

Relative Search Interest and Twitter Altmetrics of Chloroquine, Hydroxychloroquine and Ivermectin in Latin America

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ABSTRACT

This study aims to present exploratory and descriptive research about Latin America's online information search and Twitter activity and the repercussions of chloroquine, hydroxychloroquine, and ivermectin, which were at the time considered promising alternatives to prevent or treat COVID-19. From the perspective of Webmetrics and Altmetrics - data were collected and analysed from Twitter around indexed outputs by titles with one of these three drugs and from Google Trends (Relative Search Interest) in Latin American countries. The results demonstrated that there might be parallels between Google Search and Twitter activity. The results also showed that ivermectin was, among the three selected drugs, the most searched in Google Search and higher activity on Latin America's Twitter accounts.

Keywords: Relative Search Interest, Altmetrics, Ivermectin, Chloroquine, Hydroxychloroquine, Latin America, COVID-19.

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INTRODUCTION

Latin America is a region with strong historical connections related to its pre-Columbian cultures and the Iberian country's colonisation. Since the 1950s, the United States has significantly influenced Latin American policies and cultural exchanges in both ways by affinity or opposition to some values.

In the COVID-19 pandemic, the different approaches combined with local attitudes, treatments, and preventive drugs in Latin American countries contributed to the complexity of information search behaviour on the internet and social media.

Regarding public reactions against social isolation practices, it was shown that they are influenced by accessing information sources on the internet and social media, despite providing more information than ever for everyone in this global health crisis. (For further details on differences in isolation levels by country, see Google Mobility Reports).^[1]

Although some cultures are more prone to collective action favouring protection, such as wearing masks due to flu symptoms, many anti-spread habits may be stimulated by

good health communication campaigns, with social media being a new frontier.^[1] In this sense, government positioning is crucial in leading the population toward correctness attitudes during a pandemic.

There is no doubt that the COVID-19 pandemic is the most significant health emergency of this century, despite the importance of the Ebola virus crisis and other Public Health Emergencies of International Concern (PHEIC).^[2] This new etiological agent has the capability of fast and easy spread, which poses life and health-threatening risks to populations worldwide.

Given ongoing conditions of speed, volume, and variety of information on the internet, there is an abundance of health information available from numerous "accurate or inaccurate" trustworthy sources. Critical health literacy has become more crucial than ever to understand and evaluate what public health experts and politicians say in these circumstances. We are fighting not only against an infectious disease threat but also an infodemic crisis; as Tedros Adhanom, Director-General of the World Health Organization, declared, "Fake news spreads faster and more easily than this virus and is just as dangerous."^[3]

Amid the public health emergency, some drugs were selected for testing, through scientific controlled application studies,

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against the virus, as repositioning drugs or known antiviral (Solidarity Clinical Trial¹).

Nevertheless, it is essential to clarify that any medication implies collateral effects at different levels of severity and risk associated with comorbidities, age preference, and affected population. Significantly, taking medicines that are not prescribed or in the wrong dosages can present a high risk. These are problems in several Latin American countries where many medications are available regardless of prescription.

Despite the beginning of vaccination in many countries, we should still learn about this virus. It is worth mentioning that the surge for information about the virus behaviour and potential solutions for treatments fostered the increasing rate of published preprints or fast-track early articles accepted by journals that were considered to be “high impact” at a staggering level. At the same time, a remarkable rise in denial and anti-scientific movements have taken part in this fight for trends, with politics playing its role in topics through the media and general press linked to COVID-19.^[4-5]

Critical health literacy is essential to understanding processes that spread through Science and social media that allow individuals to reflect on complex health issues and critically choose the qualified information available. It is just a tiny piece in a giant semantic puzzle on how to promote, enhance and encourage positive attitudes and generate public awareness about modern Science Accountability as a language tool to tackle those challenges that were put through during the current pandemic crisis and post-pandemic, as long-term effects of the COVID-19 cycles.^[6]

In this context where disinformation is at large also a life-threatening issue. This study aims to describe the results of empirical research about internet information search and social media repercussions in Latin America based on chloroquine, hydroxychloroquine, and ivermectin that were repositioned as promising for treating or preventing SARS-CoV-2 infections. From the perspective of Webmetrics and Altmetrics data analysis, this research would like to build strategies that might help towards health disinformation. The research questions are as follows:

- a) What was the Relative Search Interest in Latin American countries on these three drugs that were the object of a broad promotion as capable of COVID-19 treatment and prevention?
- b) Is it possible to identify any parallels in the Twitter Altmetrics activity around papers published on these three drugs and the RSI in Google Trends?

To answer these questions, we explored Google Trends, from the topics: “chloroquine”, “hydroxychloroquine”, and “ivermectin” in the 20 Latin American countries, as well as Altmetric Explorer was inspected with a focus on these drugs on Twitter. First, it is essential to introduce the three drugs chosen for empirical research as below.

Main Drugs

Chloroquine is a form of quinine synthesised in 1934 and an adequate substitute for natural quinine, a compound found in the bark of Cinchona trees native to Peru. This drug has been used against malaria, general amebiasis infection, rheumatoid arthritis, and lupus erythematosus and tested as an antiviral agent against several viruses, including HIV type 1 (HIV-1), hepatitis B virus, herpes simplex virus type 1, and HCoV-229E.^[7]

Hydroxychloroquine is an analogue of chloroquine that has fewer concerns about drug-drug interactions. This medicine has been used to treat rheumatoid arthritis, SLE, and juvenile idiopathic arthritis. In the COVID-19 pandemic, studies tested this drug against the virus in contempt of some results suggesting a potential cardiac risk associated with high dosage (800 mg daily) in patients with COVID-19, especially when combined with the pro-arrhythmogenic drug azithromycin.^[8]

Ivermectin was identified in the late 1970s and was first approved in 1981 to treat certain parasitic roundworm infections for animals and in sequence for humans. The medication belongs to an anthelmintic class that paralyses and kills parasites. When used under the prescribed dosage and frequency, this drug does not present serious side effects, but headaches, dizziness, muscle pain, nausea, or diarrhoea may occur. In case of severe symptoms, it is recommended to seek immediate medical attention.

It is fundamental to elucidate that even though chloroquine and hydroxychloroquine were evaluated against SARS-CoV-2 infection, and the results showed to inhibit the growth of SARS-CoV-2 *in vitro*,^[9] the side effects can be health-threatening, ranging from seizures to impact on blood cell counts, muscle, and vision damage. In addition, most of the papers published on these drugs' effectiveness have been withdrawn, and World Health Organization (WHO) has discontinued research protocols on them². It also should be noted that a specialist doctor must monitor treatment with any medication.

In a recent *in vitro* study, Vero/hSLAM cells infected with the SARS-CoV-2 were exposed to 5 µM of ivermectin. The results showed that the treatment effectively kills almost all viral vector particles within 48h.^[10] At that moment, it was

1 <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/global-research-on-novel-coronavirus-2019-ncov/solidarity-clinical-trial-for-covid-19-treatments>

2 <https://www.who.int/news-room/q-a-detail/q-a-hydroxychloroquine-and-covid-19>

only possible to infer that clinical trials were necessary to appraise the effects of ivermectin on COVID-19 in humans.^[11]

LITERATURE REVIEW

Since the beginning of the COVID-19 pandemic, information-seeking user behaviour and information search patterns were the focus of internet studies, such as the importance of washing hands^[12] or symptoms such as loss of smell and taste,^[13] as well as public concerns and needs,^[14] and a forecasting and preparation tool.^[15]

Search-engine data has already been applied to follow the path of an epidemic and even try to predict the focus of the outbreak to help public health actions.^[16-18] Dashboards have been generated with Google data, for example, the Google Dengue Trends, and they have been accessible to the public on the internet.^[19] Nonetheless, criticism was awakened by the reliability of those prediction models^[20] as well as a hope for an equitable viewpoint has increased^[21] because it requires to be understood that big data may miss some critical data.^[22]

From this perspective, this paper is the first step towards a cross-disciplinary exploratory study supporting Webmetrics and Altmetrics investigation focused on scientific communication patterns delineated from results during the COVID-19 outbreak.

We performed data collections on Google Trends to obtain the Relative Search Interest (RSI) from 20 sovereign Latin American countries for the three drugs that were analysed, with the topics “chloroquine”, “hydroxychloroquine”, and “ivermectin” in the period of December 29th, 2019, to August 1st, 2020. Additionally, we searched Altmetric Explorer for outputs whose titles contained at least one of the three drugs’ names to obtain the number of tweets and Twitter accounts on the subjects and the incidence in the same countries analysed.

Google Trends Data Collection

In this study, we chose Google Trends topic search that provides adjusted results for query terms regardless of language or spelling and, in some cases, could combine brand names and scientific names of the drug.

The search terms to perform the topic search in each of the Latin American countries were as follows: “hydroxychloroquine”, “chloroquine”, and “ivermectin”. The purpose was to obtain a timeline of each of the three medicines and identify the most frequent and relevant associated terms throughout the period.

The study was limited to a data collection of 216 days to acquire the daily trends according to the definitions of epidemiological weeks. We wanted to have full months, and adding another 30 days resulted in only weekly data. The

sample period starts on December 29th, 2019, and ends on August 1st, 2020. No significant peaks were observed globally from August to the end of October 2020; therefore, the analysis maintained the chosen dates.

Google Trends allows access to Relative Search Interest (RSI), in the sense that the values will be related to the general interest in the search among all other searches carried out for each day or week, according to the period and the resolution. It compensates for differences in Google Search frequencies throughout the week and the year. Besides, it can change unexpectedly, for example, in the case of a critical event which may focus on the most interests in a unique subject.

The Venn diagram was made to visualise possible parallels and comparisons between the topics of the three medications. In addition, the most frequent terms associated with the medicines were categorised by country, drug and term, and a graph was plotted using Gephi.^[23]

It is essential to mention that according to Google Trends³, search data results are normalised to the time and location of a query by the following process:

- 1) Each data point is divided by the total searches of the geography and time range it represents to compare relative popularity. Otherwise, places with the most search volume would consistently be ranked highest.
- 2) The resulting numbers are then scaled from 0 to 100 based on the topic’s proportion to all searched topics.
- 3) Different regions with the same search interest for a term hardly ever do not have the same total search volumes.

Altmetric Explorer Data Collection

In the Altmetric Explorer interface, we searched for titles containing each of the three medicines from Twitter social media mentions and exported monitored Altmetric records (outputs).

Altmetric Explorer searches and data download were performed on October 31st, 2020 - after previous attempts with different approaches created since August. Consequently, we found the best strategy for data retrieval by title. Moreover, we exported data on weekly mentions on Twitter which begin on Mondays, differently from epidemiological weeks (Epi Weeks), which start on Sundays.

Based on internal Altmetric IDs, a Venn Diagram was generated using Interactivenn,^[24] an interactive visualisation tool to illustrate the overlapping outputs monitored in this research. In addition, Twitter posts and accounts from Latin American countries were separated by the tool’s geolocation

³ Google Trends, access: <https://support.google.com/trends/answer/4365533?hl=en>

counts. Likewise, a timeframe check was performed in which the oldest tweets were found to be 0.9% for chloroquine, 0.6% for hydroxychloroquine and 9.6% for ivermectin (probably due to the minor trend). Statista's data on the number of Twitter accounts from the top 20 countries in the world was added to normalise the results and improve data analysis.

After a general analysis of the 20 countries in Latin America, we selected the top five countries (Brazil, Chile, Colombia, Mexico, and Peru) to examine the Relative Search Interest and peak volume of posts on Twitter to understand possible parallels in the results of Google Trends and Twitter Altmetric data.

RESULTS AND DISCUSSION

Worldwide Google Trends

Analysing retrieved data, we found hydroxychloroquine was the drug with the highest Relative Search Interest (RSI) worldwide. On the other hand, ivermectin had the highest RSI in Latin America. Below are some results for each searched topic.

Hydroxychloroquine showed four peaks: 1) March 20th with (World-RSI = 100), 2) April 7th (World-RSI = 72), 3) May 19th (World-RSI = 69), and 4) September 28th (World-RSI = 68). The ten highest search countries were as follows: the United States (74%), India (74%), Ukraine (70%), Turkey (70%), Russia (69%), Iran (66%), United Kingdom (63%), Philippines (63%), Australia (63%), and South Africa (62%). The ten cities that searched the most about this drug were as follows: Istanbul (74%), Mumbai (74%), New York (73%), New Delhi (73%), Hyderabad (72%), Buenos Aires (41%), Guadalajara (33%), Dhaka (33%), Mexico City (32%), and Santiago (31%). It is worth pointing out that no country in Latin America was in the group with the highest RSI, but three cities were identified among those that searched the most for this drug.

The primary searches for hydroxychloroquine were by the drug name in the English language, Plaquenil (trading name), COVID, coronavirus, HCQ (an acronym for the drug), chloroquine (in English), Trump (the former USA president). Afterwards, a drug trading name in the Bulgarian and Russian language, side effects, azithromycin, malaria, leaflet, and the medication in the Russian language.

Chloroquine exhibited only a peak on March 20th (World-RSI = 82), and the ten countries with the highest RSI were: Indonesia (82%), France (74%), Nigeria (64%), Algeria (62%), Belgium (60%), Switzerland (53%), Poland (49%), Netherlands (47%), Bulgaria (45%), and Germany (44%). In line with hydroxychloroquine, no Latin American country was in the top ten group. On the other hand, although Brazil (32%) is in 18th position in the RSI ranking, the top ten cities on this medication RSI were Brazilian: São Paulo (44%), Santo

André (43%), Santos (43%), São José dos Campos (41%), São Bernardo do Campo (41%), Diadema (40%), Florianópolis (39%), Niterói (38%), Sorocaba (37%) and Porto Alegre (36%).

The primary searches for chloroquine were by the drug name, coronavirus, hydroxychloroquine, chloroquine phosphate (the substance), COVID, malaria, side effects, leaflet, Nivaquine (a trading name), Bolsonaro (the Brazilian president), and Raoult (Didier Raoult - a French microbiologist who proposed hydroxychloroquine and azithromycin for the treatment of COVID-19).

Ivermectin demonstrated the highest RSI peak on April 4 (World-RSI = 65). The top countries that searched for the drug were as follows: Bolivia (81%), Peru (79%), Guatemala (68%), Japan (68%), Colombia (6%), Mexico (61%), Dominican Republic (59%), Ecuador (53%), Bangladesh (51%), and Brazil (50%). Eight countries from Latin America were part of this group of ten. The ten cities with the highest RSI were all from Latin America: Trujillo (85%), El Alto (83%), Cochabamba (82%), Santa Cruz de la Sierra (81%), Los Olivos (80%), Comas (80%), Piura (79%), San Martín de Porres (79%), and Lima (79%).

The primary searches for ivermectin were by the drug name in English, COVID, leaflet, coronavirus, usage, Ivomec (a trading name), price, and azithromycin.

Latin America Google Trends

In this section, Google Trends and RSI data are detailed about the three drugs below to better understand how Latin American countries' populations searched for them in the Google Search Engine.

Argentina

Chloroquine (RSI = 66) and hydroxychloroquine (RSI = 73) search peaks were on March 25th. Ivermectin's search peak was shortly after April 4th (RSI = 100). Table 1 presents the top searches by drug in Argentina.

Table 1: Top searches by drug in Argentina.

Chloroquine	Hydroxychloroquine	Ivermectin
Coronavirus	Drug name in the English language	Drug name in the English language
Leaflet	Coronavirus	Coronavirus
Nivaquine (A trading name)	Leaflet	Price
Wikipedia	Price	Ivomec (A trading name)
Price	Azithromycin	Usage
Side effects	Side effects	For humans
Kairos (A pharmaceutical magazine)	Plaquenil (A trading name)	Leaflet

Argentina’s provinces search results showed that hydroxychloroquine and ivermectin were tied in the lead of RSI, and chloroquine was the least searched topic.

Bolivia

The first search peak was for chloroquine on March 8th (RSI = 3), followed by hydroxychloroquine on April 14th (RSI = 10), and the last peak was for ivermectin on May 12th (RSI = 100), with the highest RSI. Table 2 presents the top searches by drug in Bolivia.

The search results from Bolivia’s provinces indicated ivermectin was the frontrunner in RSI, in contrast to hydroxychloroquine and chloroquine, which had 10% or less RSI in a few provinces.

Brazil

The first search peak was for hydroxychloroquine on March 20th (RSI = 100) with the highest RSI, the second was for chloroquine on May 20th (RSI = 46), and the third was for ivermectin on July 7th (RSI = 42). Table 3 presents the top searches by drug in Brazil. Table 3 presents the top searches by drug in Brazil.

Table 2: Top searches by drug in Bolivia.

Chloroquine	Hydroxychloroquine	Ivermectin
Dosage	Drug name	Drug name
Chloroquine in Bolivia	Azithromycin	Ivomec (A trading name)
Composition		Side effects

Table 3: Top searches by drug in Brazil.

Chloroquine	Hydroxychloroquine	Ivermectin
Drug name	Drug name	Drug name
Coronavirus	Leaflet	Leaflet
Hydroxychloroquine	Price	Price
Bolsonaro (The Brazilian President)	Coronavirus	COVID
COVID	COVID	Price
World Health Organization	FDA (Food and Drug Administration, a federal agency of the USA)	Ivomec (A trading name)

Table 4: Top searches by drug in Chile.

Chloroquine	Hydroxychloroquine	Ivermectin
Ahumada (pharmacy)	Usage	Human usage
Hydroxychloroquine	Plaquenil (A trading name)	Dosage
Coronavirus	Price	Canal (A trading name)

Although the RSI distribution in each Brazilian state varies, the result revealed that ivermectin had the highest RSI, followed by chloroquine and hydroxychloroquine.

Chile

The chloroquine search peak was on March 22nd (RSI = 72). Hydroxychloroquine had two extremes: April 9th (RSI = 44) and May 9th (RSI = 44). Ivermectin had its highest RSI on May 29th (RSI = 100). Table 4 presents the top searches by drug in Chile.

The results in Chile regions demonstrated that ivermectin had the highest RSI, next hydroxychloroquine, and then chloroquine.

Colombia

Chloroquine had its first search peak on March 20th (RSI = 25), followed by hydroxychloroquine on March 25th (RSI = 18), and ivermectin on July 10th (RSI = 100). Table 5 presents the top searches by drug in Colombia.

Colombia’s provinces RSIs evidenced that ivermectin was the most searched medication, and chloroquine and hydroxychloroquine had the same average percentage of search interest.

Costa Rica

The first search peak found was for hydroxychloroquine on March 24th (RSI = 100), then chloroquine and ivermectin on the same day (RSI = 20) on April 5th. Table 6 presents the top searches by drug in Costa Rica.

Hydroxychloroquine was the most searched drug in the provinces of Costa Rica, with ivermectin in second place and chloroquine in third.

Table 5: Top searches by drug in Colombia.

Chloroquine	Hydroxychloroquine	Ivermectin
Drug name	Drug name	Drug name
Usage	Usage	Pills
Coronavirus	La Rebaja (pharmacy)	Dosage
Price	Plaquenil (a trading name)	Coronavirus
Aralen (a trading name)	Vademecum (pharmaceutical website)	COVID
Azithromycin	Side effects	Price
La Rebaja (pharmacy)	Price	Ivomec (A trading name)

Table 6: Top searches by drug in Costa Rica.

Chloroquine	Hydroxychloroquine	Ivermectin
Drug name	Drug name	Drug name
Usage	Side effects	Usage

Cuba

Hydroxychloroquine search peak was found on March 27th (RSI = 45), followed by chloroquine on March 28th (RSI = 44), and the last and highest peak was for ivermectin on April 7th (RSI = 100).

Cuba's search interest for the three drugs was based on the name of each substance. In addition, its provinces pointed ivermectin in the lead RSI, with chloroquine in second, and hydroxychloroquine with the least relative searched interest.

The Dominican Republic

The first search peak found was for chloroquine on March 19th (RSI= 54), followed by hydroxychloroquine on March 22nd (RSI = 63), and ivermectin on April 4th (RSI = 100). Table 7 presents the top searches by drug in the Dominican Republic.

In all but two of the Dominican Republic provinces (24 out of 26), ivermectin had the highest RSI. The remaining had one, hydroxychloroquine and the second, chloroquine, as the lead.

El Salvador

In El Salvador, chloroquine search peak occurred on March 20th (RSI = 62), ivermectin on April 4th (RSI = 100) and

hydroxychloroquine on May 27th (RSI = 61). Ivermectin had another search peak on July 6th (RSI = 100). Table 8 presents the top searches by drug in El Salvador.

In the provinces of El Salvador, ivermectin had the highest RSI, hydroxychloroquine was in second place, and chloroquine was in third.

Ecuador

A chloroquine search peak was found on March 20th (RSI = 62) nearby the hydroxychloroquine peak on March 24th (RSI = 61). The last peak was for ivermectin on April 4th (RSI = 100). Table 9 presents the top searches by drug in Ecuador.

The provinces of Ecuador showed ivermectin with the highest RSI, with hydroxychloroquine and chloroquine in the same position in second with less interest.

Guatemala

A chloroquine search peak was found on March 20th (RSI = 56), followed by one for hydroxychloroquine on March 24th (RSI = 24), and then ivermectin on July 3rd (RSI = 100). Table 10 presents the top searches by drug in Guatemala.

Table 7: Top searches by drug in the Dominican Republic

Chloroquine	Hydroxychloroquine	Ivermectin
Drug name	Drug name	Drug name
Aralen (A trading name)	Components	Coronavirus
Substance	Plaquenil (A trading name)	Dosage
Dosage	Dosage	Calox (a trading name)

Table 8: Top searches by drug in El Salvador.

Chloroquine	Hydroxychloroquine	Ivermectin
Substance	Drug name in Spanish	Drug name
	Drug name in English	COVID
		Usage

Table 9: Top searches by drug in Ecuador.

Chloroquine	Hydroxychloroquine	Ivermectin
Drug name	Drug name	drug name
Dosage	Drug in Ecuador	Ivomec (A trading name)
Aralen (A trading name)	Vademecum	Usage
Azithromycin	Azithromycin	COVID

Table 10: Top searches by drug in Guatemala.

Chloroquine	Hydroxychloroquine	Ivermectin
Drug name	Drug name	Drug name
Doses	Drug in Guatemala	Usage
Contraindications	Substance	COVID

Table 11: Top searches by drug in Haiti.

Chloroquine	Hydroxychloroquine	Ivermectin
Drug name	Drug name	Drug name
Dosage		COVID
		Usage

Table 12: Top searches by drug in Honduras.

Chloroquine	Hydroxychloroquine	Ivermectin
Drug name	Drug name	Drug name
Aralen (A trading name)	Vademecum	Dosage
Usage	Usage	Azithromycin

Table 13: Top searches by drug in Mexico

Chloroquine	Hydroxychloroquine	Ivermectin
Drug name	Drug name	Drug name
Aralen (A trading name)	Plaquenil (A trading name)	Price
Price	Price	COVID
Coronavirus	Plaquenil-PLM (A trading name)	Dosage
Hydroxychloroquine	Azithromycin	Coronavirus
Usage	Usage	Heat-PLM (A trading name)
Plaquenil (A trading name)	Chloroquine	Azithromycin

The results for Guatemala’s provinces were that ivermectin had the higher RSI for some provinces. In contrast, others returned no data (probably due to low numbers). On the other hand, chloroquine and hydroxychloroquine showed the same percentage of search interest at lower rates than ivermectin.

Haiti

Chloroquine search peak was found on March 22nd (RSI = 100), and in sequence, a hydroxychloroquine one on March 27th (RSI = 49), and for ivermectin on April 21st (RSI = 27). Table 11 presents the top searches by drug in Haiti.

Provinces of Haiti showed chloroquine on the lead but with no related searches in 7 out of 10 provinces. The search for hydroxychloroquine was second, with no related search in 8 of the ten provinces. Searches for ivermectin were reported only in one province. These results may reflect the overall lower search numbers in the country.

Honduras

A chloroquine search peak was found on March 26th (RSI = 42), and ivermectin was on April 4th (RSI = 100). As for hydroxychloroquine, two peaks were found with the same RSI: first on April 25th and the second on June 20th (RSI = 38). Table 12 presents the top searches by drug in Honduras.

Ivermectin was the most searched topic among the three drugs in this study in the provinces of Honduras. Chloroquine and hydroxychloroquine were tied at lower search rates in some provinces.

Mexico

Search peaks for chloroquine (RSI = 80) and hydroxychloroquine (RSI = 43) were found on March 20th, whilst another for ivermectin was found on April 5th (RSI = 100). Table 13 presents the top searches by drug in Mexico.

Table 14: Top searches by drug in Nicaragua.

Chloroquine	Hydroxychloroquine	Ivermectin
Drug name	Drug name	Drug name
Coronavirus	Leaflet	Usage
		Coronavirus

Table 15: Top searches by drug in Panama.

Hydroxychloroquine	Ivermectin
Drug name	Drug name
Usage	Dosage
Substance	Coronavirus

Table 16: Top searches by drug in Paraguay.

Chloroquine	Hydroxychloroquine	Ivermectin
Drug name	Drug name	Drug name
Indications	Usage	Ivomec (a trading name)
Lasca (laboratory)	Dosage	Coronavirus

Table 17: Top searches by drug in Peru.

Chloroquine	Hydroxychloroquine	Ivermectin
Drug name	Drug name	Drug name
Hydroxychloroquine	Azithromycin	Coronavirus
Usage	Substance in Peru	COVID
Coronavirus	Coronavirus	Dosage
Azithromycin	Usage	Usage
Dosage	Ivermectin	Price

Table 18: Top searches by drug in Uruguay.

Hydroxychloroquine	Ivermectin
Drug name	Drug name
Substance in Uruguay	Coronavirus
Drug name in the English language	Calox (A trading name)

Table 19: Top searches by drug in Venezuela.

Chloroquine	Hydroxychloroquine	Ivermectin
Drug name,	Drug name	Drug name
Substance in Venezuela	Usage	Usage in dogs
What is/definition	Leaflet	Dosage

The detailed results for Mexico’s provinces indicated ivermectin as the main RSI with hydroxychloroquine in second and chloroquine in third.

Nicaragua

Three search peaks for chloroquine had been found in sequence for Nicaragua: on March 21st (RSI = 50), March 25th (RSI = 51), and April 4th (RSI = 51). An ivermectin search peak was found on April 4th (RSI = 100) on the same day as the last chloroquine peak. The hydroxychloroquine search peak was on May 18th (RSI = 74). Table 14 presents the top searches by drug in Nicaragua.

In Nicaragua’s regions, ivermectin had the highest RSI, with chloroquine in second and hydroxychloroquine in third place.

Panama

The chloroquine search peak in Panama was on March 19th (RSI = 20), hydroxychloroquine on March 24th (RSI = 31), and ivermectin on April 4th (RSI = 100). Table 15 presents the top searches by drug in Panama.

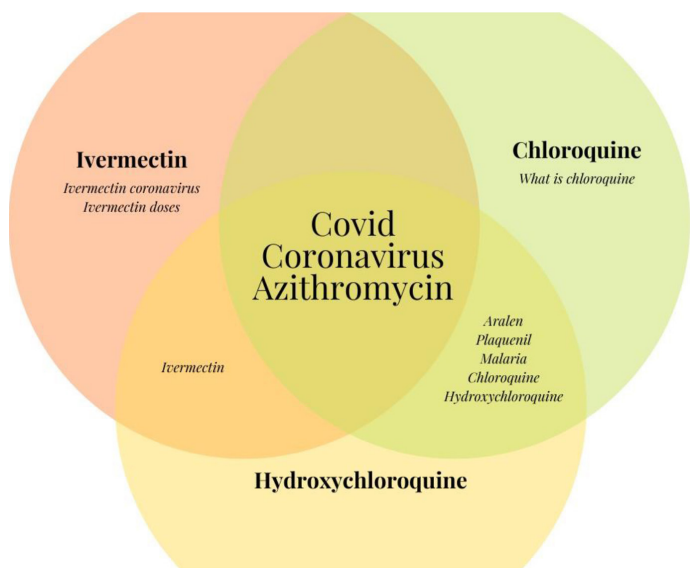


Figure 1: Venn Diagram of Google Trends associated search terms for Chloroquine, Hydroxychloroquine and Ivermectin.

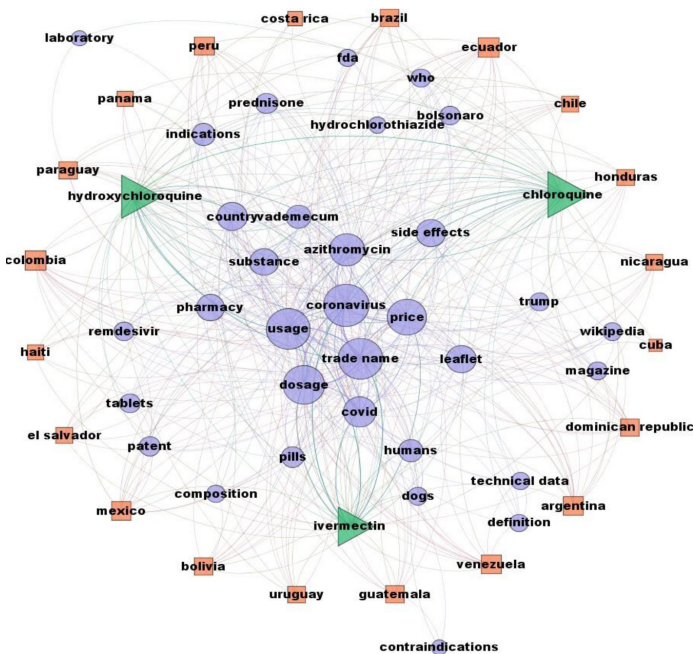


Figure 2: Graph representation of a three-mode network composed of countries, drugs and related search terms categories found in Google Trends for the period analysed.

Notably, there were no associated searches with chloroquine registered in Google Trends for Panama. Panama City was the only region that had a detailed RSI with 49% for ivermectin, 35% for hydroxychloroquine and 16% for chloroquine.

Paraguay

Search peaks were found for chloroquine on March 20th (RSI = 25), hydroxychloroquine on March 23rd (RSI = 100),

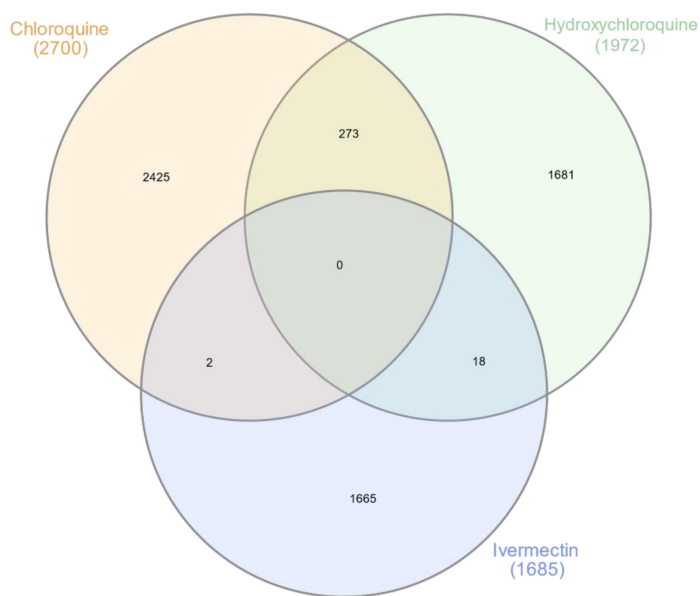


Figure 3: Venn Diagram of tracked outputs on Altmetric database with titles containing Chloroquine, Hydroxychloroquine or Ivermectin.

and ivermectin on April 4th (RSI = 56). Table 16 presents the top searches by drug in Paraguay.

In Paraguay's regions, ivermectin took the lead of RSI, followed by hydroxychloroquine in second and chloroquine in third.

Peru

Peru had search peaks for chloroquine on March 20th (RSI = 8), hydroxychloroquine on March 24th (RSI = 14), and ivermectin on May 17th (RSI = 100). Table 17 presents the top searches by drug in peru.

In Peru's provinces, ivermectin took the lead on RSI, with hydroxychloroquine in second and chloroquine in third.

Uruguay

Chloroquine search peak was found on March 24th (RSI = 73), in sequence for ivermectin on April 4th (RSI = 100), and at last hydroxychloroquine on April 13th (RSI = 39). Table 18 presents the top searches by drug in Uruguay.

No associated search terms were presented for chloroquine in Uruguay. Ivermectin had the highest RSI, followed by chloroquine in second and hydroxychloroquine in third in all the provinces of Uruguay.

Venezuela

A hydroxychloroquine search peak was found on March 21st (RSI = 47), followed by a chloroquine search peak on March 23rd (RSI = 100), and then for ivermectin on April 4th (RSI = 97). Table 19 presents the top searches by drug in Venezuela.

Table 20: Posts, Profiles, Outputs and Ratios from Altmetric database on Chloroquine, Hydroxychloroquine and Ivermectin.

Total	Chloroquine	Hydroxychloroquine	Ivermectin
Posts	310,779	728,960	47,743
Profiles	165,089	279,674	28,612
Outputs	2,700	1,972	1,685
Posts/Profiles	1.88	2.61	1.67
Posts/Outputs	115.10	369.66	28.33
Profiles/Outputs	61.14	141.82	16.98

The highest RSI was for ivermectin in Venezuela’s provinces, followed by chloroquine and hydroxychloroquine with the least interest.

Based on the presented results, it was verified that the searches performed in most Latin American countries were related to the drug name and usage, trading names, and other specific terms by country, such as local pharmacy names.

Figure 1 exhibits the result on a Venn Diagram of the most frequent and common terms among the three medications, “covid”, “coronavirus”, and “azithromycin”. In addition, we noted that five terms are usually presented in searches for chloroquine and hydroxychloroquine. As for azithromycin, this drug was disclosed jointly with hydroxychloroquine as a possible treatment for COVID-19.

Figure 2 shows a three-mode network graph that synthesises the most frequent terms associated with searches from each drug and country. In the visualisation, the drugs were represented as triangles, distributed in a triangular shape; the countries were represented as squares distributed in a circle in the outer part of the graph. The associated terms were represented as circles that were free to be adjusted by the Force Atlas 2 layout, with minimal adjustments to avoid overlap and better data readability.

The core categories of the graph had connections with trading names, usage, coronavirus, and dosage. Furthermore, use in dogs or humans was associated with ivermectin, and correlations were detected between chloroquine and hydroxychloroquine. One interesting aspect was the association of azithromycin with hydroxychloroquine and chloroquine, a term category linked with the protocol generally used in these drug tests.

Altmetric Explorer Twitter

This analysis aimed to identify possible connections amongst the three drugs in a sample from the Altmetric database. For this, a Venn diagram was plotted (Figure 3). The results showed that the titles might be associated with more than one

Table 21: Posts, Profiles, Outputs and Ratios with attributed countries determined on Altmetrics database on Chloroquine, Hydroxychloroquine and Ivermectin.

Total	Chloroquine	Hydroxychloroquine	Ivermectin
Posts	146,373	336,735	24,053
Profiles	80,901	134,968	13,844
Outputs	2,700	1,972	1,685
Posts/Profiles	1.81	2.49	1.74
Posts/Outputs	54.21	170.76	14.27
Profiles/Outputs	29.96	68.44	8.22

Table 22: Top 20 countries by Twitter account of each drug and Demographics data from Statista.

Chloroquine	Hydroxychloroquine	Ivermectin	Demographics
United States	United States	United States	United States
Brazil	Brazil	Japan	Japan
France	France	Brazil	India
United Kingdom	United Kingdom	Spain	Brazil
Canada	Canada	United Kingdom	United Kingdom
India	Spain	Mexico	Turkey
Spain	India	India	Indonesia
Australia	Australia	Colombia	Saudi Arabia
Mexico	Mexico	Peru	Mexico
Netherlands	Netherlands	Turkey	France
Japan	Japan	Venezuela	Philippines
Pakistan	Germany	France	Spain
Saudi Arabia	Saudi Arabia	Australia	Thailand
Germany	Italy	Ecuador	Canada
Italy	Peru	Panama	Germany
Colombia	Colombia	Pakistan	Argentina
Chile	Argentina	Canada	South Korea
Ecuador	Turkey	Chile	Egypt
Peru	Chile	Argentina	Colombia
Belgium	Ecuador	El Salvador	Malaysia

of the medications, particularly when considering chloroquine and hydroxychloroquine.

The Venn diagram presented the number of outputs for each drug cited in the title and their overlapping. This sample had in the title a total of 2,700 outputs with Chloroquine, 1,972 with Hydroxychloroquine, and 1,685 with Ivermectin. As pointed out, some outputs from the Altmetric database may be associated with more than one of the three drugs. An overlap of 263 outputs for chloroquine and hydroxychloroquine was found. On the other hand, overlaps for hydroxychloroquine and ivermectin were only for 18 outputs, and two outputs for chloroquine and ivermectin. In this sense, it is essential

to consider that Twitter accounts and tweets overlapping outputs may count for either drug cited in the title of the same output. Table 20 illustrates the number of posts, profiles, and outputs from the Altmetric database sample analysis, including the ratio of posts/profiles, posts/outputs, and profiles/outputs with or without a country attribution for the account. To understand the repercussions on Twitter of the outputs tracked in the Altmetric database, a sum of all posts and profiles tweeted about each selected output was collected. In this case, a profile tweeted about two different outputs will count twice, as there was no way to separate them.

The total number of posts from hydroxychloroquine were more than double for chloroquine (2.35), and chloroquine was more than six times higher than ivermectin (6.51). Although with significant differences, profiles demonstrated a smaller proportional difference with 1.7 times between hydroxychloroquine and chloroquine and 5.77 between chloroquine and ivermectin. Posts rated by profile for hydroxychloroquine was around 38% greater than the chloroquine ratio, and at the same time, it was 56% higher than the ivermectin ratio.

In contrast, when we examine the number of outputs, we can observe a change in positions when comparing chloroquine with other drugs. Thus, chloroquine's output numbers are approximately 37% greater than hydroxychloroquine and 60% higher than ivermectin.

When possible, Altmetric provides country identification for Twitter accounts. The ratio of identified Twitter posts and accounts in comparison with the total for outputs were respectively as follows: chloroquine: 47.10% and 49.00%, hydroxychloroquine: 46.19% and 48.26%, ivermectin: 50.38% and 48.39%. It was considered that although the differences in specific country attribution were found, this divergence could be due to the diversity of country's profiles which do not have the magnitude to compromise the analysis.

Table 21 now presents a similar information grid to Table 20, only with a country attributed. The results showed some differences that should be highlighted:

1) posts/profiles ratios of chloroquine and hydroxychloroquine decreased, whereas, for ivermectin, they increased. 2) posts/outputs and profiles/outputs for chloroquine and hydroxychloroquine followed the same direction and the opposite for ivermectin.

Table 22 presents the top 20 countries for each search topic based on Twitter profiles accounts and the estimated total number of profiles accounts by country. These Twitter data were collected from Statista to improve analysis of demographic repercussions worldwide, with a special look at Latin American countries. It was observed that only four

Latin American countries are amongst the top 20 in registered accounts, namely: Brazil, Mexico, Argentina, and Colombia. Furthermore, it is possible to infer a high level of debate about these drugs on Twitter, in volume and engagement, when analysing some countries amongst the top 20 Twitter accounts that are not considerably populous.

In the Twitter accounts world ranking, Brazil stands out in fourth place in the Statista demographics of Twitter, whilst in the Altmetric debate, the country is in second place for quinolone derivatives and third place for ivermectin. Besides that, Brazil maintains its relevance in the same way in Latin American countries.

The number of Latin American countries in the Altmetric debate stood out for ivermectin with 10, whereas for hydroxychloroquine 7, and chloroquine 6. It is important to elucidate that Venezuela, Ecuador, Panama, Chile, and El Salvador are not part of the top 20 in Twitter demographics. Still, they are in the leading group for ivermectin in the Altmetric debate. By analysing the top 20 countries by drug and demographic, it is viable to infer that Latin American countries were proportionally more engaged in the Twitter debate regarding treatments or prophylaxis about one or more of these drugs.

Notwithstanding our focus in Latin America, it is worth reporting that Japan demonstrated a strong interest in ivermectin (first in the ranking) and little relative interest in the other drugs studied (eleventh ranking). Considering that this country has the second-highest number of registered accounts, their absence in the trending tweets of papers on quinolone derivatives is significant. Other punctual absences can be observed in Table 22.

Google Trends and Twitter Altmetrics Parallels

Based on the Relative Research Interests on Google Trends and Twitter Altmetrics, five countries were chosen to discuss further possible parallels: Brazil, Mexico, Peru, Colombia and Chile.

Brazil was the leader in Twitter Altmetrics activity on the three drugs amongst Latin American countries. Further, this country was the worldwide leader in many cities with search interest in chloroquine. It is worth mentioning that ivermectin had the highest RSI in this country, which may be associated with the Brazilian government's declaration about the possible efficacy of nitazoxanide (Annita – a trading name) and the research investment for another vermifuge as a repositioned drug during the pandemic. The results for nitazoxanide have just recently been published in a preprint and are with ongoing scientific controversy.

Mexico ranked ninth in the top 20 Twitter demographic. On Twitter Altmetrics results for the three drugs, the country was

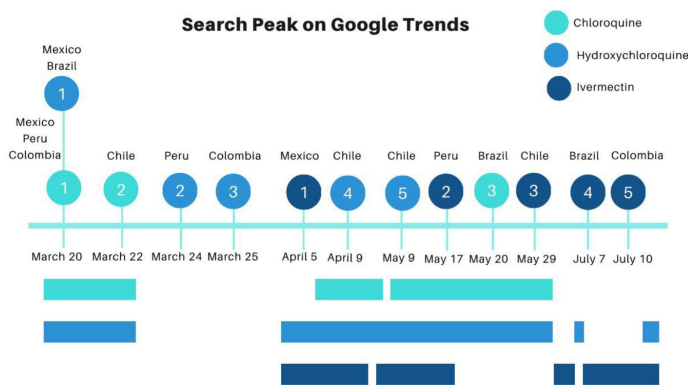


Figure 4: Search Peaks on Google Trends (numbered circles) and Trending Twitter weeks (coloured bars) for papers on the Altmetric database by title for Chloroquine, Hydroxychloroquine or Ivermectin.

the second amongst Latin America and the sixth worldwide to seek ivermectin, the drug with the highest RSI. Search interest for chloroquine and hydroxychloroquine was the same, standing in ninth place.

Colombia ranked second in the top 20 Twitter demographics. Twitter Altmetric results showed the country as third in Latin America and eighth in the world for ivermectin, the most searched interest drug in Colombia's provinces, and had the highest search peak (RSI). Search interest for chloroquine was in third place, and hydroxychloroquine in fourth amongst Latin American countries, whilst the drugs were tied in the world rankings.

Although Chile and Peru were not amongst the top 20 Twitter demographics and are not considered densely populated countries from Latin America, both stood out in the search for drugs on Twitter Altmetric data.

Chile was fifth in Latin America and eighteenth in the world for ivermectin, the most searched interest drug and the highest RSI. The result showed that chloroquine ranked fourth amongst Latin American countries and seventh in the world. For hydroxychloroquine, which was the drug that had two search peaks with the same RSI, it was fifth amongst Latin countries and the second last one in the world.

Peru was the fourth for ivermectin, the third for hydroxychloroquine and the fifth for chloroquine searches among Latin American countries. The drug of the most significant search interest and RSI peak was ivermectin. In this sense, Twitter Altmetric presented that search interest over the three drugs in Chile was evenly distributed. In contrast, Peru emphasised ivermectin.

The exploratory research examined a vast dataset to identify relative research interest (RSI) in each drug and to see whether there could be any parallels with the Twitter activity (an Altmetrics crude indicator) due to the increased volume of scientific papers and the repercussion of COVID-19. Altmetric

is considered to have roots connected with the dynamics of science and society whilst presenting the joint components of scientific communication and science communication on social media.^[25]

Figure 4 shows the search peaks for each drug in the five focused countries and global Twitter activity. For chloroquine and hydroxychloroquine, high Twitter activity on science papers was considered over 10,000 tweets per week; as for ivermectin, the threshold was 1,000 tweets.

A general parallel was observed between the RSI periods of the five Latin countries and the tweeting activity about scientific articles over any of the three drugs. Nevertheless, there is a data gap in Latin American countries. The proximity to the timeline can be noted, but the search peak relation was unclear, or it is not directly possible to establish a parallel. The intense Altmetrics activity on Twitter for Latin American countries could be more reflected in the public's interest in searching for these drugs, thus resulting in greater RSI. Therefore, it is necessary to consider collecting more detailed data to analyse the influence of Twitter Altmetric activity on Relative Research Interest (Google Search). It would be interesting to explore data from the context of the pandemic in the countries on the number of infected, deaths, cured and government actions, which makes this research increasingly complex.

FINAL REMARKS

Amongst the three drugs analysed, quinolone derivatives (chloroquine and hydroxychloroquine) were the most searched for globally, whilst for Latin America, the 'Holy Grail' was ivermectin. Even in Brazil, where the president promoted quinolone derivatives as a preventive measure or as a treatment panacea, the RSI for ivermectin was notable, with few differences between the states.

At the same time, Twitter Altmetrics showed that scientific communication and attention on social media were higher for hydroxychloroquine studies, which means that both the results and Twitter activity were more significant to this drug in the order of magnitude than for ivermectin. Perhaps, this was a reflection of the lower interaction volume of Latin American countries in the drug debate on Twitter compared to the total number of countries in the world.

Internet information search behaviour had already been used to understand epidemiological dynamics better. Social media and even Altmetric activity may be considered helpful as a part of that process. Since social distance has made us rethink and relearn how to satisfy our information needs, health critical information literacy is crucial. Although this study could not prove causality between Twitter activity and Google Search,

we could observe patterns and infer parallels, contributing to the greater knowledge generated during the COVID-19 crisis.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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