Perception of emergent epidemic of COVID-2019 / SARS CoV-2 on the Polish Internet - Preliminary Results

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Problem: Due to the spread of SARS CoV-2 virus infection and COVID-2019 disease, there is an urgent need to analyze COVID-2019 epidemic perception in Poland. This would enable authorities for preparation of specific actions minimizing public health and economic risks.

Methods: We study the perception of COVID-2019 epidemic in Polish society using quantitative analysis of its digital footprints on the Internet (on *Twitter*, *Google*, *YouTube*, *Wikipedia* and electronic media represented by *Event Registry*) from January 2020 to 12.03.2020 (before and after official introduction to Poland on 04.03.2020). To this end we utilize data mining, social network analysis, natural language processing techniques. Each examined internet platform was analyzed for representativeness and composition of the target group.

Results: We identified three major cluster of the interest before disease introduction on the topic COVID-2019: China- and Italy-related peaks on all platforms, as well as a peak on social media related to the recent special law on combating COVID-2019. Besides, there was a peak in interest on the day of officially confirmed introduction as well as an exponential increase of interest when the Polish government "declared war against disease" with a massive mitigation program. From sociolingistic perspective, we found that concepts and issues of threat, fear and prevention prevailed before introduction. After introduction, practical concepts about disease and epidemic dominate. Twitter reflected the clear, structural division of the Polish political sphere. We were able to identify potential sources of misinformation as well as key actors (especially "early adopters") and influencers.

Conclusions: Traditional and social media not only reflect reality, but also create it. Polish authorities, having a reliable analysis of the perception of the problem, could optimally prepare and manage the social dimension of the current epidemic and future ones. Due to filter "bubbles" observed on Twitter, public information campaigns might have less impact on society than expected. For greater penetration, it might be necessary to diversify information channels to reach as many people as possible which might already be happening. Moreover, it might be necessary to prevent the spread of disinformation, which is now possible due to the special law on combating COVID-2019.

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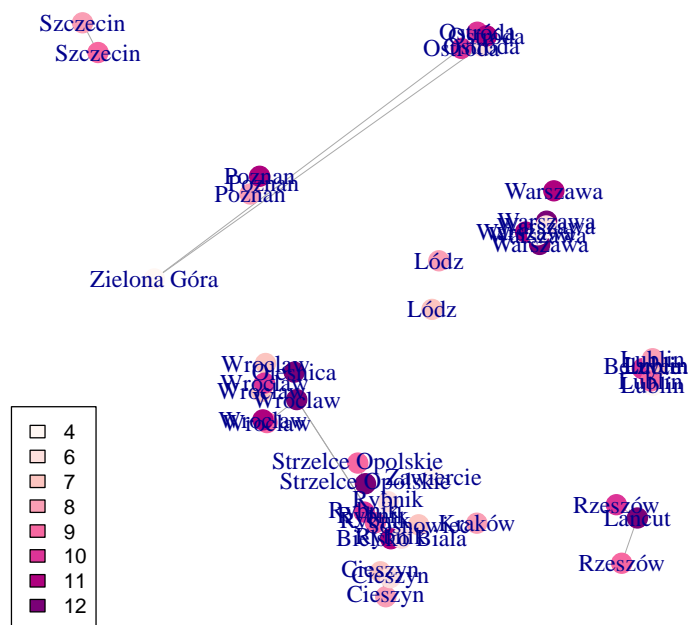
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Figure 1. Outbreak network of first 48 cases (edge – epidemiological link, node – infected patient, coordinates and names – counties and geographical coordinates with noise, colors – confirmation as day of March) (03-12.03).

INTRODUCTION

Although a large part of the Polish population has heard about coronaviruses for the first time a few weeks ago, in reality they face less dangerous coronaviruses causing simple cold all the time. Only the emergence of a novel strain from Wuhan gave the word "Coronavirus" a new meaning. Before disease introduction, less than a half of surveyed Poles believed that corona virus is the most important topic in the second half of February 2020 (IBRIS [1]). The disease was not detected in Poland until 03.03.2020, but this topic was relatively important already before introduction and started to drive media and social life after the disease introduction. During opinion poll performed on 09.03.2020 and 10.03.2020, 63% of respondents reported, that this is a serious threat for Poland, 40% that this is a serious threat for their family and 73% that this is a serious threat for the Polish Economy ([2]).

Entities such as companies, organizations or institutions use the Internet to build a brand or propagate content, e.g. through virtual marketing equivalent to the spread of virtual infectious diseases (Leskovec et al.

[3]Jarynowski et al. [4]). The spread of information (product life cycle) can also take on an epidemic nature (Jarynowski et al. [5], Toole et al. [6]) starting with the phase of growing interest (so-called "early adoption") to the phase of general interest (so-called "majority") to eventually lose popularity (so-called "lagers stage"). We also see small peaks of interest of Coronavirus in Poland (as in the case of other health threats [7]), although we observe the actual peak after the official confirmation of the virus introduction to Poland. Therefore, social media activities are being analyzed worldwide to better understand perception of diseases. This helps in some cases to track the spread of diseases (Ginsberg et al. [8], Lu et al. [9], Joshi et al. [10]). Social media can provide information and disinformation about the virus globally at unprecedented speed, fueling panic and creating so-called infodemic, massively desrupting entire countries such as Italy (Guardian [11]). The Internet is a good ground for propagation of views often contradicting the current state of medical knowledge [12]]. Propaganda and persuasion techniques are widely used easily reach certain target groups susceptible to conspiracy theories . Especially that content authors polarize society, which may be the object of interference by foreign intelligence[13] . Thus a virus outbreak is accompanied by panic-related behaviors [14] influencing in its turn the epidemic spread Perra et al. [15], Fenichel et al. [16], Wang et al. [17], and the Internet is the main mediating mechanism. Besides, we are dealing with collective behavior, such as xenophobic, where the people from affected countries are blamed for the danger and symbolic violence is used against them on the Internet (quote from Twitter: "Chinese should be banned from entering our country").

Methodology

In this work, by quantitative analysis of digital traces on the Internet (e.g. social media), we reconstruct the superficial sociological picture of the discourse around COVID-19 in the following key dimensions:

- the number and nature of social media events such as information queries

- sentiment and conceptual fields analysis

- social network analysis

- topic modeling technique

- the presence of an external field.

Up to our knowledge there were no previous studies quantitatively linking the Internet activities and risk perception of infectious disease in Poland ([18, 19]). Thus the present study is a first exploratory attemp filling this gap.
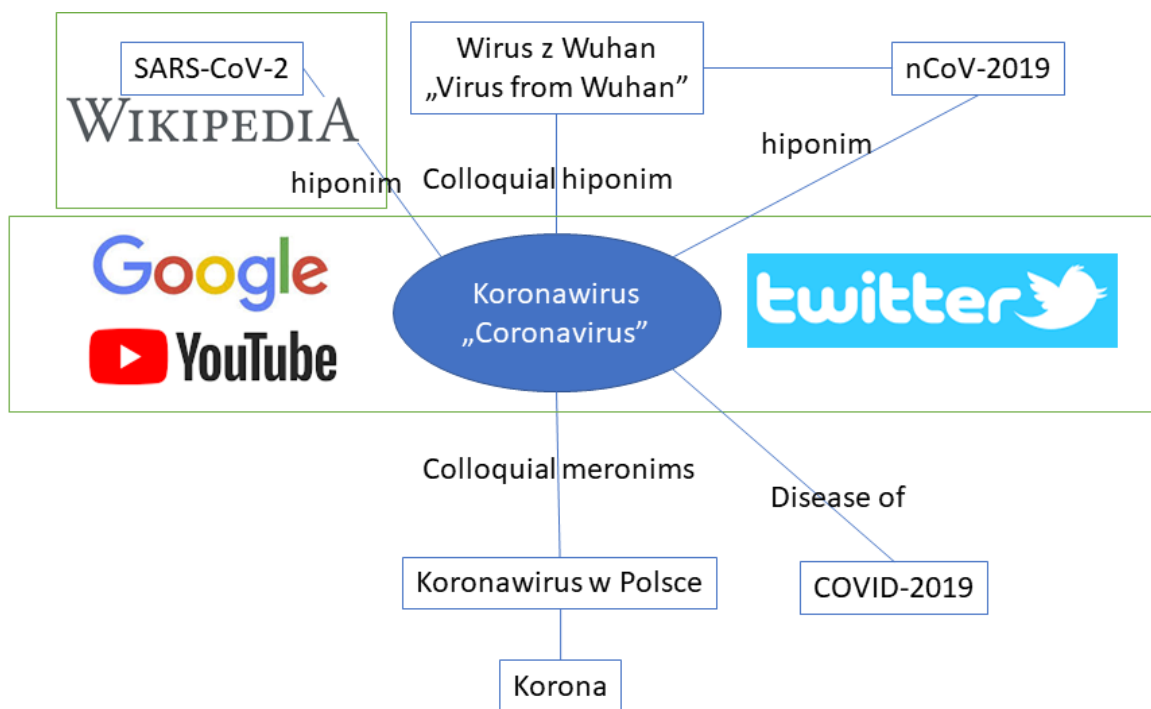
Figure 2. Rational behind using selected keywords in analysis.

We primarily analyze quantitative digital footprint data on the Internet from January 2020 to 11.03.2020, including their representativeness. The number of internet users in Poland in January 2020 was 28.1 million (PBI [20]) and 28.6 milion in 2019 (PBI [21]). Internet covers 85% of the total literate population. Therefore, the passive representativeness of the Internet is relatively high, but active (own content creation) is biased towards younger age groups and women. The former group has a high activity on the Internet, e.g. an average Polish teenager spends about 5 hours a day on the Internet (Tanaś et al. [22])) and the later group is responsible for generation of up to 85% of health-related content in social media. Over 99% of young Polish women use the Internet (Jarynowski and Belik [23])). We used a colloqial keyword "Koronavi-urus"/"Coronavius" in queries of web services ([19]) due to its penetration in the society. Other keywords (even are also in use) are much less popular (exeption for Wikipedia, where medical term SARS-CoV-2 was choosen) [Fig. 2].

In our study each considered internet platform is described separately and has its own specific bias. Ultimately, data analysis can be also biased due to involvement of media platform content presenting algorithms in the discourse. E.g. technology giants like Google, Twitter, Facebook are supposed to implement fact verification algorithms to filter out false information. Being aware of this, computational techniques of social sciences (Jarynowski et al. [5]), despite some disadvantages and their exploratory nature, provide us the opportunity to analyze a huge amount of digital footprint data at low cost and in a short time.
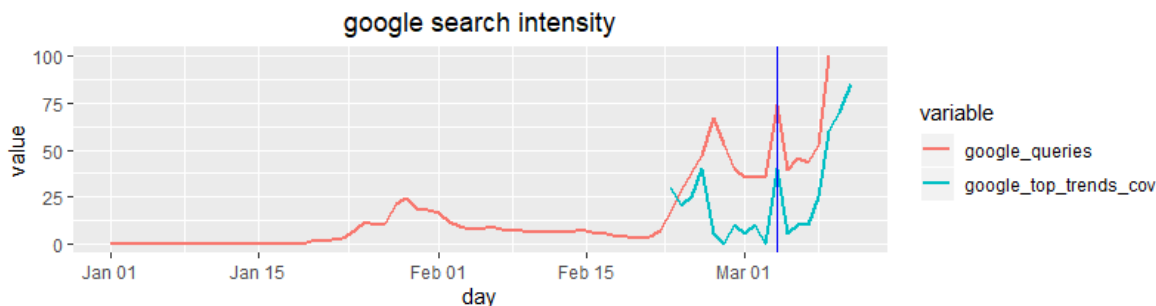
Figure 3. Searched Queries intensity with the word "corona virus"/"Koronawirus" in Polish Google (01.01-11.03) and procentage of "coronavius" related issues in to top trends topics (23.01-12.03) both generated using the Google Trend tool. Disease introduction marked with the blue vertical line.

GOOGLE TRENDS

Google has a share among Polish Internet users at the level of 95% with over 8 billion entries per month and is the undisputed leader on the Polish Internet market (PBI [20]). Interest in novel Coronavirus can be measured by the number of queries in Google [Fig. 3]. According to Google Ads on average , there were $2 \cdot 10^5$ searches monthly of term "Koronawirus". However it is calculated based on historical data so there were dozens of thousand searches daily in the late February 2020.

The subject of the corona virus occurred recently after the outbreak in Wuhan. It is important to note, that until disease introduction to Poland there were no Coronavirus related searches in top 25 Google queries at all. Although "coronavirus" related queries were observed in top trends before introductions, they start to dominate top queries only after the massive mitigation measures were taken such as school/university and boarder closure around 09-12.03 [Fig. 3]. Prior to the disease introduction two phases of interest can be distinguished [Fig. 3]:

-from the end of January and beginning of February when the epidemic was announced and confirmed in China. We see a small peak around 25.01 (e.g. death of Liang Wudong) and around 29.01 (e.g. first case in Germany);

- from the end of February till beginning of March (when the number of infections increased in Italy). We see a clear peak around 27.02 (e.g. fake news about possible introduction of the disease to Poland [24]).

After disease introduction we can see a peak on introduction day (04.03) and substantial growth after important measures were implemented by Polish authorities (09-11.03).

People are looking for information on epidemiological topics related to infection and epidemics as well [Fig. 4]. It should be noted that professional vocabulary such as "hand hygiene" practically does not appear in queries (below the noise threshold compared to other epidemiological terms [Fig. 4]). Issues
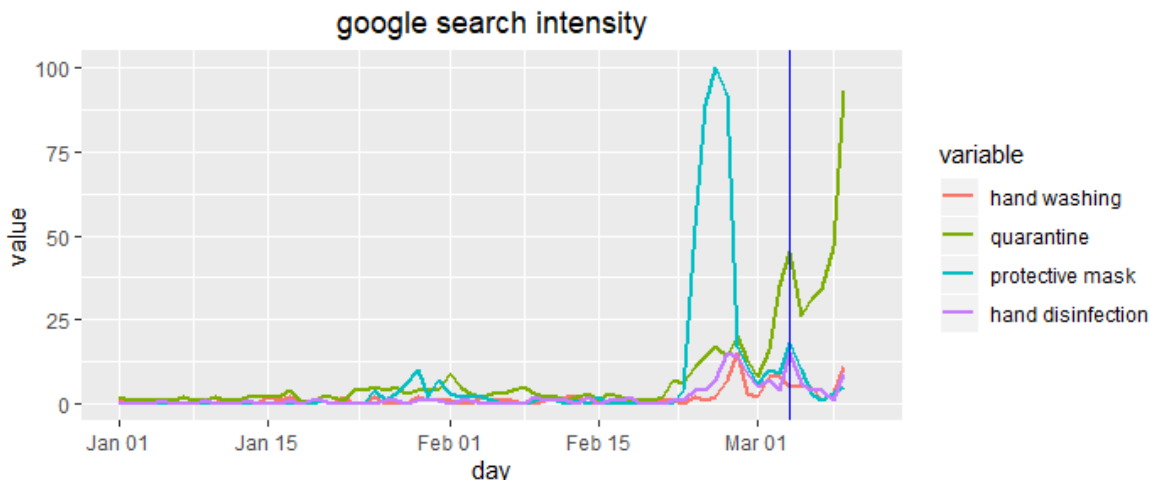
Figure 4.   The intensity of queries with the phrases "quarantine", "protective mask", "hand washing", "hand disin-fection" ("kwarantanna" "maska ochronna", "mycie rąk", "dezynfekcja rąk") in Polish Google (01/01-11/03/2020) generated using the Google Trend tool. Disease introduction marked with the blue vertical line

related to hand hygiene have a peak in late February and beginning of March. Masks search had their peak of popularity at the end of February and the lack of increase in popularity in March (compared to other epidemiological dates) may e.g. be due to the effectiveness of information campaigns on their effectiveness or simply due to the lack of availability of the goods.

The search activity for information on infection in Poland is still much lower than in countries with high connectivity of people movement (Lai et al. [25]) and already confirmed cases of infection [Fig. 18]. Such a peripheral location of Poland (among others) lead to the first confirmed case introduced by land rather than by air. (that was foreseen by the authors of the article already in January 2020 (Interdisciplinary [26])).

In addition, analyzing semantic networks, we recognize the most common co-occurring phrases in the search engine together with the word "Coronavirus" [Fig. 5]. Such a network contains information on how the predictor - the corona virus noun - relates to its arguments in a query phrase ([27]).

Befere virus introduction, we observe [Fig. 5], that most often the questions are associated with a threat (e.g. if it is / will reach / to Poland / close to Poland; can one die / how it kills) (czy jest/ dotrze w/do Polski(ce)/ blisko Polski; czy można umrzeć/jak zabija). Second level searches concerns prevention (e.g. how to prevent /guard/ protect yourself) (jak zapobiec/ chronić się/ zabezpieczyć się). In addition, there are third-level threads such as symptoms, history, or restrictions. The aspect of geographical proximity is also very important, thus the terms nearby, near, next to dominant semantic field around the word "Coronavirus".

After virus introduction, there is domination of practical questions (e.g. how to do the test / when to call a doctor / how to treat / asymptomatic course / can you go for a walk / is it in air/ do you do shopping / leave
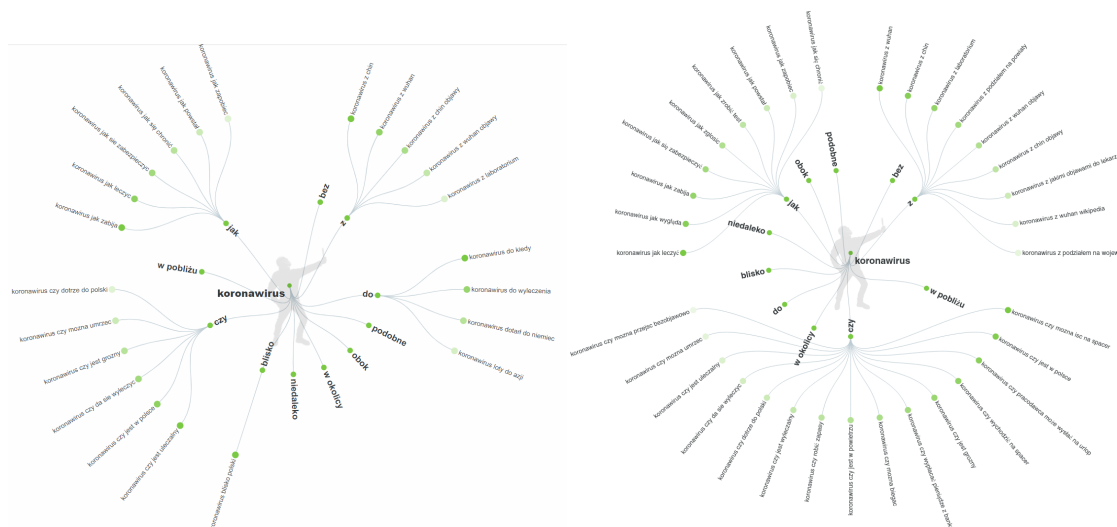
Figure 5.   Semantic web (prepositions) of the noun "corona virus" in Google search engine before introduction (snapshot of 29.02) [left] and after introduction (snapshot of 12.03) [right] generated using the Answer the Public tool for selection country Poland and language Polish (AnswearPublic [28])

from the employer / map) (jak zrobić test/ kiedy dzwonić po lekarza/ jak się leczyć/ przebieg bezobjawowy/ czy można iść na spacer/ czy jest w powietrzu/ czy robić zasapy/ urlop od pracodawcy/ mapy).

WIKIPEDIA

Wikipedia traffic is another indicator of the social activity (social contenting). Wikipedia has an Internet coverage of 57% with over 350 million entries per month among Polish Internet users (PBI [20]). There is an significant overespresentation of users with tertiary education and living in big cities (affinity index>120 ([29])) We looked at the history page view an discussions around the articles "SARS-CoV-2" ([30]) i and "Spread of virus infection SARS-CoV-2"/"Szerzenie się zakażeń wirusem SARS-CoV-2" ([31]) in Polish Wikipedia.

Before introduction, we see a growing trend in the number of queries with a small peak around 13.02 (which does not appear in other media and is related probably to giving a new name to the virus and the disease) and a clear peak around 27.02 (e.g. a fake news about disease in Poland). The first days of March are characterized by a slight decline in interest, perhaps due to the saturation of knowledge of basic definitions of the disease in society.

After introduction, there is a small peak around day of introduction and slight grow during during actual epidemic and massive mitigation strategies. On 04.03, a new page for spreading in Poland only was launch, which could transfer some views.
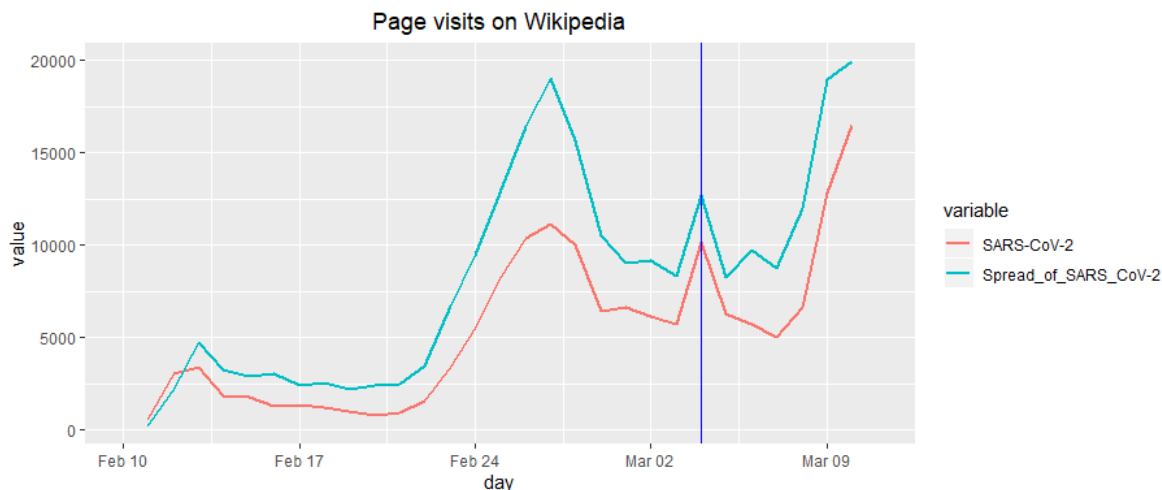
Figure 6. The number of views on the article "Spread of SARS-CoV-2 virus infection"/ "Szerzenie się zakażeń wirusem SARS-CoV-2" and "SARS-Cov-2" (10.02-11.03.2020) on Wikipedia. Disease introduction marked with the blue vertical line

The intensive discussions concern, among others, the effectiveness of protective masks or the reliability of data from the PRC (People's Republic of China). No data is available before 10.02.2020, what is associated with changes in the title of the articles due to changes in the name of the virus and disease by WHO.

EVENT REGISTRY

We choose EventRegistry (EventRegistry [32]) as a traditional media search engine because it has a large range of online magazines representing various political sites. In addition, it gives priority to the digital versions of other broadcasting channels, including television, radio or newspapers. Between January 31 and March 11 (10755 (before 4603 and 6152 after introduction) representative articles were selected (the non-systematic sampling method was applied).

One can see the weekly seasonality of the articles and 3 peaks of interest: at the end of January, the second half of February and the beginning of March [Fig. 7].

[Fig. 8].

Topics before introductions were concentrated around geography and politics, but after introduction economical issueas clearly dominate.

To a large extent, tags represent providers of information and official positions, which is why actors such as the Minister of Health or Sanitary Inspection appear quite often [Fig. 9] before and after introduction. Before introduction we see geographical relationships from outside Poland (China, Italy, Wuhan, etc.), but
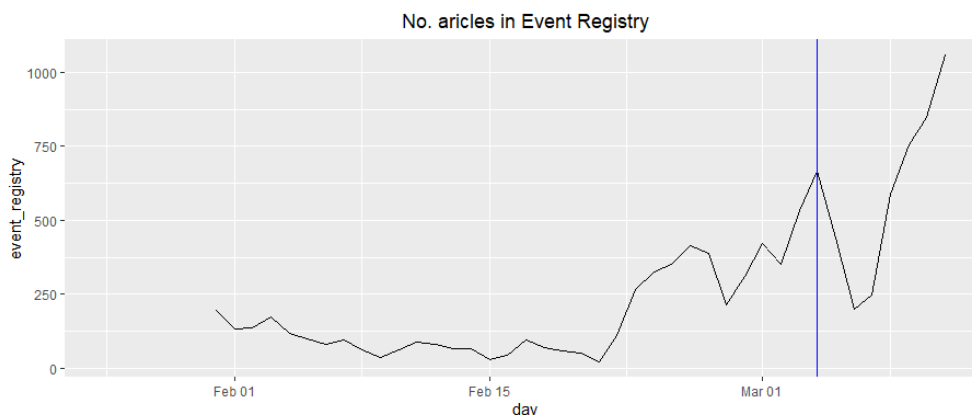
No. aricles in Event Registry

Figure 7. Number of articles in time 31.01-11.03 (generated using the Event Registry tool). Disease introduction marked with the blue vertical line

after introduction local geography dominates (Zielona Góra, Wrocław, Poznań, Warsaw, etc.).

TWITTER

Twitter in Poland has low popularity (~3 million registered users) and is mainly used by foreigners, journalists and politicians (Sotrender [33]). However, Twitter provides an API for data download available to general public almost for free. This allowed us to analyze not only text of tweets, but also their context (geolocalizing, retweeting, commenting, etc.). A lot of interest in infection can be seen on Twitter in Polish (210182 tweets with #Koronawirus in about 50 days).

There is not so much attention on Twitter till late February. There are peaks 27.02 (fake news about possible case in Poland), 02.03 (discussion about special anti-COVID-2010 act), 04.03 (disease introduction) and huge increase in interest 9-11.03 (massive mitigation strategies implemented).

We applied Social Network Analysis (Wasserman et al. [34]) to the twitter data and build a network with vertices representing twitter accounts and edges representing retweets (Jarynowski et al. [35]). The network revealed various connections (social impact, trust, friendship, etc.) between accounts being social actors and the characteristics of the actors (political affiliation, views, etc.). We choose to illustrate situation before disease introduction, because there was no massive attention of the topic yet, so it was easier to demonstrate important features as communities and influential actors. An automated community analysis weighted Louvain algorithm (Blondel et al. [36]) was used for this purpose and the vertices were colored the same color if they belongs to the same community. Retweet network [Fig. 11] shows how the discourse is divided into the ruling party (gray), opposition (orange) and the protestant religious and political group / „Idz pod prad" (yellow).

CONCEPT FREQUENCY — Main topics before first confirmed case (left)

Concept	Frequency
China (region)	3,114
Epidemic	2,300
Virus	1,858
Wuhan, China	1,836
Italy	1,732
Infection	1,685
Europe	1,397
Pneumonia	998
World Health Organization	953
Ministry of Health (Poland)	895
Germany	878
Hubei, China	863
Japan	829
United States	745
Hospital	716
South Korea	707
China	686
France	671
Province	666
Quarantine	628
Poles	581
Hong Kong	578
Physician	569
Influenza	568
Iran	518
Fever	501
Government	492
Cough	468
Philippines	465
Asia	449
United Kingdom	432
Lombardy, Italy	427
Severe acute respiratory syndrome	422
Beijing, China	412
Thailand	405
Finland	392
Warsaw, Poland	382
Łukasz Szumowski	366
Prime minister	352
Taiwan	336
Veneto, Italy	335
Vaccine	333
Singapore	332
Russia	331
United States dollar	328
Prezydent miasta	304
European Union	302
Vietnam	279
Polish Press Agency	277
Spain	273
Ministry of Foreign Affairs (Poland)	263
Państwowa Inspekcja Sanitarna	254
Polish złoty	251
Milan, Italy	244
Aerodrome	239
Market (economics)	233
Australia	233
Pathogen	220
Advertising	215
Reuters	205
Wrocław, Poland	201
Shortness of breath	200
Pandemic	194
Temperature	191
Hygiene	191
Exchange (organized market)	188
Airplane	186
Disease	186
Sejm	183
Medication	180
Case fatality rate	180
Gross domestic product	179
Police	176
Shanghai, China	174
Demand	171
Austria	170
Andrzej Duda	168
Animal	166
Twitter	165
Respiratory system	164

CONCEPT FREQUENCY — Main topics after first confirmed case (right)

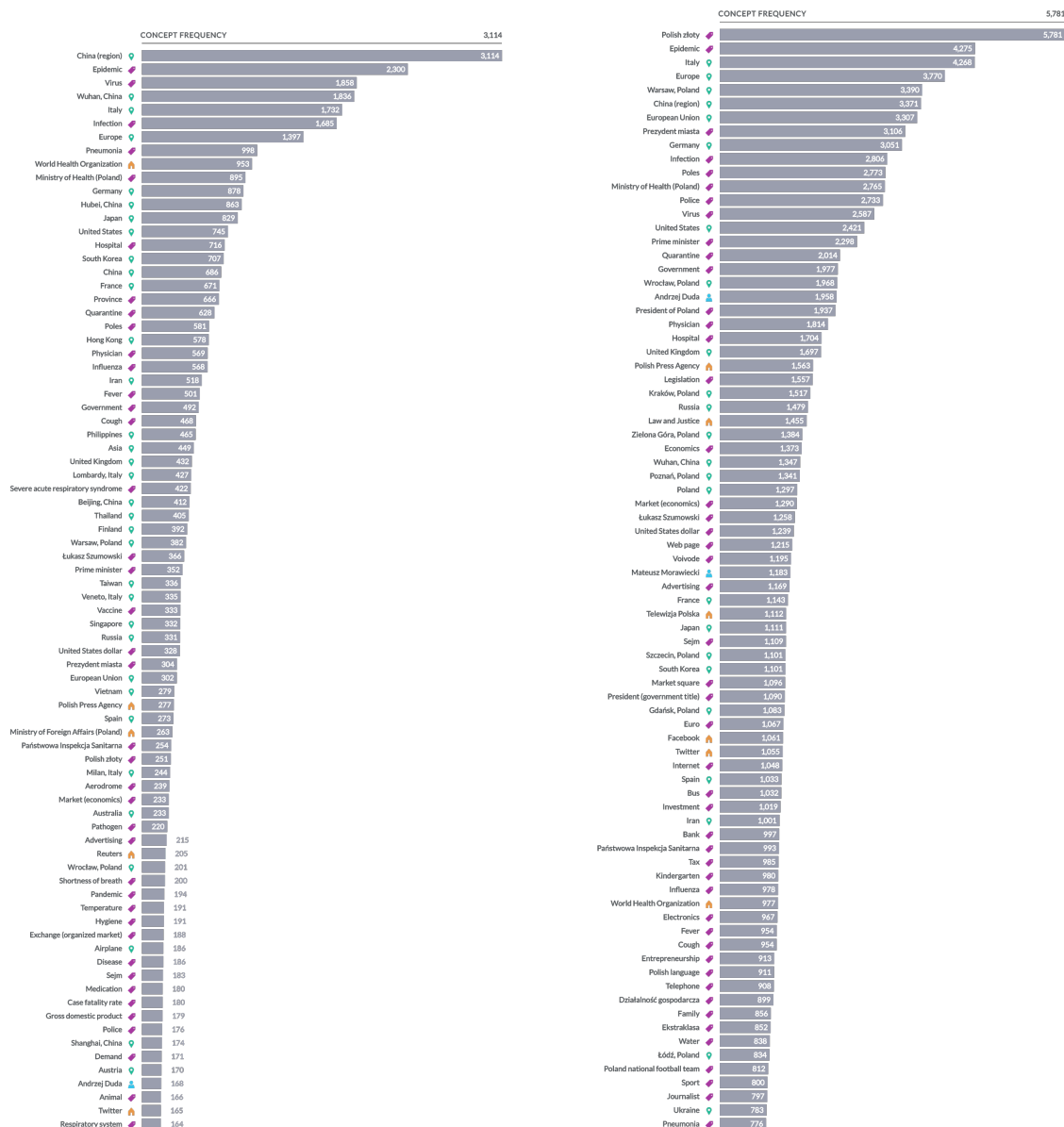| Concept	Frequency
Polish złoty	5,781
Epidemic	4,275
Italy	4,268
Europe	3,770
Warsaw, Poland	3,390
China (region)	3,371
European Union	3,307
Prezydent miasta	3,106
Germany	3,051
Infection	2,806
Poles	2,773
Ministry of Health (Poland)	2,765
Police	2,733
Virus	2,587
United States	2,421
Prime minister	2,298
Quarantine	2,014
Government	1,977
Wrocław, Poland	1,968
Andrzej Duda	1,958
President of Poland	1,937
Physician	1,814
Hospital	1,704
United Kingdom	1,697
Polish Press Agency	1,563
Legislation	1,557
Kraków, Poland	1,517
Russia	1,479
Law and Justice	1,455
Zielona Góra, Poland	1,384
Economics	1,373
Wuhan, China	1,347
Poznań, Poland	1,341
Poland	1,297
Market (economics)	1,290
Łukasz Szumowski	1,258
United States dollar	1,239
Web page	1,215
Voivode	1,195
Mateusz Morawiecki	1,183
Advertising	1,169
France	1,143
Telewizja Polska	1,112
Japan	1,111
Sejm	1,109
Szczecin, Poland	1,101
South Korea	1,101
Market square	1,096
President (government title)	1,090
Gdańsk, Poland	1,083
Euro	1,067
Facebook	1,061
Twitter	1,055
Internet	1,048
Spain	1,033
Bus	1,032
Investment	1,019
Iran	1,001
Bank	997
Państwowa Inspekcja Sanitarna	993
Tax	985
Kindergarten	980
Influenza	978
World Health Organization	977
Electronics	967
Fever	954
Cough	954
Entrepreneurship	913
Polish language	911
Telephone	908
Działalność gospodarcza	899
Family	856
Ekstraklasa	852
Water	838
Łódź, Poland	834
Poland national football team	812
Sport	800
Journalist	797
Ukraine	783
Pneumonia	776

Figure 8. Main topics before first confirmed case (31.01-01.03) (left) and after first confirmed case (04-11.03) (right) (generated using the Event Registry tool)

In addition, further discourse participants were identified [Fig. 11]. Violet are users who exchange funny and ironic content. Interestingly, the extreme right (apart from the Protestant movement) and extreme left do not form their own cluster and can be often found in blue color communities on the border between the ruling party and the main opposition. The subject of "Coronavirus" in Poland has conflict-generating potential, and as a consequence a dispute has emerged between the ruling party promoting information content and confirming the belief that the Polish state is prepared to fight the virus (gray cluster), and the opposition negating its ability to fight the virus [Fig. 11]. For example, Twitter accounts classified already
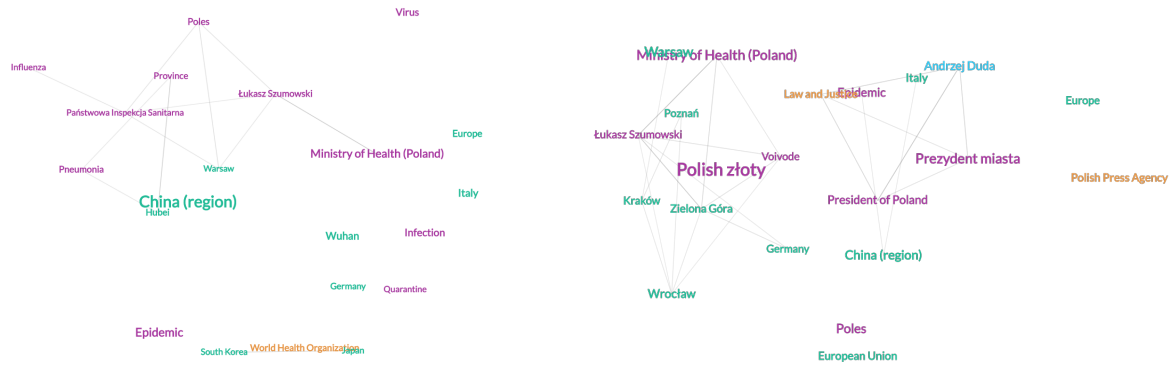
Figure 9. Co-occurring tag's network (31.01-01.03) (left) and after first confirmed case (04-11.03) (right) (generated using the Event Registry tool.
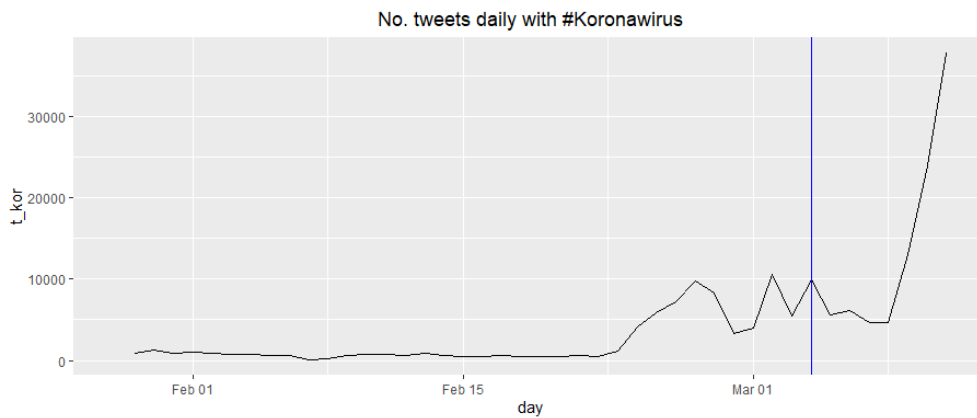

Figure 10. Number of tweets per day with the Koronawirus hashtag in Polish language (28.01-11.03.2020). Disease introduction marked with the blue vertical line

as potentially belonging to the so-called trolls (which in other studies were classified to the extreme right in the context of elections to the European Parliament (OKO [37]), or far-left side in the context of African Swine Fever (Jarynowski et al. [38]), promoted content in the buffer area (attacking both the ruling party and the mainstream opposition. The passing of the special act on preventing and combating COVID-19 by the Sejm (Sejm [39]), correlate with a non-trivial division of the communities on Twitter. 400 MPs of the PiS ruling party (gray) and mainstream opposition – KO, Lewica, PSL (orange) – supported the law, and 18 deputies of the far right and left (blue) did not support it [Fig. 11].

We also looked on the most frequent words excluding Si words [Tab. I]. There are mainly words related to topics around politics, due to the political and journalistic bias of Twitter.
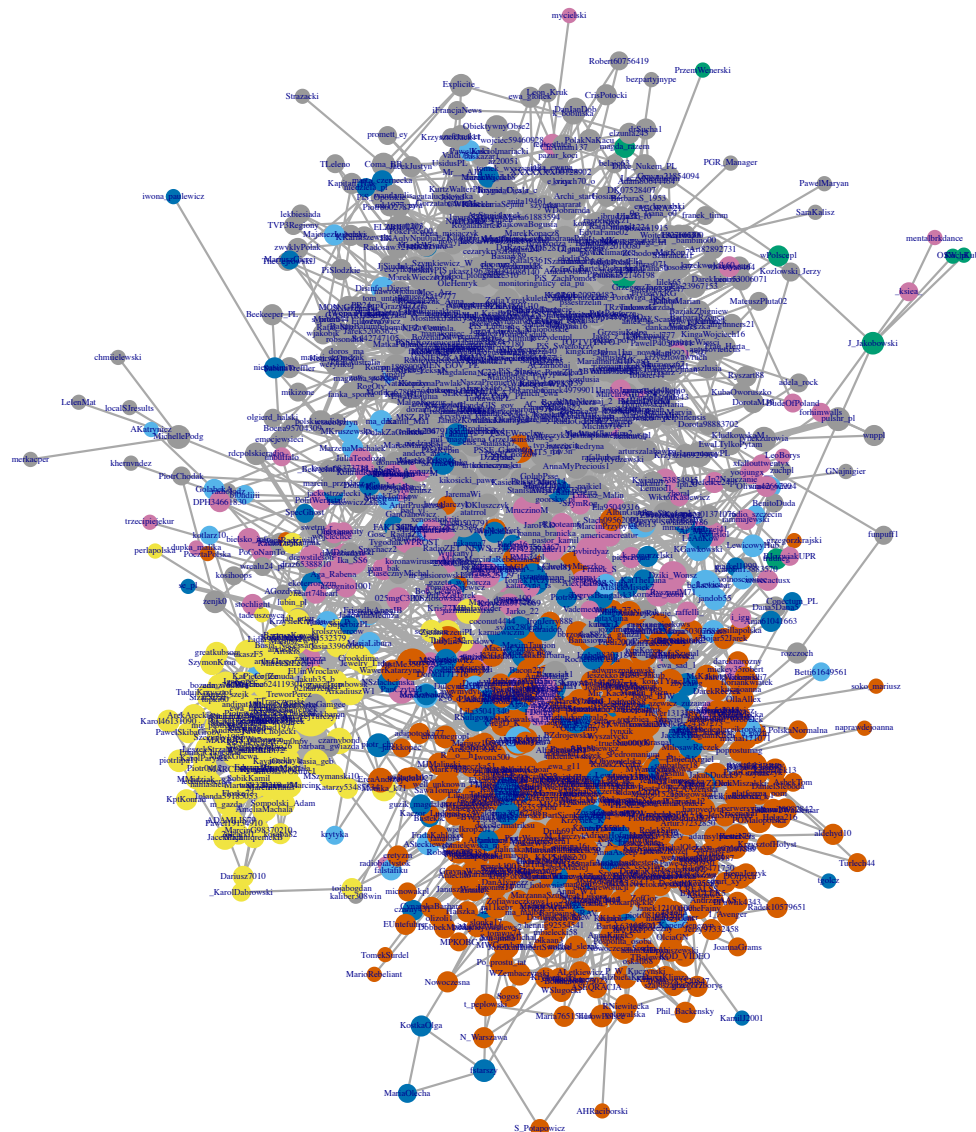
Figure 11. A network of retwitts with the Koronawirus hashtag. Gray - the ruling camp, orange - the opposition, yellow - the Protestant group with the Koronawirus hashtag in Polish (18.02-28.02.2020). This network only shows accounts that have generated at least 3 tweets and connections that represent at least 2 retweets.

YOUTUBE

Youtube has a share among Polish Internet users at the level of 68% with about 700 million entries per month (PBI [20]). In addition, streams from the mobile app should be taken into account, as it is most popular app on Poles' smartphones (PBI [20]). For our analysis, we selected videos on the main subject of "corona virus" ([40]) using keyword search. One observes multiple peaks (25.01, 31.01, 27.02, 2.03, 04.03, and 9-11.03.) on Youtube similar to all other social media [Fig. 12].

Id	item	count	item en	id	item	count	item$_{en}$
1	Dziś	447	today	18	Mamy	122	we have
2	14	421	14	19	Wygadywanie	118	talking
3	Minister	401	Minister	20	.@StKarczewski	116	v-ce pres$_{senat}$)
4	Głosowanie	291	Voting	21	Świat	114	World
5	Premier	283	Prime Minister	22	Pierwszy	110	First
6	Rząd	199	Government	23	Niestety	105	unfortunately
7	Prezydent	187	President	24	Propozycja	102	proposition
8	Panie	182	Mr	25	Wszyscy	102	All
9	Epidemia	180	Epidemic	26	Zakończyło	100	Finished
10	Donald	178	Donald	27	Przewodniczący	95	Chairman
11	Objawy	163	Symptoms	28	INFORMACJA	92	information
12	Polska	148	Poland	29	Odnoszę	89	Answering
13	.@M_K_Blonska	143	candidate$_{pres}$	30	Wczoraj	85	Yesterday
14	Sławomir	140	Sławomir	31	Pacjent	81	Patient
15	Lekarze	131	Physicians	32	Kolejne	78	next
16	Podstawowe	129	Basics	33	Włochy	74	Italy
17	Szef	126	Chef	34	Strach	65	fear

Table I. Counts of most frequent words without Stop words during 18.02-28.02.2020.

OTHER MEDIA

The fastest growing profile in January and February 2020 in the entire Polish Facebook is („Konflikty i katastrofy światowe") "Conflicts and global disasters" which gained over 120 thousand followers in one month. New followers (with recent increased activity related to corona virus information). The most popular post in the Vlog category in January 2020 was a video material titled "Wuhan market" on SA Wardęga's profile (@sawardega), which was eventually marked as containing false information (Sotrender [41]).

There are other social platform not covered by this research as Instagram (popular platform among teenagers with affinity index>120 in this age category ([42])). Topic of Coronavius was not so popular at
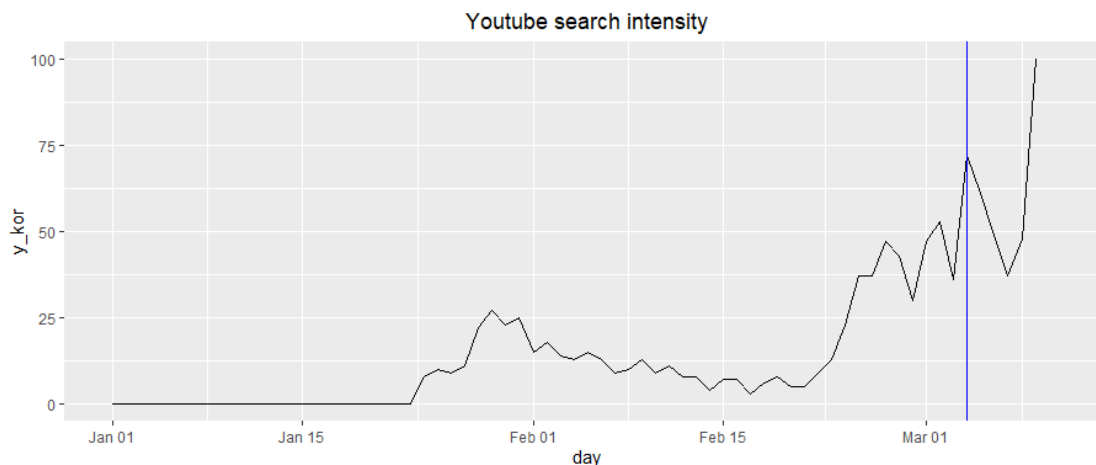
Figure 12. The intensity of queries with the word "Koronawirus" on Youtube (01/01-11/03/2020) generated using the Google Trend tool. Disease introduction marked with the blue vertical line

Instagram until disease introduction. The most popular hashtag after introduction of the virus "odwolaj-cieszkolyxd" and its related to school closure.

For a better coverage we will need blogs (e.g. blog Media@jesion gathers hundreds thousands entries be day ([43]) and comments under Internet media also. While articles form media as wp.pl onet.pl, interia.pl have billions entries monthly and articles their articles on Coronavirus reaches on average dozens of thousands entries with hundreds of comments.

COMPARISON OF INTEREST TIME SERIES FROM DIFFERENT PLATFORMS

We also visualized the available time series from different platform together with marked importat events to the Polish public [Fig. 13]. From time line as well as Google queries semantics [Fig. 5] and tags/topics in news [Fig. 8, 9], that geographal proxy of the disease seems to drives a lot and interest (e.g, cases in Germany). We see that still traditional news agencies (well represented in Event Registries) as well as Google search could ahead in time and form more 'sharp' peaks than social media platform (discussion about events delayed and 'smother'). We detected the lags between different platforms for given topics (e.g news from event registry are ahead of comentatory media in fake news on possible introduction). Twitter (15% penetration rate among Polish Internet users) has significantly different time pattern than other analyzed platforms:

- it does not have Chinese phase at all;

- it has a least 3 fold faster growth rate than other media in Epidemic and Mitigation phase.

Pearson correlations coefficients were calculated [Fig. 14]. All measured intensities are positively
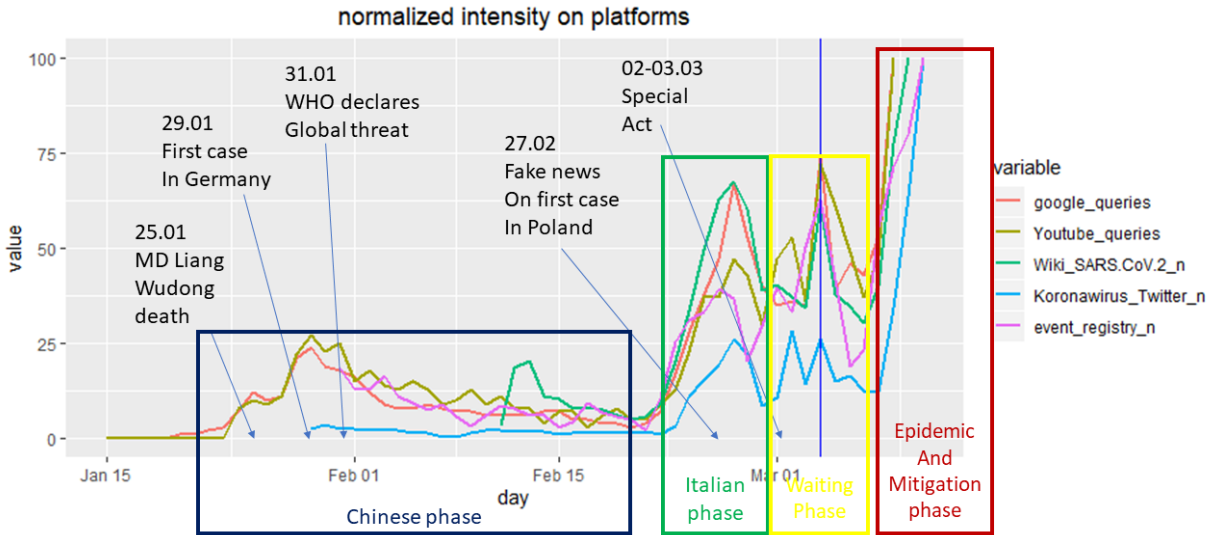
Figure 13. The intensity of topic Koronawirus on various media platform with (15.01-11.03). Time series normalized that 100 means maximal value for a given series. Disease introduction marked with the blue vertical line.
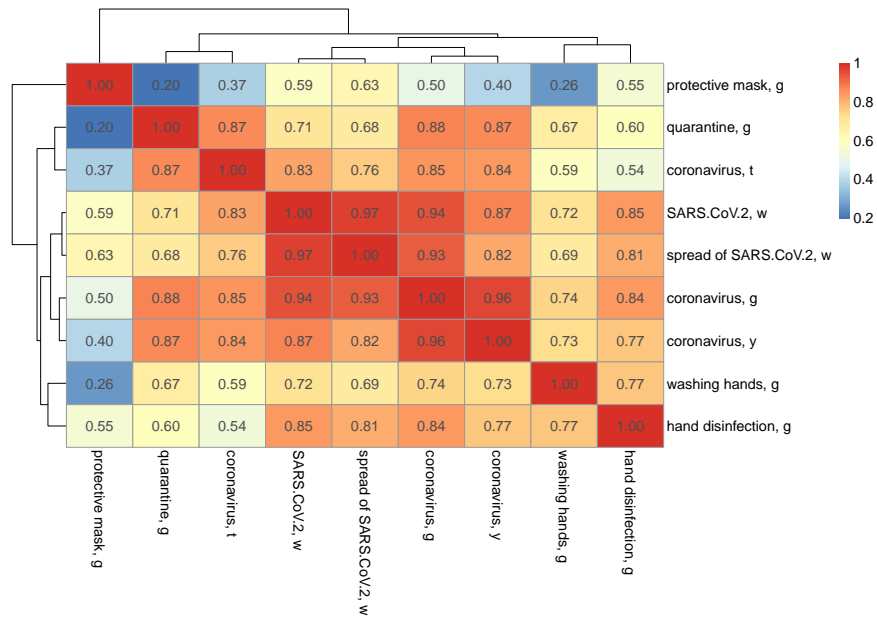
Figure 14. The Pearson's correlation matrix for the epidemic related search terms on various media platform (g – Google, w – Wikipedia, y – Youtube, t – Twitter). With the significance level of 5% all correlations were significant except the pair "antiviral mask, g"/"quarantine, g". Colorcode corresponds to correlation strenght.

correlated. Protective mask as a signal of fear/perception of risk is less correated with other variables more related to information needs. "Procective mask" and "Washing hands" is much less correlated than "Procective mask" and "hand disinfection", which could mean, that people search for professianal solutions rather thans simple and working ones.

CONCLUSIONS

In the face of the COVID-19 pandemic, there is an unprecedented flood of information (information noise) and our task was to retract the important events and feature from the most widely range of Internet media in Poland, The knowledge of quantitative characteristics of the "Coronavirus" perception in Poland is an important prerequisite for a proper crisis management (Trzos et al. [44]) such as design of protection policies in the area of risk management and adequate education of citizens by the stakeholders identified in Poland. For example, at present, government mitigation programs or hygiene education principles published on Twitter fall into the information bubble of supporters of the ruling party [Fig. 11].We provided list of central accounts for each social platform, which have been active already before disease introduction. Lack of interest in general public ([45]) could be associated with low epidemiological awareness of average Poles, especially when COVID-19 is massively discussed in traditional and social media by a relatively small but loud group of people.

Before official introduction we observed in Poland two information phases related to outbreaks in China (the end of January) and in Italy (the second half of February) and one commentary and update phase in social media in the beginning of March related to, among others, the special act on COVID-19 mitigation [Fig. 13]. Information media (Wikipedia and Google) do not display the third phase, because probably the awareness about the virus and the knowledge on the disease has already become saturated, and people are interested mainly in the current update on Twitter, Youtube, or other electronic media. After disease introduction to Poland, there is an peak on introduction day and fast growth of interest in Epidemic and Mitigation Phase [Fig. 13]. Although boundaries between different types of information and knowledge are blurring. Under conditions of a market-consumer society, private goals of individuals come into conflict with responsibility of the whole society or community. For example, economic consequence of supply and demand lead to price increases of medical devices ([46]).

Only by analyzing Twitter we have the full control over the methodology and research techniques. The most difficult is the access to Facebook data, despite the highest population penetration and the largest ranges, it does not allow automated analysis (Facebook [47]) and we can only rely on manual work-intensive research of commercial companies (Sotrender [33, 41]), whose research methodology may differ from scientific standards. There are attempts to use available Facebook Ads campaigns in context to "Coroanavirus" [48], which is available.

In order to prepare and manage the crisis in an optimal way, a deeper perception analysis in the form of reliable quantitative and qualitative analysis is requested. Especially, according to the results of empirical research (Taranowicz [49]), society expects institutional activities and in the event of an epidemic, it is the

"state (...) that is responsible for the poor health of the population". Perhaps one of the reasons the Chinese have been so successful in controlling the spread of the infection is that social media like Wecht (Wang et al. [50], Zhang et al. [51]), or Internet forums (Liu and Lu [52]) were analyzed by algorithms (Lu et al. [53], Paul and Dredze [54], Salathe et al. [55]) with goal to mitigate the spread of COVID-19. Combining the behavior changes detected via social media analysis with the detailed information on human mobility via e.g. mobile phone tracking (Schneider et al. [56]), sophisticated computational models of infectious disease spread could implemented (Belik et al. [57], Vespignani [58]) allowing to simulate various scenarios and assess possible human and economic losses. Furthermore, impact of public information campaigns could be measured by internal surveys of public opinion for parties and organizations. In addition, such approach could fill gaps in socio-medical research on collective actions during an important public health disruption event such as infectious diseases. (Jarynowski and Belik [59]).

REFERENCES

[1] IBRIS. Koronawirus ponad polityka. `https://wiadomosci.onet.pl/tylko-w-onecie/wybory-prezydenckie-2020-sondaz-andrzej-duda-prowadzi-potrzebna-ii-tura/cmk8ssw`, 2020. Accessed: 2020-03-04.

[2] OKO. Sondaż ipsos o koronawirusie. dwie trzecie widzi duże zagrożenie, ale nie panikujemy. `https://oko.press/sondaz-ipsos-o-koronawirusie/`, 2020. Accessed: 2020-03-12.

[3] Jure Leskovec, Lada A Adamic, and Bernardo A Huberman. The dynamics of viral marketing. *ACM Transactions on the Web (TWEB)*, 1(1):5–es, 2007.

[4] Andrzej Jarynowski, Jarosław Jankowski, and Anita Zbieg. Natural vs artificial viral spread within the online community. *E-methodology*, 2:71–78, 2015.

[5] Andrzej Jarynowski, Andrzej Buda, and Piotr Nyczka. *Obliczeniowe nauki spoleczne w Praktycze*. WN:Glogow, 2014.

[6] Jameson L Toole, Meeyoung Cha, and Marta C González. Modeling the adoption of innovations in the presence of geographic and media influences. *PloS one*, 7(1), 2012.

[7] Andrzej Jarynowski and Andrzej Buda. Exploring arsenic danger awareness in the polish copper basin–simulation of engagement in online networking. *E-methodology*, 5(5):58–71, 2018.

[8] Jeremy Ginsberg, Matthew H Mohebbi, Rajan S Patel, Lynnette Brammer, Mark S Smolinski, and Larry Brilliant. Detecting influenza epidemics using search engine query data. *Nature*, 457(7232):1012–1014, 2009.

[9] Fred Sun Lu, Suqin Hou, Kristin Baltrusaitis, Manan Shah, Jure Leskovec, Jared Hawkins, John Brownstein, Giuseppe Conidi, Julia Gunn, Josh Gray, et al. Accurate influenza monitoring and forecasting using novel internet data streams: a case study in the boston metropolis. *JMIR public health and surveillance*, 4(1):e4, 2018.

[10] Aditya Joshi, Ross Sparks, James McHugh, Sarvnaz Karimi, Cecile Paris, and C Raina MacIntyre. Harnessing tweets for early detection of an acute disease event. *Epidemiology*, 31(1):90–97, 2020.

[11] Guardian. Italian minister tries to calm coronavirus panic and attacks profiteers. `https://www.theguardian.com/world/2020/feb/27/italian-minister-tries-to-calm-coronavirus-panic-and-attacks-profiteers`, 2020. Accessed: 2020-03-04.

[12] Anna Kata. Anti-vaccine activists, web 2.0, and the postmodern paradigm–an overview of tactics and tropes used online by the anti-vaccination movement. *Vaccine*, 30(25):3778–3789, 2012.

[13] Sean Jacobs. Political propaganda spread through social bots. *Media, Culture, & Global Politics*, pages 1–22, 2017.

[14] Gregg Gonsalves and Peter Staley. Panic, paranoia, and public health—the aids epidemic's lessons for ebola. *New England Journal of Medicine*, 371(25):2348–2349, 2014.

[15] Nicola Perra, Duygu Balcan, Bruno Gonçalves, and Alessandro Vespignani. Towards a characterization of behavior-disease models. *PloS one*, 6(8), 2011.

[16] Eli P Fenichel, Carlos Castillo-Chavez, M Graziano Ceddia, Gerardo Chowell, Paula A Gonzalez Parra, Graham J Hickling, Garth Holloway, Richard Horan, Benjamin Morin, Charles Perrings, et al. Adaptive human behavior in epidemiological models. *Proceedings of the National Academy of Sciences*, 108(15):6306–6311, 2011.

[17] Zhen Wang, Michael A Andrews, Zhi-Xi Wu, Lin Wang, and Chris T Bauch. Coupled disease–behavior dynamics on complex networks: A review. *Physics of life reviews*, 15:1–29, 2015.

[18] Loukas Samaras, Elena García-Barriocanal, and Miguel-Angel Sicilia. Syndromic surveillance using web data: a systematic review. In *Innovation in Health Informatics*, pages 39–77. Elsevier, 2020.

[19] Sudhakar V Nuti, Brian Wayda, Isuru Ranasinghe, Sisi Wang, Rachel P Dreyer, Serene I Chen, and Karthik Murugiah. The use of google trends in health care research: a systematic review. *PloS one*, 9(10), 2014.

[20] PBI. Polski internet w styczniu 2020. `http://pbi.org.pl/badanie-gemius-pbi/polski-internet-w-styczniu-2020/`, 2020. Accessed: 2020-03-04.

[21] PBI. Polski internet w styczniu 2019. `http://pbi.org.pl/badanie-gemius-pbi/polski-internet-w-styczniu-2019/`, 2019. Accessed: 2020-03-04.

[22] M Tanaś, W Kamieniecki, M Bochenek, and R Lange. Raport z badania nastolatki 3.0. *Warszawa, NASK*, 2017.

[23] Andrzej Jarynowski and Vitaly Belik. Choroby przenoszone drogą płciową w dobie internetu i e-zdrowia: kalkulatory ryzyka. *Kraków: Biblioteka Jagiellońska*, 2018.

[24] Gazeta Wyborcza. Chybicka: "w Łodzi potwierdzono koronawirusa". `https://wiadomosci.gazeta.pl/wiadomosci/7,114884,25741826,chybicka-w-lodzi-potwierdzono-koronawirusa-minister-zdrowia.html`, 2020.

Accessed: 2020-03-12.

[25] Shengjie Lai, Isaac Bogoch, Nick Ruktanonchai, Alexander Watts, Yu Li, Jianzing Yu, Xin Lv, Weizhong Yang, Hongjie Yu, Kamran Khan, et al. Assessing spread risk of wuhan novel coronavirus within and beyond china, january-april 2020: a travel network-based modelling study. *medRxiv*, 2020.

[26] Interdisciplinary. Kiedy 2019-ncov trafi do polski? `http://interdisciplinary-research.eu/kiedy-2019n-cov-trafi-do-polski`, 2020. Accessed: 2020-03-04.

[27] Marek Maziarz, Maciej Piasecki, Ewa Rudnicka, Stan Szpakowicz, and Paweł Kędzia. plwordnet 3.0–a comprehensive lexical-semantic resource. In *Proceedings of COLING 2016, the 26th International Conference on Computational Linguistics: Technical Papers*, pages 2259–2268, 2016.

[28] AnswearPublic. Answear the public. `https://answerthepublic.com`, 2020. Accessed: 2020-03-04.

[29] PBI. Wikipedia i jej użytkownicy. `http://pbi.org.pl/wp-content/uploads/2017/09/2017-09-26-Wikipedia_analiza.pdf`, 2018. Accessed: 2020-03-12.

[30] Wikipedia. Sars-cov-2. `https://pl.wikipedia.org/wiki/SARS-CoV-2`, 2020. Accessed: 2020-03-04.

[31] Wikipedia. Szerzenie sie zakazen wirusem sars-cov-2. `https://pl.wikipedia.org/wiki/Szerzenie_się_zakazen_wirusem_SARS-CoV-2`, 2020. Accessed: 2020-03-04.

[32] EventRegistry. Event registry. `https://www.eventregistry.org`, 2020. Accessed: 2020-03-04.

[33] Sotrender. Twitter w polsce – podsumowanie 2018 roku. `https://www.sotrender.com/blog/pl/2019/02/twitter-w-polsce-podsumowanie-2018-roku-infografika/`, 2019. Accessed: 2020-03-04.

[34] Stanley Wasserman, Katherine Faust, et al. *Social network analysis: Methods and applications*, volume 8. Cambridge university press, 1994.

[35] Andrzej Jarynowski, Michal B Paradowski, and Andrzej Buda. Modelling communities and populations: an introduction to computational social science. *Studia metodologiczne*, 39:117–139, 2019.

[36] Vincent D Blondel, Jean-Loup Guillaume, Renaud Lambiotte, and Etienne Lefebvre. Fast unfolding of communities in large networks. *Journal of statistical mechanics: theory and experiment*, 2008(10):P10008, 2008.

[37] OKO. Proba wplyniecia na wyniki wyborow? dwie siatki patriotycznych trolli wspieraly konfederacje. `https://oko.press/proba-wplyniecia-na-wyniki-wyborow-dwie-siatki-patriotycznych-trolli-wspieraly-konfede` 2019. Accessed: 2020-03-04.

[38] Andrzej Jarynowski, Daniel Platek, Łukasz Krzowski, Anton Gerylovich, and Vitaly Belik. African swine fever-potential biological warfare threat. Technical report, EasyChair, 2019.

[39] Sejm. Glosowanie nad projektem 266. `https://www.sejm.gov.pl/Sejm9.nsf/agent.xsp?symbol=glosowania&NrKadencji=9&NrPosiedzenia=7&NrGlosowania=7/`, 2020. Accessed: 2020-03-04.

[40] Youtube. Koronawirus. `https://www.youtube.com/`, 2020. Accessed: 2020-03-04.

[41] Sotrender. Facebook trends styczen 2020 – burzliwych 31 dni nowego roku. `https://www.sotrender.`

com/blog/pl/2020/02/facebook-trends-styczen-2020-burzliwych-31-dni-nowego-roku/,
2020. Accessed: 2020-03-04.

[42] PBI. Instagram i jego polscy użytkownicy. `http://pbi.org.pl/wp-content/uploads/2018/07/`
`2018-07-Instagram.pdf`, 2018. Accessed: 2020-03-12.

[43] Media@jesion. Pytania i odpowiedzi dotyczące covid-19. `https://medium.com/@jesion/`
`dlaczego-powinniśmy-się-przejmować-często-zadawane-pytania-i-odpowiedzi-dotyczące-covi`
2020. Accessed: 2020-03-12.

[44] Arkadiusz Trzos, Łukasz Krzowski, and Katarzyna Długosz. Specyfika działań ratownictwa medycznego. *Na Ratunek*, 4:17, 2017.

[45] Widzialni. Marketing wirusowy koronawirusowa. `https://www.widzialni.pl/blog/`
`marketing-wirusowy-koronawirusa/`, 2020. Accessed: 2020-03-04.

[46] Ceneo. Koronawirus atakuje sklepy. boom na maski i... nie tylko. `https://`
`subiektywnieofinansach.pl/koronawirus-atakuje-a-w-sklepach-boom-na-maski-i-nie-tylko-w`
2020. Accessed: 2020-03-04.

[47] Facebook. Facebook for developers. documentation. `https://developers.facebook.com/docs`,
2020. Accessed: 2020-03-04.

[48] Yelena Mejova and Kyriaki Kalimeri. Advertisers jump on coronavirus bandwagon: Politics, news, and business. *arXiv preprint arXiv:2003.00923*, 2020.

[49] Iwona Taranowicz. Zdrowie i sposoby radzenia sobie z jego zagrożeniami. *Analiza socjologiczna. Wrocław: Oficyna Wydawnicza Arboretum*, 2010.

[50] Wenjun Wang, Yikai Wang, Xin Zhang, Yaping Li, Xiaoli Jia, and Shuangsuo Dang. Wechat, a chinese social media, may early detect the sars-cov-2 outbreak in 2019. *medRxiv*, 2020.

[51] Jun Zhang, Weili Wu, Xin Zhao, and Wei Zhang. Recommended psychological crisis intervention response to the 2019 novel coronavirus pneumonia outbreak in china: a model of west china hospital. *Precision Clinical Medicine*, 2020.

[52] Chuchu Liu and Xin Lu. Analyzing hidden populations online: topic, emotion, and social network of hiv-related users in the largest chinese online community. *BMC medical informatics and decision making*, 18(1):2, 2018.

[53] Xin Lu, Shuo Qin, Petter Holme, Fanhui Meng, Yanqing Hu, Fredrik Liljeros, and Gad Allon. Beyond the coverage of information spreading: Analytical and empirical evidence of re-exposure in large-scale online social networks. *arXiv preprint arXiv:1907.12389*, 2019.

[54] Michael J Paul and Mark Dredze. You are what you tweet: Analyzing twitter for public health. In *Fifth International AAAI Conference on Weblogs and Social Media*, 2011.

[55] Marcel Salathe, Linus Bengtsson, Todd J Bodnar, Devon D Brewer, John S Brownstein, Caroline Buckee, Ellsworth M Campbell, Ciro Cattuto, Shashank Khandelwal, Patricia L Mabry, et al. Digital epidemiology. *PLoS computational biology*, 8(7), 2012.

[56] Christian M Schneider, Vitaly Belik, Thomas Couronné, Zbigniew Smoreda, and Marta C González. Unravelling daily human mobility motifs. *Journal of The Royal Society Interface*, 10(84):20130246, 2013.

[57] Vitaly Belik, Theo Geisel, and Dirk Brockmann. Natural human mobility patterns and spatial spread of infectious diseases. *Physical Review X*, 1(1):011001, 2011.

[58] Alessandro Vespignani. Modelling dynamical processes in complex socio-technical systems. *Nature physics*, 8 (1):32–39, 2012.

[59] Andrzej Jarynowski and Vitaly Belik. Analiza kosztow rozprzestrzeniania sie afrykanskiego pomoru swin w polsce. *Public Health Forum*, V(XIII):72, 2019.

[60] WHO. Who director-general's opening remarks at the media briefing on covid-19 - 11 march 2020. `https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2` 2020. Accessed: 2020-03-12.

[61] Worldmeter. Covid-19 coronavirus outbreak. `https://www.worldometers.info/coronavirus/`, 2020. Accessed: 2020-03-04.

[62] Bruno Latour. On recalling ant. *The sociological review*, 47(1_suppl):15–25, 1999.

[63] Mario Diani. *The cement of civil society*. Cambridge University Press, 2015.

[64] Sejm. Rzadowy projekt ustawy o szczegolnych rozwiazaniach zwiazanych z zapobieganiem, przeciwdzialaniem i zwalczaniem covid-19. `https://www.sejm.gov.pl/Sejm9.nsf/PrzebiegProc.xsp?id=016EAA75EDD551EBC125851E0077C1C2`, 2020. Accessed: 2020-03-04.

[65] KtoMaLek. Zabraknie lekow w aptekach? `https://portal.abczdrowie.pl/na-razie-mamy-zapasy-lekow-gorzej-moze-byc-pod-koniec-roku-przestoj-w-chinskich-fabryk` 2020. Accessed: 2020-03-04.

[66] GPW. Gielda papierow wartosciowych w warszawie. `https://www.gpw.pl`, 2020. Accessed: 2020-03-04.

[67] Mobirank. Social media users in poland. `https://mobirank.pl/2018/12/04/liczba-uzytkownikow-facebooka-instagrama-i-messengera-w-polsce-11-2018/`, 2018. Accessed: 2020-03-04.

SUPPLEMENTARY INFORMATION

Extended Context

On 11.03.2020 WHO declares pandemic ([60]), because European countries are having troubles in fighting the disease. Although (based on current knowledge on 12/03/20220) virus interactivity is moderate ($R_0 \sim 2$)(Worldmeter [61]) and mortality is low in healthy and young populations (<1%)(Worldmeter [61]), the virus contributes to profound disruptions on i) economy– global shortages in product supply and falls in stock exchanges; ii) society – panic, restrictions on migration and participation in mass events; iii) culture – restriction of freedoms and stringent mitigation measures. Probably, no other media phenomenon except corona virus epidemic were observed on such a scale in the history of the Internet. In the present

study we assess the perception of SARS CoV-2 virus and COVID-2019 disease using quantitative analysis of agents and events in online media (Jarynowski et al. [5]).

Sociological analysis of health issues deals with the complex relationship between mass culture and medical knowledge. For this reason, there is no direct translation between scientific evidence (e.g. the question of the effectiveness of vaccination or protective masks in infection prevention) and colloquial knowledge describing infectious disease (Taranowicz [49]). Due to the fact that different agents perceive the risks associated with the virus differently (including scholars, who present extremely different, often unsupported opinions), perception analysis is necessary and this is the main purpose of this article. Using elements of the actor-network theory (ANT ([62])) we emphasize the essence of semiotic networks, putting the agency of the biological viral factor affecting the behavior of people (actors) into scene. The field, or space of potential semantic connections between meanings is expressed by representatives of various organizations, social capital or ideology. We are also interested in the way (Diani [63]), actors cooperate with each other, distribute resources or enter into conflict, drawing boundaries for each other (which is clearly observed in Twitter networks [Fig. 11]) .

It should be noted here that by examining the popularity of concepts about infectious diseases we operate on their common sense rather than medical meanings. For example, the highest peak of interest in HIV in USA occurred in 2015 (more than five fold the average number of queries on Google), when an American actor Charlie Sheen confessed to being seropositive, which is not related to medical advances in the field of immuno or vaccinology.

Event Registry in Poland

The selection of sources corresponds to a large extent to the mainstream media. This means this data set might be biased by reporting style and possible information framing. In addition, the very low coverage of public media in online reality indicates a potentially low impact of information campaigns carried out with their help.

In the cloud of words we can see words used in reporting (people, cases, number, confirmed) [Fig. 16].

News about Poland in forein languages

Sentiment analysis (on a set of foreign-language articles about Poland) showed that neutral sentiment dominates and there is a slight advantage of positive over negative sentiment [Fig. 17]. In the course of time, negative sentiment slightly increased on 14.02 (e.g. the first fatal case of corona virus in Europe), 16.02

Figure 15. Main news sources (31.01-01) (left) and after first confirmed case (04-11.03) (right) (generated using the Event Registry tool))

Figure 16. Words cloud (31.01-01.03) (left) and after first confirmed case (04-11.03) (right) (generated using the Event Registry tool).

(e.g. complaints from Polish PMs about the government's failure to respond to the threat) and significantly on 10.02 (e.g. comparing Oran "Sabin" to a virus), 24.02 (Israel suspends trips to Nazi concentration camps in Poland). Positively marked 15.02 (e.g. calming tone of the president at the election convention for re-election) and 02-03.03 (positive reaction of the world to the special act against COVID-19 ([64])).
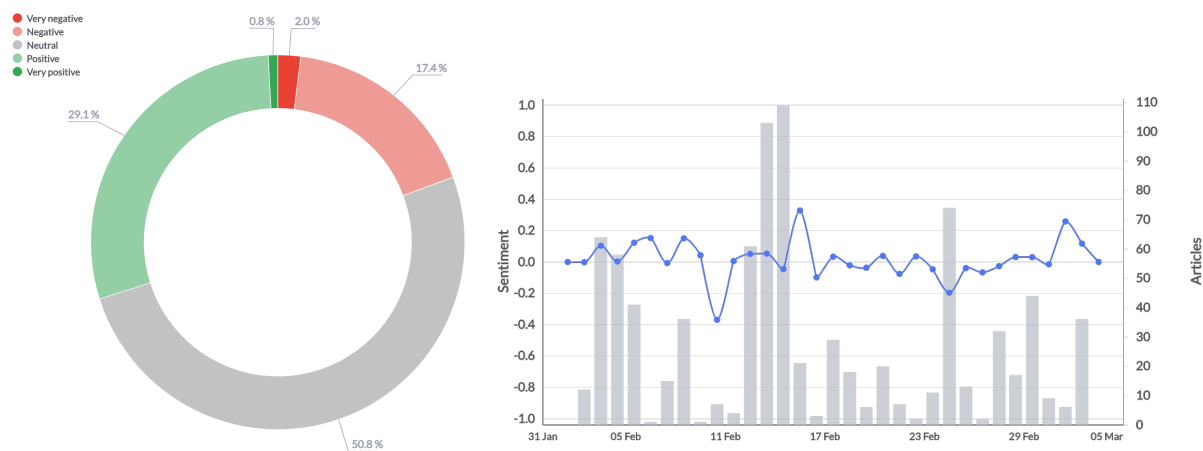
Figure 17. Sentiment pie chart (left) and average sentiment values in time (right) (generated using the Event Registry tool for 2579 articles containing the tag Poland in non-Polish languages for which sentiment is computable).
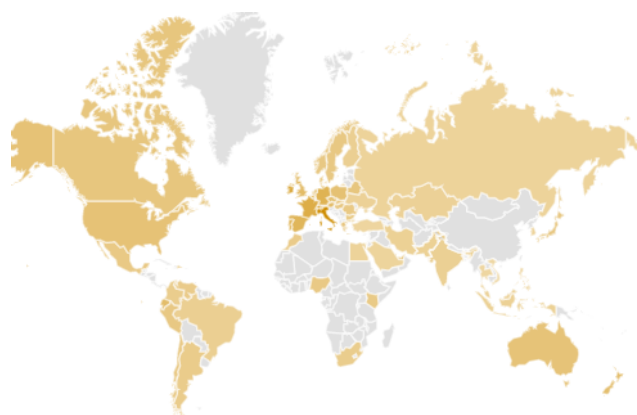

Figure 18. Interest by country Worldwide of "Coronavius" in second part of Generated from Google queries using the Google Trend tool (the darker the shade of a given color, the greater the intensity).

Google Trends: Geography

Compared to other parts of the world (USA, Western Europe), interest in this topic in Poland was low (Widzialni [45]), and from the end of February 2020 it is still only moderate [Fig. 18].

Additionally, we observe that in the southern voivodship, as well as in the Pomeranian and Kuyavian-Pomeranian voivodship, people are less often looking for the phrase "protective mask" associated with fear [Fig. 19].
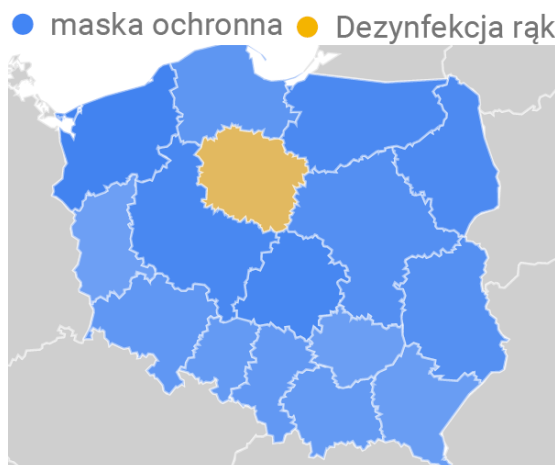
Figure 19.   Interest of the phrase "protective mask"/maska ochornna (bue) and "hand disinfection"/dezynfekcja rąk (blue) by provinces (25/02-03/03/2020). Generated from Google queries using the Google Trend tool (the darker the shade of a given color, the greater the intensity).

Price comparing apps and market situation

Interest for protective masks and their prices could be use to track attention to the epidemic. It could serve as a proxy of panic reactions. Masks can be sold via price comparison websites ([46]) or by a pharmaceutic searching app (KtoMaLek [65]). Huge demand and limited supply caused a huge price surge. Around arrival of the first case, masks and other means of standard hygiene such as disinfectant liquids on the commodity market were almost unavailable. Despite the global recession of the financial market since mid-February caused by disruptions of the supply chain (mainly due to outbreak in China), we are dealing with an increase in the prices of medical device manufacturers such as Mercator on Warsaw Stock Exchange (GPW [66]). In the investigated period there were shortages of the personal protective equipment for medical personnel around the world, representing a feedback loop with panic and media attention. Moreover, people are extensively buying food with a long expiration date.

Facebook

Facebook has a share among Polish Internet users at the level of 79% with about 4.5 billion visits per month (PBI [20]). Besides a large number of visits via mobile applications should be added. Facebook has the highest penetration among all social media with about 17 million users and dominates in almost all demographic categories (age / gender / education / place of residence) except teenagers (Mobirank [67]). Although Facebook does not allow automatic analysis of data from its portal ([47]) thanks to companies monitoring the media market, we can still provide the most important information about the COVID-19

discourse (Sotrender [41], Mobirank [67]).

The fastest growing profile in January and February 2020 in the entire Polish Facebook is („Konflikty i katastrofy światowe") "Conflicts and global disasters" which gained over 120 thousand followers in one month. New followers (with recent increased activity related to corona virus information). The most popular post in the Vlog category in January 2020 was a video material titled "Wuhan market" on SA Wardęga's profile (@sawardega), which was eventually marked as containing false information (Sotrender [41]).

Extended Youtube

The most-watched videos are dominated by news programs, including videos with over 1 million page views by the Ministry of Health (ministerstwo zdrowia), Amazing Facts and „Science. I like it" (nauka to lubie). Channels directly related to China are very popular, e.g. channels with over 1 million views by "Weronika Truszyńska", "CJ Channel" or "Chinese Business". Another group are vlogs commenting on current events with spreading conspiracy theories, e.g. such channels with over 1 million views "Video-prezenacje" and „TV Globalist". You can also find many minor expert, political, humorous, financial and stock exchange reports on the topic. Hundreds of thousands of views can be found in channels by physicians who lost their licenses, such as Hubert Czerniak or Jerzy Jaśkowski. Youtube blocked the videos by Jerzy Zięba, because he proposed in one of them to treat the infection with perhydrol infusions (commercially available bleach). Moreover, Youtube deploys algorithms, aimed on rage reduction if a key word such as "Koronawus" appears in a vlog.

After disease introduction Youtube over 1 M got (Sanitary Inspector form Slubice near Frankfurt/Oder) a viral "easy" to understand but a bit too comic and describing sensitive information (however showing to the public on example how sanitary inspection works). There as some accounts over 500k views as "Uwaga! Naukowy Bełkot", "Poszukiwacz", "Dla Pieniędzy". Topic touches with almost every area of live and hundrets thousendsas views of sport videos and other exotic topics.

Extended Twitter

If we look onto the accounts according to their weighted degree centrality (Blondel et al. [36]), The most central vertices are political and government accounts as well as those related to the Protestant group ("Idz pod Prad") [Tab. II]. For example, at the current time interval, government mitigation programs, or hygiene education on Twitter are falling into the information bubble of the ruling camp supporters.

item	account	centrality	item	account	centrality
1	MichalSzczerba	949	14	prezydentpl	356
2	Leszczyna	914	15	Bart_Wielinski	344
3	MZ_GOV_PL	820	16	AndrzejDuda	331
4	PremierRP	800	17	LewitujacyUmysl	326
5	Platforma_org	654	18	Jowita_W	298
6	AndrzejTurczyn	590	19	PiotrMuller	283
7	KONFEDERACJA_	538	20	KChojecka	280
8	MiroslawSuchon	520	21	michalrachon	274
9	KrzysztofBrejza	494	22	KancelariaSejmu	269
10	idzpodpradpl	468	23	PawelChojecki	263
11	M_K_Blonska	443	24	pigmalion55	263
12	GIS_gov	406	25	KosiniakKamysz	234
13	MikiWrobelek_	360	26	ADReverse	205

Table II. The most central accounts in the Twitter network (18.02-28.02.2020).

Model of information propagation

We propose a null simple model which was suggested from our observation from Poland. We have distinguished 2 mains modifiable variables: Information Campaigns and Spread of Information, misinformation and rumors. Crisis management committee and public relation team should consider:

- coverage of information campaigns, especially that we can observe (at least on Twitter) filter bubbles. We have showed the most important information providers on Facebook, Twitter, News (represented by Event Registry) and Youtube, which should be in contact with public relation team. However, blogs are not covered by our analysis as well statistics of entries for a source providers are also unknown (at least for us)

- information, misinformation and rumors should be real time monitored by authorities. Accounts sus-
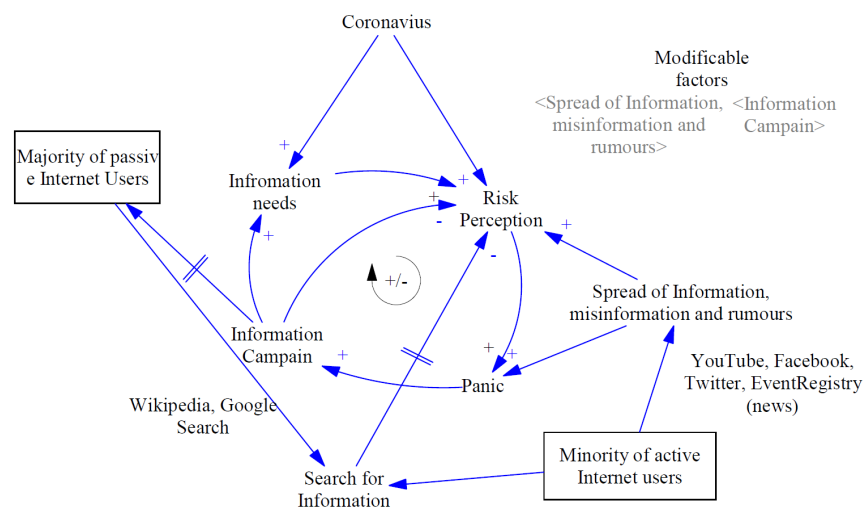
Figure 20.   Causual diagram and model of interactions between Panic, Media, and Risk Perception retrieved from observation during preepidemic situation in Poland.

pected for being foreign agents as well as these spreading obvious misinformation and rumors could be visually marked as suspected by administrative decision.

Extended Conclusions

Up to now (the beginning of March 2020) there is no effective vaccine and no specific drug therapy against COVID-19 and there are epidemic outbreaks in all EU countries. The only mitigation methods so far are contact reduction (e.g. isolation / quarantine, restrictions for travel or mass assembly) and the reduction of the probability of infection transmission (e.g. standard precautions such as hand hygiene or immunomodulation like sleeping well). The virus will probably cause an epidemic outbreak in Poland soon and its elimination might not be possible for at least months. Panic can occur when people overestimate a threat or do not understand it [Fig. 20] . The more and more often the information about corona virus is repeated - the more important it is going to be. It is worth raising the ethical role of media platforms that have technical capabilities to moderate the discourse on infection. This applies to traditional journalism too, which in the pursuit of luring the reader fuels sensational content. In social media one can think about preventative censorship, especially since the new special act would give such opportunities.

Like the actual COVID-19 epidemic, theories are spreading virtually across the Internet such as: "the virus has escaped from a BSL-4 class laboratory near Wuhan", "this is an American biological weapon giving advantage over China in a trade conflict," "the virus serves to depopulation of humanity and the creation of a New Order world's government," "the virus is harmless, and serves the interests of pharmaceutical com-

panies", "the virus is a punishment for the godlessness of the Chinese people", "infection can be avoided by hidden therapies that the doctor will not tell you". They fall on fertile ground, due to the script mechanism of simplifying reality, where simpler explanations are more easily absorbed by people. Especially since we don't know enough about COVID-19, and the recommendations and opinions of authorities such as WHO, ECDC or CDC are still being updated.

Social media provide information and misinformation on infectious diseases around the world at unprecedented speeds (also in Poland). Platforms committed themselves to fight the dissemination of false information about the epidemic and content that may be false. Facebook, Twitter, and Youtube add an appropriate label, remove content / block accounts. Unfortunately, only Twitter allowing API access to its data can be used to analyze the virus perception and its impact on the society. Although COVID-2019 might cause more disruption due to panic reactions to it than due to its actual epidemic risk, once introduced the epidemic might pose a serious challenge to the Polish healthcare system due to e.g. lack of staff and shortage of quick diagnostic tests.