



Research paper

Areas of interest and sentiment analysis towards second generation antipsychotics, lithium and mood stabilizing anticonvulsants: Unsupervised analysis using Twitter

Juan Pablo Chart-Pascual^{a,b,c,d,*}, Maria Montero-Torres^{g,h}, Miguel Angel Ortega^{e,g,h}, Lorea Mar-Barrutia^{a,c,d}, Iñaki Zorrilla Martinez^{a,b,c,d}, Melchor Alvarez-Mon^{f,g,h}, Ana Gonzalez-Pinto^{a,b,c,d}, Miguel Angel Alvarez-Mon^{g,h,i}

^a Psychiatry Department, Osakidetza Basque Health Service, Araba University Hospital, Vitoria-Gasteiz, Spain

^b University of the Basque Country UPV/EHU, Vitoria-Gasteiz, Spain

^c Bioaraba Health Research Institute, Vitoria-Gasteiz, Spain

^d CIBERSAM

^e Cancer Registry and Pathology Department, Hospital Universitario Príncipe de Asturias, Alcalá de Henares, Spain

^f Immune System Diseases-Rheumatology and Internal Medicine Service, Centro de Investigación Biomédica en Red Enfermedades Hepáticas y Digestivas, University Hospital Príncipe de Asturias, Alcalá de Henares, Spain

^g Ramón y Cajal Institute of Sanitary Research (IRYCIS), 28034 Madrid, Spain

^h Department of Medicine and Medical Specialities, University of Alcalá, 28801 Alcalá de Henares, Madrid, Spain

ⁱ Department of Psychiatry and Mental Health, Hospital Universitario Infanta Leonor, Madrid, Spain



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ABSTRACT

Background: Severe mental disorders like Schizophrenia and related psychotic disorders (SRD) or Bipolar Disorder (BD) require pharmacological treatment for relapse prevention and quality of life improvement. Yet, treatment adherence is a challenge, partly due to patients' attitudes and beliefs towards their medication. Social media listening offers insights into patient experiences and preferences, particularly in severe mental disorders. **Methods:** All tweets posted between 2008 and 2022 mentioning the names of the main drugs used in SRD and BD were analyzed using advanced artificial intelligence techniques such as machine learning, and deep learning, along with natural language processing.

Results: In this 15-year study analyzing 893,289 tweets, second generation antipsychotics received more mentions in English tweets, whereas mood stabilizers received more tweets in Spanish. English tweets about economic and legal aspects displayed negative emotions, while Spanish tweets seeking advice showed surprise. Moreover, a recurring theme in Spanish tweets was the shortage of medications, evoking feelings of anger among users.

Limitations: This study's analysis of Twitter data, while insightful, may not fully capture the nuances of discussions due to the platform's brevity. Additionally, the wide therapeutic use of the studied drugs, complicates the isolation of disorder-specific discourse. Only English and Spanish tweets were examined, limiting the cultural breadth of the findings.

Conclusion: This study emphasizes the importance of social media research in understanding user perceptions of SRD and BD treatments. The results provide valuable insights for clinicians when considering how patients and the general public view and communicate about these treatments in the digital environment.

1. Introduction

Schizophrenia and related psychotic disorders (SRD) and Bipolar

Disorder (BD) are chronic and disabling mental disorders that, in most cases, begin during youth and are estimated to have a global prevalence ranging from 1 % to 2 % (Carvalho et al., 2020; Owen et al., 2016; Vieta

* Corresponding author at: Department of Psychiatry, Hospital Universitario Araba, Calle Olaguibel 29, Vitoria 01004, Alava, Spain.

E-mail address: johnnychart@gmail.com (J.P. Chart-Pascual).

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et al., 2018). Given the chronic nature of these illnesses, establishing a maintenance treatment is essential to prevent relapses, reduce the risk of suicide, alleviate residual symptoms, and enhance functionality and quality of life (Barnes et al., 2020; Gonzalez-Pinto et al., 2006a; Owen et al., 2016; Taylor et al., 2014; Yatham et al., 2018).

One of the main issues encountered in maintenance treatment of these type of disorders is the high rate of abandonment (Barnes et al., 2020; García et al., 2016; Kane et al., 2013). There are numerous factors that have been associated with the lack of adherence. Among the treatment-related factors, it is noteworthy to emphasize the significance of fear of experiencing side effects and the negative attitudes towards the medication (García et al., 2016; Jónsdóttir et al., 2013; Kane et al., 2013; Lacro et al., 2002). Non-adherence is closely linked to increased rates of hospitalization due to relapses, loss of functionality, quality of life, and deaths by suicide (Lin et al., 2021; MacDonald et al., 2016; Scott and Pope, 2002; Taipale et al., 2020; Kishimoto et al., 2021).

Traditionally, research on patient's experiences and healthcare professional's prescription preferences regarding treatment has been based on surveys, interviews, cohort studies or naturalistic approaches (Corcoran et al., 2010; Haslam et al., 2004; Li et al., 2021; Mohammed et al., 2016; Pérez de Mendiola et al., 2021). Multiple studies have shown that patients tend to project a favorable self-image and exhibit conformity when responding to surveys, questionnaires, or other traditional resources to express their opinions, even if it does not truly reflect what they genuinely think. This phenomenon is known as desirability bias (Windschitl et al., 2022). Consequently, they might withhold their negative opinions and biases towards certain medications during medical consultations, instead expressing them in informal online forums, such as social media platforms (Farrar et al., 2021; Leonardo et al., 2020; Robinson et al., 2019).

Regarding prescription studies conducted with healthcare professionals through surveys, interviews, or other traditional methods, the vast majority express significant concern about the potential bias arising from the selection of professionals involved (Hidalgo-Mazzei et al., 2023). Depending on the region where the study is carried out, there can be varying prescription patterns, diverse levels of training and drug usage, and even differing opinions concerning different treatments (Pérez de Mendiola et al., 2021).

However, in recent years, the analysis of social media publications has emerged as a relevant and promising tool to gain a more comprehensive understanding of the factors involved in the therapeutic process or the experience of the illness (Farrar et al., 2021; Golder et al., 2020; Hobbs et al., 2019; Wang et al., 2023). It is worth noting that conversations on social media are characterized by their informal and spontaneous nature, which can provide a more authentic insight into the beliefs and opinions of patients, family members, and professionals (Alvarez-Mon et al., 2019; Berry et al., 2017; Joseph et al., 2015). This approach allows for the exploration of a wide range of perspectives, including those of patients who may be reluctant to seek conventional medical attention (Emmert-Streib et al., 2019; Golder et al., 2021; Teo et al., 2018).

An increasing number of studies have demonstrated a strong correlation between what users discuss and comment on Twitter and clinically relevant events. These studies have explored information from tweets related to significant current issues, such as suicide rates, alcohol consumption rates or the distressing epidemic of opioid abuse that is impacting the USA significantly (Curtis et al., 2018; Hswen et al., 2018; Sarker et al., 2019). By analyzing this data, researchers have been able to uncover valuable insights into the relationships between social media discussions and critical health phenomena.

Currently, there is a growing number of studies focusing on various areas of mental health issues in social media platforms, such as suicide, depression or eating disorders (Berry et al., 2017; Branley and Covey, 2017; Hswen et al., 2018; Lachmar et al., 2017). Moreover, research has also been conducted on different pharmacological groups, such as antidepressants, antipsychotics, psychotherapies or even other techniques

such as electroconvulsive therapy (Alvarez-Mon et al., 2021b; Alvarez-Mon et al., 2022; de Anta et al., 2022, 2023). These studies have identified the primary themes prevalent in tweets, the social perception of treatments, and the sentiment analysis of posts, yielding results that corroborate those obtained through traditional research methods such as clinical trials, observational studies or meta-analyses.

Regarding the different treatments for SRD and BD, research utilizing social media platforms on treatments has been scarce so far. Given its significance for the prognosis of these type of disorders, this study aims to achieve the following objectives: (1) Investigate the frequency of online communications about pharmacological treatments used for SRD and BD among Twitter users between 2008 and 2022 (2) Determine the primary thematic content of Twitter posts (3) Analyze the emotions associated with these publications.

2. Methodology

2.1. Twitter data collection search strategy

In this study, our focus was on searching for tweets that referenced second generation antipsychotics, lithium and mood stabilizing anti-convulsants commonly used as first or second line treatments in SRD and BD (Barnes et al., 2020; Yatham et al., 2018). To gather the tweets, we utilized the Twitter Binder search engine, which provides access to 100 % of public tweets. We collected all tweets containing any of the following list of keywords, which consist of the generic names of the included medications and all their English and Spanish marketed brand names approved by the Federal Drug Administration (FDA), the Spanish Drug Agency (AEM), or both: Litio, Lithium, Plenur, Lithium Carbonate ER, Lithobid, Eskalith, Lithonate, Acido Valproico, Valproic acid, Depakine, Depakine Crono, Depakene, Depakote, Lamotrigina, Lamotrigine, Crisomet, Labileno, Lamictal, Lamictal XR, Lamictal CD, Lamictal ODT, Carbamazepina, Carbamazepine, Tegretol, Carbatrol, Epiol, Equetro, Tegretol, Tegretol XR, Teril, Aripiprazol, Aripiprazole, Abik, Abilify Maintena, Abilify, Arizol, Adexyl, Apaloz, Atildon, Tractiva, Zyklor, Abilify, Aristada, Asenapina, Asenapin, Sycrest, Saphris, Lurasidona, Lurasidone, Latuda, Olanzapina, Olanzapine, Ziprexa, Zypbada, Arenbil, Olaxax, Zalasta, Zolafren, Ziprexa, Paliperidona, Paliperidone, Xeplion, Invega, Trevicta, Byannli, Inpalix, Parnido, Paliperidone Palmitate, Quetiapina, Quetiapine, Psicotric, Psicotric Retard, Rocoz, Seroquel, Seroquel Prolong, Atrolak, Atrolak Prolong, Qudix, Qudix Prolong, Quentiax, Quentiax Prolong, Rocoz, Rocoz Prolong, Risperidona, Risperidone, Risperdal Consta, Risperdal, Okedi, Arketin, Calmapride, Risperdal, Ziprasidona, Ziprasidone, Zeldox, Geodon.

The inclusion criteria for the tweets were: (1) Being public; (2) Usage of the aforementioned keywords; (3) Published between January 1, 2008, and December 31, 2022; (4) Written in English and Spanish.

2.2. Content analysis process

This study leveraged cutting-edge techniques in artificial intelligence (AI), specifically machine learning (ML) and deep learning (DL), along with natural language processing (NLP), to conduct a comprehensive analysis of extensive textual data obtained from the selected tweets that met the inclusion criteria. AI, encompassing ML and DL, empowered computer systems to autonomously learn from data, identify intricate patterns, and make independent decisions (Helm et al., 2020). The ML approach involved supervised, unsupervised, and semi-supervised learning methods. The focus of this study was on unsupervised learning, particularly utilizing latent Dirichlet allocation (LDA) as the primary model for topic modeling, aiming to reveal concealed themes and patterns within the text data (Reddy et al., 2018).

Prior to subjecting the data to LDA modeling, a preprocessing stage was executed using Python's NLP libraries (e.g., TweetNormalizer). Tweets were categorized based on their original language, with Spanish tweets grouped separately, while the remaining tweets were translated

to English using a Googletrans application. Subsequently, irrelevant text elements like numbers, abbreviations, hashtags, emojis, and unknown characters were eliminated, and tokenization was applied for further processing. To optimize the LDA model, a grid search was conducted to identify the optimal number of topics (K) and beta hyperparameters. Higher beta values led to topics with more words (Sarker, 2021). The search for the optimal number of topics ranged from 2 to 8, with a step

size of one, and the beta was adjusted to 15 words per topic to maximize the coherence score. The coherence score, reflecting the quality of the extracted topics, yielded values of 0.36 and 0.46 for four topics in the Spanish and English databases, respectively (Egger and Yu, 2022).

To delve deeper into the emotional aspects of the data, sentiment analysis was employed using advanced models from Hugging Face’s machine learning platform. The “Emotion English DistilRoBERTa-base”

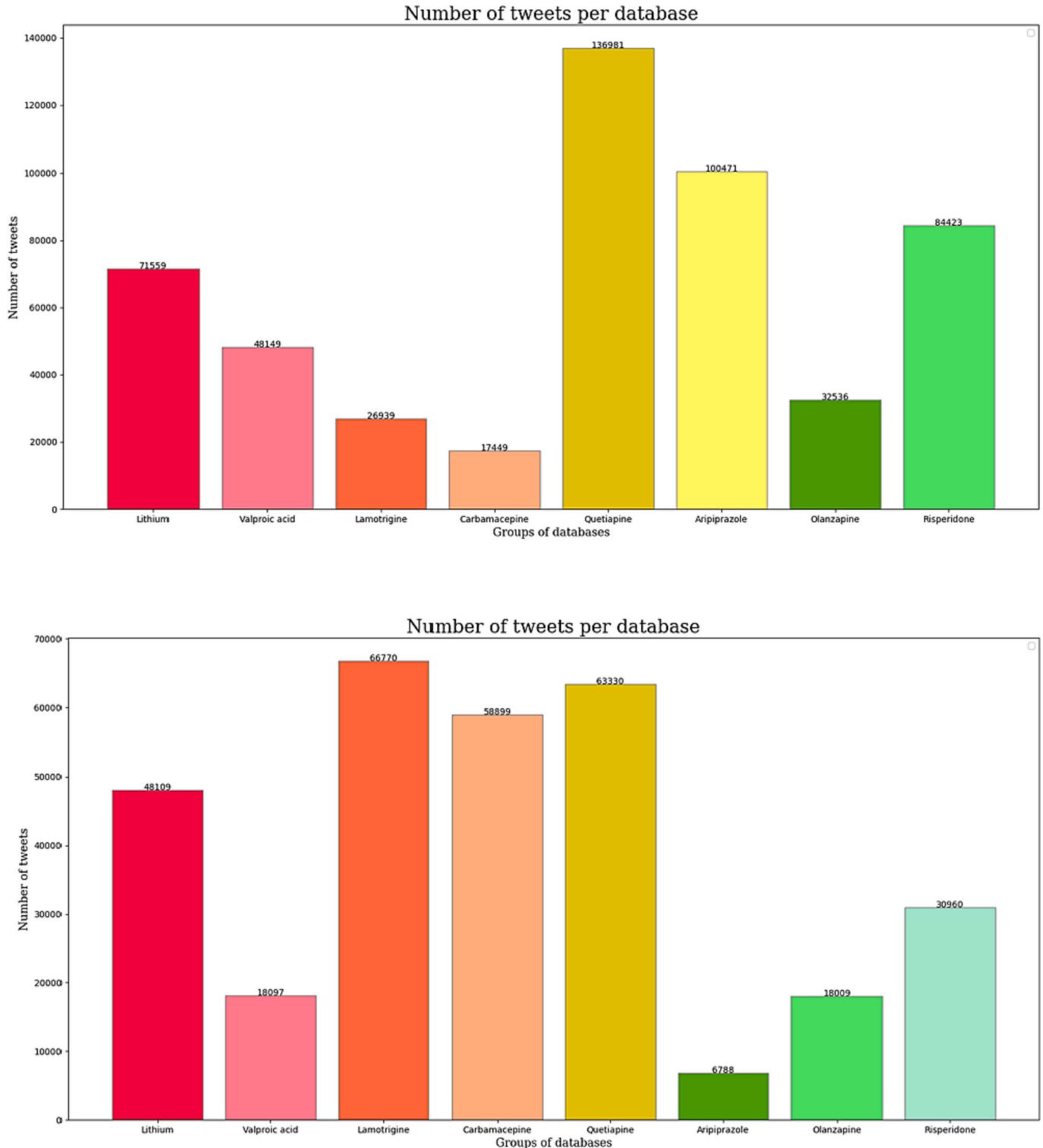


Fig. 1. Top panel: Number of tweets in English per drug Published between January 1, 2008, and December 31, 2022. Bottom panel: Number of tweets in Spanish per drug Published between January 1, 2008, and December 31, 2022

model, a fine-tuned version of DistilRoBERTa-base, was applied to the English database, while the “Beto emotion analysis” model, based on the BETO Base model, was used for the Spanish database. Both models classified tweets in each topic into six fundamental emotions, namely anger, disgust, fear, joy, sadness, and surprise (Ekman, 1999).

2.3. Ethical aspects

This study received approval from the Research Ethics Committee of the University of Alcalá and adheres to the ethical principles of research established in the Declaration of Helsinki (Seventh Revision, 2013).

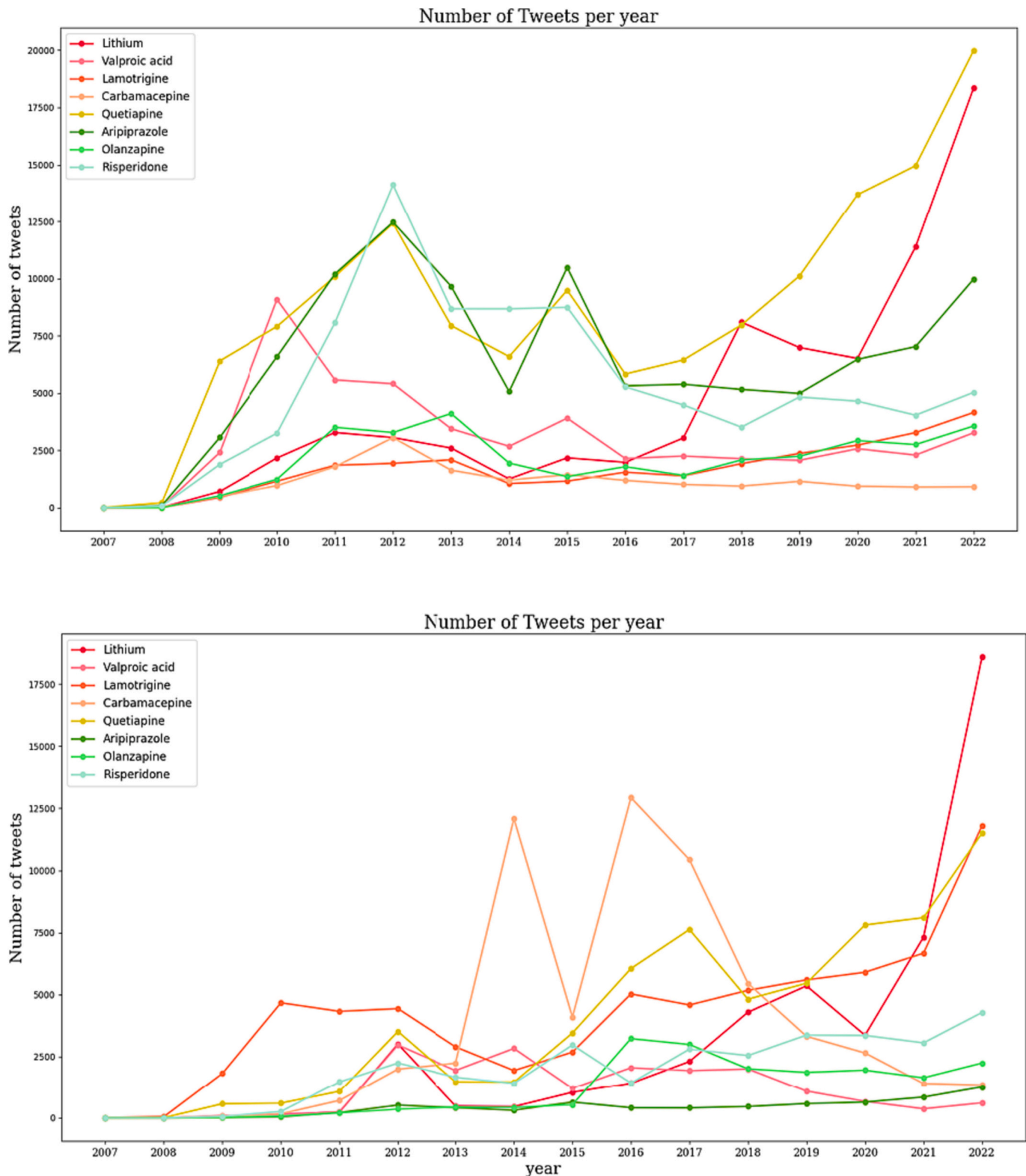


Fig. 2. Annual frequency of English (Top panel) and Spanish (Bottom panel) tweets mentioning Lithium, mood stabilizing anticonvulsants and second generation antipsychotics used in SRD and BD. Each color represents a specific drug as indicated by the legend on the left.

However, this research did not directly involve human subjects or include any human interventions, as it utilized publicly available tweets. Nevertheless, we took special care not to disclose the names of users and avoided including tweets that could potentially reveal their identities.

3. Results

3.1. Total count of tweets

A total of 893,289 tweets mentioning the selected drugs were analyzed, with 577,342 in English and 315,947 in Spanish. As observed in Fig. 1, Quetiapine, Risperidone, and Aripiprazole had the highest number of tweets in English. In Spanish, Lamotrigine, Carbamazepine, and Quetiapine generated the most tweets, followed by Lithium. In the overall tweet count, second-generation antipsychotics received more tweets than mood stabilizing anticonvulsants and Lithium. Quetiapine was the medication with the highest number of tweets among all the drugs analyzed.

Asenapine, Ziprasidone, Paliperidone, and Lurasidone did not receive enough tweets in Spanish to proceed with statistical analysis and topic modeling. Therefore, they were excluded from the analysis.

3.2. Number of tweets per year

The general trend for most of the studied drugs, as observed in Fig. 2, showed a progressive increase in the number of tweets over the 15-year study period, particularly from the year 2020 onwards. Regarding tweets in English, Quetiapine, Lithium, and Aripiprazole exhibited the most significant rise in the number of tweets, especially after 2020. Some drugs, such as Risperidone, Lamotrigine, and Valproic Acid, initially experienced a surge in tweets that gradually declined over the years, with a slight resurgence between 2021 and 2022.

In the case of tweets in Spanish, it is evident that Lithium, Lamotrigine, Quetiapine, and Risperidone were the four drugs with the highest tendency to generate tweets per year. Notably, there were two considerable increases in the number of tweets mentioning Carbamazepine between 2013 and 2018, followed by a rapid decline until 2022. Similar to the English tweets, there was a notable upsurge between 2020 and 2022, particularly concerning several drugs, mainly Lithium, Lamotrigine, and Quetiapine.

3.3. Topic modeling

3.3.1. Main topics and number of associated tweets

After conducting the topic modeling analysis of the studied tweets, the most frequent themes were identified, ranked from the highest to the lowest number of tweets received, as shown in Fig. 3, for both languages. In English, the most common topics were related to legal and judicial issues with the pharmaceutical industry (Topic 2), followed by economic aspects of treatments (Topic 3), drug approval by regulatory agencies (Topic 1), and online purchasing and active search for medications (Topic 0). On the other hand, in Spanish, the most frequent topics included seeking advice regarding treatment (Topic 0), drug shortages and dispensing difficulties (Topic 2), dosage and indication of the drugs studied (Topic 1), and the various pharmaceutical forms and presentations of the studied drugs (Topic 3).

3.3.2. Number of tweets per year for each main topic

In the English tweets per year, as observed in Fig. 4, the most prominent theme was related to legal and judicial issues concerning the studied medications in the pharmaceutical industry (Topic 2), with a notable surge starting from the year 2017. Between 2018 and 2013, tweets referencing the economic aspects of the drugs (Topic 3) gained significant interest but showed a declining trend starting from 2016. The tweets related to treatment approvals (Topic 1) and the online request for medications (Topic 0) remained relatively stable throughout the

studied years, with a slight resurgence from the year 2021.

Regarding the tweets in Spanish, the predominant themes were heterogeneous during the studied years. As highlighted from 2018 onwards, as reflected in Fig. 4, there was a considerable increase in tweets seeking advice regarding treatment (Topic 0), coinciding with a rise in tweets starting from 2020 that referred to the dosage and indications of the studied drugs (Topic 1). Notably, there was an increase in tweets related to drug shortages and dispensing difficulties between the years 2015 and 2018 (Topic 2). All the main topics found in the Spanish tweets showed, to some extent, an upward trend by the end of 2022.

3.4. Emotional analysis

A sentiment analysis was conducted for each relevant topic identified, examining emotions such as fear, sadness, joy, anger, surprise, and disgust. The evolution of these emotions was evaluated over the years in relation to the most relevant topics selected. In the analysis of emotions in tweets addressing the most important topics identified in the topic modeling, various emotions were observed, ranked by importance, as depicted in Fig. 5. Among English tweets, the topic of legal and judicial issues with the pharmaceutical industry (Topic 2) primarily evoked emotions of sadness, fear, and surprise among users. Economic aspects of treatments predominantly elicited feelings of fear and sadness (Topic 3).

Regarding Spanish tweets, those focused on drug shortages and dispensing difficulties (Topic 2) primarily triggered emotions of anger and surprise. Requests for treatment advice generated feelings of surprise and joy (Topic 0). Lastly, tweets about drug dosage and indications (Topic 1) were predominantly associated with feelings of joy.

4. Discussion

In this study, it was observed how the topics of interest and emotions generated in tweets mentioning the most common drugs prescribed for SRD and BD, differed between those published in English and those published in Spanish. In English tweets, second generation antipsychotics gathered the highest number of mentions. Conversely, Spanish tweets displayed a heightened interest in mood stabilizers. Regarding the content, English tweets stood out for their interest in economic and legal aspects, whereas Spanish tweets showed interest in seeking advice and recommendations. As for the sentiment analysis, it was found that English tweets focused on economic and legal aspects were associated with anger and fear, while Spanish tweets discussing advice and recommendations were associated with surprise, joy, and anger.

Over the past 20 years, numerous studies have highlighted the differences in prescribing treatments for SRD and BD across various countries (Karanti et al., 2016a; Lin et al., 2020; Su et al., 2020). These variations have been attributed to several factors, including the availability of medications, differing regulatory approvals or differences in the training of healthcare professionals regarding specific drugs, such as Lithium (Hidalgo-Mazzei et al., 2023; Malhi et al., 2023). In our study, we have identified significant discrepancies in drug mentions in English versus Spanish tweets, which coincides with these differences in the prescribing patterns worldwide. Specifically, we noted a predominance of mentions of second generation antipsychotics in English tweets which is consistent with the increase of prescriptions of these drugs in countries such as the United States, Australia or the United Kingdom in the past decades (Hálfánarson et al., 2017; Radha Krishnan et al., 2023; Su et al., 2020). Whereas in Spanish, there was a greater proportion of tweets related to mood stabilizers. Among the different causes that could explain this finding, one important one is the higher rate of prescription of mood stabilizers in countries such as Spain, compared to others like the EEUU or Asian countries, where it has been described that there is a tendency to prescribe first, a second generation antipsychotic, rather than a first line mood stabilizer such as Lithium, in diseases such as BD (Karanti et al., 2016a; Lin et al., 2020).

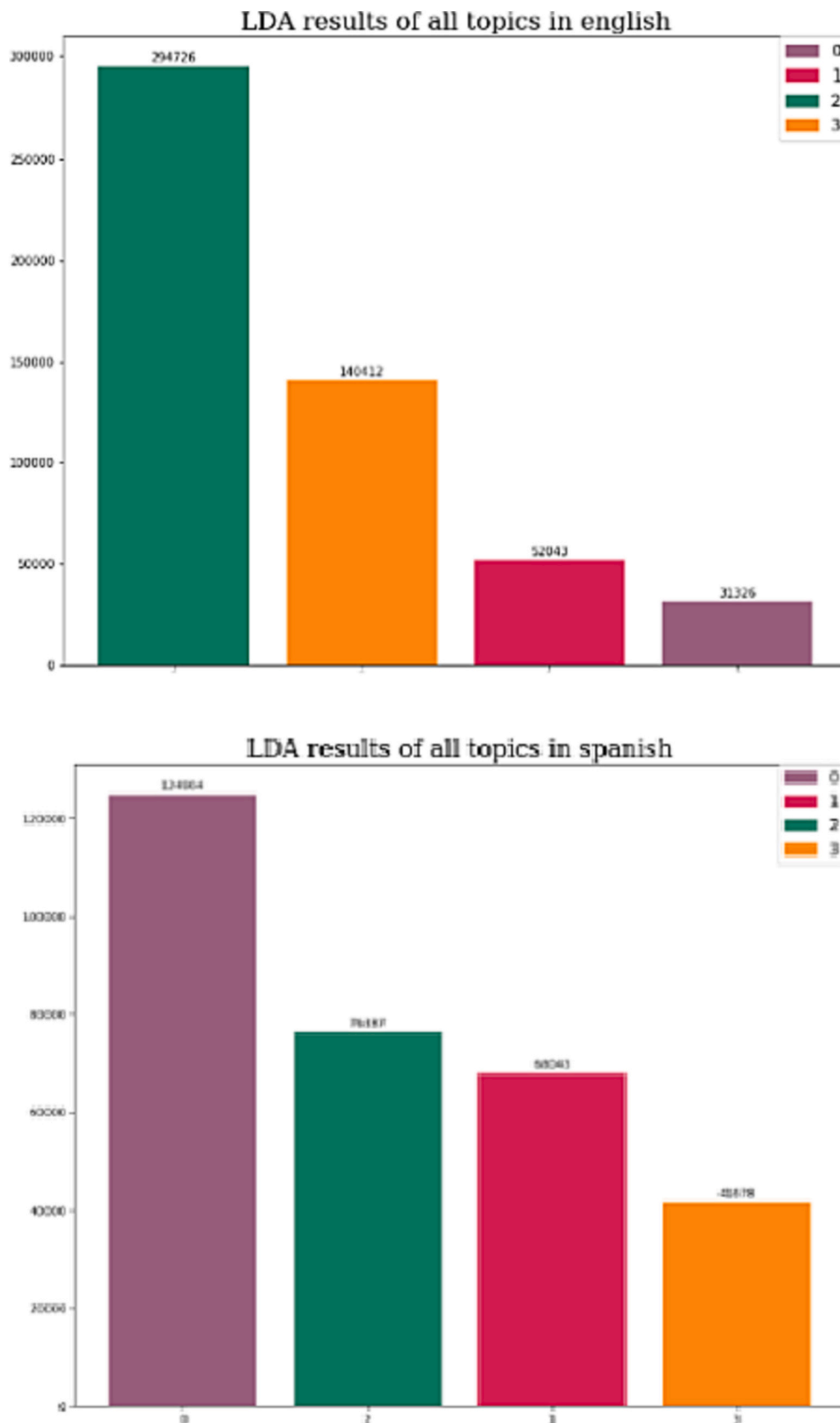


Fig. 3. Top panel: Tweets per topic in English. Bottom panel: Tweets per topic in Spanish.
Topics English: Topic 0: Online purchasing and active search for medications. Topic 1: Drug approval by regulatory agencies. Topic 2: Legal and judicial issues with the pharmaceutical industry. Topic 3: Economic aspects of treatments.
Topics Spanish: Topic 0: Seeking advice regarding treatment. Topic 1: Dosage and indications. Topic 2: drug shortages and dispensing difficulties. Topic 3: Pharmaceutical forms and presentations of the studied drugs

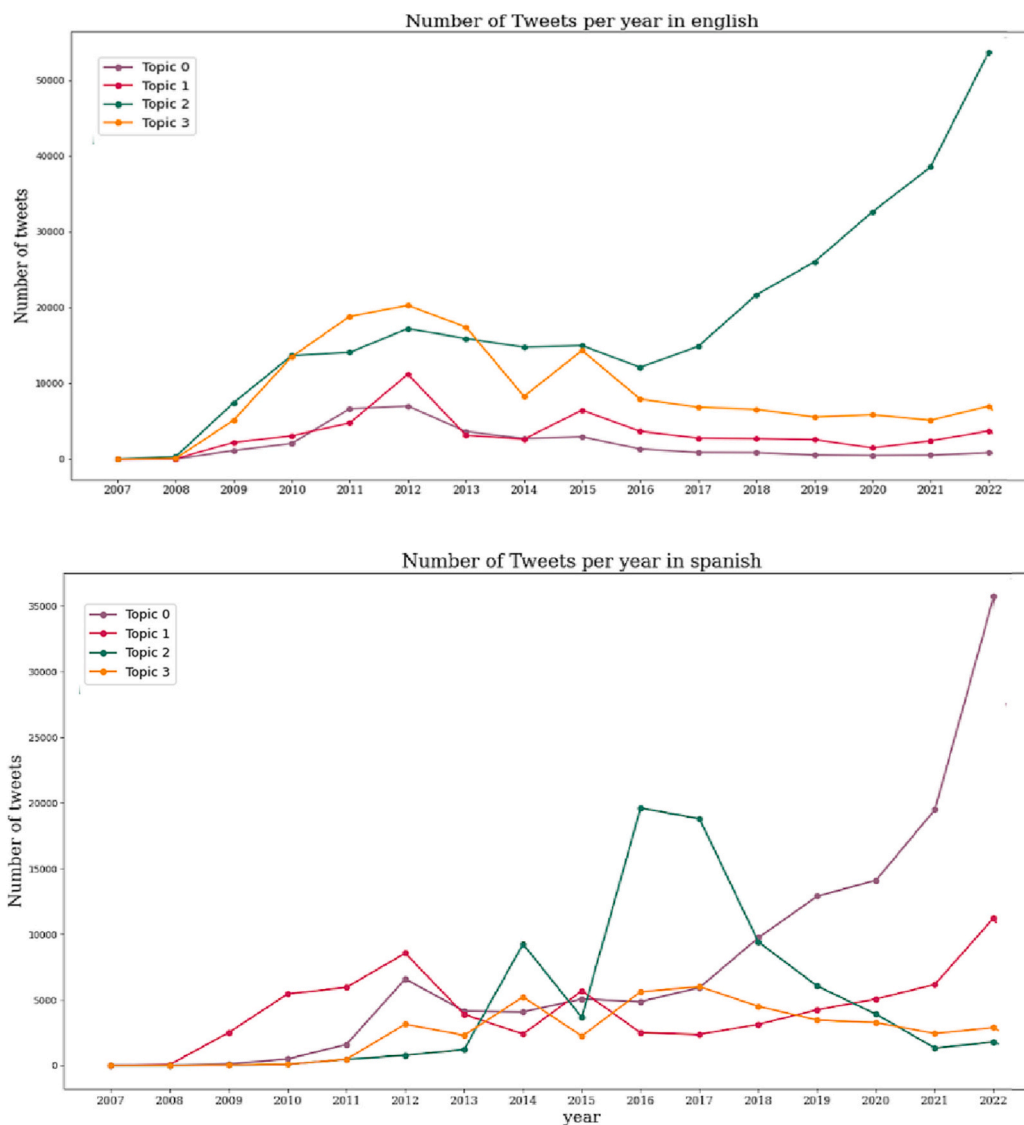


Fig. 4. Top panel: Tweets per topic per year in English Bottom panel: Tweets per topic per year in Spanish.
Topics English: Topic 0: Online purchasing and active search for medications. Topic 1: Drug approval by regulatory agencies. Topic 2: Legal and judicial issues with the pharmaceutical industry. Topic 3: Economic aspects of treatments.
Topics Spanish: Topic 0: Seeking advice regarding treatment. Topic 1: Dosage and indications. Topic 2: drug shortages and dispensing difficulties. Topic 3: Pharmaceutical forms and presentations of the studied drugs

The COVID-19 pandemic has catalyzed a noteworthy shift in the prescription patterns of psychotropic drugs (Amill-Rosario et al., 2022; Bilbul et al., 2020). Fig. 2 depicts a consistent increase in Twitter mentions of these drugs from 2008 to 2022, with a particularly steep rise starting in 2020. Recent studies have reported an uptick in the prevalence of a broad spectrum of mental disorders and a higher rate of relapses, temporally aligned with the pandemic (Wu et al., 2021; Xiong et al., 2020). Our findings reveal that second generation antipsychotics such as Quetiapine, Aripiprazole, Risperidone, and Olanzapine have experienced a notable surge in Twitter mentions since 2020, reflecting the increase in their prescribed use following the pandemic outbreak, that has been described in several studies (Bliddal et al., 2023; Robinson et al., 2022). This finding may also correspond with the heightened use of second generation antipsychotics in the treatment of other mental health conditions that have shown increased incidence in the post-COVID era (Bilbul et al., 2020; DeShong et al., 2023; Wu et al., 2021). Furthermore, the intensified use of second-generation antipsychotics in dementia treatment is significant, with researchers like Luo et al. recently reporting a considerable post-pandemic increase (Luo et al.,

2023).
 Another drug that showed a significant increase in the number of tweets since 2020 was Lithium. Although multiple factors could explain this increase in mentions, since 2020 there has been an increment of articles talking about the controversy surrounding its use in the treatment of BD, particularly raising concerns about its underutilization (Hidalgo-Mazzei et al., 2023; Lin et al., 2020; Malhi et al., 2020, 2021, 2023). This is partly due to apprehensions about its side effects and the need for continuous monitoring, leading many professionals to decrease its prescription (Gomes et al., 2023; Hidalgo-Mazzei et al., 2023; Pérez de Mendiola et al., 2021). Despite this, lithium continues to be the gold standard in BD treatment, as reflected in the main clinical guidelines (Taylor et al., 2014; Yatham et al., 2018), owing to its greater efficacy and clinical benefits, including anti-suicidal and neuroprotective effects, compared to other mood stabilizers or atypical antipsychotics (Abidin et al., 2011; Gonzalez-Pinto et al., 2006b; Hayes et al., 2016) However, it is clear that there is a discrepancy between the major guidelines (Taylor et al., 2014; Yatham et al., 2018) and the current prescription patterns (Karanti et al., 2016b; Lin et al., 2022; Lin et al., 2020; Poranen et al.,

Topic comparison in english database



Topic comparison in spanish database

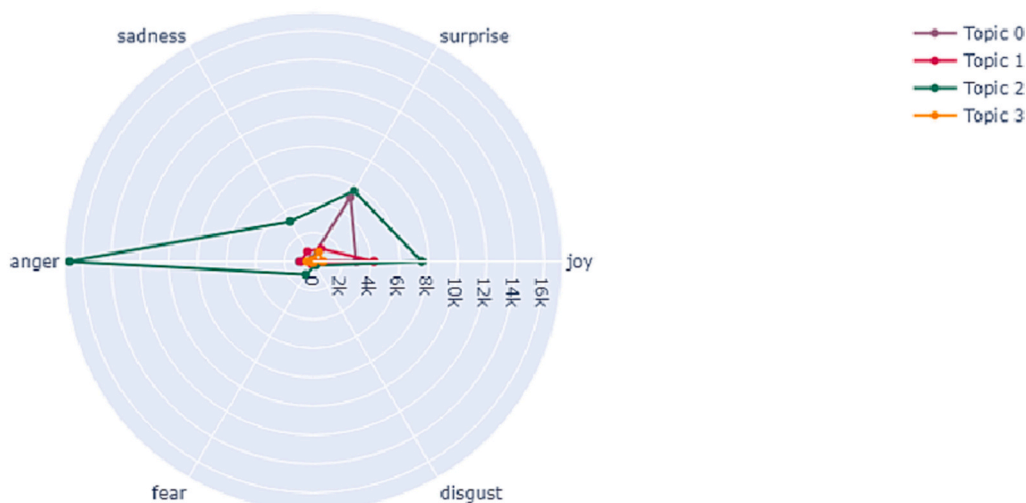


Fig. 5. Top panel: Analysis of emotion in the main topics of English tweets. Bottom panel: Analysis of emotion in the main topics of Spanish tweets.
Topics English: Topic 0: Online purchasing and active search for medications. Topic 1: Drug approval by regulatory agencies. Topic 2: Legal and judicial issues with the pharmaceutical industry. Topic 3: Economic aspects of treatments.
Topics Spanish: Topic 0: Seeking advice regarding treatment. Topic 1: Dosage and indications. Topic 2: drug shortages and dispensing difficulties. Topic 3: Pharmaceutical forms and presentations of the studied drugs

2022), which is generating controversy regarding the drug’s use (Gomes et al., 2023; Malhi et al., 2023; Nielsen and Licht, 2023).

Other results that have drawn our attention in the temporal evolution of tweets, include the peaks in tweets about various drugs during the years studied, prior to the pandemic. For example, in 2015, there was a surge in English tweets about Aripiprazole, which coincided with the approval of the generic version of the medication (Rubin, 2015). Another example is the peaks found between 2014 and 2016 in Spanish tweets about Carbamazepine, which aligned with periods of drug shortage issues in various regions of South America (Dirección de Medicamentos y Tecnologías en Salud, 2016).

The main themes found through the analysis of topic modeling have revealed also significant variability between English and Spanish tweets. Particularly in English, there is a striking interest in legal matters concerning the pharmaceutical industry of the various drugs under study. Risperidone, Quetiapine, Valproic Acid, and Olanzapine, among others, are medications whose pharmaceutical companies have been involved

in lawsuits primarily due to their promotion for unapproved indications by regulatory agencies (Office of Public Affairs | Abbott Labs to Pay \$1.5 Billion to Resolve Criminal and Civil Investigations of Off-Label Promotion of Depakote | United States Department of Justice, 2012; Office of Public Affairs | Pharmaceutical Giant AstraZeneca to Pay \$520 Million for Off-Label Drug Marketing | United States Department of Justice, 2010). In all these cases, the date of the verdict coincides with an increased number of tweets during those years. Furthermore, we have corroborated that this type of content primarily generates frustration and anger among Twitter users, leading to a heightened negative perception towards different approved treatments for SRD and BD. This factor directly correlates with a lower treatment adherence rate and, consequently, a poorer prognosis for the disease (García et al., 2016; Martínez-Aran et al., 2009; Sajatovic et al., 2004, 2006).

Another relevant theme found in the English tweets is the economic concern surrounding the studied treatments. In our study, we have been able to confirm that these tweets are primarily associated with feelings

of fear. It is regrettable that the economic aspect poses an additional barrier to the proper treatment of patients (Kane et al., 2013). With this study, we aim to emphasize the crucial need to explore new strategies to alleviate this significant concern regarding the economic aspects of treatment. As has been described, just like the negative perception of treatment, the lack of financial resources is a major factor that has been identified as a predictor of treatment adherence (García et al., 2016; Kane et al., 2013; Velligan et al., 2009).

In Spanish tweets, the main theme revolved around seeking advice and recommendations regarding the studied drugs. In response to such posts, we observed that the predominant sentiment generated was surprise. It is essential to bear in mind that due to the public and informal nature of Twitter, anyone can respond to such posts, offering advice and misinformation about treatments. This poses a significant danger for patients taking these medications since, as numerous studies have confirmed, an increasing number of people turn to social media platforms like Twitter to gather information about the medication they are receiving (Alvarez-Mon et al., 2021a). If such information is false, it becomes an additional barrier for patients to take their medication appropriately. Conversely, increasing the presence of accurate content, based on scientific evidence, becomes a crucial and easily accessible measure for patients. This can significantly improve their perception of the medication they are receiving, and consequently, possibly enhance their adherence to the treatment. Therefore, this result underscores the need to implement strategies focused on the development of psycho-educational programs on social media especially focused on pharmacological aspects.

Another theme observed in both English and Spanish tweets is the presence of tweets seeking to obtain the medication online. In the case of Spanish tweets, it was mainly due to shortages. There are numerous drugs that intermittently face supply issues in various parts of the world, particularly Valproic Acid or Carbamazepine (CIMA: Centro de información online de medicamentos AEMPS, s. f.). The increase in tweets concerning these drugs coincides with periods when shortages have been predominantly reported. This poses yet another barrier for patients to take their medication properly.

Unlike the tweets posted in Spanish, those in English show an increase in posts seeking to acquire medication online, but without a theme of shortages behind them. In a study published by (Chen et al., 2023) it was found that the number of tweets containing information requesting the purchase of stimulant drugs correlated with exam dates at various American universities and institutes. Another more recent example was observed with the well-known antidiabetic medication Ozempic. It was noticed that the drug was easily available online due to its effectiveness as a weight loss aid, which led to many diabetic patients who genuinely needed the medication being unable to access it (Vu, 2023).

In our study, we observed an important theme of tweets requesting the studied medications. Currently, there are numerous psychotropic drugs that are used illicitly, primarily anxiolytics (Darker et al., 2015; Smith et al., 2016). Additionally, abuses of antidepressants and antipsychotics have been reported (Chaves et al., 2023; Schifano et al., 2018) including drugs like Olanzapine, Ketamine or Quetiapine, being this last drug the one that receive more tweets in our study.

The potential of social media platforms, particularly Twitter, as a reflection of societal and healthcare challenges is increasingly being recognized in public health and medical research (Allem et al., 2020; Carabot et al., 2023; Golder et al., 2020; Ricard and Hassanpour, 2021). The study by Sarker et al., is a prime example, showcasing how Twitter posts can signal drug abuse, underlining its importance for toxicovigilance (Sarker et al., 2016). These platforms provide a rich, real-time data source, which, as Song et al., note, is being considered for integration into pharmacovigilance practices (Song et al., 2023). The immediacy with which information is shared on social media addresses some of the main limitations of traditional pharmacovigilance methods, such as delayed reporting and data retrieval (Edwards, 2012; Härmark

and van Grootheest, 2008). By tapping into the discourse on platforms like Twitter, researchers and healthcare professionals could gain faster insights into drug-related issues, from shortages and abuse to adverse drug reactions potentially enabling quicker and more effective responses to health challenges such as the ones described in our study.

Continued research is essential to ascertain and enhance the utility of social media in tracking public health trends, particularly in the realm of psychopharmacology in which the attitudes and beliefs that patients and professionals have, are so important in several factors such as a good adherence to treatment.

5. Limitations

Our study offers valuable insights into the sentiments and topics surrounding the main drugs used in SRD and BD treatment. However, there are inherent limitations. First, the analysis relies on Twitter data, which may not represent the full demographic diversity of the patient population. Twitter's user base tends to be younger and more tech-savvy, which could influence the nature and content of the discussions. Second, while some medications like Lithium are primarily used for BD, others have more extensive uses across various mental health and medical conditions, potentially diluting the specificity of the conversations related to SRD and BD. Nevertheless, the exploration of sentiments and topics related to these drugs is critical, as it helps us understand the primary concerns and experiences of patients, thereby enriching patient-centered care. Third, the unsupervised nature of our analysis presents challenges in definitively ascertaining the specific medical context of discussions. A potential solution to this issue is the application of supervised analysis techniques. Advances in artificial intelligence now enable more nuanced analysis and could allow for a more precise attribution of discussions to specific medical contexts in future research. Lastly, our study's focus on only English and Spanish tweets may limit its global applicability.

6. Conclusions

This study highlights the significance of harnessing social media research to gain a comprehensive understanding of user perceptions regarding the treatment of SRD and BD. By analyzing the content and emotions expressed in tweets, this research offers clinicians valuable insights into how patients and the wider public perceive and discuss these treatments within the digital sphere. As social media continues to play an increasingly integral role in shaping health-related discussions, incorporating these findings into clinical practice can improve treatment outcomes, increase patient satisfaction, and foster more patient-centered care in the realm of SRD and BD treatment. However, given the limitations associated with social media data, it is vital for clinicians to supplement this approach with traditional research methods to ensure a comprehensive and nuanced understanding of patient perspectives and experiences. In conclusion, this study provides a stepping stone for the integration of social media research in mental health studies. However, to fully capitalize on the wealth of insights that social media can offer, further studies based on social media listening are needed.

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CRediT authorship contribution statement

J.P. Chart-Pascual: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation,

Conceptualization. **M. Montero-Torres:** Software, Formal analysis, Data curation. **Miguel Angel Ortega:** Visualization, Validation, Resources, Project administration, Methodology, Investigation. **L. Mar-Barrutia:** Writing – review & editing. **I. Zorrilla:** Writing – review & editing. **Melchor Alvarez-Mon:** Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition. **A. Gonzalez-Pinto:** Writing – review & editing, Supervision. **Miguel Angel Alvarez-Mon:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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