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Retrospective time-trend analysis of drug sales for smoking cessation from 2010-2020 in Portuguese community pharmacies

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ABSTRACT

Introduction: The prevalence of smoking worldwide is reflected in many serious health problems. Several drugs are available at the community pharmacy to help smokers achieve abstinence.
Objectives: The present work performed an exploratory retrospective time-trend analysis of sales of three medicines approved by Portuguese health authorities for smoking cessation: nicotine, varenicline, and bupropion in Portuguese community pharmacies from 2010 to 2020.
Methodology: Drug sales data from pharmacies across continental Portugal were provided by the Portuguese National Authority for Medicines and Health Products (INFARMED) and analyzed descriptively. An interrupted time-series analysis using segmented least-squares multiple regression was conducted on annual sales of medicines. A Person correlation between varenicline sales and medical consultations was evaluated.
Results: Nicotine, available over the counter, is the preferred pharmacotherapy, and varenicline was the second choice. January tended to be the month with the most sales. Bupropion sales revealed marginal figures. Varenicline showed a sharp increase in sales after 2017, driven by reimbursement from the national healthcare system. There was a statistically significant correlation between the number of medical consultations and varenicline sales. The segmented regression model demonstrated a robust fit, showing that the intervention year of 2017 was noticed across the three medicines. There was a sharp decrease in sales of prescription varenicline from 2019 to 2020, likely due to reduced access to medical appointments during the COVID-19 pandemic.
Conclusion: Sales of medication for smoking cessation reveal seasonal patterns, and drug co-payment from health systems increases interest in smoking cessation medication.

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INFORMAÇÃO DO ARTIGO

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RESUMO

Introdução: A prevalência do tabagismo em todo o mundo reflete-se em graves problemas de saúde. Vários medicamentos estão disponíveis nas farmácias comunitárias para cessação tabágica.
Objetivos: O presente trabalho realizou uma análise temporal (2010-2020) das vendas de três medicamentos aprovados pelas autoridades de saúde portuguesas para o tratamento do tabagismo — nicotina, vareniclina e bupropiona — nas farmácias comunitárias portuguesas.
Metodologia: Os dados de vendas de medicamentos em farmácias de Portugal Continental foram fornecidos pela Autoridade Nacional do Medicamento (INFARMED) e analisados de forma descritiva. Uma análise de séries temporais interrompidas, por meio de regressão múltipla, foi realizada para as vendas anuais. Foi avaliada uma correlação de Pearson entre as vendas de vareniclina e as consultas médicas.
Resultados: A nicotina, disponível sem receita médica, é a farmacoterapia preferencial, sendo a vareniclina a segunda opção. Janeiro é, tendencialmente, o mês com mais vendas. As vendas de bupropiona foram marginais. A vareniclina apresentou um aumento acentuado nas vendas após 2017, impulsionado pela comparticipação do sistema de saúde. Verificou-se uma correlação estatisticamente significativa entre o número de consultas médicas e as vendas de vareniclina. O modelo de regressão segmentada provou que o ano de intervenção de 2017 foi observado em todos os medicamentos. A queda acentuada nas vendas de vareniclina de 2019 para 2020 provavelmente deveu-se ao menor acesso a consultas médicas durante a pandemia de COVID-19.
Conclusões: As vendas de medicamentos para a cessação tabágica revelam padrões sazonais, e o copagamento de medicamentos pelos sistemas de saúde aumenta o interesse em deixar de fumar.

Introduction

In the modern world, tobacco usage is one of the primary causes of premature death, reaching 7 million deaths annually, of which 1,2 million deaths correspond to second-hand smoke.[1] The most common way of tobacco consumption comes in the form of cigarette smoking, but other products, such as smokeless products, waterpipe tobacco, cigars, bidis, and kreteks, also contribute to worse health conditions.[1]

The European Commission conducted a survey aimed at understanding Europeans' attitudes toward tobacco and other nicotine products.[2] Concerning traditional tobacco products, 21% of Portuguese participants were smokers, meanwhile, 15% were former smokers, and 64% never smoked. In the European Union (EU) plus the United Kingdom, 23% were smokers and 22% of people were former smokers. Furthermore, it was also demonstrated that in Portugal and the EU, men displayed a higher prevalence of smoking, with 27% and 26% respectively, when compared to women, which was 21% in the EU and 16% in Portugal. The age interval with the most prevalent smokers was between 25 and 39 years old in both Portugal and the EU.[2] The overall consumption of nicotine products was also studied, with 20% of Portuguese participants being daily consumers, meanwhile in the EU that rate was 23%.[3]

The prevalence of smoking worldwide is reflected in many serious health problems, so it is extremely important to find new strategies and therapies that can help smokers achieve abstinence and prevent others from starting to smoke. One of the main issues with tobacco products is nicotine dependence. Nicotine is known to be as addictive as other drugs such as heroin and cocaine. It causes long-term dependence, and even patients who suffer from serious health conditions related to smoking often resume smoking after reaching abstinence for a set period.[3]

Several pharmacotherapies were approved to aid in smoking cessation. Nicotine replacement therapy (NRT), varenicline, bupropion, and cytisinicline (also known as cytisine) are the main four drugs recommended for treatment options by World Health Organization for smoking cessation in adults.[4] A study evaluated the safety and efficacy of nicotine, varenicline, and bupropion on individuals with and without psychiatric disorders and concluded that neither bupropion nor varenicline significantly increased the chances of manifestation of moderate or severe adverse effects. The study also concluded that varenicline was the most efficient alternative to quitting smoking when compared to the other choices.[5]

In Portugal, there are four drugs approved by the medicines national authority for smoking cessation, namely, nicotine, varenicline, bupropion, and, more recently, since 2021, cytisinicline.[6] Nicotine is available as an over-the-counter medicine, meanwhile, varenicline and bupropion require a medical prescription to be sold. Nicotine formulations are available in tablets, gums, oral spray solution, and transdermal patches. On the other hand, varenicline and bupropion are available only as tablets. Nicotine is responsible for tobacco dependence, acting as an agonist of nicotinic cholinergic receptors, thus being used to reduce the craving and abstinence symptoms.[7] Varenicline is a partial agonist to α4β2 nicotinic acetylcholine receptors

and has high compatibility for α6β2-nAChRs.[8] This medicine was reimbursed at 37% by the SNS in January 2017, although it was available on the market without reimbursement prior to that date.[9] Bupropion was developed as an antidepressant that blocked the reuptake of dopamine and noradrenaline, and has proven useful in smoking cessation by blocking dopamine reuptake in the mesolimbic dopamine system, which is responsible for modulating rewards obtained from nicotine use [10]. Moreover, bupropion also inhibits various nicotinic acetylcholine receptors.[10]

This article aims to explore the time-trend analysis of sales of three medicines approved by the data regarding the trending sales of three anti-smoking drugs, nicotine, varenicline, and bupropion in Continental Portugal between 2010 and 2020.

Methodology

This paper conducted a retrospective, exploratory time-trend analysis of sales for three medicines (Nicotine, Varenicline, and Bupropion). Sales data for medicines sold in pharmacies across continental Portugal were provided by the Medicines and Health Products Information Center (CIMI) of the Portuguese National Authority for Medicines and Health Products (INFARMED). Data are presented in the number of packages of the three smoking cessation medicines, Nicotine, Varenicline, and Bupropion, approved by authorities at the time and sold in local pharmacies of Continental Portugal from January 2010 through December 31, 2020. Also, data was organized by yearly units and monthly units sold. Units sold in the administrative autonomic regions of Azores and Madeira were not included. Also, this analysis does not include medicines provided in a hospital environment. Nicotine, unlike the other two drugs, is available as an over-the-counter medicine and is sold at local points for non-prescription medicine sales, such as supermarkets. Sales from these points are not included in our data, as they were not provided by CIMI INFARMED. Regarding bupropion, only one medicine has been approved in Portugal for smoking cessation, but this drug can be prescribed both as an antidepressant and an anti-smoking medicine. Since the data provided only the number of packages sold, not individual units, it was not possible to estimate the defined daily dose and normalize it to the population size.

Data regarding the number of medical consultations in local health units and hospitals in continental Portugal were obtained from the National Health Ministry (Ministério da Saúde, Direção-geral da Saúde). These figures only include medical appointments performed at the National Health Service and do not include those made in private clinics or hospitals. Data were compiled in Microsoft Excel, and statistical analysis and graphs were generated in GraphPad Prism 11 (CA, USA). A multiple regression analysis using the least-squares method for the interrupted time-series analysis was conducted, with further details provided in the text and Figure 1 legend. A Pearson correlation was used to examine the association between varenicline sales and medical consultations. The Pearson correlation matrix evaluated the immediate association (LAG 0) alongside potential delayed responses, with medical consultations following sales trends up to 2 years (LAG 1, for one-year post-intervention, and LAG 2, for two years post-intervention). The threshold for statistical significance was set at $p < 0.05$.

Results

Monthly and Yearly Sales of Nicotine, Varenicline, and Bupropion

The monthly sales of nicotine medicines are shown in Table 1. Notably, every year except 2015 saw January as the month with the highest unit sales.

In January 2016, 17370 units were sold, representing not only the peak sales value for nicotine but also the highest across the board. Conversely, 2015 experienced a decline in sales, with February registering only 4918 units – the lowest figure for that year and overall. January consistently proved to be the most productive month for sales, except in 2015, when October achieved the highest sales volume with 7285 units sold, compared to January 2015's 5998 units.

Regarding yearly nicotine sales, 2012 was the year with the highest number, with 124834 units sold, accounting for 10,9% of total sales over the ten years analyzed. In contrast, 2014 and 2015 had the lowest sales, with 75428 and 68956 units sold, respectively. Another important detail concerns the year 2020, which recorded the second-highest number of units sold at 120888, representing 10.6% of total sales.

Table 1 -Absolute frequency of monthly sales of nicotine packages in Continental Portugal (2010-2020).

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Jan	10022	10639	13481	12632	10218	5998	17370	12209	15516	13422	14735
Feb	8722	8544	13349	8888	7201	4918	10050	9723	10870	10100	11542
Mar	10017	9036	12598	8478	6225	5576	9149	10174	9593	9320	12594
Apr	8986	7810	9400	8728	5992	5250	7342	8077	9235	9303	8831
May	8953	8435	10954	7655	6610	5254	7974	10435	8821	9923	9289
Jun	8641	7504	8589	6511	5551	5392	7130	8269	8584	8310	9063
Jul	9272	7033	8927	7187	5725	5560	7441	8205	9714	9256	9512
Aug	9703	8266	8509	6789	5237	5554	7536	8205	8219	9207	8188
Sep	9660	7533	9525	7881	5860	6197	8307	9271	9043	10214	9887
Oct	9242	7609	12019	8860	6439	7285	8241	10490	10303	10224	9181
Nov	9489	7084	9360	7191	4969	6050	7654	10776	9024	9514	8968
Dec	8867	6513	8123	6856	5401	5922	7182	10442	7933	8991	9098

Table 2 discriminates the monthly sales of varenicline in Continental Portugal. The results showed an increase in sales from 2017 to 2020. January was the month with the highest sales, except for 2017. Furthermore, January 2019 registered the highest number of varenicline sales across the board. December 2014 registered the lowest sales volume for that year, and overall, with only 1882 units sold. In 2020, despite contributing 10,10% of total varenicline sales, from April onwards sales decreased by half or more compared to January, February, and March 2020.

Table 2 -Absolute frequency of monthly sales of varenicline packages in Continental Portugal (2010-2020).

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Jan	3251	3786	3041	3431	2926	2308	3169	4824	6896	6938	6827
Feb	2887	3309	2534	2808	2344	1924	2916	4358	5784	6084	5853
Mar	3207	3830	3169	2571	2567	2251	2996	6095	5861	5688	5931
Apr	2825	3327	2319	2541	2176	2266	2516	5153	5613	5754	3199
May	3310	3658	2289	2569	2161	2379	2645	5703	5530	5739	2571
Jun	2952	2772	2214	2082	1974	2338	2506	5348	5572	4753	2851
Jul	3021	2683	2423	2440	2126	2581	2373	5604	5932	5606	3326
Aug	3228	2678	2362	2129	1923	2454	3060	5058	5606	5066	3339
Sep	3123	2796	2344	2284	2206	2606	3105	5111	5320	5225	3528
Oct	2950	2571	3163	2587	2365	2767	2909	6207	6185	5760	3596
Nov	3778	2677	3034	2352	1990	2597	2639	5700	5250	5228	3463
Dec	2903	2376	2565	2112	1882	2633	2397	5125	5533	5506	3241

Regarding yearly varenicline sales, 2017 and 2018 had the highest volumes, followed by 2019 and 2020. However, the greatest increase in sales occurred between 2016 and 2017, with a 48.3% rise. Conversely, 2014 experienced the lowest sales volume at 26640 units.

The analysis of the monthly bupropion sales indicated a more heterogeneous perspective (Table 3). The months with the highest and lowest sales differ from year to year. It's possible to verify that December 2010 was the month with the highest sales, with 112 units, followed by July 2015 with 107 units. It's also important to note that in 2011, April and September were the months with the highest sales, reaching the number of 72. In the case of 2015, both March and May displayed the lowest number of sales for that year, with 43 units sold, and 2017 and 2018 displayed the same behavior, having January as the most profitable month (76 and 63 units sold, respectively) and December as the least profitable month (31 and 19 units sold, respectively). Finally, 2020 recorded the lowest overall sales figures, with November selling just 6 units.

Table 3 -Absolute frequency of monthly sales of bupropion packages in Continental Portugal (2010-2020).

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Jan	88	56	53	66	52	49	72	76	63	20	52
Feb	71	59	51	46	42	48	76	43	47	40	41
Mar	73	60	56	34	56	43	53	57	41	45	62
Apri	50	72	58	46	36	46	66	36	51	45	48
May	74	68	60	55	43	43	48	46	42	50	40
Jun	62	43	27	56	69	73	53	50	49	32	28
Jul	75	67	44	61	53	107	52	50	60	40	44
Aug	84	58	57	50	42	79	84	58	58	40	7
Sep	89	72	63	52	47	69	60	51	42	45	13
Oct	51	51	70	53	63	47	36	46	45	44	8
Nov	79	56	35	62	37	44	56	54	41	37	6
Dec	112	60	49	50	40	45	58	31	19	53	27

The yearly sales of bupropion show that 6894 units were sold in total, with 2010 being the most profitable year with 908 sales (representing 13,2% of the 10 years). On the other hand, 2020 stands out as the year with the lowest sales, with only 376 units sold, equivalent to 5,5% of total bupropion sales. It should also be noted that, across the board, the values of bupropion sales were very low compared to the other anti-smoking medicines. For instance, comparing the best year for bupropion (2010) with the worst year of nicotine sales (2015), it's possible to see that nicotine sold more 98,7% units.

We converted the whole volume of sales into the percentage global sales of nicotine, varenicline, and bupropion and their contribution to the total sales of anti-smoking drugs in Continental Portugal during the years analyzed. Nicotine composed more than two-thirds of the total anti-smoking drug packages sold, with 70,5%. Meanwhile, bupropion sales were minimal, not even reaching 1% of total sales, indicating that its use as an anti-smoking drug is limited. Regarding varenicline, it contributed to 29,1% of total sales.

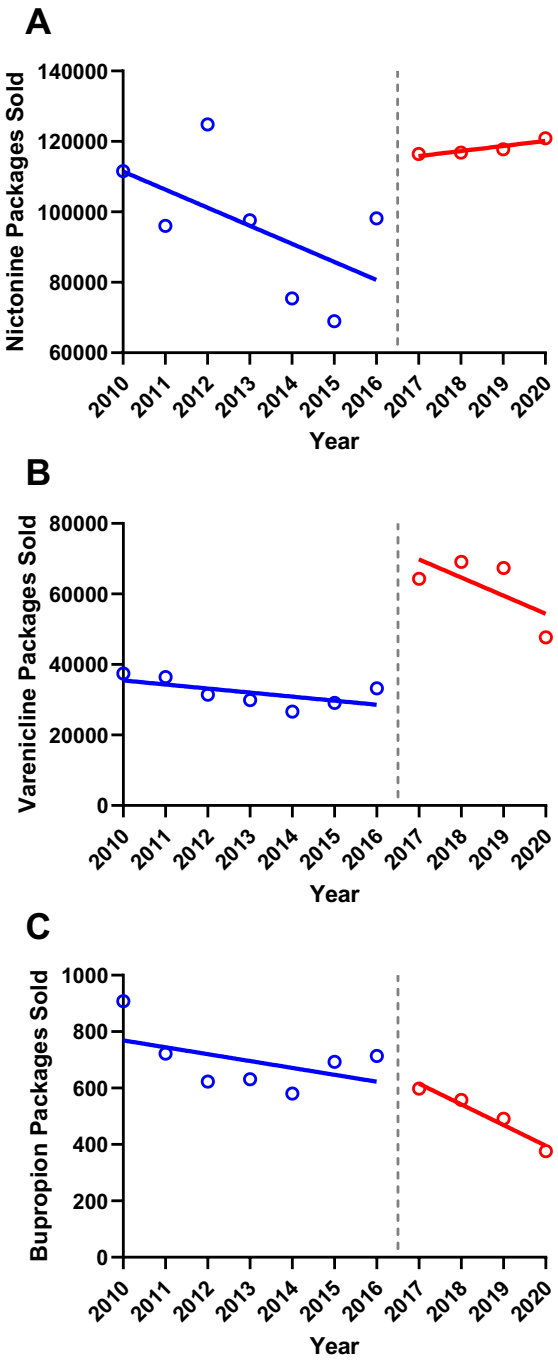

Figure 1. An Interrupted Time Series (ITS) analysis using segmented least-squares multiple regression was conducted on annual sales of Nicotine (A), varenicline (B), and bupropion (C) in Continental Portugal (2010-2020). The year 2017 was defined as the year of intervention. Dots represent the number of packages sold. The regression line is presented in blue for the data from the years before intervention, and in red for the years post-intervention

Interrupted time series analysis of medicines sales

An interrupted time-series analysis using segmented least-squares multiple regression was conducted to assess the impact of the 2017 public health policy shift on annual sales of Nicotine, varenicline, and bupropion in continental Portugal (2010-2020). The segmented regression model demonstrated a robust fit, showing that the intervention year of 2017 was noticed across the three medicines (Figure 1).

Regarding nicotine sales (Figure 1A), the multiple regression model (R^2 = 0.56, F(3, 7) = 3.058, p = 0.101) revealed a pre-intervention trend (2010–2016) in which sales showed a negative trajectory, decreasing by an estimated average of 5130 units per year. Meanwhile, in the post-intervention period (2017–2020), there was an immediate change in 2017 sales, estimated by an increase of 33689 units, and the slope showed a positive shift. By combining the pre-intervention and post-intervention slopes, the trajectory post-2017 inverted from a negative trend to a sustained positive sales growth.

Meanwhile, for varenicline sales (Figure 1B), the multiple regression model (R^2 = 0.921, F(3, 7) = 27.29, P = 0.0003) revealed a pre-intervention trend (2010–2016) in which sales remained relatively stable, with a slight baseline decline. Meanwhile, in the post-intervention period (2017–2020), there was an immediate level change in 2017 sales, with an estimated increase of 46375 units. Following the initial shock, the long-term post-intervention slope experienced an estimated downward trajectory adjustment of 3994 units per year.

For bupropion sales (Figure 1C), the multiple regression model (R^2 = 0.7161, F(3, 7) = 5.885, P=0.0250) revealed a pre-intervention trend (2010–2016) where sales exhibited a gradual underlying decline, decreasing by an estimated average of 24 units per year. Meanwhile, in the post-intervention period (2017–2020), there was a downward trajectory adjustment of an estimated 49 units per year. Combining the baseline and post-intervention parameters yields a definitive post-2017 real decrease trajectory per year, driving Bupropion sales to the lowest decade figure in 2020.

Correlation of varenicline sales with the number of smoking cessation medical consultations

Given that varenicline is only dispensed in pharmacies with a medical prescription, we also analyzed the number of medical consultations for smoking cessation. We did not perform this analysis for bupropion because of its low sales. We correlated varenicline sales with the number of smoking cessation medical consultations conducted by the Portuguese National Health Service in Figure 2. Based on the curves obtained in Figure 2A, the increase in medical consultations from 2017 to 2018 matched the rise in varenicline sales. Moreover, there was a sharp decrease in medical consultations from 2019 to 2020, approximately 40%.

Statistical analyses of the relationship between varenicline sales and medical consultations were conducted using Pearson's correlation. A statistically significant correlation was observed between varenicline sales and medical appointments from 2017 to 2019. The results demonstrate a statistically significant, moderately strong synchronous relationship in 2017 (Lag 0, r = 0.664, p = 0.026). Furthermore, a statistically significant forward-lagged effect was detected in 2018, the year after the intervention (Lag 1, r = 0.661, p = 0.037), confirming that the volume of medical consultations in 2017 continues to exert a strong, robust influence on varenicline sales in the subsequent year. That lag effect was lost in 2019 (Lag 2: r = 0.646, p = 0.060), two years post-intervention, and the difference was not statistically significant.

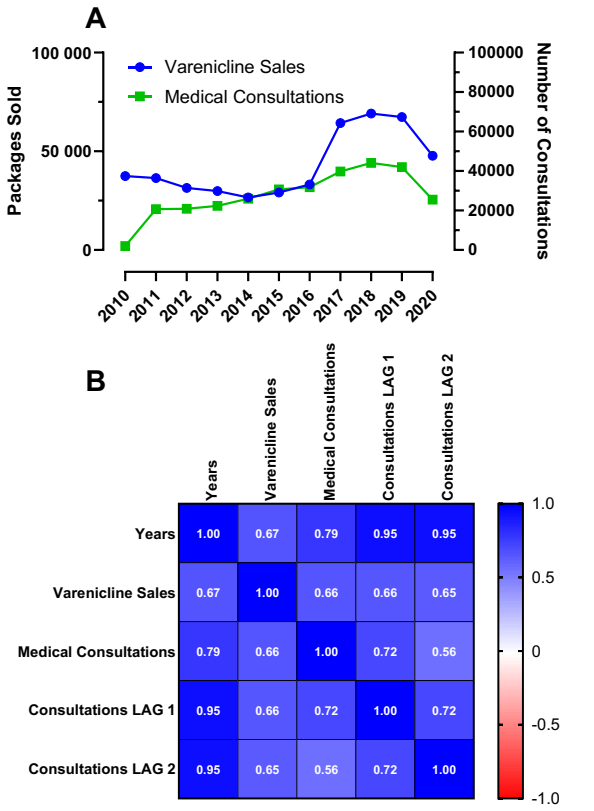

Figure 2. Correlation between varenicline sales and medical consultations. A. Absolute frequency of yearly varenicline package sales and the yearly number of medical consultations for smoking cessation performed by the National Health Service in Continental Portugal (2010-2020). B. Pearson correlation matrix heatmap containing the corresponding correlation coefficients. The color bar denotes Pearson's correlation coefficient (r), ranging from negative (red) to positive (blue) association. The analysis evaluated the immediate association (LAG 0) alongside potential delayed responses, with medical consultations following sales trends up to 2 years (LAG 1 and LAG 2).

Discussion

This paper focused on analyzing the sales of nicotine, varenicline, and bupropion in continental Portugal from 2010 to 2020.

Regarding nicotine, the results showed that NRT representing 70,5% of medicines sold in local pharmacies for patients attempting to quit smoking. A reason that might explain this result is the fact that nicotine is a more accessible drug in comparison with the other two, because it doesn't require a prescription and it's available over the

counter. Also, other establishments like parapharmacies and some supermarkets are allowed to sell these over-the-counter drugs, and those sales are not reflected in our data. Therefore, we must assume that the real number of nicotine packages sold is higher than the figures presented herein. NRT products were the most studied and utilized smoking cessation medicines in Portugal, in line with other European countries.[11]

The year 2020 was marked by the COVID-19 pandemic, which significantly affected the sales of medicines. During this pandemic period, local pharmacies in Portugal remained fully open, with no restrictions on access. In fact, from 2019 to 2020, sales of nicotine in local pharmacies increased slightly, while sales of Varenicline and Bupropion decreased sharply. A representative study conducted in England, comparing the prevalence of smoking cessation therapies before and during the pandemic, reached the same conclusion, indicating that out of these three medications, NRT was the most used therapy to quit smoking.[12] This might be due to the accessibility of this medicine, which was even more relevant during the pandemic period since pharmacies remained open and NRT was possible to obtain without a prescription. Varenicline and bupropion sales declined during this period, possibly because a medical prescription was required. In some cases, this might have led patients to switch treatments and seek alternatives like NRT, which became even more noticeable during the pandemic period.[12] The same trend was also seen in Finland, another European country, where NRT sales were significantly higher throughout 2020 compared to 2019, which was related to the COVID-19 pandemic.[11]

It was also noted that January scored the highest sales for nicotine, with the notable exception of January 2015, which might indicate a seasonal pattern of sales. A reason for this seasonal variation can be the New Year's resolution for quitting smoking, which led to January's high sales. A study made in Canada showed similar conclusions, indicating that the demand for smoking cessation therapies increased during February and March and that the demand for smoking cessation therapies during summer was lower, possibly due to the holidays.[13]

Despite the COVID-19 pandemic, 2020 scored the second-highest number of package nicotine sales. January, February, and March scored the highest sales, followed by a decrease in sales in the next months. This result may indicate that patients were stockpiling due to concerns about Covid restrictions and decreased access to these medications, primarily because of the quarantine period, or even fear of medication shortages. A similar result was observed in a study in the United States, which indicated that sales of nicotine products in the first quarter of 2020 peaked, particularly for lozenges. These results once again may indicate a case of stockpiling. Also, the study noted a decrease in sales from Quarter 2 onwards regarding nicotine products.[14] Another study from the United States reported substantial increases in NRT sales from March 8 to April 4, 2020, suggesting a stockpiling behavior to cope with the pandemic restrictions.[15] A similar trend was also observed in Finland, where a significant increase was observed in NRT sales during the lockdown, contrasting a steady growth trend that existed before the lockdown. Additionally, as the lockdown measures in that country eased, sales of NRT products began to decline after a peak in June.[11]

Varenicline started to be reimbursed by the National Health Service in 37% from 2017 onwards, as a measure to help patients afford smoking cessation medication [9]. The co-payment of varenicline was made effective starting January 2017. The results obtained concerning varenicline showed a major increase in sales from 2016 to 2017, 2018 being the most profitable year for varenicline sales. These results can be attributed to government-approved reimbursement, which helped make varenicline more affordable.

We used a time-lagged correlation to evaluate the relationship between varenicline sales and medical consultations. Our findings reveal a statistically significant correlation with a dual mechanism, characterized by a strong simultaneous immediate effect in 2017 and a prolonged carryover effect in the following year, that establishes medical consultations as a crucial factor to explain the increase in varenicline sales. The correlation between varenicline sales and medical appointments for smoking cessation clearly shows that the co-payment by the National Health Service introduced in 2017 led to more interest in this treatment, which requires a medical prescription. The data strongly implies that medical consultations drive sales. Moreover, there was a sharp decrease in varenicline sales from 2019 to 2020, which was related to the COVID-19 pandemic's lack of access to health services during the quarantine period, where the number of medical appointments also decreased. In accordance, the National Health Service reported less 39% medical appointments and less 52% first medical consultations for smoking cessation in 2020 when compared to 2019.[16]

Bupropion displayed a very different sales behavior when compared to nicotine or varenicline and represents a marginal sales figure. One possible explanation is that the prices of these medications might discourage some individuals from continuing treatment. Another concern about bupropion is that the potential adverse effects might be more prevalent than those of the other two drugs, including serious seizures,[17] and therefore might not be the first choice for physicians to prescribe. The manifestation of these effects may discourage patients from initiating or completing the treatment. In accordance, in England, bupropion was the least-used medication with a 0.5% rate in the pre-pandemic period and 0.4% in the pandemic period. Between 2015 and 2021, Bupropion also showed the lowest quit rate of all cessation methods, displaying only 11.1% of quit rate.[12]

As for varenicline, which requires a prescription, bupropion registered a decrease in 2020 sales. These results seem consistent with what was observed in Italy, reporting that during the quarantine period due to the COVID-19 pandemic, restricted access to prescriptions and health facilities contributed to the decrease in sales.[18]

An interrupted time-series analysis demonstrated the impact of the 2017 public health policy shift on annual sales of the three medicines in Continental Portugal (2010-2020). On one side, varenicline sales increased, but also

nicotine, which might be associated with more access to medical consultations for quitting smoking. On the other hand, bupropion showed a clear trend of decreasing after that year, possibly due to a shift toward more varenicline prescriptions after 2017. Overall, data on the sales of these three medicines reveal the impact of the 2017 public health policy shift on Portugal.

Our findings that the shift in health policies has a strong impact on smoking cessation and medication sales are corroborated by data from other European countries. Changes in tobacco taxation or medicine price changes, smoking prevalence, or even the presence of clear clinical guidelines, can have a strong impact on smoking cessation. A study assessed the smoking behavior of smokers in six to eight European countries (including the United Kingdom, Germany, France, Spain, Poland, Romania, Greece, and Hungary) in 2016.[19] The results exposed a huge cost-based fracture, in the United Kingdom, where the National Health Service has reimbursement and subsidies for smoking cessation medications, reported the highest rate of quit attempts. In contrast, in Hungary or Greece, where treatment was not reimbursed, the lowest intention to quit was revealed.[19] Therefore, this agrees with our data that when policies are made for smoking cessation, such as those that occurred in England, where large investments in smoking cessation were made, there will be an increase in quitting smoking. Another study analyzed the impact of the radical transition in French health policies for reimbursement of nicotine medicines.[20] In 2016, the country offered a fixed annual reimbursement of €150 per patient; between 2018 and 2019, it changed to direct coverage of 65% by the national health plan, with no spending limit and no upfront payment by the user. The result was a 15-fold increase in the number of nicotine boxes dispensed, proving that pharmacy reimbursement eliminates crucial economic barriers and increases interest in smoking cessation [20]. In line with our results, the use of varenicline and NRT increased dramatically in France after the medication became free for patients.[21]

It must also be noticed that the appearance of e-cigarettes led to a decline in the use of traditional pharmacotherapy in some countries. Using representative data from across the European Union, a study found that the use of pharmacotherapies to support smoking cessation declined from 14.6% in 2012 to 11.1% in 2017.[22] The authors point out that the prevalence of use of these medications was directly impacted by the exponential growth of e-cigarettes. This does not seem to be the case in Portugal, where the policy change in 2017 greatly enhanced both the number of consultations to quit smoking and sales of nicotine and varenicline in pharmacies.

This study has several limitations. First, the data provided by CIMI INFARMED were the number of packages, not single-dose units, and given their origin and nature, it was not possible to estimate the defined daily dose or normalize it to population size. This renders difficult to compare figures among the three drugs. Nicotine is available as an over-the-counter medicine and is sold at local points of non-prescription medicine sales, such as supermarkets, which are not included in our data, which might underestimate the overall sales of this drug and may bias the interpretation of the nicotine replacement market. Bupropion sales refer to a single medicine approved in Portugal for smoking cessation, and this drug can be prescribed as an antidepressant. There are other medicines on the market with bupropion approved for depression that could potentially be prescribed for smoking cessation, thereby potentially affecting this data interpretation. It's also important to note that drug sales don't reflect whether patients effectively initiated or completed treatment, nor do they indicate the treatment's success rate. In the case of NRT, previously published data indicate that adults acquire these medications for purposes other than complete cessation.[14,23]

Conclusion

Sales of smoking cessation medication exhibit seasonal patterns, with January the most profitable month overall. There was a clear increase in sales of varenicline following the co-payment from the health system established in 2017, a factor that can lead to increased interest in smoking cessation. There was a statistically significant correlation between the number of medical consultations and varenicline sales. For all medicines, 2017 marked a shift in sales due to changes in healthcare policy. In 2020, the negative impact of the COVID-19 pandemic on access to medical consultations led to lower acquisition of prescription-based medications.

All data supporting the results can be found in the manuscript.

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References

1. WHO. *WHO Report on the Global Tobacco Epidemic, 2025: Warning about the Dangers of Tobacc*. World Health Organization; 2025. https://www.who.int/publications/i/item/9789240112063
2. European Commission. *Attitudes of Europeans towards Tobacco and Electronic Cigarettes: Report*. Publications Office; 2021. Accessed August 22, 2023. https://data.europa.eu/doi/10.2875/490366

3. WHO. *MPOWER: A Policy Package to Reverse the Tobacco Epidemic*. WHO Press; 2008. https://www.afro.who.int/publications/mpower-policy-package-reverse-tobacco-epidemic
4. WHO. *WHO Clinical Treatment Guideline for Tobacco Cessation in Adults*. World Health Organization; 2024. https://www.who.int/publications/i/item/9789240096431
5. Anthenelli RM, Benowitz NL, West R, et al. Neuropsychiatric safety and efficacy of varenicline, bupropion, and nicotine patch in smokers with and without psychiatric disorders (EAGLES): a double-blind, randomised, placebo-controlled clinical trial. *Lancet*. 2016;387(10037):2507-2520. doi:10.1016/s0140-6736(16)30272-0
6. CIM. Medicamentos para o tratamento da dependência do tabaco. Ordem dos Farmacêuticos. January 10, 2024. Accessed June 30, 2025. https://www.ordemfarmaceuticos.pt/pt/artigos/medicamentos-para-o-tratamento-da-dependencia-do-tabaco/
7. De Biasi M, Dani JA. Reward, addiction, withdrawal to nicotine. *Annu Rev Neurosci*. 2011;34:105-130. doi:10.1146/annurev-neuro-061010-113734
8. Tonstad S, Arons C, Rollema H, et al. Varenicline: mode of action, efficacy, safety and accumulated experience salient for clinical populations. *Curr Med Res Opin*. 2020;36(5):713-730. doi:10.1080/03007995.2020.1729708
9. Serviço Nacional de Sáude. Cessação Tabágica - Comparticipação medicamento. February 14, 2017. Accessed July 8, 2024. https://www.sns.gov.pt/reforma-faq/cessacao-tabagica-%e2%80%a2-comparticipacao-medicamento-6/
10. Clark A, Tate B, Urban B, et al. Bupropion Mediated Effects on Depression, Attention Deficit Hyperactivity Disorder, and Smoking Cessation. *Health Psychol Res*. 2023;11:81043. doi:10.52965/001c.81043
11. Aro M, Sandström P, Ståhl T, et al. Sales of tobacco and nicotine replacement therapy products, especially nicotine pouches, increased in Finland during the COVID-19 pandemic. *Nord Stud Alcohol Drugs*. 2024;41(4):394-402. doi:10.1177/14550725241243150
12. Jackson SE, Cox S, Shahab L, Brown J. Prevalence of use and real-world effectiveness of smoking cessation aids during the COVID-19 pandemic: a representative study of smokers in England. *Addiction*. 2022;117(9):2504-2514. doi:10.1111/add.15903
13. Veldhuizen S, Zawertailo L, Ivanova A, Hussain S, Selby P. Seasonal Variation in Demand for Smoking Cessation Treatment and Clinical Outcomes. *Nicotine Tob Res*. 2021;23(6):976-982. doi:10.1093/ntr/ntaa214
14. Trigger S, Xu X, Malarcher A, Salazar E, Shin H, Babb S. Trends in Over-the-Counter Nicotine Replacement Therapy Sales, U.S., 2017–2020. *Am J Prev Med*. 2023;64(5):650-657. doi:10.1016/j.amepre.2022.12.008
15. Sung J, Shrestha SS, Kim Y, Emery S, Wang X. Changes in Sales of Tobacco and Nicotine Replacement Therapy Products Before and During the COVID-19 Pandemic. *Prev Chronic Dis*. 2023;20:220406. doi:10.5888/pcd20.220406
16. Ministério da Saúde, Direção-Geral da Saúde. Programa Nacional para Prevenção e Controlo do Tabagismo 2020. Published online 2021. https://www.sns.gov.pt/noticias/2021/06/25/prevencao-e-controlo-do-tabagismo-3/
17. Hays JT, Ebbert JO. Adverse effects and tolerability of medications for the treatment of tobacco use and dependence. *Drugs*. 2010;70(18):2357-2372. doi:10.2165/11538190-000000000-00000
18. Farina B, Massullo C, De Rossi E, Carbone GA, Serraino R, Imperatori C. Psychotropic medications sales during COVID-19 outbreak in Italy changed according to the pandemic phases and related lockdowns. *Public Health*. 2021;201:75-77. doi:10.1016/j.puhe.2021.10.005
19. Hummel K, Nagelhout G, Fong G, et al. Quitting activity and use of cessation assistance reported by smokers in eight European countries: Findings from the EUREST-PLUS ITC Europe Surveys. *Tob Induc Dis*. 2018;16(2). doi:10.18332/tid/98912
20. Rochoy M, Babol A, Péan C, Deleplanque D, Gautier S, Berkhout C. Trends in the delivery of reimbursed nicotine replacement therapies between 2016 and 2019 in France. *Therapies*. 2022;77(5):561-570. doi:10.1016/j.therap.2022.01.010
21. Dautzenberg B, Dautzenberg MD. Smoking cessation drugs in France: First effects of reimbursement under the general regime. *Tob Prev Cessat*. 2019;5(Supplement). doi:10.18332/tpc/105207
22. Filippidis FT, Laverty AA, Mons U, Jimenez-Ruiz C, Vardavas CI. Changes in smoking cessation assistance in the European Union between 2012 and 2017: pharmacotherapy versus counselling versus e-cigarettes. *Tob Control*. 2018;28(1):95-100. doi:10.1136/tobaccocontrol-2017-054117
23. Hammond D, Reid JL, Driezen P, et al. Smokers' use of nicotine replacement therapy for reasons other than stopping smoking: findings from the ITC Four Country Survey. *Addiction*. 2008;103(10):1696-1703. doi:10.1111/j.1360-0443.2008.02320.x