RESEARCH ARTICLE

A descriptive study of the regional and time-point changes in the Filipinos' internet search for tooth decay and toothache

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ABSTRACT

Background: The Philippines has one of the highest prevalence of untreated tooth decay (TD) in the world. Toothache (TA) is a common sequel of chronic and untreated TD. Google Trends (GT) offers an inexpensive and fast method of assessing search trend for these health conditions.

Objectives: This study aimed to characterize the regional and time-point variations in the Filipinos' internet searches for TD and TA.

Methods: A descriptive analysis of a search query done on Google Trends using the search terms TD and TA was done. The parameters were constrained to include only data from the Philippines, from November 2009 to November 2019, under the health category, and the web search database.

Results: The top three regions that had the highest searches for TA were MIMAROPA (100%), ARMM (100%), and Caraga (82%), while CAR (27%), Metro Manila (27%), and Ilocos Region had the highest search results for TD. From 2009 (19.85%) the searches for TA progressively increased until 2019 (92.61%), while the searches for TD remained comparable from 2009 (25.09%) to 2019 (25.98%).

Conclusion: The results of this study reveal regional and time-point differences in the Filipinos' search interests for TD and TA.

Keywords: *toothache, tooth decay, health behavior, data mining, Google Trends*

Introduction

The World Health Organization (WHO), *Fédération Dentaire Internationale* (FDI) World Dental Federation, and Department of Health (DOH) of the Republic of the Philippines have been advocating for the promotion of oral health [1,2,3,4,5]. These institutions encourage the prevention of dental caries through anticipatory measures as opposed to dealing with the burden of dental pain [6]. Dental caries that are left untreated progress to dental pain and affect the day-to-day productivity and overall quality of life of a person [7,8,9]. Dental pain affects a person's perception of the need to seek dental services. Alleviating the burden brought by dental pain results in an improvement in the social and psychological well-being of an individual. In developing countries, rural areas, and remote places, the treatment of preference is tooth extraction [10,11,12,13].

In the Philippines, dental caries (87.4%) and periodontal diseases (48.3%) have been tagged as the most common oral health illnesses. The DOH pointed out regular visits to the dentist, early diagnosis, preventive care, fluoridation, good nutrition, reduction of sugar intake, and regular toothbrushing with flossing as key components to avoid dental caries. The Rural Health Units (RHU), health centers in the cities, and public health hospitals are the primary sources of these services. Despite these, the services are limited only to oral examination, dental sealants, toothbrushing instructions, oral health education, and dental fillings. These are some of the strategies undertaken by the DOH to meet its vision of attaining 12%-20% of Orally Fit Children (OFC) by 2020 [5]. Notwithstanding these efforts, the Filipino still suffers from the dearth of funding for oral health and limited services. In addition, the majority prefer to receive these services from private clinics or short-term dental missions and use out-of-pocket payments or direct payment by an individual from one's personal money [14]. The valuation of dental services and the dental profession as a whole is currently very low in

the country [15]. These conditions might leave the person with no choice but to seek answers from the internet and self-medicate [16,17].

About 3.5 billion searches per day or 1.2 trillion searches per year find their way to the Google search engine, which accounts for 70% of the internet search business [18]. The insights they provide and the prediction mechanism they can offer regarding the attitude towards health and actual well-being of the population may be the value of these aggregates of data. Google Trends or GT (https://trends.google.com/) is a product of the American multinational technology company, Google LLC, that can analyze these search pattern statistics. Free, easy-to-use, and ability to segregate data per nation or region and at different time points are just some of the features that make this online portal useful. Health-seeking behavior information from the internet has been previously reported and implicated to aid in actual healthcare treatments [19]. In the past, GT has been used to assess behavioral patterns through search interest for Ebola, dengue, breast cancer, Zika, and malaria [21,22,23,24].

The aim of this study was to characterize the Filipinos' internet searches for tooth decay (TD) and toothache (TA). Specifically, the objectives were to (1) show the regional differences, and (2) exhibit the temporal changes in the searches for TD and TA in the Philippines. To the knowledge of the researchers, there has been no study correlating the peak popularity of internet searches by Filipinos on dental caries and dental pain from 2009 to 2019. This information will be valuable in explaining and understanding the oral health-seeking behavior of the Filipinos, as an increasing interest in TA over TD may indicate the delay in seeking treatment until symptoms occur. This study also showed the changes in the aforementioned search terms among regions and per year which may indicate the rising need for dental services in some areas.

Methodology

A brief introduction to Google Trends

Through an analysis of web queries on the Google Search databases, GT provides retrieval of internet search patterns. These search outputs may be downloaded in comma-separated value (CSV) files for further analyses in a statistical software. GT can provide real-time data or those search aggregates made in the last seven days or non-real-time data which can span as far as 2004. These data are anonymized, categorized, and aggregated to allow the presentation of interests in specific search terms and certain geographic locations. Data are normalized to the time and location of the search query. Individual data points are divided each by the overall searches within the geographic location of choice and the selected time range. Grounded on a topic's ratio to all searches on all topics, the values are then adjusted on a range from 0 to 100 (Figure 1).

Search query

The search terms TA, categorized as a disease, and TD, categorized as syndrome, were chosen to be included in the search query. The search parameters were limited to the Philippines as location, November 2009 to November 2019 as timeline, health as search category, and web search as the database. Several charts and projected data were then produced by the graphic user interface of GT. These charts were the interest over time chart, subregion comparison breakdown chart, interest by subregion per search term, and related queries per search term. The interest over time chart showed a bar graph comparing the overall average of the search terms in the given search parameters. The right side of the panel also contains a line chart that conveyed the frequency and amplitude of bulk searches expressed in relative search volume (RSV). The RSV is expressed in units called peak popularity which represents the search interest to all searches done in relation to the highest peak for the reference place and time. The peak popularity ranges from 0-100 where 100 is the maximum percentage and 0 is the minimum. The minimum entry pertains to an absence of data or inadequacy of data to be plotted.

The compared breakdown by region panel contains a color intensity map chart that can be manipulated to show the density of RSV per region and per term. The related queries panel contains the other search terms used by the internet users which can be sorted by top queries or rising queries. The top queries are the search terms that were most popularly used, where 100 is the value given to the term with the highest entry. The rising queries are the search terms that make the largest increase in the frequency of searches. The data were downloaded in CSV files. While the Philippines is generally bilingual, or multilingual in some places, related queries were checked for consistency. GT also considers related searches done in the local dialect. The related terms for TA are toothache, tooth, toothache remedy, tooth pain, toothache medicine, ache, medicine for toothache, toothache, toothache home remedy, and toothache reliever. For TD the related search terms are cavity teeth, toothache, tooth decay treatment, tooth decay

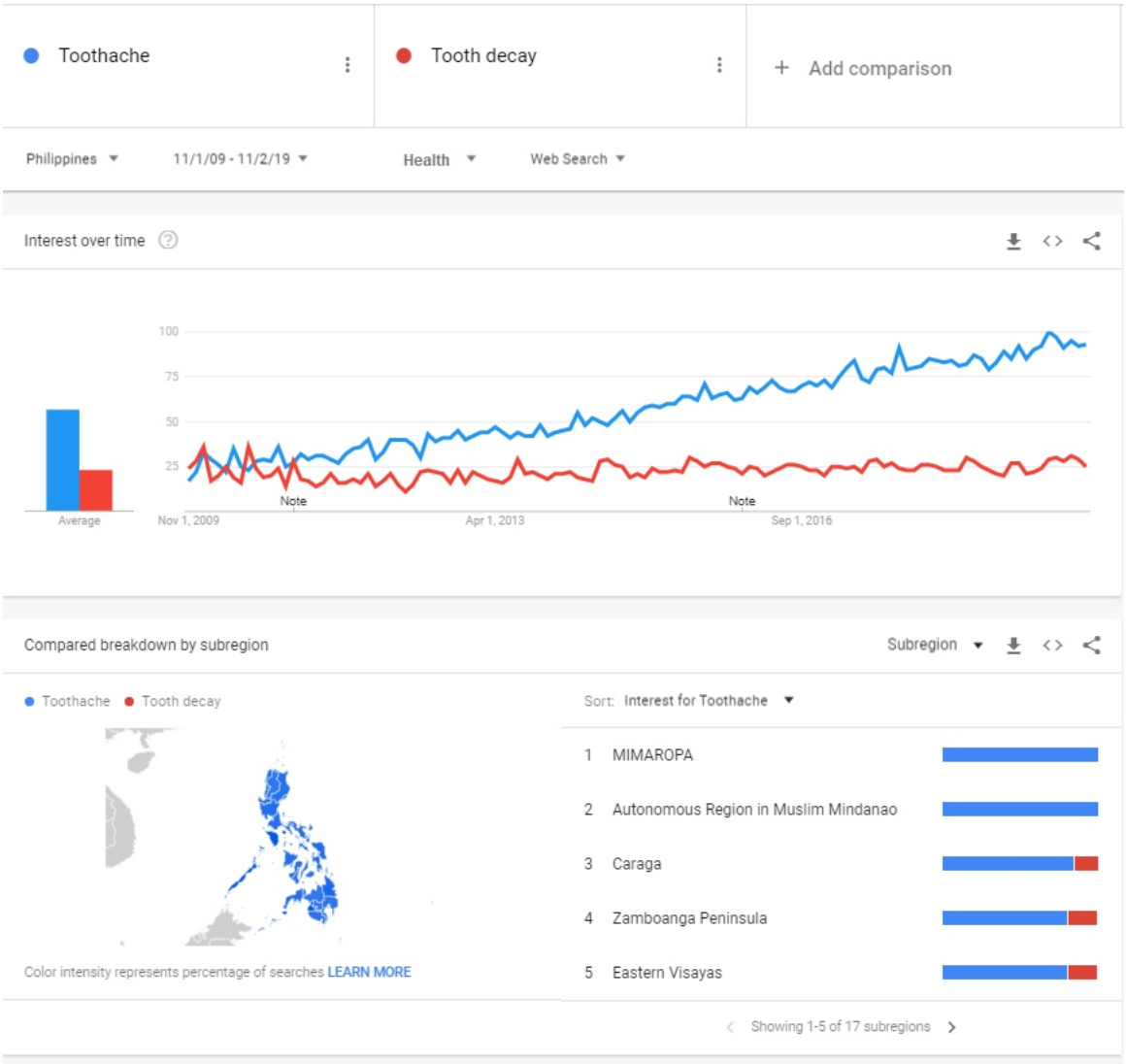

Figure 1. *A screenshot of the graphical user interface of Google Trends (https://trends.google.clom/).*

cure, tooth extraction, caries, cavity meaning, teeth with cavities, gingivitis, and cavities meaning.

Ethical approval was sought from the Institutional Review Board of the School of Dentistry of Southwestern University PHINMA but was found to be exempt.

Statistical analysis

From the CSV files, data containing the RSV per region were imported into a grouped table where the two columns were designated as the search terms and the rows were labeled as the regions. Data were plotted into grouped stacked bars. The data containing the interest-over-time were imported on a column table where the columns were categorized into search terms and further subdivided into sub-columns which represented the RSV per month. The rows represented the years which were segregated individually. The yearly temporal changes of the search terms were plotted in a connecting line graph. Descriptive statistics were done on GraphPad Prism 8.

Results

A total of 17 regions of the Philippines were included in the GT database. For the yearly changes in search trends, 11 years of search data at 12 months per year were considered.

Search interests for toothache and tooth decay per region

The average RSV for TA in the Philippines from 2009-2019 was 79.65%. The top three regions that had the highest searches for TA were MIMAROPA (100%), ARMM (100%), and Caraga (82%). The other regions that scored above the mean

were Cagayan Valley (81%) and Bicol (80%). Majority or 12 of the regions, such as Central Luzon (79%), Western Visayas (79%), Soccksargen (78%), Calabarzon (77%), Zamboanga Peninsula (77%), Northern Mindanao (76%), Davao Region (75%), Eastern Visayas (75%), Central Visayas (75%), Ilocos Region (74%), Metro Manila (73%), and CAR (73%) scored below the mean.

At an average RSV of 20.35% for TD, the regions that scored above it were CAR (27%), Metro Manila (27%), Ilocos Region (26%), Central Visayas (25%), Eastern Visayas (25%), Davao Region (25%), Northern Mindanao (24%), Zamboanga Peninsula (23%), Calabarzon (23%), Soccksargen (22%), Western Visayas (21%), and Central Luzon (21%). There were only five regions that recorded RSV below the average. These were Bicol (20%), Cagayan Valley (19%), Caraga (18%), ARMM (0%), and MIMAROPA (0%) (Figure 2).

Temporal changes of searches for tooth decay and toothache from 2009 to 2019

With an average RSV of 55.25%, a progressively increasing trend can be observed in the search interests for TA. In 2009 (19.85%), 2010 (31%), 2011 (31.92%), 2012 (37.42%), 2013 (47.50%), and 2014 (50.58%) the search volumes were below the mean. Substantial increase in the search interests were seen in 2015 (64.33%), 2016 (69.25%), 2017 (79.33%), 2018 (83.92%), and 2019 (92.61%).

At an average of 22.62% searches per year for TD, the RSV in the year 2009 (25.09%) exceeded that but plummeted in the year 2010 (19.25%), 2011 (17.42%), 2012 (18.17%), 2013 (19.17%), and 2014 (22.50%). The Filipinos regained enthusiasm in 2015 (25.58%), 2016 (25.25%), 2017 (25.58%), 2018 (24.83%), and 2019 (25.98%) as the search for TD surpassed the yearly average during these years (Figure 3).

Discussion

Aside from impaired speech, eating problems, sleep disturbance, and reduced school performance, untreated dental caries or TD affects the quality of life by producing pain as a sequela [25,26]. In the Philippines and across the globe, TD remains to be the predominant chronic illness in children.

Even though only five out of the 17 regions scored above the mean in searches for TA in this study, it is alarming to note that all regions exceeded well above 50%. As the GT score of

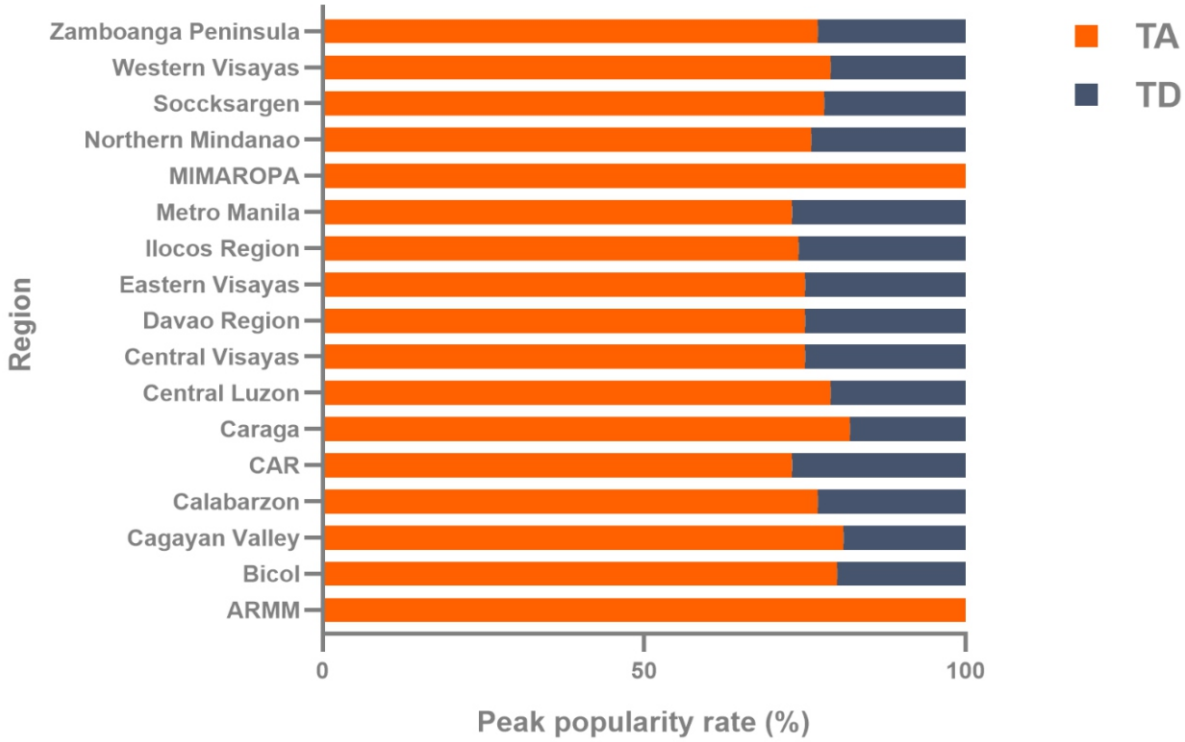

Figure 2. *The search interest for TA and TD among the regions of the Philippines from 2009-2019. MIMAROPA=Occidental Mindoro, Oriental Mindoro, Marinduque, Romblon, and Palawan, CAR=Cordillera Administrative Region, ARMM=Autonomous Region in Muslim Mindanao, TA=toothache, TD=tooth decay.*

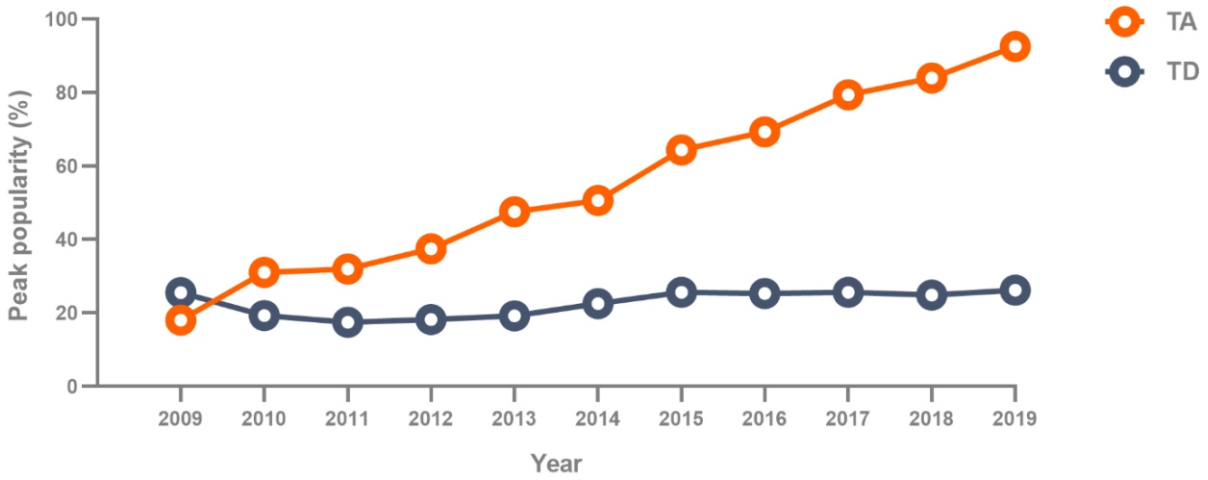

Figure 3. *The annual trend of search interest for TA and TD in the Philippines from 2009 to 2019. TA=toothache, TD=tooth decay.*

0% is considered low and 100% for high interest, a score of 50% is considered moderate. This result may indicate that people from all over the Philippines are seeking treatment for TA over the internet. This might mean that these internet users are self-diagnosing and on the verge of self-treatment. There has been a growing prominence on the autonomy of the patient in terms of health decision-making [27,28]. This could also be interpreted that TA is widespread at a nationwide scale. It is likewise interesting to note that the top five regions that accumulated the highest interest in TA are among the regions whose Gross Regional Domestic Product (GRDP) is below PHP 50000. The GRDP is the average income of people in a given region [29]. A Canadian study, found that Filipino children were almost 5-times more likely to have serious untreated dental ailments than White children. It also found that together with Arabs, Filipinos had the worst dental caries prevalence and the average count of DMFT (decayed, missing, and filled teeth). This has been attributed to lower socioeconomic status and poor oral hygiene [30]. Notwithstanding this study, another study found that parents of Filipino immigrants are open to newer models of preventive oral healthcare and are willing to adapt to better oral health practices [31].

In this study, the search term TD was meant to suggest the Filipinos' oral health-seeking behavior in terms of wanting to treat dental caries. Nutrition and the widespread availability of refined sugary products in the Filipino diet may also play a role in the rising prevalence of TD. Yabao *et al.* [32] found that dental caries increased with added sugar consumption in La Trinidad, Benguet. They found that the molar teeth in the temporary dentition were most prone to caries and resulted in dental pain. This phenomenon was the result of public health awareness deficit and the lack of early caries prevention knowledge. The provincial capital of La Trinidad is located in CAR which scored highest at 27% RSV, along with Metro Manila, in its interest for TD in this study. This coincides with another paper that reported CAR's 100% caries prevalence rate nationwide in 1998 [33]. This was the highest in the Philippines at that time.

When comparing the results for TD and TA, the latter scored significantly higher in this study. This may be due to the neglect in treating TD which frequently results in TA. Poverty, parents' educational attainment, dental insurance coverage, parents' willingness-to-pay for dental services, fear of dentists, and ethnicity are just some of the reasons why people defer the treatment of TD [34,35,36,37,30]. Although in some studies, people in developed countries also seek dental treatment for the relief of pain and not for preventive purposes [38,39].

From a 19.85% RSV in 2009 to a whopping 92.61% in 2019, the search interest for TA gradually increased in a span of 11 years. The rising trend in TA and the persistent interest for TD may be due to the poverty incidence in the Philippines. Even though the poverty incidence in the Philippines regressed in 2018 (16.6%) compared to 2015 (23.3%), this still translates to 17.6 million Filipinos living below the poverty threshold. About 5.2% of Filipinos still have insufficient income to afford basic food needs in 2018 [29] . The lesser the supply of dental services the greater the demand from the public. The diminished role of dentists in public health education, the lack of dentists in the public health system, the Department of Health and government's inadequate prioritization of oral health, and insufficient sustainable programs from the Philippine Dental Association

may also contribute to the public's self-seeking behavior for treatment [36]. Other reasons could be the increasing population and the growing number of internet users in the Philippines. According to The World Bank, the Philippines had a total population of 92.41 million in 2009 but grew to 106.65 million in 2018 [40]. Additionally, at an average of 10 hours and 2 minutes of internet use per day and 99% active in at least one social media site, the Philippines ranks first in internet usage globally [41].

The findings presented in this study are merely based on the descriptive analysis of time series data downloaded from GT. Facebook, Twitter, YouTube and other social media sites can also be harvested for information [42,43,44]. Even if GT can provide insights into the search behaviors of a certain population, these data are percentages gathered from samples and not the tangible numbers. Moreover, GT does not have the capability to segregate the data according to age and gender [19]. Actual data from government agencies with demographic information could be correlated in inferential studies. Despite having English as one of the Philippine's official languages, using dialect-specific terms in the search query in a multilingual country like the Philippines may have repercussions. With the impending ASEAN integration, a prospective study on oral health-seeking behavior, including the other ASEAN countries, could also yield importance [45].

In conclusion, this study reported geographic disparities in the Philippine regions' search interest for TA and TD. The results also showed an increasing interest in TA and an unremitting interest in TD from 2009 to 2019.

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