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Original Article

SEASONALITY AND CHANGES IN ADHD MEDICATION SALES TO PHARMACIES IN POLAND FROM 2018 TO 2023

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ABSTRACT

To investigate the seasonality and the impact of the COVID-19 pandemic on ADHD medication, including immediate-release (IR), long-acting (LA), and osmotic-controlled release oral delivery system (OROS) methylphenidate and atomoxetine consumption in Poland between February 2018 and April 2024. Data on ADHD medication consumption were analyzed using defined daily doses (DDD) per 1,000 inhabitants per day. Seasonal variation was assessed with the Holt-Winters method, and changes post-March 2020 were evaluated by comparing pre- and post-pandemic monthly values. The test statistic, denoted as Q, measured pairs of months where post-pandemic values exceeded pre-pandemic ones, with a p-value < 0.05 indicating a significant increase. There was a clear seasonal pattern in ADHD medication consumption, with a decrease observed in June, July, and August for all the drugs and formulations studied. A statistically significant increase in consumption ($p < 0.05$) was observed for ADHD medications overall, as well as for atomoxetine and the IR and LA formulations of methylphenidate. However, no significant increase was noted for the OROS formulation of methylphenidate after the onset of the pandemic in March 2020. The consumption of ADHD medications in Poland has shown a notable increase in recent years. The identified seasonality patterns and the observed rise in consumption may provide valuable insights for improving healthcare system planning and optimization, as well as for preparing to address emerging challenges.

KEYWORDS: methylphenidate, atomoxetine, trend, utilisation, psychopharmacoepidemiology.

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1. Introduction

ADHD (Attention Deficit Hyperactivity Disorder) is a chronic neurodevelopmental disorder with onset in childhood, typically before the age of 12. It is characterized by persistent symptoms of inattention, hyperactivity, and impulsivity. The condition may present predominantly as inattention, hyperactivity and impulsivity, or as a combination of both [1]. Symptoms of ADHD markedly impair functioning across multiple situations and settings, diminish quality of life [2], and contribute to emotional and social impairment [3,4].

Epidemiological data indicate that the global prevalence of ADHD was estimated at 3.4% among children and adolescents [5] and at 2.6% among adults [6]. Data on ADHD prevalence in Poland are limited, accessible governmental sources reported that ADHD prevalence in Poland was 0.66% in 2022, based on patients registered in public health system only [7]. However, given that no significant regional differences in ADHD prevalence has been observed worldwide [8-10], we assume that the epidemiological data for the Polish population may be underestimated, considering the popularity of private healthcare and the fact that more than 60% of patients seek treatment outside the public health system [11]. This preference for private healthcare may be partly driven by limited accessibility of services in the public sector. According to data from the Polish National Health Fund, waiting times for appointments with child and adolescent psychiatrists range — depending on the region — from several months to even several years [12].

Treatment methods are divided into non-medication and medication approaches. ADHD medications are classified as stimulants (methylphenidate (MPH) and amphetamines with their derivatives) and non-stimulants (atomoxetine (ATX), guanfacine, and clonidine) [13]. Both groups have been found effective in reducing ADHD symptoms in both youths and adults [14]. What's more, recent findings from a population-based study indicate that treatment with ADHD medication is associated with a lower risk of unintentional injuries and a lower risk of all-cause mortality [15]. During the observational period of our study, the registered ADHD medications available in Poland were methylphenidate and atomoxetine. Methylphenidate was available in three formulations: immediate release (IR), long-acting (LA), and osmotic-controlled release oral delivery system (OROS). The IR formulation has an action time of 2-4 hours, the LA

formulation lasts 6-8 hours, and the OROS formulation provides effect for 12-14 hours. In Poland, at the time of writing this publication, lisdexamfetamine and dexamphetamine are already available.

While both stimulant and non-stimulant medications have proven effective, their use may also be associated with certain side effects. A meta-analytic data indicate that methylphenidate is associated with an increased risk of delayed sleep onset [16], decreased appetite and weight [17], elevated systolic blood pressure (SBP) and heart rate (HR) [18], as well as reduced expected height gains [19]. Common side effects of atomoxetine include appetite decrease, gastrointestinal symptoms or sleep related disorders [20]. According to another study changes in SBP and HR values were minimal [21]. During the early treatment phase, a decrease in growth was observed, with a tendency for attenuation at the 2-year follow-up [22]. Therefore, monitoring the occurrence of adverse effects is an essential component of treatment. It should be emphasized that a substantial proportion of adverse effects are of mild to moderate severity and are transient in nature. The proportion of serious events is low, and the benefits of pharmacological treatment outweigh the potential risks and often it is even the main method to reduce severity of ADHD symptoms.

With regard to ADHD medication use, the term 'drug holidays' is also used in the scientific literature. They are short and agreed cessations of medication for a period of time due to clinical purposes, such as reduction of adverse effects, especially growth impairment, or assessment of the ongoing need for medication [23-25]. Since ADHD symptoms primarily impair functioning in academic settings, treatment interruptions are most commonly introduced during weekends or school breaks, such as the summer holidays which in Poland typically occur in July and August. Implementing drug holidays always requires an individualized assessment of the clinical need and potential risks and benefits. They should not be proposed when the potential losses resulting from worsening functioning during the period without medication outweigh the anticipated benefits of treatment interruption.

In March 2020 World Health Organization declared a pandemic due to the spread of novel coronavirus – SARS-Cov-2. To prevent the transmission of the virus, the authorities in various countries introduced regulations mandating isolation and social distancing. These interventions probably impacted individuals with ADHD by worsening ADHD symptoms. In 2021, most countries recorded higher ADHD medication use than predicted [26].

The aim of this study is to evaluate the impact of Covid-19 pandemic on the utilization of ADHD medication, as well as to investigate the seasonal patterns of ADHD medication consumption in Poland.

2. Materials and methods

2.1. Data collection and preparation

To analyze seasonality and changes in ADHD drug consumption, data on the quantity of ADHD medications sold to Polish pharmacies between February 2018 and April 2024 were obtained from the IQVIA database. The database included both generic and original drug products and does not contain individual-level data. Then, we calculated the defined daily doses (DDD) per 1,000 inhabitants per day for each drug and for each month, according to the World Health Organization definitions: DDD of MPH is 30 mg and atomoxetine is 80 mg. The value of 'the defined daily doses (DDD) per 1,000 inhabitants per day for each drug and for each month' was calculated according to following formula:

$$DDD\ per\ 1000\ inhabitants\ per\ day\ = \left(\frac{Total\ amount\ of\ drug\ used\ (mg)}{DDD\ (mg)} \times \frac{1000}{Population\ \times Number\ of\ days\ in\ month}\right)$$

In this way, six time series were created, containing the values of DDD per 1,000 inhabitants per day for each month from February 2018 to April 2024 for methylphenidate (collectively), as well as its three preparations (IR, LA, and OROS), for atomoxetine, and for methylphenidate and atomoxetine combined.

2.2. Data analysis

Two research hypotheses were formulated:

1. There is a decrease in the use of ADHD medications in July and August each year in Poland.

2. There is a difference in ADHD medication consumption in Poland between the periods before and after March 2020.

March 2020 was selected as a temporal reference point to separate earlier from later observations, as it marks the onset of major public health measures in Poland in response to the COVID-19 pandemic. This choice serves solely to define pre- and post-periods for comparison in the time series and does not imply causal attribution of any observed changes.

To assess seasonal variation, the multiplicative seasonal exponential smoothing (Holt-Winters method) was applied to the time series data. This allows for accounting both for a slowly varying trend and a seasonal variation which is of multiplicative nature. This means a proportional increase or drop, in contrast to a change by a fixed amount, depending on the month. Consequently, a seasonal correction factor is obtained for each month. If it is less/more than 100% then the month is associated with a drop/increase in the value of the series.

To assess potential changes in ADHD medication consumption between periods before and after March 2020, we compare two values, one from before and one from after March 2020 (the outbreak of the pandemic), and assess which value is larger, provided their corresponding months coincide. For example, comparisons are made between September 2018 and September 2021, or February 2020 and February 2024. We then count the number of pairs in which the latter value exceeds the former, considering this as potential evidence of an increase, if the count significantly exceeds what would be expected under the null hypothesis of no increase due to the pandemic. If this condition is met, we reject the null hypothesis and conclude that a significant increase occurred.

The total number of such pairs N=104 corresponds to the number of months within the period February 2018 to

April 2024 (spanning 75 months) in which the former month precedes March 2020, and the months are the same except for the year. Our test statistic is defined as:

Q: = the number of month pairs, before and after the COVID-19 pandemic outbreak (March 2020), in which the latter value exceeds the former.

Under the assumption of no significant change, the expected value of Q is N/2. However, due to the autocorrelation present in the time series data, we expect the standard deviation of Q to be greater than $\frac{N^{1/2}}{2}$, suggesting that the tails of the distribution of the test statistic will be wider than would be expected if the data were independent. Moreover, we cannot assume the distribution is normal. To investigate this further, we generated B = 50,000 time series of length L=75, each with an autocorrelation coefficient of 1−α, where α is the principal autocorrelation coefficient derived from exponential smoothing, as this is the correct quantitative measure of autocorrelation. These generated series do not include any imposed seasonality, as we are comparing values from months separated by an integer number of years.

The p-value is calculated as:

$$p - value = \frac{n + 0.5}{B + 0.5}$$

where *n* is the number of generated time series for which the test statistic calculated in the same way as Q is greater than or equal to the value of Q from the original series. This approach assumes a one-sided null hypothesis, where there is no increase after the initial 25 observations.

3. Results

Table 1 shows the annual values of DDD, DDD per 1000 inhabitants per day, and the relative changes in both parameters for MPH and its formulations, ATX, and all ADHD medications between February 2018 and April 2024.

Table 1. Consumption of ADHD medications in Poland (2018–2023) in DDDs and DDDs per 1000 inhabitants per day, including relative changes (%), by drug and formulation. The dataset for 2018 begins in February, as data from January were not available.

Year	2018	2019	2020	2021	2022	2023
ADHD Medication Combined						
DDDs	3,606,268	4,344,472	4,398,946	5,640,563	8,920,074	12,863,219
Relative change in DDD (%)	-	20.47	1.25	28.22	58.14	44.21
Consumption in DDD per 1000 inhabitants per day	0.28	0.31	0.31	0.41	0.65	0.94
Relative change in DDD per 1000 inhabitants per day (%)	-	10.75	1.29	29.20	59.46	44.70
Methylphenidate						
DDDs	3311553	4085532	4053632	5172735	8132875	11681668
Relative change in DDD (%)	-	23.37	-0.78	27.61	57.23	43.64
Consumption in DDD per 1000 inhabitants per day	0.26	0.29	0.29	0.37	0.59	0.85
Relative change in DDD per 1000 inhabitants per day (%)	-	12.98	-0.75	28.58	58.53	44.13
Methylphenidate - IR						
DDDs	436280	611500	761745	1107620	2067875	3343530
Relative change in DDD (%)	-	40.16	24.57	45.41	86.70	61.69
Consumption in DDD per 1000 inhabitants per day	0.03	0.04	0.05	0.08	0.15	0.24
Relative change in DDD per 1000 inhabitants per day (%)	-	28.35	24.61	46.51	88.25	62.24
Methylphenidate - LA						
DDDs	1700755	2148890	2144585	2696215	4436450	5897680
Relative change in DDD (%)	-	26.35	-0.20	25.72	64.54	32.94
Consumption in DDD per 1000 inhabitants per day	0.13	0.15	0.15	0.19	0.32	0.43
Relative change in DDD per 1000 inhabitants per day (%)	-	15.70	-0.17	26.68	65.91	33.39
Methylphenidate - OROS						
DDDs	1174518	1325142	1147302	1368900	1628550	2440458
Relative change in DDD (%)	-	12.82	-13.42	19.31	18.97	49.85
Consumption in DDD per 1000 inhabitants per day	0.09	0.09	0.08	0.10	0.12	0.18
Relative change in DDD per 1000 inhabitants per day (%)	-	3.32	-13.39	20.22	19.96	50.37
Atomoxetine						
DDDs	294715	258940	345314	467828	787199	1181551
Relative change in DDD (%)	-	-12.14	33.36	35.48	68.27	50.10
Consumption in DDD per 1000 inhabitants per day	0.02	0.02	0.02	0.03	0.06	0.09
Relative change in DDD per 1000 inhabitants per day (%)	-	-19.54	33.40	36.51	69.67	50.61

Table 2. Percentage share of ADHD medication in total DDDs in Poland (2018–2024), by substance and methylphenidate formulation (IR, LA, OROS). The dataset for 2018 begins in February, as data from January were not available. Data for the year 2018 are available starting from February, while data for 2024 are available up to April.

	2018	2019	2020	2021	2022	2023	2024
MPH	91.83	94.04	92.15	91.71	91.17	90.81	91.70
IR	13.17	14.97	18.79	21.41	25.43	28.62	29.22
LA	51.36	52.60	52.91	52.12	54.55	50.49	53.37
OROS	35.47	32.43	28.30	26.46	20.02	20.89	17.42
ATX	8.17	5.96	7.85	8.29	8.83	9.19	8.30

Between 2018 and 2023 total annual DDD increased 3.57 times for ADHD medication combined, 3.53 times for MPH, 7.66 times for IR MPH, 3.47 times for LA MPH, 2.08 times for OROS MPH and 4.01 times for atomoxetine.

Percentages for MPH and ATX as well as for three MPH formulations are summarized in Table 2. We observed that the proportions of total DDDs for MPH and ATX remained relatively stable over the years. Among the MPH formulations, however, the share of IR MPH has been gradually increasing, while the share of OROS MPH has been steadily declining between 2018 and 2024.

The seasonal correction factors obtained for each month reveal a clear seasonal decline in ADHD medication consumption, as illustrated in Fig. 1.

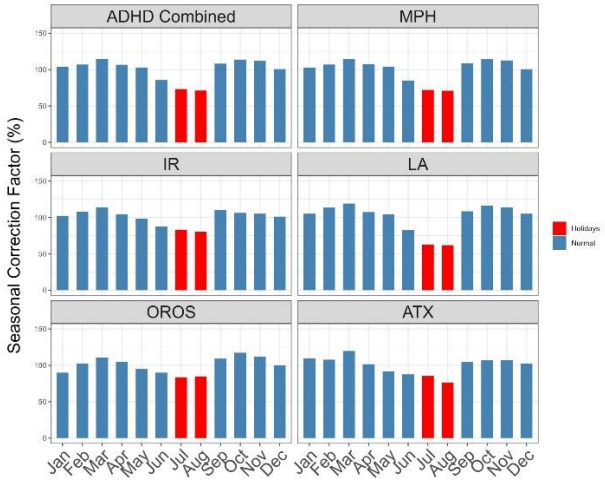

Fig. 1. Seasonal correction factors for each month. Red columns refer to July and August.

Table 3 summarizes the test statistics (Q), smoothing parameter (α) and corresponding p-values for each drug, showing that, with the exception of OROS MPH (p = 0.268), all medications exhibited a statistically significant increase in DDD since the onset of the pandemic, which corresponds to the trends depicted in the time-series plots in Fig. 2.

Table 3. Summary of the analysis of the pandemic's impact on ADHD medication usage.

	Q	α	p-value
ADHD medication combined	93	0.143	0.013*
ATX	94	0.177	0.0058*
MPH	92	0.131	0.017*
IR MPH	103	0.216	<0.0001*
LA MPH	92	0.233	0.0044*
OROS MPH	64	0.091	0.268

Q - the number of month pairs, before and after the COVID-19 pandemic outbreak (March 2020), in which the latter value exceeds the former, α – smoothing coefficient derived from the Holt-Winters method; *p-value < 0.05

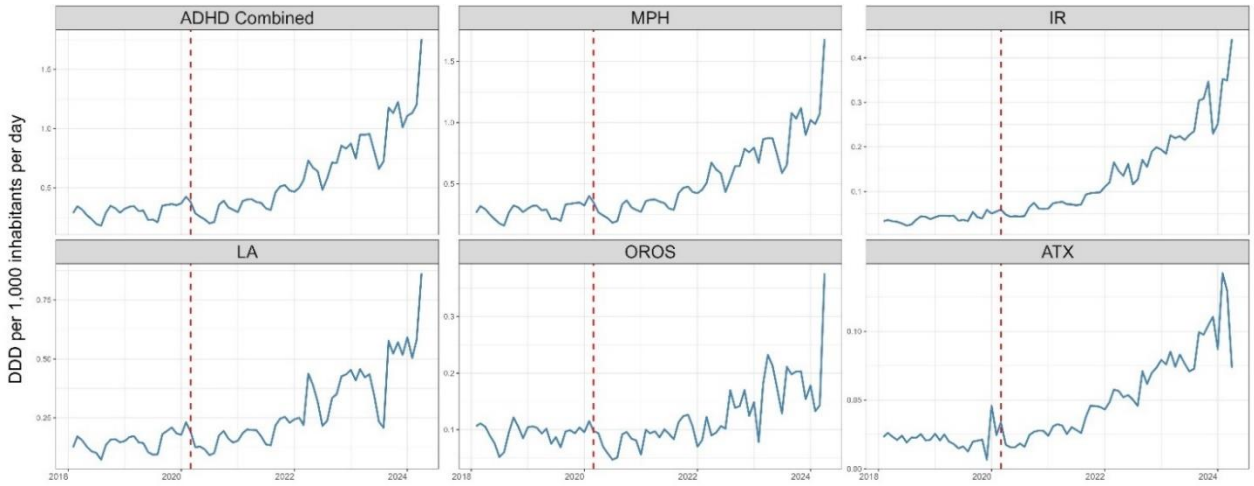

Fig. 2. Time series plots. Red dotted lines indicate the onset of the Covid-19 pandemic in March 2020.

4. Discussion

The rise in ADHD medication consumption observed in our study reflects a globally recognized phenomenon [26,27]. However, the increase in annual consumption in our study exceeded values reported internationally. According to [26], between 2018 and 2021, the relative change in global annual ADHD medication consumption — measured in DDD per 1,000 inhabitants per day — was 11.20%, compared to 46.43% observed in our study.

Despite the rapid increase, the consumption values in Poland still remain lower than those reported globally. According to our study, in 2021, the DDD per 1,000 inhabitants per day in Poland was 0.41, compared to 3.43 globally. Although further growth was observed in the following years, by 2023 it had only reached 0.94 [26].

When examining the share of individual substances in ADHD medication consumption worldwide, data indicate that amphetamine, lisdexamfetamine, and dexamphetamine account for over 50% [26]. Medical products containing lisdexamfetamine and dexamphetamine have only been available in Poland since 2025, which may partially explain the lower consumption of ADHD medications in Poland compared to other countries during the study period. Other contributing factors could include limited access to mental health specialists and their uneven distribution across the country. As of the end of 2021, the highest number of child and adolescent psychiatrists per 100,000 individuals in this population was recorded in the Łódzkie and Mazowieckie regions (13.8 and 13, respectively). The lowest figures were observed in the Opolskie and Podkarpackie regions (3.8 and 3.3, respectively) [28]. On the other hand, growing social awareness is contributing to the increasing use of ADHD medication. Some studies suggest that ADHD may be overdiagnosed in certain populations. Overdiagnosis can result from broadening diagnostic criteria, increased public and clinical awareness, and social or educational pressures. While this phenomenon has been reported in North America, its extent in Poland remains unclear and warrants further investigation [29,30].

The observed difference in the proportion of IR MPH and OROS MPH, with an increasing trend for the former and a decreasing trend for the latter (Table 2), is unexpected, as it contrasts with clinical guidelines that generally favor OROS MPH for its once-daily dosing and potentially better adherence. Based on the available data, it is difficult to clearly determine the cause of this phenomenon. Drawing from clinical experience, we hypothesize that it may be related to periodic difficulties in accessing OROS MPH in Poland.

Our results indicate the notable seasonal pattern in MPH and its formulations as well as in atomoxetine consumption. July and August showed the most pronounced decreases in DDD per 1,000 inhabitants per day relative to the expected non-seasonal baseline. Similar seasonal changes were reported in Taiwan, Türkiye and US [31-33].

These findings suggest that the application of 'drug holidays' during summer is likely a common clinical practice. Data regarding the implementation of psychostimulant drug holidays yield ambiguous and sometimes contradictory results. The findings from one randomized controlled trial suggest that weekend holidays during MPH administration reduce the side effects of insomnia and appetite suppression without a significant increase in symptoms, either on weekends or on the first school day after them [34]. Another study reported that psychostimulant drug holidays have an impact on both body weight and growth [35]. One study showed an effect on height when psychostimulant drug holidays were implemented twice, consecutively, during the summer period, one year apart [36]. Other studies found no effect of psychostimulant drug holidays on growth, although two of them did report an effect on body weight [37-39].

The impact of stimulant discontinuation on the severity of ADHD symptoms remains a subject of debate. Matthijssen et al. [40] report that in a subset of patients, symptom relapse does not occur following discontinuation. The results of our study indicate that a seasonal decrease in consumption is also observed in the case of atomoxetine.

Discontinuation of atomoxetine may contribute to a partial relapse of ADHD symptoms [41]. Compared to stimulants, temporary discontinuation of atomoxetine is less practical due to the long period (6–8 weeks) required to achieve its full therapeutic effect [42]. What's more, there is a lack of high-quality evidence to support the routine discontinuation of atomoxetine to minimize adverse effects. However, some parents and physicians may choose to suspend treatment during summer holidays either due to concerns about side effects or to reassess whether ongoing pharmacological treatment is still necessary for the child.

The results of our study indicate the presence of seasonality in ADHD medication dispensings. Although patient-level data were not available in our study, it can be hypothesized that drug holidays are implemented in a subset of patients. It should be noted that pharmacy sales data do not provide information on whether patients actually took the medication, and adherence may therefore vary. Drug holidays should be determined on a case-by-case basis rather than uniformly recommended [43].

The lockdown and remote work resulting from the outbreak of the COVID-19 pandemic contributed to the exacerbation of symptoms and deterioration of functioning in individuals with ADHD [44]. This may explain the increase in medication consumption observed after March 2020 (Table 3) and is consistent with data reported from other countries [26]. An exception is the lack of an increase in OROS MPH consumption (Table 3), which is likely due to distribution difficulties of the medication within Poland [45].

This study has several limitations. DDD was used as a standard, widely recognized metric to enable comparison of medication consumption over time and across different drugs. However, DDD is based on adult reference doses, so the values may not accurately reflect the actual intensity of treatment in the predominantly pediatric ADHD population. The lack of clinical data at the individual patient level prevented the analysis of reasons for the reduction in dispensings, the duration of treatment interruptions, and the identification of patient subgroups affected by the seasonality phenomenon or the impact of the COVID-19 pandemic. DDD/1,000

inhabitants/day is a composite measure that conflates treatment prevalence with average dose and/or duration. As the analysis is based on aggregated sales data, it does not allow differentiation between an increase in the number of treated individuals and changes in mean dosing or treatment length. The Q statistic used in this analysis does not adjust for underlying secular trends and does not estimate changes in level or slope at the time of the interruption. Consequently, a pre-existing long-term upward trend may inflate the Q statistic even in the absence of an effect specifically attributable to the COVID-19 pandemic. Therefore, the results should be interpreted as descriptive and hypothesis-generating rather than as causal estimates of pandemic-related changes. Additionally, the available data did not allow for the assessment of the effects of drug holidays on the severity of ADHD symptoms or the resolution of adverse events. Therefore, based on our findings, it is not possible to formulate clinical recommendations regarding which patients would benefit from planned medication discontinuations.

5. Conclusions

To our knowledge, this is the first study to assess seasonality of ADHD medication use in Poland. It revealed a clear seasonal pattern, particularly during the summer holidays, with a marked reduction in July and August. The COVID-19 pandemic contributed to an overall increase in ADHD medication consumption — except for OROS-MPH, which did not exhibit the same rise. Relatively low utilization rates in Poland may stem from limited access to mental health specialists, their uneven geographic distribution, and low public awareness. Addressing these barriers will require tailored strategies, such as ensuring reliable access to OROS-MPH and expanding specialist services. Finally, decisions regarding drug holidays should be made on a case-by-case basis, carefully weighing the potential benefits and drawbacks for each patient.

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