Tendency of Internet Search Data of Oral Neoplasms and Impact of Public Health Programs in European Union

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Abstract

Background: Tobacco and alcohol are the main risk factors for oral squamous cell carcinoma, the low survival rate of which is a public health problem. European-wide health policies (prevention campaign, tobacco packaging) have been put in place to inform the population of the risks associated with their consumption. Due to the increase in smoking among women and changes in sexual practices, the incidence of this disease is still too high. The identification of data from internet research on the population could make it possible to measure the impact and better orient these preventive measures.

The objective was to analyse the data on interest shown in oral cancers from several online databases, and to cross-reference them with the data on the introduction of European public health programs.

Methods: A search of data from Google ©, Wikipedia © and Twitter © users in 28 European countries relating to oral cancer between 2004 and 2019 was carried out. Bibliometric analysis of press and scientific articles over the same period was also analysed. The association between these data and the introduction of public health programs in Europe has been studied.

Results: Changes in tobacco packaging correlated with a significant increase in internet research on oral cancer in 7 countries. Unlike national policies and campaigns, the European awareness program Make Sense has had no influence on internet research. There was an asymmetric correlation in internet searches between publications on oral cancer from scientific articles or "traditional" media (weak association) and those from internet media such as Twitter © or Wikipedia © (strong association).

Conclusion: Our work highlights 7 areas of work around which oral cancer awareness in Europe could be refocused.

Background

Oral cancers and their risk factors

The clear majority of oral cancers are attributable to tobacco and alcohol. The population should be informed about the potential consequences of their consumption. [1,2]

The increase in consumption of tobacco among women and the evolution of sexual practices have led to an increase in oral cancers among women and oropharynx cancers caused by Human Papilloma Virus (HPV) respectively. [3-5]

The low survival rate of oral cancers justifies effective prevention and screening.

Prevention of oral cancers and raising awareness of them among the population of the European Union.

By limiting the consumption of tobacco and alcohol and raising public awareness, the worldwide prevalence of the disease could be reduced by 75%. [6]

Prevention is also an economic issue. In Europe, the average annual cost of an oral cancer patient in 2012 was between €20.000 and €23.000.

In the European Union, smokers have been informed of the risks of tobacco consumption since the introduction of directive 2014/40/EU. Since 2016 this has forced the 28 member states to follow rules on manufacturing, presentation and sale of tobacco and its derived products.

Since 2013, the Make Sense Campaign (MSC) has been raising awareness and providing information to the European population on head and neck cancers. Organised by the European Head & Neck Society (EHNS), it involved 18 countries in 2018. In parallel, certain European countries have organised their own national campaigns.

Evaluating the effects of health measures on the EU population.

It would be tedious to survey a population as large as that of the EU to evaluate the large-scale impact of these measures.

It has been shown that on the internet, on-line search trends mirror temporal trends. They show peaks or increases during epidemics or for any other increase in interest in an illness. [9,10]

The analysis of data obtained by this biases would be effective for the study of illnesses, with precision comparable to normal epidemiological methods. [11-13]

In 2016, Ayers et al. raised the possibility of using Big Data to rapidly and cheaply evaluate the effects of awareness campaigns. They studied the effects of national no smoking day in the United States (Great American Smokeout) and showed that it led to a significant increase in the number of internet searches. [14]

The objective of our study was to analyse the search data related to oral cancers from Google Trends©, the bibliometric analysis of scientific articles on the topic, Wikipedia page consultations, articles published in the press and on Twitter© and to cross check them with the data on the introduction of anti-tobacco public healthcare programmes in the EU.

Methods

Working outline and inclusion criteria

This observational retrospective bibliometric analysis used search data collected from Google©, Wikipedia© and Twitter© users in the 28 EU countries between January 1st, 2004 and September 30th, 2018 inclusive.

The data on press articles published and the bibliometric analysis of scientific articles during the same period were collected.

The link between these results and the introduction of public health programmes in the EU over the same period was studied.

On the 30th of September 2018, the countries included in this study had to: be members of the EU, have an internet penetration rate (percentage of the population with internet access) of over 50%, have a Google© search engine usage rate of over 50% and participate in the MSC.

Identification of public health programmes related to oral cancers in the EU

The oral cancer risk factor prevention awareness campaigns of each EU country included were researched alongside the public data from the World Health Organisation (WHO) and the EHNS.

A search was carried out on the WHO website (http://www.euro.who.int) in the 'health topics' category. The health programmes of each EU country were then identified using the 'alcohol use', 'oral health', 'tobacco', 'vaccines and immunization' and 'human papilloma virus and cervical cancer' pages.

Data collection

Data collection was standardised for each country.

A list of oral cancer clinical presentation key words was created and translated into the 24 official languages of the EU. For countries with more than one official language, the key words in each official language were listed.

a) Google Trends ©

Search terms based on the key words were entered into Google Trends© in the official language(s) of each included country to generate data linked to interest shown during the time period and in the geographical area studied.

The research was carried out according to recommendations from Nuti et al. by entering each key word as a 'search term' in the 'health' category. [11]

Google Trends© data does not provide an absolute value for interest in each search term. However, it does give an index (relative search volume -RSV-) which refers to the number of searches carried out for each term in comparison to the total number of searches carried out on Google.

Search terms which generated no data (RSV=0) for a country were excluded from the analysis.

b) Wikipedia

The Wikipedia page view statistics for oral cancers in the languages of each of the included countries were collected from July 1st, 2015 (date from which the statistics are publicly available) until September 30th, 2018.

Data was collected using the same key words as those previously used in the official language(s) of each country.

Pages whose view statistics were not available were not included.

c) Twitter ©

Public messages on Twitter © (Tweets) about oral cancers between January 1st, 2013 and September 30th, 2018 were identified using a key word search in the 24 official languages of the EU.

The start date was chosen empirically by the authors, considering that before 2013, this social network was not as widely used in the EU as in the period 2013-2018. A preliminary search that found more than 100.000 Tweets about oral cancers during this period confirmed the choice.

The key words used were identical to those used for the collection of data on Google Trends© and Wikipedia.

The number of users posting Tweets as well as the number of reactions ('retweets' and 'likes') were recorded.

d) Europresse ©

The Europresse database was used to evaluate media coverage of oral cancers.

A search of press articles was carried out. The search area was limited to Europe between January 1st, 2004 and September 30th, 2018. The same search terms were used as those for Google Trends©, Wikipedia et Twitter ©.

e) Bibliometric analysis

The Web of Science Core Collection and MEDLINE databases were used to carry out a bibliometric analysis of scientific articles published between January 1st, 2004 and December 31st, 2018. The oral cancer key words were the same as those found in the MeSH (Medical Subject Headings), combined with the Boleen operator "OR": "mouth neoplasm", "mouth cancer", "oral cancer".

Graphical and statistical methods of analysis

Using the data generated by Google Trends©, Wikipedia, Twitter and Europresse©, descriptive statistics and scatter plots were created for each search term with adjusted polynomial trendlines. [11,16-18]

Linear regression showed us the evolutionary trend of the bibliometric analysis of scientific articles.

To observe the relationship between 1 (searches carried out on Google©, Wikipedia, Twitter, Europresse) and 2 (the introduction of healthcare programmes), a Student's t test was carried out. Thus, one could compare the data linked to interest before and after the introduction of a healthcare programme and assess the significance of its variations.

Finally, Microsoft Excel© and MathWorks MATLAB© software were used to compare the search results from Google©, Wikipedia, Twitter, Europresse© and those from the bibliometric analysis, using variance analysis (ANOVA) and the Pearson coefficient of linear correlation, after verification of the conditions of application of these statistical tests.

All statistical tests were used after verification of their application conditions.

Results

Public health programmes

All the prevention measures found concerned tobacco: the introduction of health warnings and shock images on cigarette packets in Belgium (2006), Spain (2011), France (2011), Romania (2008) and the United Kingdom (2008), and the enforcement of directive 2014/40/EU in all 28 EU countries.

Three awareness campaigns were analysed: the MSC in Europe (every September since 2013), Mouth Cancer Awareness Day (MCAD) in Ireland (every September since 2010) and Mouth Cancer Action Month (MCAM) in the United Kingdom (every November since 1977).

Google Trends©

20 EU countries were included and 8 countries (Cyprus, Greece, Hungary, Italy, Malta, Portugal, Romania and Sweden) were excluded due to a lack of usable data.

In total, 43 searches in 17 languages for 4 key words were carried out: lip cancer (10 times), tongue cancer (13 times), gum cancer (6 times) and mouth cancer (13 times).

We noted a general increase in the popularity of the search terms over the period studied with an average increase in interest of 8.1% (mouth cancer: 14.2%, lip cancer: 8.3%, gum cancer: 5.5%, tongue cancer: 4.5%).

Wikipedia

The statistics for Wikipedia page views connected to oral cancers were available in 9 languages (Table 1).

Table 1. *Visits of the Wikipedia pages on oral cancers in different languages, Descriptive statistics (July 2015- September 2018).*

	Language	Page visits (2015-2018)	Monthly mean	Monthly median	Standard deviation	Variance	Range	Minimum	Maximum
1	English	966625	24785.25	24120	3111	9678349.72	12161	18894	31055
2	German	333502	8551.33	8694	1851.90	3429543.54	3769	5206	12739
3	Italian	147616	3785.02	3767	981.37	963085.39	3769	2145	5914
4	French	77300	1982.05	1628	1170.44	1369946.89	6098	936	7034
5	Dutch	55216	1415.79	1349	280.36	78601.69	1140	838	1978
6	Polish	50757	1301.46	1298	274.76	75493.20	1295	799	2094
7	Portuguese	39018	1000.46	1001	297.19	88323.83	1380	477	1857
8	Slovenian	14180	363.59	367	67.99	4622.62	307	257	564
9	Finnish	11080	284.10	279	74.65	5572.30	316	167	483

Figure 1 shows the evolution of Wikipedia page views over the period. We noticed a slight decrease in interest in these pages (-2.5%).

Twitter©

125.595 Tweets published by 49.168 users were documented in the 24 EU languages between January 1st, 2013 and September 30th, 2018. They generated 116.444 reactions (62.000 likes and 53.507 retweets).

On average, 1820 Tweets about oral cancers were published every month (median=1427 standard deviation=1268.81). The number of Tweets decreased by 22.65% between 2013 and 2018.

91% of Tweets about oral cancers were published in English. The 100 Tweets with the most reactions were published using accounts with high numbers of followers and routinely relayed the oral cancer diagnosis of a public figure.

Press articles

Searches on Europresse revealed 787 articles in English, 735 in French and 392 in German (Figure 1). Searches for articles in other languages did not return enough results to be useful.

On average, 4.44 articles about oral cancers in English (median=3, standard deviation=3.93), 4.15 in French (median=4, standard deviation=2.24) and 2.21 in German (median=2, standard deviation=1.57) appeared in the press every month between 2004 and 2018, with an overall increase of 12.2%.

Bibliometric analysis

11.875 scientific articles about oral cancers were published worldwide between 2004 and 2018, a yearly average of 789. The number of publications increased by 225% between 2004 and 2018 (Figure 1).

Worldwide, the most prolific countries were: The United States (3693 articles, 31.1% of publications), China (1710, 14.4%), Japan (1561, 13.14%), Taiwan (1486, 12.51%) and India (1410, 11.8%).

33.7% of articles (3998 articles) were published in EU countries. The United Kingdom (6th, 1068 articles, 8.99% of publications), Germany (8th, 557, 4.7%) and Italy (9th, 467, 3.93%) were the three most productive countries in the EU.

Introduction of new public healthcare programmes

The influence of the introduction of public health measures on the interest shown in oral cancers on Google©, Wikipedia and in the press, is shown in Table 2.

Table 2. Influence of public health policies on Google© and Wikipedia searches for oral cancers and in press articles on the subject in Europe. When one of the search terms studied isolated produced a significant result, it was highlighted (bis).

	Country or language	Monthly mean	Mean before the 2014/40/EU directive	Mean before health warnings (countries having adopted them before the 2014/40/EU directive)	Mean before the introduction of a national campaign	Mean after the 2014/40/EU directive	Mean after health warnings (countries having adopted them before the 2014/40/EU directive)	Mean during MSC	Mean during a national campaign
Google Trends© (RSV) 2004-2018									
1	Germany	25.45	24.80	-	-	28.21 p=0.175	-	26.38 p=0.87	-
1bis	Germany (for the isolated term "Mundkrebs")	23.21	21.68	-	-	29.67 p<0.01	-	28.3 p=0.24	-
2	Austria	15.40	15.49	-	-	15.06 p=0.842	-	12.21 p=0.85	-
3	Belgium	15.84	15.57	9.99	-	17.00 p=0.741	16.73 p= 0.06	15.33 p=0.88	-
3bis	Wallonia (keywords in French isolated)	27.5	26.95	12.25	-	29.82 p=0.48	29.87 p=0.02	27.83 p=0.97	-
4	Bulgaria	9.35	9.19	-	-	9.99 p=0.68	-	9.33 p=1.00	-
4bis	Bulgaria (for the isolated term "Рак На Гърдата")	0.98	0.85	-	-	1.5 p=0.03	-	1.66 p=0.35	-
5	Croatia	11.50	12.03	-	-	9.26 p=0.236	-	7.25 p=0.86	-
6	Denmark	21.08	18.24	-	-	33.15 p<0.001	-	32.50 p=0.17	-
7	Spain	30.66	30.17	27.57	-	32.74 p=0.450	33.43 p= 0.03	30.67 p=1.00	-
8	Estonia	3.00	3.09	-	-	2.62 p=0.808	-	0.00 p=0.47	-
9	Finland	10.01	7.28	-	-	21.53 p<0.001	-	12.33 p=0.69	-
10	France	16.03	15.32	14.51	-	19.05 p=0.01	17.43 p= 0.01	17.28 p=0.75	-
11	Ireland	9.12	8.48	-	6.87	11.82 p=0.18	-	13.00 p<0.001	10.4 p=0.03
12	Latvia	3.60	3.24	-	-	5.10 p=0.16	-	3.50 p=0.97	-

13	Lithuania	4.66	3.92	-	-	7.79 p=0.063	-	8.33 p=0.41	-
14	Luxembourg	15.34	14.82	-	-	17.55 p=0.283	-	15.44 p=0.88	-
15	Netherlands	16.52	16.89	-	-	14.94 p=0.527	-	10.50 p=0.36	-
16	Poland	12.51	12.43	-	-	12.84 p=0.764	-	8.00 p=0.58	-
17	Czech Republic	4.16	4.15	-		4.20 p=0.96	-	2.54 p=0.69	-
17bis	Czech Republic (for the isolated term "Rakovina Úst")	0.37	0.27	-	-	0.79 p=0.01	-	0.16 p=0.64	-
18	United Kingdom	24.82	23.79	26.1	24.82	29.21 p<0.001	24.35 p= 0.11	27.33 p=0.35	28.79 p= 0.02
19	Slovakia	10.07	9.48	-	-	12.59 p=0.247	-	9.83 p=0.97	-
20	Slovenia	1.63	1.60	-	-	1.79 p=0.896	-	2.67 p=0.75	-

Wikipedia (Number of page visits) 2015-2018

1	English	24785	25109	-	-	24726 p=0.78	-	21836 p=0.08	-
2	German	8551	10269	-	-	42874 p= 0.01	-	7352 p= 0.21	-
3	Italian	9785	3799	-	-	3782 p= 0.02	-	3612 p= 0.73	-
4	French	1982	2972	-	-	1807 p< 0.001	-	1661 p= 0.59	-
5	Dutch	1416	1864	-	-	1285 p= 0.39	-	1211 p= 0.18	-
6	Polish	1301	1390	-	-	1285 p= 0.39	-	1096 p= 0.15	-
7	Portuguese	1000	682	-	-	1058 p< 0.001	-	1067 p= 0.66	-
8	Slovenia	363	331	-	-	369 p= 0.2	-	341 p= 0.53	-
9	Finnish	284	321	-	-	277 p= 0.18	-	235 p= 0.21	-

Europresse© (Number of articles) 2004-2018									
1	English	4.44	3.86	-	-	6.3 *p*= 0.001	-	8.83 *p*= 0.007	MCAD 11.15 *p*<0.001 MCAM 9.17 *p*<0.001
2	French	4.15	4.17	-	-	2.51 *p*= 0.34	-	9.33 *p*<0.001	-
3	German	2.21	2.02	-	-	3.78 *p*= 0.22	-	5.33 *p*<0.001	-

A significant increase in Google© searches followed the introduction of health warnings on cigarette packets in Spain(P=0.03), France (P=0.01) and in the French speaking part of Belgium (P=0.02). We observed a significant increase in interest shown in oral cancers since the enforcement of directive 2014/40/EU in Denmark (P<0.001), Finland (p<0.001), France (P=0.01) and the United Kingdom (P<0.001). A significant increase in search terms corresponding to "mouth cancers" was also seen in Germany (p<0.001), Bulgaria (p=0.003) and the Czech Republic (P=0.01).

The MSC had no influence on Google© searches, except in Ireland (P<0.001).

Interest shown in oral cancers has increased significantly in Ireland since 2010 and the introduction of MCAD (P=0.03) as well as in the month of September when this week of awareness raising (P<0.001) coincides with the MSC. A significant difference in search volume for oral cancers was found during the MCAM in the United Kingdom (P=0.02).

On the contrary, the data obtained for Wikipedia searches showed a significant decrease in the number of average monthly visits after the enforcement of directive 2014/40/EU on the German (P =0.001), Italian (P=0.02), French (P<0.001) and Portuguese (P<0.001) pages.

There was no significant temporal association between the MSC and the number of Wikipedia page visits concerning oral cancers.

On Twitter, we observed a significant increase in the number of Tweets in April (P<0.001), as shown in the regular peaks seen in Figure 2. There was no change during the MSC (P=0.13).

The study of the temporal association between the introduction of public healthcare programmes and the publication of articles in the press showed a significant increase in the number of publications about oral cancers during each awareness campaign.

Several peaks in interest common to several databases were observed in September 2010, January and October 2016, March 2017 and January 2018.

The analysis of the relationship between the ANOVA results and the calculation of the Pearson coefficient of linear correlation (Table 3) showed that associations and correlations existed between our results.

Table 3. Measurement of the Pearson correlation coefficient (CCC) between the results obtained after ANOVA analysis.

	Google Trends©	Wikipedia	Twitter©	Europresse	Bibliometrics
Google Trends©	-	CCC=0.04 P<0.001	CCC=0.07 P<0.001	CCC=0.11 P<0.001	CCC=0.21 P<0.001
Wikipedia	-	-	CCC=0.06 P<0.001	CCC=-0.08 P<0.001	Insufficient data
Twitter©	-	-	-	CCC=0.8 P<0.001	CCC=0.96 P<0.001
Europresse	-	-	-	-	CCC=0.12 P<0.001
Bibliometrics	-	-	-	-	-

All our results were positively associated outside of the relationship between articles in the press and the number of Wikipedia page visits, but the correlation was extremely weak, if not zero.

A weak correlation was found between the publication of articles in the press about oral cancers and 1) the interest shown in them on Google© (0.11, P<0.001), and 2) the publication of scientific articles (0.12, p<0.001). We observed a weak correlation between the publication of scientific articles and interest shown in oral cancers on Google© (0.21, P<0.001). Finally, a very strong correlation was found between the publication of scientific articles and 1) articles appearing in the press (0.8, P<0.001) et 2) the number of Tweets published (0.96, P<0.001).

Discussion

Our study shows the weak temporal association between the introduction of public health programmes and the interest shown in oral cancers on the internet in most EU countries.

Shock images and health warnings

These results reveal an increase in interest shown in oral cancers after the introduction of health warnings. It has already been show that the type of explicit message associated with shock images have an impact on smokers. [19-22]

Nevertheless, the use of shock images could have the opposite of the desired effect due to a saturation of overly directive messages. [19-25]

These warnings could be accompanied by educational therapeutic medical information. In Canada and Australia, advice on how to give up smoking is printed on cigarette packets.

European campaigns vs national campaigns

We have shown the weak temporal association in interest shown in oral cancers on the internet during the MSC, excluding that shown by the press. An upturn in interest in Europe was only observed in Ireland and the United Kingdom, who organise their own awareness campaigns. These are not organised uniquely by scholarly societies, but on a smaller scale by dedicated foundations and associations who include patients in their organisational structure.

The importance of social networks and celebrities

We highlighted the fact that the general population tends to follow the news rather than look for precise medical information.

Twitter posts which provoked the most reactions came from influential accounts. It has been shown that celebrities can influence the wider public for a cause, at least for those paying attention to these "star" people.. [26-29]

Evans et al. describe the "Angelina Jolie effect", noting a significant increase in breast cancer screening in the United States after the actress publicly announced her mastectomy in May 2013 and called for more screening. [30,31]

We were also able to link an interview with a former baseball star (Jim Kelly) in March 2017, which called for Americans to get themselves tested during the Oral, Head & Neck Cancer Awareness campaign (OHNCA), with a spike in internet searches. Similar spikes were seen in September 2010 and in October 2016, after Michael Douglas was interviewed about oral cancer.

Awareness of oral cancers could be raised with the collaboration of celebrities who could inform their fan-base about the consequences of their life choices.

The influence of the names of prevention campaigns

The Wikipedia and Twitter© search tools include data from the United States in their English language search results as the algorithm does not allow for messages to be isolated or for searches by geographical area.

The United States organises an awareness campaign which appeared to generate an upturn in online interest. Oral cancers are clearly identified in the name of the campaign, like those organised in Ireland and the United Kingdom, but unlike the MSC.

A peak in interest in English databases in January 2018, after the launch of the American screening campaign "Check Your Mouth™", confirms this assessment.

Alcohol and HPV

Our study did not take these risk factors into account due to the absence of a European awareness-raising policy specific to them.

Regarding these risk factors that can influence the choice of keywords that people search for to better "understand" cancer, the use of Google Trends' "Related queries" function had no influence on the search selection strategy.

Our bibliometric analysis showed an increase in scientific interest in oral cancers. This was probably due to a surge in cancers attributed to infection by HPV, mainly concerning cancers located in the throat, particularly at the base of the tongue, which were not studied in this work.

We also noted a spike in interest in online searches in January 2016, following the publication of Agalliu et al.'s article. which brought to light the role of HPV-16 in the pathogenesis of oral cancers.

However, Syrjänen et al. already demonstrated this 35 years ago, although the impact was not as great as that observed today. [33-35]

The population should be informed of the risk of oropharynx cancers connected to contamination by HPV. Healthcare professionals, besides mouth head and neck specialists, should be informed, particularly about the benefits of vaccination against HPV. [35,36-38]

Limits

Unlike other databases used in this study, Google's© did not give us the absolute number of page consultations related to oral cancers. [11-13,39-41]

Unlike a typical epidemiological investigation, populations and sub-populations could not be identified. The geographical area and inclusion period were vast and not identical for all the databases analysed. It was not possible to know if internet users carried out multiple searches or searches from different devices.

The bibliometric period studied coincided with a global surge in the number of scientific publications which were part of a global trend for the commercialisation of research and could have fallen victim to the inherent abuses of this practice. [42-45]

Public health policies were not collected exhaustively and the interest shown in oral cancers was dependant on an internet connection. The causality between these two factors could therefore be criticised.

The choice of keywords, sometimes similar between sites despite different search preferences, and sometimes unknown to the general public, is an inevitable bias in this type of research and a limitation to be taken into account in the conclusions.

Similarly, there may have been a bias in the selection of the sample, especially regarding the importance of social networks and celebrities for people who do not pay attention to these "star people" and therefore have no influence on what they say.

The concrete impact of policy measures on the number of screenings, consultations, diagnoses or waiting times were not considered in our work.

However, awareness campaigns are vocal in the organisation of screening sessions. Although the proof is limited, it seems that a visual examination during a screening campaign would reduce the oral cancer mortality rate among high risk patients. These campaigns therefore seem important in raising awareness for a scientifically well documented condition that is still relatively unknown to the general public. [46]

Conclusion

Our work identifies 7 foci towards which raising awareness of oral cancers in Europe could be oriented.

1. Modify the health warnings on cigarette packets to go beyond shock messages or images.
2. Encourage initiatives organised at a national level.
3. Involve celebrities and public figures in the promotion of awareness campaigns.
4. Encourage greater involvement of associations and foundations in the organisation of the MSC.
5. Rename the MSC as currently it does not evoke a medical awareness campaign. Especially since the general public remains unaware of oral cancers.
6. Rename "head and neck cancers" as "mouth, head and neck cancers".
7. Implement an awareness raising policy of the dangers of tobacco and other risk factors.

Declarations

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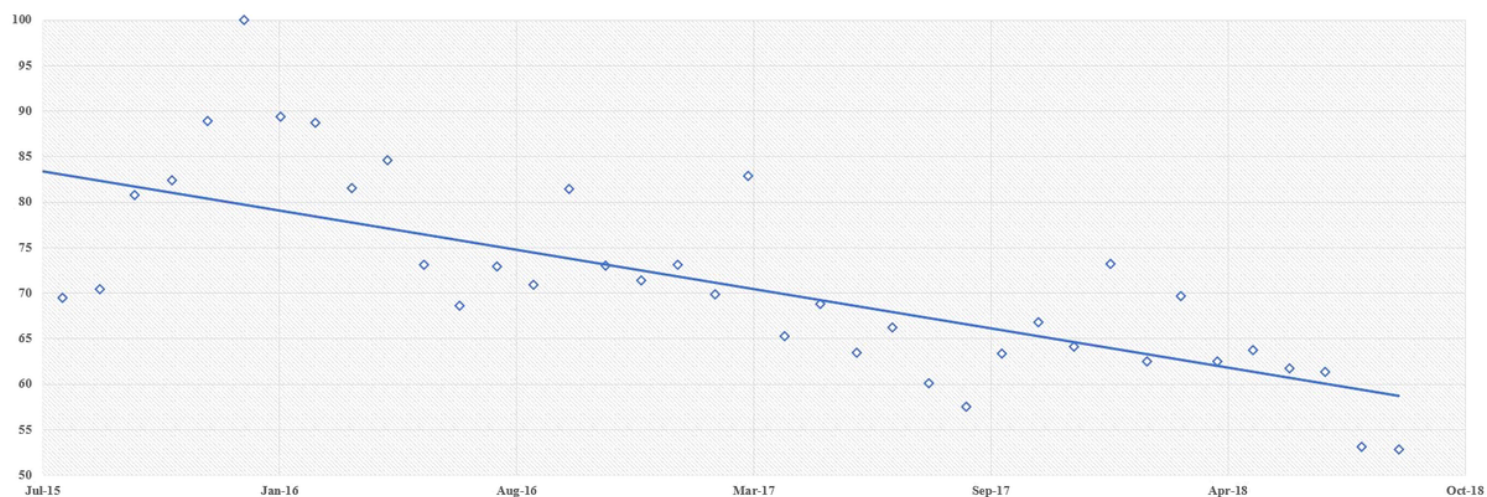
Figures

Figure 1

Evolution of the number of consultations of the 9 Wikipedia pages concerning oral cancers included according to time (2015-2018). The equation for the linear regression curve is: y = -0.0216x + 994.45, R^2 = 0.5083
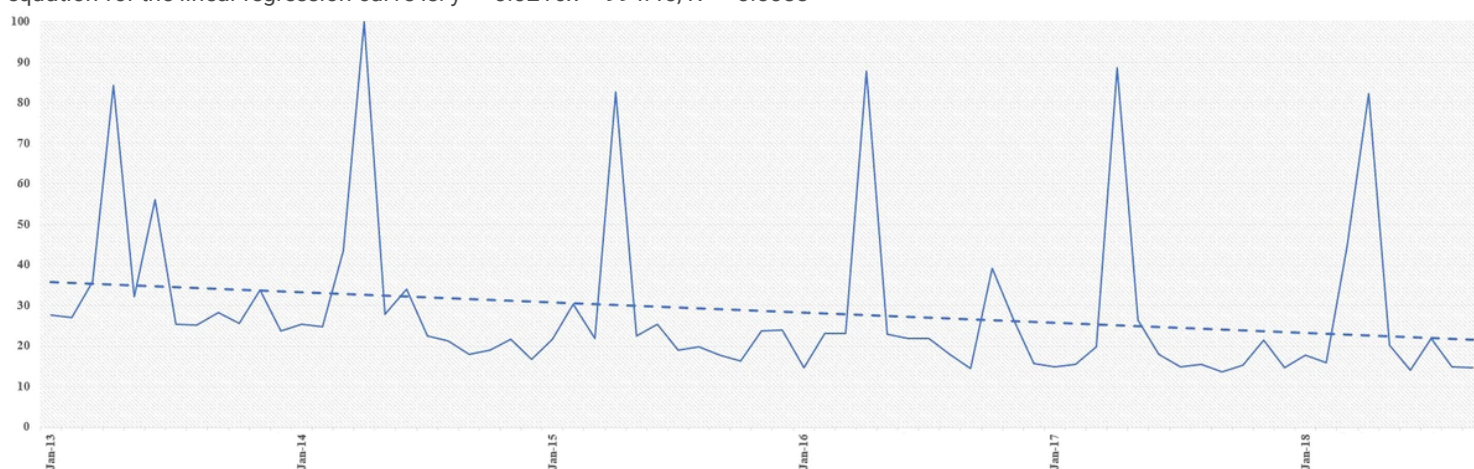

Figure 2

Evolution of the number of Tweets worldwide (2013-2018). The equation for the linear regression curve is: y = -0.4316x + 20081, R^2 = 0.04.