related HHC visits.
ED: Emergency Department; HCC : HealthCare Center ; NDD : NeuroDevelopment Disorders; MH : Mental Health

Linear increasing trends were observed for adolescents across sex and diagnosis types although patients were mostly adolescents with mood-, anxiety- and others-disorders (eating and sleep disorders). In contrast, the younger children (0-12 years) exhibited stable annual percent changes between 2014 and 2018, then a 2-years incremental decline after the COVID-19 pandemic (post-2020). This increase across 2019-2022 was the highest for children with NDD and behavior disorders. Several explanations can be suggested such as increased prevalence of mental health concerns among adolescents in the general population along with an improved identification, screening, and treatment referral for patients with NDD. In France, the national strategy for autism and neurodevelopmental disorders [35] is the simplest explanation. This strategy has been implemented since 2018 to change clinical practices and reduce waiting times to outpatient mental health care and overwhelmed community-based system, that were detrimental to patients, their relatives, and the healthcare providers. It led to the implementation of recommendations by the HAS in 2020 on Neurodevelopmental Disorders - Identification and guidance of children at risk [36]. Early identification and support for children aged 0-6 has been massively expanded since 2018 with the implementation of 76 coordination and referral platforms (CRP) deployed throughout France. In 2022, a booklet for identifying NDD in children aged 7 to 12, also intended for teachers, has been operational. These CRPs dedicated to NDD children have started providing support and diagnosis, that might have led to the specific decrease of the HCC visits as described previously. In the next years, an incremental decline of the NDD visits is expected at the hospital towards the socio-medical centers and CRPs.

As expected, internalizing and behavioral disorders remained for adolescents, the first attending visits to the hospital through ED. This consisted into a substantial increase over years, that was previously reported across the world [37] and that has become a particular public health concern since they often lead to suicidal thoughts. [38] Note that differences appear in intensity and age range since major psychiatric disorders such as manic episode (F30) bipolar disorders (F31), major depression (F33) schizophrenia, schizotypal and delusional disorders (F20-29), and behavioral syndromes associated with physiological disturbances and physical factors (F52-59), that are less associated with NDD diagnosis during the period of childhood, were not included. In Europe, several studies have demonstrated a drastic increase in anxiety-, mood-, and behavioral disorders [14,29,39] from 2007 to 2016, especially among adolescent girls [40,41]. This trend underscores the importance of improving capacity of EDs to provide high-quality care for children and adolescents experiencing such symptoms or though community-based services. Initiatives based on comprehensive screening, safety planning and coordinated follow-up care, have been reported in ED to reduce the risk of suicidal thoughts and behaviors among adolescents with internalizing and behavioral disorders, mainly in US. More are needed in Europe.

As consensually observed, twice many boys were visiting HCC for NDD than girls. Trends observed in this study, diverged slightly across studies since age range and diagnosis types of interest were different. Very few studies [33,42] examined neurodevelopmental diagnoses and care pathway across sex. Boys showed a higher visit rate for NDD, while adolescent girls exhibited the highest visit rate for anxiety-, behavior-, and mood disorders. Girls had also this rate peaking about 82% of the NDD & MH-related HCC visits at age 15 while boys had a smoother peak about 29.5% at younger age (12 years). Previous results showed that girls had the highest number of visits since they were predominantly seeking help for mood, anxiety, and other disorders [43]. Young people showed complex pattern on psychopathology but also on contextual non-psychiatric factors, whom sex and age are important contributors in neurodevelopmental conditions.

LIMITATIONS OF THE STUDY

The present study aimed at (i) characterizing French national trends for NDD and related MH among children and adolescents compared to the current reports and (ii) evaluating, beyond the COVID-19 pandemic specifics, how age and Sex influence on HCC visits for NDD-related symptoms and care pathway. This study has several limitations. Firstly, identification of MH symptoms, and hereby visits related to NDD, depends on the code system used and the definition of the targeted disorders. Here, the ICD codes that is taken by most studies [44] and that included NDD and their most psychosomatic- and psychiatric-related symptoms [12,14], were chosen. Some of our results differ from previous literature due to our focus on NDD and their most related MH conditions. Therefore, NDD diagnoses, and care pathway's characteristics should account more systematically for sex and age [33].

Over the 10 years period, IC-9-CM was updated to IC-10-CM in 2016 with substantial differences. Given it, these finding and patterns relative to mood-disorders may have been overestimated,

however our results and interpretations are consistent with the previous literature.

Secondly, our dataset consists into cross-sectional information at HCC visit level and not the patient. Accounting for repeated HCC visits nor for causality between diagnoses at admission visit and at discharge over the 10 years period, was not feasible in this study. Relationship between diagnoses and care pathways can not to assessed at patient level.

NDD diagnoses and care occur mainly outside the hospital. In France, delivery of care is shared among independent physicians, public hospitals, and private hospitals [45]. Moreover, there is a combined health and social care sector that provides care and supportive services to elderly and disabled people. The PMSI is based on the production of a standard discharge summary for each acute hospital stay, which describes the nature of the treatment and examinations, the diagnosis underlying the hospital admission and associated diagnoses or complications [45].The PMSI database does not include primary care and community-based healthcare data although like in other countries, most health problems are managed within primary health care in France [46]. Similar study should be undertaken with primary care information.

PERSPECTIVES AND FUTURE RESEARCH

Mental health needs are commonly seen in children and adolescents with NDD, and they are often addressed partially. Practitioners focus on NDD concerns reported by the referrer [47] by lack of consultation time and limited access to structured dedicated healthcare support[48] since the care pathway of NDD and related-MH occurs among several outpatient services. [49] Identifying NDD profiles and unmet mental health concerns accounting for age and sex specificities [32] would facilitate design of integrated caregiver services and hereby, strategies for prevention, diagnosis, and intervention. Evidence is growing to demonstrate that technology-based diagnosis for NDD population is promising,[50] and need to translate into clinical practice after rigorous scientific validation.

Conclusion

Over the past decade, neurodevelopmental and mental health concerns have raised several challenges to the general population and the healthcare systems. This study showed a strong Sex and age specificities on the diagnosis type and the care pathway of neurodevelopmental and related mental health among children and adolescents. These finding suggest the urgent need to improve emergency and outpatient service capacity in a more coordinated manner. More specifically, Sex and age impacts on diagnoses and care pathway, also give insights into characteristics for NDD, revealing a necessity to expand beyond hospitals to alternatives like CRPs developed in France for screening, diagnosis, and therapy since 2018. Among adolescents, similar infrastructures could address their specific needs to fill the gap between the hospital and socio-medical centers. The preliminary results of the initiatives during the national strategy for autism and neurodevelopmental disorders [35] strongly suggest that building a continuum between hospital, outpatient services, and even later school-based system, is addressing gaps and deficiencies in mental health services for young people, those at risk along with those with manifest disorders.

Altogether, these findings could help French but also European policies to patient-tailor care pathway depending on their sex and diagnosis from screening, interventions, and monitoring during this sensitive period of development.

Competing interest statement- The authors have no conflicts of interest to declare. M.C. and L.I.P. are employees of O-Kidia, and V.D.V. has stock and ownership interest in O-Kidia. As part of the study, M.C., L.I.P. V.D.V., and P.S. 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. P.S. reports support through. Medical Information Department, Alpes-Maritimes Hospitals Group. P.S as the manuscript's guarantor affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

Funding statement: The study is funded partially by the bank of innovation (grant: PIA4/DOS0213764/00) to O-Kidia. The funding institution had no role in study design, data collection, data analysis and interpretation, writing the manuscripts or the decision to submit for publication.

Author Contributions: Dr Douet Vannucci and Prof Pascal Staccini had full access to all the data in the present study and take responsibility for the integrity of the data and the accuracy of the data analysis.

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Supervision: Vanessa Douet Vannucci.
The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Data Sharing Statement: This study is based on healthcare center (HCC) information extracted between January 1st, 2014 and December 31st, 2022 from the comprehensive retrospective PMSI database (Programme de médicalisation des systèmes d'information, https://www.epmsi.atih.sante.fr/welcomeEpmsi.do from the Diamant database), that includes patients, stays, diagnoses and procedures in French public and private HCC. The study was covered by the common rule exemption and did not require institutional review board review as data are deidentified. The use of data from the PMSI was authorized by the National Commission for Data Processing and Civil Liberties (CNIL; authorization n°1419102 v6) and captured through the Technical agency for information on hospital care (ATIH: accreditation 2015-111111-56-18/orders M14N056).

Patient and Public Involvement statement: It was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research.

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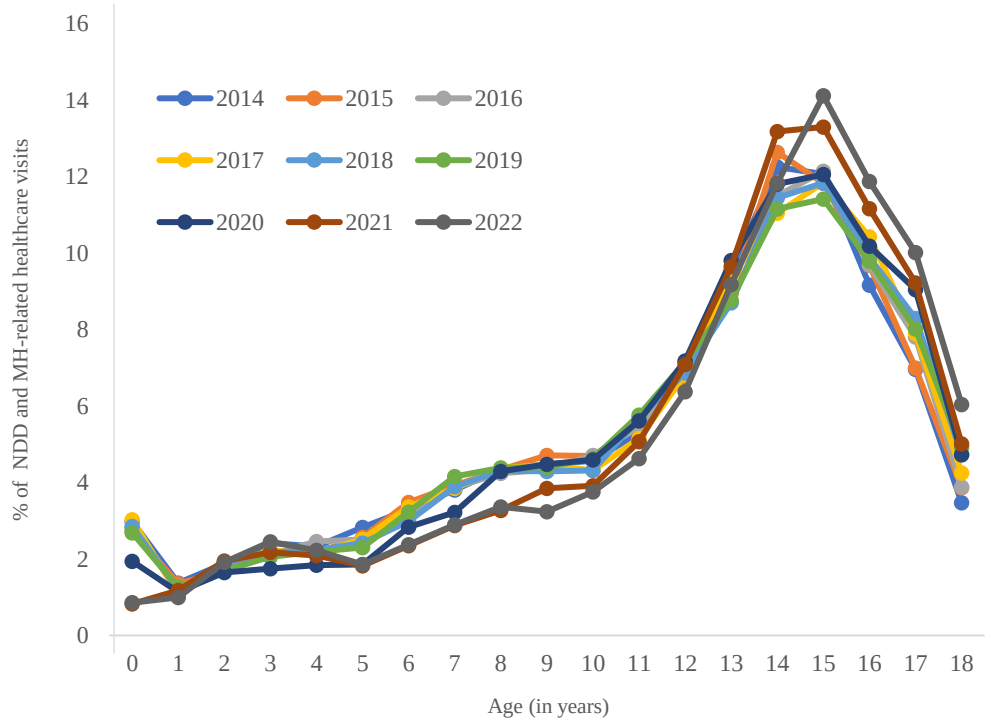
SUPPLEMENTARY MATERIAL

eTable 1. in Supplement 1 lists the *ICD-10-CM* codes that identified mental health–related visits in our study from the PMSI database.

Mental-health conditions	ICD-10-CM
Neurodevelopment disorders	F80-89
Behavior disorders	F90-99
Mood disorders	F32, F34, F39
Anxiety	F40-48
Sleep disorders & Eat disorders	F50, F51

eFigure 1. French National Trends In Neurodevelopmental And Mental Health-Related Healthcare Center Visits Per Age Among Youth, 2014-2022



NDD: neurodevelopmental disorders; MH : mental health

eTable 3. French National Trends In Neurodevelopmental And Mental Health-Related Healthcare Center Visits Per Care Pathway Among Youth, 2014-2022.
NDD: neurodevelopmental disorders; MH : mental health
NA : Not applicable

	2014	2015	2016	2017	2018	2019	2020	2021	2022	TOTAL
NDD & MH -related admission	31,351	1,357	31,483	32,730	32,504	33,702	28,867	35,442	31,940	289,376
Annual % change	NA	,02%	0,40%	3,81%	-0,70%	3,55%	-16,75%	18,55%	-10,96%	NA
ADMISSION (% NDD&MH-related admission, n= 289,376)										
Hospital	274	21	382	396	404	408	365	539	495	3,584
Annual % change	NA	5%	16%	4%	2%	1%	-12%	32%	-9%	NA
Socio-medical centers	3		4	2	1	6	8	11	5	46
Annual % change	NA	0%	-50%	-100%	-100%	83%	25%	27%	-120%	NA
Emergency Department	14,181	4,458	14,628	15,694	16,338	17,072	15,347	19,709	17,786	145,213
Annual % change	NA	%	1%	7%	4%	4%	-11%	22%	-11%	NA
Home	16,893	6,572	16,469	16,638	15,761	16,216	13,147	15,183	13,654	140,533
Annual % change	NA	2%	-1%	1%	-6%	3%	-23%	13%	-11%	NA
DISCHARGE (% NDD&MH-related discharge, n= 289,373)										
Hospital	2,125	,283	2,413	2,547	2,814	2,822	2,845	3,665	3,550	25,064
Annual % change	NA	%	5%	5%	9%	0%	1%	22%	-3%	NA
Socio-medical centers	77	3	75	83	103	95	134	149	108	917
Annual % change	NA	7%	-24%	10%	19%	-8%	29%	10%	-38%	NA
Home	29,148	8,980	28,994	30,100	29,585	30,784	25,892	31,628	28,281	263,392
Annual % change	NA	1%	0%	4%	-2%	4%	-19%	18%	-12%	NA