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Artículos originales

## Trends and seasonality of information searches, carried out through Google, on metabolic syndrome and occupational health: infodemiological study

Tendencias y estacionalidad de las búsquedas de información, realizadas a través de Google, sobre síndrome metabólico y salud laboral: estudio infodemiológico

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The authors declare no conflict of interest.

## Resumen

**Objetivo:** Este estudio tuvo como objetivo analizar y relacionar el interés de la población, a través de tendencias de búsqueda de información, sobre el Síndrome Metabólico (MS) con la Salud Laboral (OH).

**Método:** Estudio ecológico y correlacional del Volumen Relativo de Búsqueda (RSV) obtenido de la consulta de Google Trends, segmentado en 3 períodos buscados relacionados con la antigüedad; fecha de consulta: 30 de septiembre de 2023.

**Resultados:** La media más baja del RSV fue para el tema MS ( $2,23 \pm 0,87$ ), aunque hubo una correlación positiva en el RSV entre MS y OH ( $R = 0,56$ ;  $p < 0,05$ ). Se observó asociación ( $p < 0,05$ ) entre los 3 períodos estudiados, excepto para los temas Hipertensión y Obesidad Central, pero significativamente menor en el período actual para los Temas MS y OH. Se encontró una estacionalidad moderada en el tema MS ( $KPSS = 0,14$ ;  $p > 0,05$ ), y se demostraron diferencias significativas en la búsqueda de información entre países desarrollados y no desarrollados ( $p > 0,05$ ).

**Conclusiones:** A través de sus búsquedas de información, toda la población demostró tener un menor conocimiento sobre la MS que sobre las enfermedades que la componen. Se encontró relación entre las búsquedas de información realizadas sobre MS y OH. El estudio de las tendencias de búsqueda de información puede proporcionar información útil sobre el interés de la población por los datos de enfermedades, así como permitiría gradualmente analizar diferencias en popularidad, o interés incluso entre distintos países.

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**Palabras clave:** Salud Laboral; Síndrome metabólico; Infodemiología; Tendencias de Google.

## Abstract

**Objective:** This study aimed to analyse and relate the population interest through information search trends, on Metabolic Syndrome (MS) with the Occupational Health (OH).

**Method:** Ecological and correlational study of the Relative Search Volume (RSV) obtained from Google Trends query, segmented into 3 searched periods concerning antiquity; date of query: September 30, 2023.

**Results:** The lowest mean of the RSV was for the MS Topic ( $2.23 \pm 0.87$ ), albeit there was a positive correlation in the RSV amid MS and OH ( $R = 0.56$ ;  $p < 0.05$ ). Association ( $p < 0.05$ ) was observed between the 3 periods under study, except for the Hypertension and Central Obesity topics, but significantly lower in the current period for the MS and OH Topics. Moderate seasonality was found in the MS topic ( $KPSS = 0.14$ ;  $p > 0.05$ ), and significant differences were demonstrated in the information search between developed and undeveloped countries ( $p > 0.05$ ).

**Conclusions:** Through their information searches, the whole population showed to have a dearth of knowledge of MS than of its component diseases. A relationship was found between the information searches carried out on MS and OH. The study of information search trends may provide useful information on the population's interest in the disease data, as well as would gradually allow the analysis of differences in popularity, or interest even between different countries.

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**Keywords:** Occupational Health; Metabolic Syndrome; Infodemiology; Google Trends.

## Highlight

Numerous studies have demonstrated the validity of Infodemiology (a methodology that combines information theory with the study of epidemiology) applied to topics such as flu outbreaks or venereal diseases, which allows us to infer that it can be used successfully in the field of public health for other topics of interest.

In this case, a technique for extracting information from the general interests of the population is applied to a disease, Metabolic Syndrome, never used before.

Thanks to the results obtained, public health researchers will have an added monitoring tool for active surveillance within the Metabolic Syndrome disease. This tool is of special interest for prevention campaigns developed by Public Health centres.

## Introduction

Since 1988, when Reaven<sup>(1)</sup> first systematically described it, an abundance of research has advanced an understanding of the pathophysiology, epidemiology, prognostic implications, and therapeutic strategies related to the Metabolic Syndrome (MS).

The MS is a clinical entity with metabolic and hormonal alterations, characterized by a set of risk factors: abdominal obesity, insulin resistance, hypertension, and dyslipidemia. It is a complex disorder related to the endocrine system that, along with a sedentary lifestyle and unhealthy eating habits, affects many people around the world and greatly interferes with the quality of life and in the employment of this population<sup>(2,3)</sup>.

Thus, Niazi et al.<sup>(4)</sup> assessed the MS frequency and its associated risk factors in health workers, finding that, in addition, age, shiftwork and inactivity were associated to MS which was an important risk factor to be considered for employees' public health. Furthermore, Yamaguchi et al.<sup>(5)</sup> pointed out the work stress impact on workers' health, giving that the increase requirements in work throughout time was associated with a higher risk of MS.

A current publication shows that the number of people suffering from MS is gradually and constantly increasing. In this paper, it is claimed that this growth is occurring because of the campaigns that promote eating healthy and do the required exercise are not enough or not accomplish their purpose. Therefore, the authors request to carry out campaigns aimed at the public considering their language and concerns<sup>(6)</sup>.

Facing this situation, the idea that the population provides data on their tastes, searching services including the search on their disease thwart the search information behaviour on Web has already been explored in recent years<sup>(7)</sup>.

Google is an engine search that provides information to whatever person, which by means of the procured outcomes may readily access to the existed documents on the Network. Google, which does not need presentation, was founded in 1997, and it is considered the most search engine in the world with a market share that thoroughly overflows other search engines as Baidu o Yandex (the most used engines in China and Russia respectively)<sup>(8)</sup>. Although, Google Trends (GT) is not Google's best-known implement, is a freely accessible tool that reports the volume of searches conducted by the users worldwide to expound on how frequently a term is searched and in what places. The search data on the Internet may provide helpful information on the demeanour population patterns<sup>(9,10)</sup>.

In the health field, Eysenbach<sup>(11,12)</sup> coined the term "infodemiology" (information + epidemiology) as an emerging set of public health information methods in order to analyse search behaviour, communication, and publication on the Internet. That is, observing and analysing the behaviour based on the Web to know the human demeanour with the purpose of foretelling, assessing, and even preventing the health-related problems that constantly arise in the quotidian life<sup>(13)</sup>.

Nowadays, in a marked scenario by the growing usage of social networks and interactivity resources, its inclusion in digital spaces for health communication becomes a relevant issue. Over the past de-

cade, using Web-based data on health public issues in which infodemiology has shown to be useful for assessing various human demeanour features.

As Orduña-Malea<sup>(14)</sup> pointed out, it may be used in newscasting tasks (forecasting the present, that is, foretelling values that are occurring at the same time data is generating and it may be used as well in forecasting tasks (predicting future trends). Thus, this tool may facilitate to know many issues i.e., the most searched services, which are the new trends, and what needs are users demanding. GT is the indicated tool for gathering information and it has already been used in a wide range of topics hitherto, with studies in the field of diabetes<sup>(15)</sup>, obesity<sup>(16)</sup>, hypertension<sup>(17)</sup>, diet<sup>(18)</sup> and occupational health<sup>(19)</sup> among others.

Consequently, the aim of this paper was to study and relate the population interest athwart information search trends on Metabolic Syndrome (including Abdominal Obesity, Hypertension, Diabetes, Cholesterol and Triglycerides) with the Occupational Health (OH).

## Methods

### Design

An ecological and correlational study of information search trends using Google.

### Data collection search

The information search data was procured by means of direct search, online access, and Google Trends (GT): <https://trends.google.es/>.

The scope was worldwide and in all categories. The study period was from 1 January 2004 to 30 September 2020. Searching and compiled data date were 10 October 2023.

To examine the evolution of the Relative Search Volume (RSV), the period to study was segmented into three periods: The first was from January 2004 (when GT provided the first data) to December 2009, the second from January 2010 to December 2016, and the third period was from January 2017 to September 2023.

### Tool

Google Trends (GT) is free and open access that provides standardized statistics of Google Trends for different searches since January 1, 2004. It analyses the inquiries to delimit how many searches were carried out on a specific term in comparison with the total quantity of the conducted searches by users on Google for the same term and in the same period.

GT rules out terms with low volume search or duplicated searches performed by the same user in a short while.

### Search topic

Searches were conducted on the following topics: “Metabolic Syndrome”, “Hypertension”, “Diabetes”, “Central Obesity”, “Cholesterol”, “Triglycerides” and “Occupational Health”. The outcomes were taken from over the World and in all categories.

The results of the terms sharing the same concept in any language were obtained considering the use of the word as a “Topic” in this tool. (For example: if it is searched “Occupational Health”, the search includes results of the following topics “Job Security”, “Safety Committee” o “Health at Work”, among others).

### Data collection and storage

The procured outcomes were downloaded in a standardized “CSV” (comma-separated values) format, which allowed them to be stored in a spreadsheet file. The quality control of this information was per-

formed through double tables, amending the possible inconsistencies by consulting the original downloaded table.

## Variables

Relative Search Volume (RSV): Result provided by Google Trends whose values are normalized on a scale from 0 (relative search volume less than 1% of the maximum volume) to 100 (relative search volume reaches its maximum). For instance, an RSV = 25 represents 25% of the highest observed search proportion during the period under study.

- Trend: temporal behaviour and evolution of the searches carried out in a specific topic, long term.
- Seasonality: periodic and foreseeable variation in a time series with a period less than or equal to one year.
- Unfolding level by country: an indicator created by the “United Nations Development Programme” that measure the breakthrough degree of each country dealing with variables such as life expectancy, education, and per capita income. For its classification, the United Nations Statistics Division Website (<http://data.un.org/>) was consulted, which determines the three levels of development: developed, developing and least developed.

## Data analysis

For quantitative data, its mean, and standard deviation (SD), median, maximum, and minimum were calculated. The Kolmogorov-Smirnov test (with Lilliefors correction) was used to verify the normality of the variables. The Kruskal Wallis test was employed to compare the medians amid groups, and the Wilcoxon test with Benjamini & Hochberg adjustment was used to study the association between groups.

The temporal evolution of search trends was analysed by means of regression analysis calculating the coefficient of determination (R<sup>2</sup>). Pearson correlation coefficient was employed to procure the relation amid quantitative variables.

The Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test (tests the void hypothesis that an observable time series is seasonality against the alternative of a unit root) was used to verify seasonality.

The level of significance used in all the hypothesis tests was  $\alpha \leq 0.05$ , using asterisks to represent the strength of the association: \* p-value < 0.05; \*\* p-value < 0.01; \*\*\* p-value < 0.001 for Kolmogorov-Smirnov test, Kruskal Wallis test and Wilcoxon test. \* p-value > 0.05 for Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test.

The R software version 4.2.2 with the Rstudio work suite version 2023.09.0 build 463 was used for data analysis.

# Results

## Relative Search Volume (RSV)

From the study of the procured data from GT it was verified that the Kolmogorov-Smirnov test discarded normality for all the subjects under study (“Metabolic Syndrome”, “Hypertension”, “Diabetes”, “Central Obesity”, “Cholesterol”, “Triglycerides” and “Occupational Health”:  $p < 0.05$ ) (Table 2), thus, we worked with nonparametric population comparison tests. The RSV values for each topic can be found in Table 1 and the trends can be seen in Figure 1.

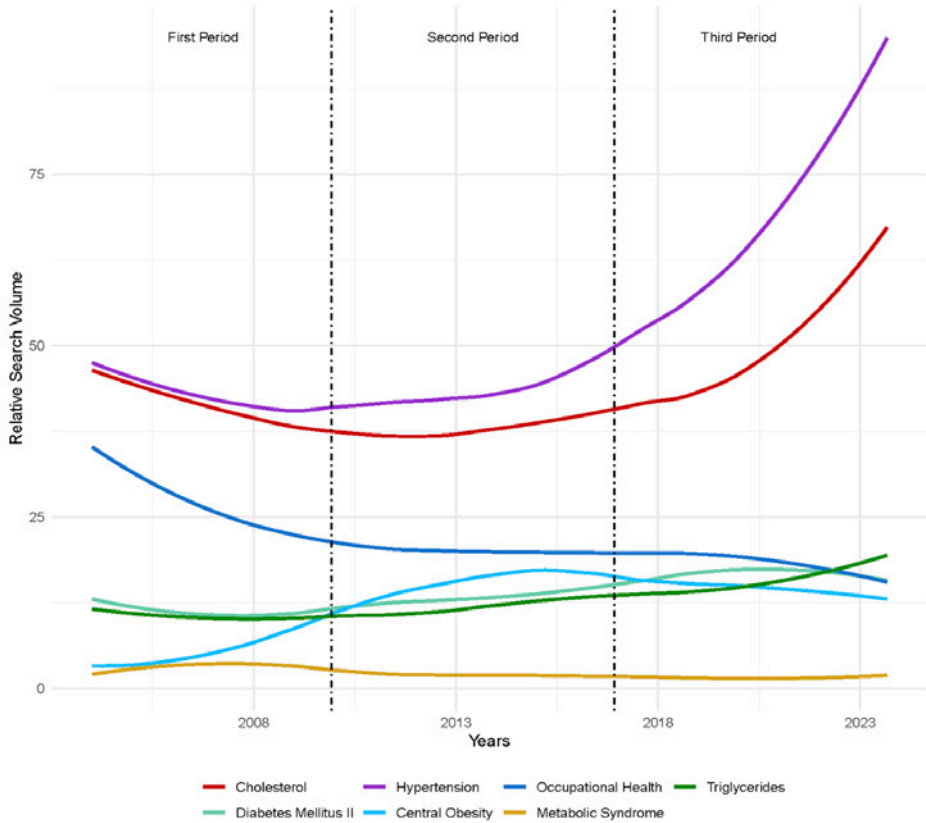


Figure 1. Search trends procured from Google Trends according to the 3 periods.

Table 1. Median and Pearson Determination Coefficient for RSV.

Topics	M Global	PDC Global	M1	PDC1	M2	PDC2	M3	PDC3
Occupational Health	21	-0.76 ***	26	-0.79 ***	20	-0.26 *	19	-0.67 ***
Metabolic Syndrome	2	-0.71 ***	3	0.3 *	2	-0.44 ***	2	0
Hypertension	46	0.77 ***	43	-0.57 ***	44	0.41 ***	64	0.91 ***
Central Obesity	14	0.72 ***	5	0.87 ***	15	0.58 ***	15	-0.39 ***
Diabetes	14	0.82 ***	11	-0.38 **	13	0.48 ***	17	0.04
Cholesterol	41	0.52 ***	41	-0.69 ***	38	0.35 **	49	0.82 ***
Triglycerides	12	0.84 ***	11	-0.2	12	0.72 ***	15	0.77 ***

M = Median; PDC = Pearson Determination Coefficient

Statistical results correspond to Pearson Correlation Coefficient with his corresponding p-values:

\* p-value < 0.05; \*\* p-value < 0.01; \*\*\* p-value < 0.001

**Table 2.** Statistical results and normality test.

Topics	Min	Mean	SD	Max	KS
Occupational Health	14	21.58	4.75	38	0.19 ***
Metabolic Syndrome	1	2.23	0.87	5	0.33 ***
Hypertension	35	51.59	14.61	100	0.22 ***
Central Obesity	3	12.25	5.03	21	0.17 ***
Diabetes Mellitus II	8	13.84	2.68	20	0.13 ***
Cholesterol	29	42.93	7.76	71	0.16 ***
Triglycerides	8	12.71	2.65	20	0.17 ***

*Min = Minimum; SD = Standard Deviation; Max = Maximum; KS = Kolmogorov–Smirnov normality test*

*Statistical results correspond to Kolmogorov–Smirnov test with his corresponding p-values:*

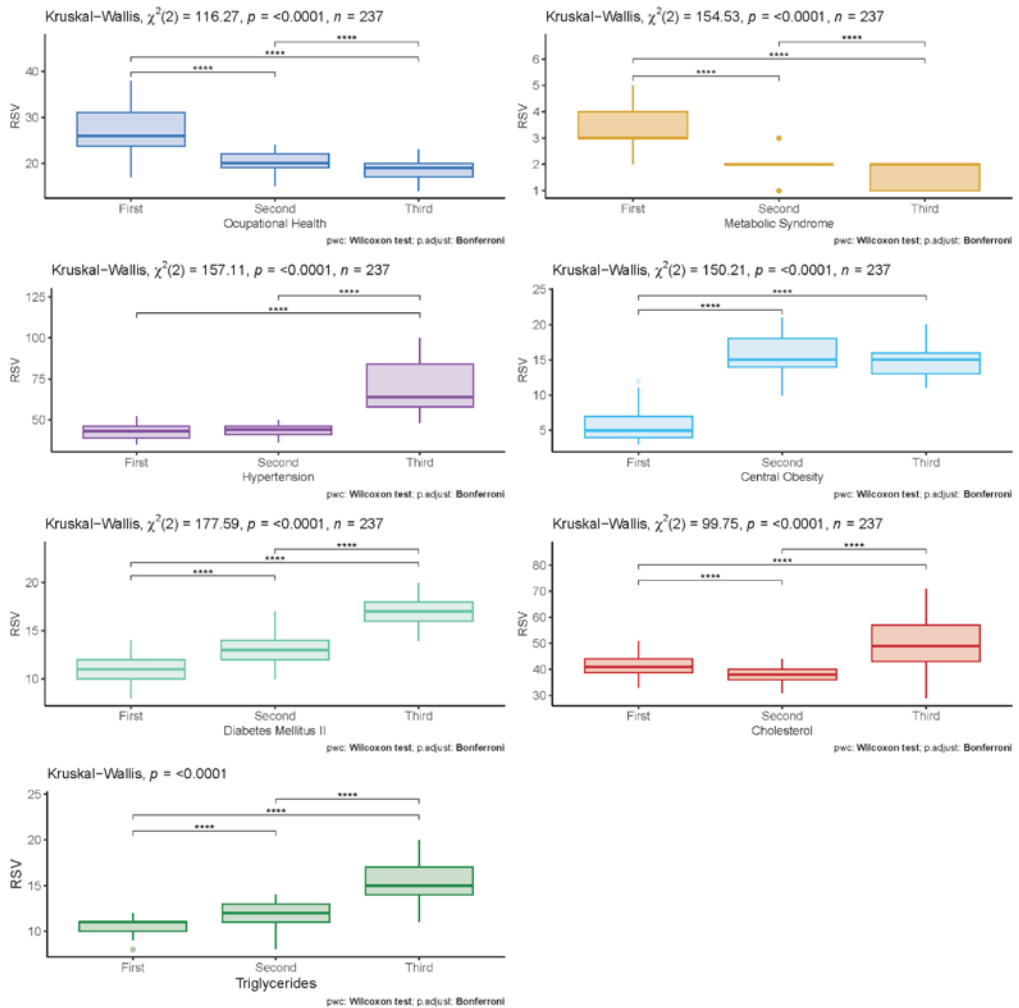
*\* p-value < 0.05; \*\* p-value < 0.01; \*\*\* p-value < 0.001*

The relationship between MS and OH demonstrated a positive correlation ( $R = 0.56$ ;  $p < 0.001$ ). The correlation observed between MS and its related topics featured the following outcomes: regarding Hypertension ( $R = -0.37$ ;  $p < 0.001$ ), Diabetes ( $R = -0.36$ ;  $p < 0.001$ ), Central Obesity ( $R = -0.70$ ;  $p < 0.001$ ), Cholesterol ( $R = -0.08$ ;  $p > 0.05$ ), Triglycerides ( $R = -0.40$ ;  $p < 0.001$ ).

## Trends

From the RSV data searches, the search trend was obtained for the studied Topics (Figure 1), showing the median and the evolution (established by the coefficient of determination) for the time series, as well as for each of the three analysed periods. Specifically, for MS and OH, a linear decreasing pattern was observed in both cases.

Having segregated the data according to the studied period, it was possible to calculate using the Kruskal-Wallis test, whether the RSV demonstrated the same distribution (Figure 2). It has been noted that in all the analysed Topics and for all periods, significant differences were found, of lesser or greater intensity, except for two comparisons: the Hypertension, where there was no relationship between the first and second period, and the Central Obesity, where there was no relationship between the second and third period.



**Figure 2.** Box plots of the Relative Search Volume results of the analysed Topics according to the different time periods.

### Seasonality

Throughout the years, the study seasonality in the searches was annually performed for the study period. Using the specific and non-parametric test for seasonality search (KPSS), it was observed that only the Topic Metabolic Syndrome featured seasonality. The situation was not observed in the searches with the other Topics (Figure 3).



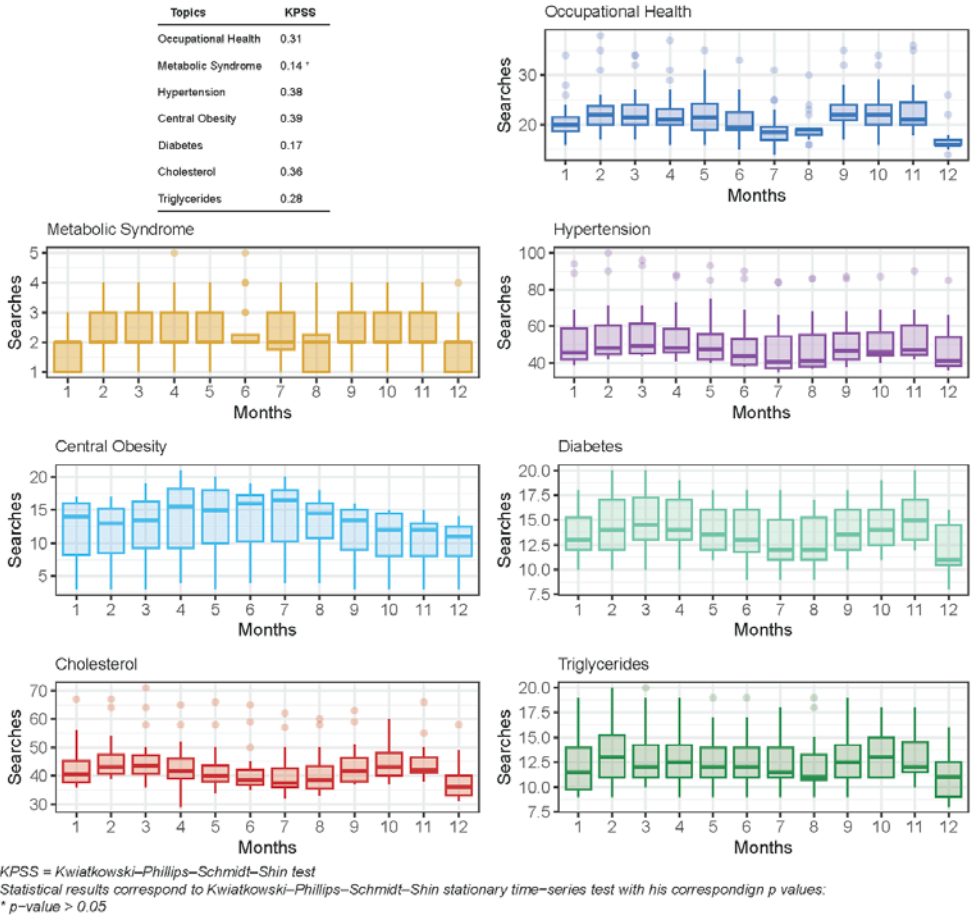
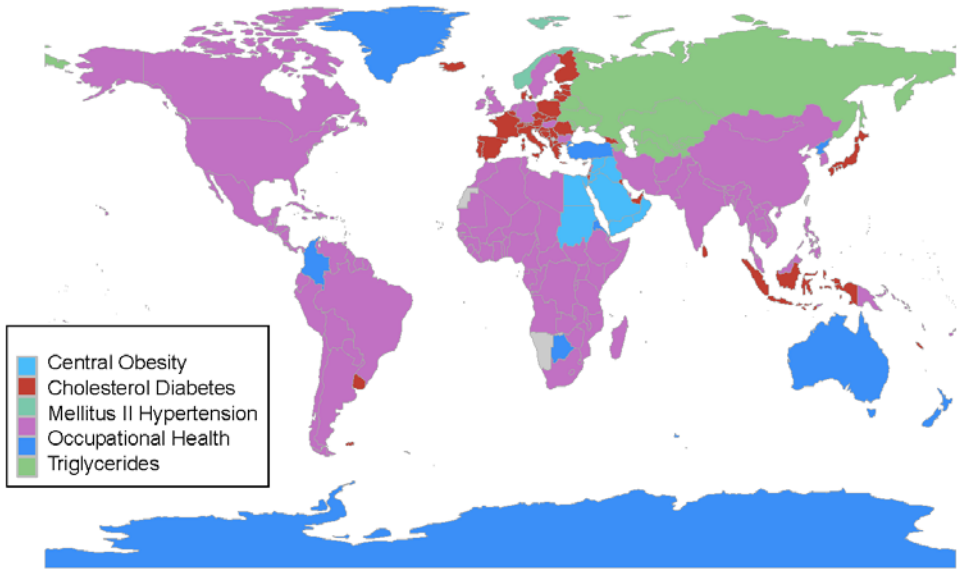


Figure 3. Box plots of the seasonality of each Topic grouped by month.

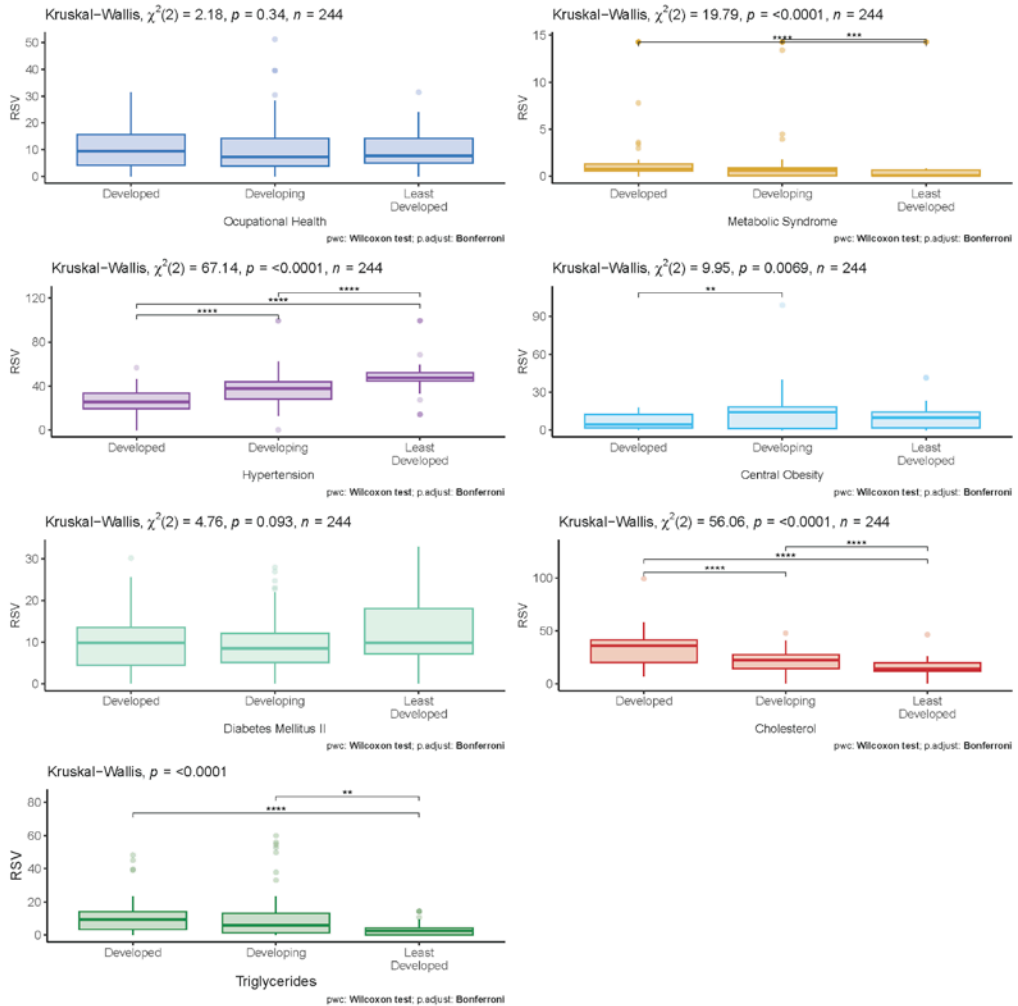
### Interest according to country

The interest in searches for the topics studied by country can be seen in Figure 4, which highlights the topic that featured the most searched topic. Neither of them the MS was the most searched topic.



**Figure 4.** Most searched topic by country.

To determine the possible differences in population interest, procured from RSV, according to the level of development of the country, following the classification of the United Nations Development Program, a group comparison analysis was carried out for each topic. For the OH topic no significant differences were found in the RSV, albeit there were meaningful differences on the SM Topic between developed and developing countries versus underdeveloped countries, see Figure 5.



**Figure 5.** Box plots of the Relative Search Volume outcomes of the classified Topics according to the development level of the different countries.

## Discussion

In this work, it has been verified that GT provides information on the population’s interest in disease data and permits the analysis of differences in the popularity of certain Topics and even between different countries over time. In this infodemiological ecological study, the global popularity of searches on MS and OH related topics was ranked among Google users. The analysis disclosed some results that deserve a detailed discussion.

Nevertheless, it should take into consideration that this is an ecological data analysis, and the findings might not be representative at the individual level<sup>(20,21)</sup>. For instance, RSV trends are at the population level and may not deduce that only the individuals who suffer from metabolic syndrome are those who indeed create all the search volume concerning this pathology.

## Relative Search Volume (RSV) and Trends

The good correlation observed between the MS and OH Topics demonstrates a similar trend in both searches for this information, albeit there is a disparity in the correspondences amid MS and its component pathologies (Hypertension, Abdominal Obesity, Diabetes, Cholesterol and Triglycerides). This situation can also be seen in the RSV medians, which in all cases are higher than that calculated for MS. To these data, it should be added that while the ailments that make up the MS feature increasing trends in the search of information, both MS and OH demonstrated diminishing results (significantly lower in the current period).

Although the relationship between MS and OH is not coincidental<sup>(22)</sup>, these observations might be because the general population are acquainted with the diseases that make up MS, while the ailments that compound MS and OH are not, or at least not to the degree of the other search Topics. This would justify the relation amid these two Topics with each other, but the different demeanour with the others. Thus, the low correlation observed between some terms might have been due to their different social awareness.

This assessment is according to Santacruz-Salazar et al work<sup>(23)</sup>, on MS knowledge in overweight or obese patients, in which they concluded that these people had a dearth of knowledge of MS aspects in comparison with those who were overweight, and the participants recognized SM as symptomatic pathology, but not as a set of risk factors. Lo et al.<sup>(24)</sup>, carried out similar research on the knowledge of MS in Chinese adults, in which study participants showed a poor understanding of this pathology. By the same token, another study demonstrated that education level has an impact on MS knowledge in elderly people, and, thus, the development of health education programs would enhance the prevention and self-control of SM<sup>(25)</sup>.

Ayala-Aguirre et al.<sup>(26)</sup>, in a recent study, pointed out that searching by using technical words as in the case of MS is not common in GT. The vast majority of the population does not search using technical terms; they tend to perform this type of search using general topics or frequently common words. That is to say, the diseases that make up MS are better known in isolation, and therefore, it is not startling that these diseases are more searched by the general population as well as they associate them with MS.

## Seasonality

In most of the tests for searching seasonality, the null hypothesis is the existence of a unit root that would discard seasonality, notwithstanding, in the KPSS test we use the analysis of moving median over the time period of study to straightway test for seasonality, allowing the detection of time trends, even if we do not have constant mean signals over the entire time period of the study. In this way, this test is more robust when finding seasonality in a signal in which the trend is not gradually constant (recall the trends in figure 1). Moreover, it is the non-parametric version of the moving median study, so it is appropriate for our variables under study.

Occasionally, MS has been featured as an epidemic disease<sup>(27)</sup> as well as related to healthy lifestyles<sup>(28)</sup>. Seasonal change in the incidence of the epidemiological disease is a common phenomenon. Although sometimes the mechanisms responsible for this incidence and the epidemiological aftermath of seasonality are not well understood<sup>(29)</sup>.

On this matter, the possible variations in the search information were studied and was verified whether it demonstrated a temporal evolution (according to seasonality) in the form of sawtooth, as pointed out in a previous study<sup>(10)</sup>. On the other hand, it was not possible to observe any milestone, as the special interest that responded to specific events (i.e., significant increase in the incidence of the disease, specific prevention campaigns and so on) since they generally result in a heightened interest of the population in the subject and thus, a considerable number of information searches<sup>(30)</sup>. The detection of milestones (peaks of searches) is relevant information to demonstrate epidemiological behaviour as well as to verify the relationship with certain moments of increasing disease data<sup>(31,32)</sup>.

In this study, it was not observed that any Topic features an evolution in its RSV in the form of sawtooth nor it was possible to corroborate the existence of any notable milestone, even so moderate seasonality was found for the MS and Diabetes topics, however, it was not conclusive for the rest of the analysed topics.

### Interest according to country

The RSV data obtained with GT facilitate to have an insight into the interest of the public, from different countries, in the topic under study. As it has been proved and according to previous work<sup>(21)</sup>, search engine trends are a tool that may integrate into real-time the monitoring of the population's health information needs.

From the procured outcomes, which were shown visually on the world map, it was found that in none of them was the MS the most searched topic. However, it should be noted that there were significant differences regarding information search on MS between developed and developing countries in contrast with the less developed countries. These results would be consistent with what we have seen previously when studying RSV and search trends in which it was observed that the education level influences knowledge about MS<sup>(33)</sup> and consequently, in the information searching interest.

Although the onset of MS was in the Western world, however, it has become a truly global problem<sup>(27)</sup>. The main causes were increased urbanization, nutritional transition and reduced physical activity, these conditions gave rise to the prevalence of MS to increase swiftly in developing countries, leading to rising morbidity and derived mortality<sup>(34)</sup> which would justify the increased interest in information search on MS.

However, when analysing RSV's, it should be taken into consideration that it is difficult to know the responsible relationship of outcomes by region regarding Google access (or any search engine) and these may be due to different reasons (appearance of news in the main media of a certain country, regional health campaigns focused on a certain disease and so on), and, remember that GT only provides results of searches that have high traffic<sup>(35)</sup>.

On the other hand, no country was found where the RSV of the Topics under study was not reported. This circumstance, if it was found, is mainly due to two motives: the digital divide or the filtering of social content.

Regarding the digital divide, it is not only a technological problem, but also the differences that appear in having or not an Internet connection, or in the type of connection. Digital health services depend on sociodemographic and socioeconomic factors. The filtering of social content (censorship) befalls in countries for which Internet blocking is observed, censoring topics that contradict the accepted social rules of a country (pornography, gambling, alcohol, and drugs, LGTBI content and so on). These countries that are characterized by censoring online news and information are known as "enemies of the Internet"<sup>(36,37,38)</sup>.

### Limitations of this study

According to Johnson & Mehta<sup>(20)</sup>, given that Google Trends does not provide real usage data and more accurate time intervals, decreases the forecasting capability. Besides, greater transparency is lacking, since there is no information on the specific methods and models that Google uses to calculate the RSV, and as it has been suggested in several publications<sup>(10,21,39)</sup>, the outcomes procured using this tool might be swayed by media interest, mainly advertising campaigns, which may not exactly correspond to the interest of the general population.

## Conclusion

Through their information searches, the whole population showed to have a dearth of knowledge of MS than of its component diseases. A relationship was found between the information searches carried out on MS and OH.

The study of information search trends may provide useful information on the population's interest in the disease data, as well as would gradually allow the analysis of differences in popularity, or interest even between different countries.

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