Research Article

Google Trends and Trend Analysis of Online Behaviour During the COVID-19 Pandemic: A Saudi Arabian Experience

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Mental health condition was greatly affected by COVID-19 Pandemic through various social distancing measures implemented to counter its spread. Netizens were all abuzz on personal issues like anxiety, depression, and even panic. This study aimed to determine the COVID -19 Pandemic's effect on mental health as reflected through manifested online behaviors. Data were collected through the Google Trends using specific search terms, and official government health data. These were analyzed using trends analysis. Results showed three instances of actual COVID -19 case spiked increases that showed influence to Saudi residents as reflected on their online reactions. Prevailing behaviors were reflected in their actual search term inputs, and presented adaptation despite the unpredictable rise and fall of actual COVID -19 cases in the kingdom. Thus, search trending data can be an alternative in looking for behavioral patterns as impact measures to social and health events like the COVID- 19 Pandemic.

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1. Introduction

One the early months of 2022, the COVID-19 Pandemic global cases were down by 12% and reported deaths decreased as well by 25% but the World Health Organization was still adamant about declaring a formal "*end*" insisting continued surveillance and vigilance[1]. Everybody was advised continued adherence to pandemic health measures which still poses real health threats. After two years, how much have we been affected? Such a question requires many other ways of answering to display the said pandemic impact. In the earliest part of 2020, the undoubted effect of the pandemic was apparent especially its impact on the psychological and mental health conditions of every affected individual in most of the known territories[2][3][4].

Article from Social Media Statistics, the kingdom of Saudi Arabia has a total population of 35.59 million and total internet users of 34.84 million[5] marking a real electronic presence and participation. From that same population, 29.30 million were considered active social media users and 33.59 million Saudis were accessible through their mobile internet. These conditions had actually brought real-life reflection of the Saudi psyche in their search behavior, otherwise known as "digital health"[6]. Google came as the highest-ranked search engine utilized at 96.60% by Saudi netizens spending an average of 4 hours and 35 minutes using the internet on mobile devices. According to 2020 research[7], online behavior

(*social media engagements*) and mental health showed positive benefits especially in creativity and communication improvement. Workloads and responsibilities were done faster and more efficient. Personal aspects like family and significant relationships were made seemingly improved as connections were made readily available. A contrary study in early 2014, it showed controversial topic with many admonitions for support research wishing to prove the relationship between "*mental health issues like depressive symptoms, changes in self-esteem, and internet addiction*" showing disadvantageous and negative effects[8]. Taking into account that a great majority of the Saudi population is considered young (age 15-34 years old), early studies even showed that internet addiction showing this much early in their lives was associated with stressful life conditions, especially among adolescent internet users[9][10] who were highly engaged in social media and online games. Whether there can be that positive or negative impact on personal lives, what is clearly evident in this situation is that their digital presence (as may be exacerbated by the pandemic restrictions and protocols) can be an alternative reflection showing directly or indirectly their general mental health conditions. Every activity done online are automatically imprinted into the internet system and mostly harvested by websites (like Google Search/Trends) which usage carried an implied concurrence to their terms and conditions. In return, the same websites will utilize this information to greatly improve their marketing services and product advertisements. The seeming innocent use of their services are actually a ploy designed to establish what users are thinking, their preferences, and their state of mind through selections and searches.

In a research endeavor with the hope of targeting larger sample and increasing its inferential reliability, this condition could then be used as an alternative form to conducting a possible analysis of their digital imprints. Saudi netizens may be reflecting emotions and deep unexpressed concerns especially during the COVID-19 Pandemic time due to seclusions imposed by government-sanctioned health restrictions. This COVID-19 pandemic has been ravaging the entire kingdom from the early part of 2020 through the first quarter of 2022. This study explored that alternative scenario and found patterns in trends presented by the actual COVID-19 cases against the patterns of trends about search terms mental health, depression, anxiety, and panic.

2. Methods

2.1. Data Extraction and Procedure

The study utilized data from two (2) sources. First, actual COVID-19 cases of the first week of March 2020 until the third week of April 2022 from the Ministry of Health-Kingdom of Saudi Arabia (MOH-KSA) through its publicly accessible website (https*://covid19.moh.gov.sa*). There were 112 observation points, equivalent to 112 weeks reflecting the actual COVID-19 cases in the entire Kingdom of Saudi Arabia. Second, the search trend of the following terms (mental health, depression, anxiety, and panic) was sourced from the Google Trends data center publicly accessible through their website (https*://trends.google.com/trends/?geo=SA*). Notice that these search terms were observed to have been the focus and concerns of the Saudi netizens during the same time intervals on focus. The said different search terms were individually processed following same procedures through the help of Google Trends' available search engines.

2.2. Data Analysis

The data used in this study were analyzed using two statistical applications/packages: IBM SPSS Version 23 and ExcelStat Version 2019. Statistical analysis utilized time series regression, autocorrelation using the Durbin-Watson Test, and the graph or chart builders of the previously mentioned statistical applications. All significance levels were set at $p \leq .05$ in this study while $p \leq .01$ was considered even better in some results.

2.3. Ethical consideration

Google Trends, a private multinational technology enterprise, and the Ministry of Health (MOH) websites, a Saudi government website that regularly publishes data on health including COVID-19 pandemic information, were the primary sources of data both offering public and readily available data for both research and non-research consumers. Following the guidelines provided by the British Psychological Society (BPS) on internet-mediated sources considered as public domains or internet sites that offer active and readily available data, the following considerations were put in place to provide conditions upholding utmost confidentiality, respecting copyright and consent issues. Data underwent a process of anonymizing data elements like usernames, reference points, or personal identifying information. The focus of this research endeavor was a presentation of a clear summarized and cumulative data set and interpretations. Data ownership and sources were properly acknowledged by citing them as sources. Accordingly, there is no need for the local institution to facilitate and issue ethical approval according to existing local policies as respondents were not directly from the institutions' purview and jurisdiction.

3. Results

3.1. Descriptive Measures

With the COVID-19 cases appearing in different countries and territories, the Kingdom still had zero count in the 1st two (2) months of 2020 but the search terms in focus already had picked up in numbers even in the month of January 2020 (ST-Mental Health = 100 (f); 25 (Mn); ST-Depression = 238 (f); 59.5 (Mn); ST-Anxiety = 254 (f); 63.5 (Mn); and ST-Panic = 100 (f); 25 (Mn). Using the peaks of Covid-19 cases as reference points, there were observed to have happened three times specifically during the June 2020, May 2021, and January 2022. Specifically, June 2020 was considered COVID-19 Case Wave 1 (C19CW1) with cases at 99,294 (f); 24,823.50 weekly average and relatively showed the following trends result: ST-Mental Health = 117 (f); 29.3 (Mn); ST-Depression = 312 (f); 78.0 (Mn); ST-Anxiety = 267 (f); 66.8 (Mn); and ST-Panic = 133 (f); 33.3 (Mn). May 2021 was considered COVID-19 Case Wave 2 (C19CW2) with cases at 37,262 (f); 7,452.40 weekly average and relatively showed the following trends result: ST-Mental Health = 97 (f); 19.4 (Mn); ST-Depression = 233 (f); 46.6 (Mn); ST-Anxiety = 258 (f); 51.6 (Mn); and ST-Panic = 135 (f); 27.0 (Mn). Lastly, January 2022 was considered COVID-19 Case Wave 3 (C19CW3) with cases at 133,945 (f); 26,789.0 weekly average and relatively showed the following trends result: ST-Mental Health = 126 (f); 25.2 (Mn); ST-Depression = 222 (f); 44.4 (Mn); ST-Anxiety = 222 (f); 44.4 (Mn); and ST-Panic = 93 (f); 18.6 (Mn).

Observation Period		Covid Cases		ST: Mental H.		ST: Depression		ST: Anxiety		ST: Panic	
Month	**Year**	**f**	***Mn***	**f**	***Mn***	**f**	***Mn***	**f**	***Mn***	**f**	***Mn***
January	2020	-	0.0	100	25.0	238	59.5	254	63.5	100	25.0
February	2020	-	0.0	92	23.0	245	61.3	217	54.3	96	24.0
March	2020	1,299	259.8	131	26.2	340	68.0	288	57.6	218	43.6
April	2020	17,512	4378.0	94	23.5	259	64.8	211	52.8	140	35.0
May	2020	68,331	13666.2	142	28.4	284	56.8	284	56.8	182	36.4
June	2020	99,294	24823.5	117	29.3	312	78.0	267	66.8	133	33.3
July	2020	82,498	20624.5	86	21.5	221	55.3	273	68.3	106	26.5
August	2020	46,838	9367.6	112	24.4	271	54.2	303	60.6	124	24.8
September	2020	17,876	4469.0	104	26.0	210	52.5	246	61.5	99	24.8
October	2020	11,584	2896.0	115	28.8	234	58.5	192	48.0	77	19.3
November	2020	12,128	2425.6	104	20.8	273	54.6	247	49.4	117	23.4
December	2020	4,979	1244.8	85	21.3	196	49.0	206	51.5	85	21.3
January	2021	5,990	1198.0	107	21.4	243	48.6	298	59.6	110	22.0
February	2021	9,371	2342.8	93	23.3	217	54.3	189	47.3	88	22.0
March	2021	11,166	2791.5	83	20.8	233	58.3	202	50.5	90	22.5
April	2021	24,308	6077.0	78	19.5	185	46.3	173	43.3	84	21.0
May	2021	37,262	7452.4	97	19.4	233	46.6	258	51.6	135	27.0
June	2021	34,103	8525.8	92	23.0	222	55.5	233	58.3	92	23.0
July	2021	34,856	8714.0	110	27.5	195	48.8	259	51.8	74	18.5
August	2021	24,830	4966.0	121	24.2	248	49.6	188	47.0	110	22.0
September	2021	2,760	690.0	129	32.3	204	51.0	264	52.8	76	19.0
October	2021	1,681	336.2	172	34.4	220	44.0	212	53.0	90	18.0
November	2021	1,054	263.5	123	30.8	193	48.3	192	48.0	90	22.5
December	2021	3,599	899.8	108	27.0	205	51.3	192	48.0	90	22.5
January	2022	133,945	26789.0	126	25.2	222	44.4	222	44.4	93	18.6
February	2022	57,763	14440.8	127	31.8	188	47.0	205	51.3	107	26.7

Observation Period		Covid Cases		ST: Mental H.		ST: Depression		ST: Anxiety		ST: Panic	
Month	**Year**	**f**	***Mn***	**f**	***Mn***	**f**	***Mn***	**f**	***Mn***	**f**	***Mn***
March	2022	5,456	1364.0	104	26.0	206	51.5	246	61.5	74	18.5
April	2022	2,222	740.7	83	27.7	137	45.7	115	38.3	63	21.0

Table 1. *Descriptive Measures of Covid-19 Cases VS Search Trends*

3.2. Time Plot Analysis

The weekly COVID-19 case counts from the Year 2020 until the first quarter of the Year 2022 showed a strong cyclic behavior with no apparent trend over this time period (Figure 1. A). Also, there were three (3) identifiable clear peaks that could be considered pandemic waves and, later on, will be used as COVID-19 Case Wave 1 (C19CW1), COVID-19 Case Wave 2 (C19CW2), and COVID-19 Case Wave 3 (C19CW3).

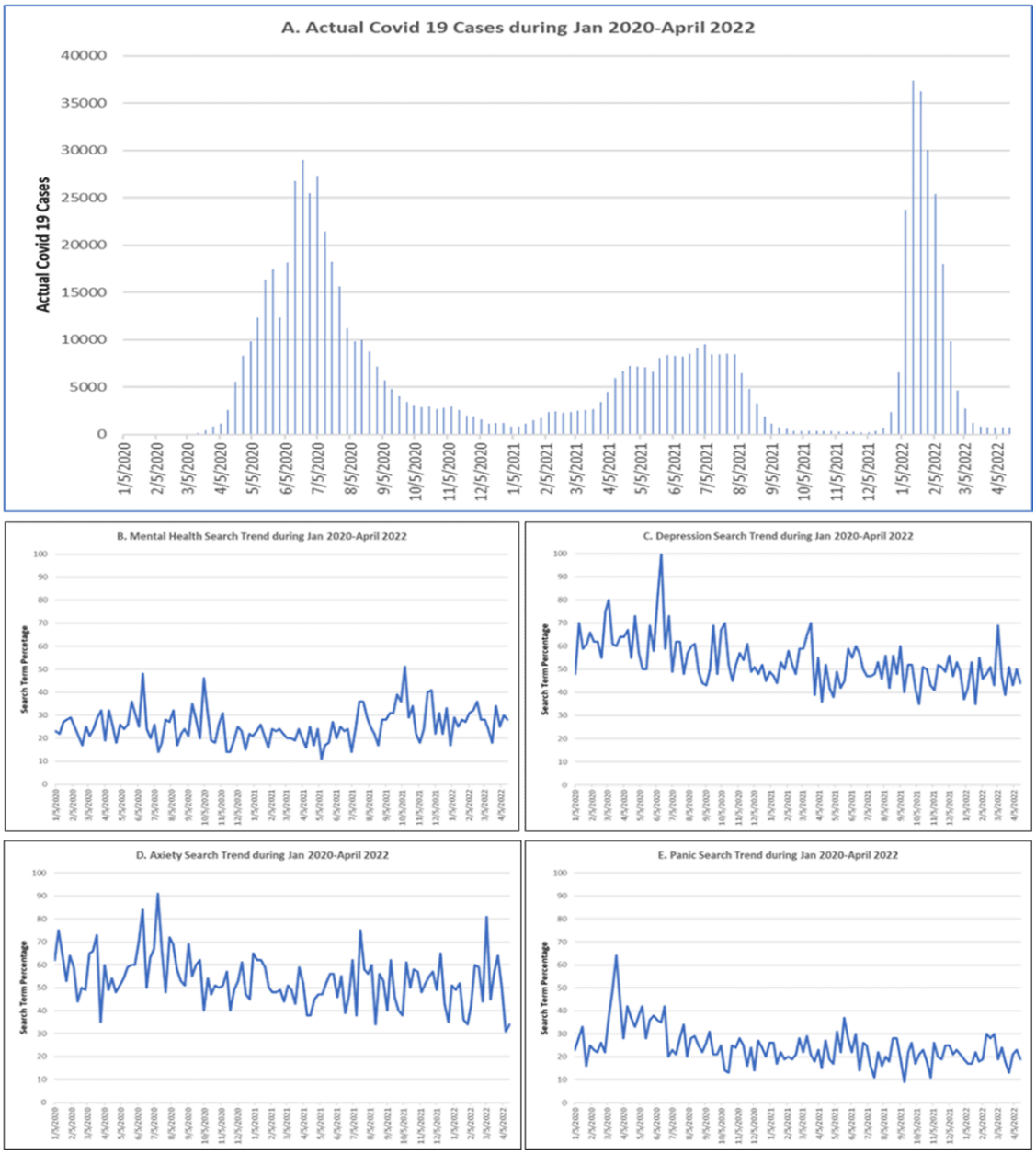

Figure 1.*General trends of all search terms VS Actual COVID-19 Cases in Saudi Arabia*

There was no statistically significant main trend found, F(1, 110) = 0.852, p=.358. As far as the Google Trends data were concerned, the study utilized one (1) main search term, Mental Health, which has appeared in the top ten most searched in all years 2020-2022 among the Saudi netizens. Referring to Figure 1.B, the search term Mental Health seemed to show a strong cyclic behavior with no apparent seasonality. Analysis showed no statistically significant main trend found, F(1, 110) = 3.136, p=.079. There were also related behavioral terms that came relevant to the main search term, and the study focused on three (3) others (e.g., Depression, Anxiety, and Panic).

On search term Depression, results showed some strong cyclic behavior with no apparent seasonality but had a statistically significant main trend, F(1, 110) = 41.204, p=.001 (Figure 1. C). The search term Anxiety showed strong cyclic behavior with no apparent seasonality but had a statistically significant main trend, F(1, 110) = 12.591, p=.001 (Figure 1.D). Furthermore on the search term panic, the same result of strong cyclic behavior was found with no apparent seasonality but the same statistically significant main trend, F(1, 110) = 41.843, p=.001 (Figure 1. E). On the test for possible autocorrelation utilizing the Durbin-Watson test, the following were the results; COVID-19 cases (d =.137, R2 =.008), search term Mental Health (d =1.494, R2 =.028), search term Depression (d = 1.718, R2 =.273), search term Anxiety (d = 1.784, R2 =.103), and search term Panic (d = 1.424, R2 =.276). For transparency's sake, there seemed to have positive autocorrelation on all focused variables; hence no active decision was taken to further extrapolate for prediction purposes as it could lead to inappropriate standard errors for the regression coefficient estimates.

3.3. Trends Comparison

There shall be two parts to this presentation, starting with the gross comparison of actual COVID-19 cases against an individualized pairing with the different search terms (mental health, depression, anxiety, and panic). It shall be followed with more detailed same comparison pairings but with additional observation focused on the three (3) identified clear peaks considered pandemic waves and now referred to as COVID-19 Case Wave 1 (C19CW1), COVID-19 Case Wave 2 (C19CW2), and COVID-19 Case Wave 3 (C19CW3).

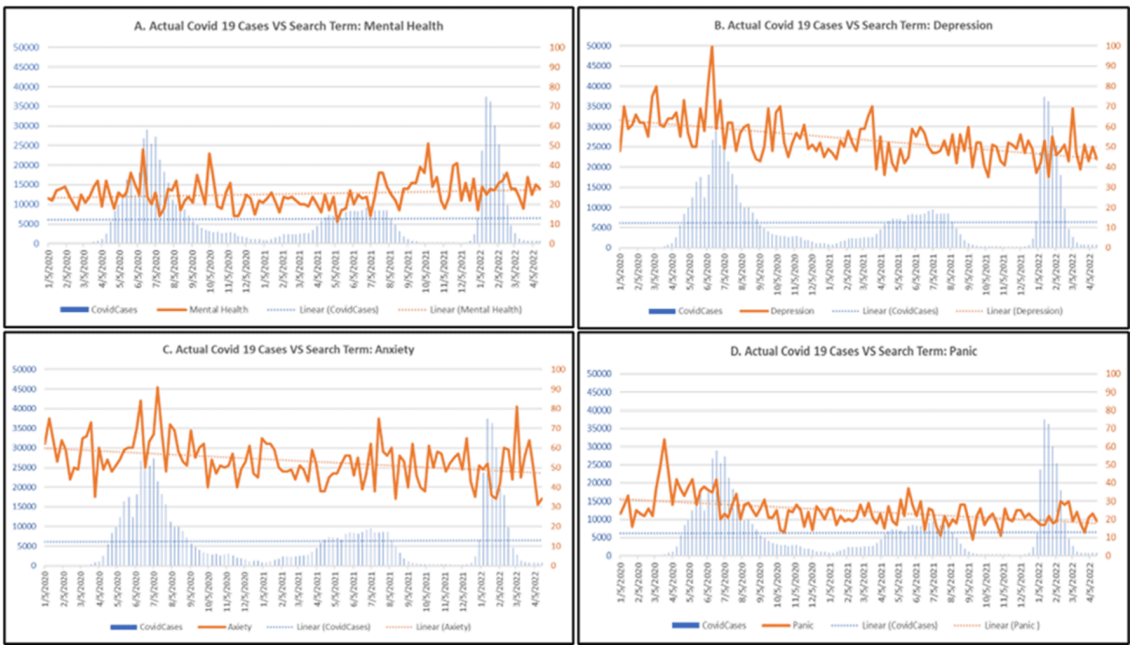

Figure 2.*Trends Comparison*

In Figure 2.A, the actual COVID-19 cases had an equation of Y = 0.4097X – 11856 (R2 = 0.0002) which indicated a positive slope with very minimal and almost negligible incremental effect to the Y-intercept with the squared r value suggesting the least fit for the model. With Search Term (ST): Mental Health, data had Y = 0.005X – 193.94 (R2 = 0.0289), suggesting a

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positive slope with minimal incremental effect on the Y-intercept. Contrasting relevant findings, the almost non-existent trend in actual COVID-19 cases (e.g., seeming no increase or decrease) appeared to suggest a positive or increasing trend in the ST-mental health. A generally increasing mental health appreciation among the Saudi netizens may have been because of the prevailing COVID-19 pandemic. Cursory estimation of the paired trends, the C19CW1 has caused two (2) peaks of mental health appreciation during the approximated periods of the first week of June and the first week of October 2020. During the C19CW2, another peak was found during the second week of July 2021, which was a little bit delayed appearing during the downtrend of this COVID-19 case wave. On the C19CW3, considered the highest in cases, there came no dramatic reaction except for the continued rise of mental health concerns from the same Saudi netizens.

In Figure 2.B, ST: depression had an equation of Y = -0.0228X + 1060.5 (R2 = 0.22838), which indicated a negative slope with minimal decremental effect to the y-intercept with the squared r value suggesting the least fit for the model. When contrasted with the previously mentioned COVID -19 cases condition, gross trend comparison seemed to have suggested a sustained decrease in ST: depression. In contrast, COVID-19 cases continued their unpredicted rise and fall throughout the inclusive study period. During the C19CW1, there came an immediate highest level of ST: depression during the middle of May 2020, followed by a sudden rise a month before C19CW2, and a delayed rise after C19CW3 experienced during 1se week of March 2022.

In Figure 2.C, ST: anxiety had an equation of Y = -0.0151X + 722.04 (R2 = 0.1147), which indicated a negative slope with minimal decremental effect to the Y-intercept with the squared r value suggesting the least fit for the model. When contrasted with the previously mentioned COVID-19 cases condition, gross trend comparison seemed to have suggested a sustained decrease in ST: depression. In contrast, COVID-19 cases continued their unpredicted rise and fall throughout the inclusive study period. During the C19CW1, two (2) peaking incidents occurred within a month and a little delayed peaking incident during the C19CW2. On the C19CW3, there was a clear delayed reaction with its highest peak during the downtrend of the COVID-19 cases.

In Figure 2.D, ST: panic had an equation of Y = -0.0158X + 723.31 (R2 = 0.2194), which indicated a negative slope with minimal decremental effect to the Y-intercept with the squared r value suggesting the least fit for the model. When contrasted with the previously mentioned COVID-19 cases condition, gross trend comparison seemed to have suggested a sustained decrease in ST: panic. In contrast, COVID-19 cases continued their unpredicted rise and fall throughout the inclusive study period. During the C19CW1, a premature appearance of peaking incident of very early even on the upswing of COVID cases that continued to drop. That same minimal peaking happened together during the C19CW2. On the C19CW3, there was a clear moderated reaction despite the highest peak of cases that continued a general decline in trend.

4. Discussion

The COVID-19 Pandemic was a real tragedy in modern history that undoubtedly had and continuously distressing significant populations of the world. Though current statistics show a global slowdown in morbidity and mortality, general mental health is still a concern not just among Saudis but the world. Knowing and understanding what is happening or what has happened during the past two (2) years of pandemic experience could be provided by free and available data from Google Trends and actual COVID-19 cases from official sources.

Clearly, Saudi Arabia experienced three separate peaks of COVID-19 actual cases from the start of the pandemic until the first quarter of 2022. The first COVID-19 case was discovered or reported officially on March 02, 2020 though cases were already reported everywhere, especially from its supposed origin[11]. Results from this study showed no specific trend even though it was clearly cyclic nature. A 2020 study observed and clarified, no specific model could seem to fit and possibly predict the spread of the SARS-CoV-2 virus in the different locations of the kingdom[12]. Interestingly, it confirmed and specified there were "*so many moving parts*" that may be referring to essential factors that can "only make prediction improbable" meaning doubtful[13]. Prediction and trend analysis are critical to aid decision making based on science[14] as each institution crafts policies and regulatory guidelines to reduce, if not stop, the spread of COVID-19 infection into the general population. Importantly, mental health is one crucial concern institutions and individuals must consider checking on. The COVID-19 pandemic had varied impacts on the world economy and has affected socio-economic conditions leading to changes in behavioral patterns[15] among the affected individuals. Incidentally, one study[16] explained that the different variations of lockdowns during the pandemic period instituted by government authorities shown the most significant effect resulting to mental health concerns like depression, anxiety, and panic. Because of the advancement in mobile communications and internet technology, exhibited behaviors are mirrored in their online activities like their Google searches and social media engagements. Some studies even confirmed the value of Google Trends as a way to engage scientifically and study online behaviors[17], and that strategy was utilized here in this research endeavor.

The Google Trends data showed mental health had been included in the leading search topics in what seemed to represent the Saudi netizen psyche or, at the very least, current psychological concerns. These concerns about mental health became so apparent among young and educated individuals of high socio-economic urban dwellers[18] because of two things; (1) the bombardment of news about the even increasing COVID-19 cases, and (2) actual outbreak that came into their locality as shown in peaks which were highly monitored. Two studies[19][20] showed that even during the "lul periods" or between waves of SARS-CoV-2 virus outbreaks, online behavior showed no meaningful decrease but of sustained engagement in mental well-being. Moreover, in times of peaks in every wave experience when health institutions of every country implemented the most restrictive measures, related mental health searches seemed to also peaked by individuals across different social classes[21][22]. Furthermore, women and non-partnered individuals experienced a more significant deterioration in mental health, including those who were separated from their families.

For now, results showed a general decrease in those trends, demonstrating Saudi netizens' adaptation to the "new normal." On anxiety, the highest observation was during the earliest part of the first wave of peak COVID-19 cases showing how this pandemic affected daily life[23]. One preliminary observation on anxiety search trends is that in every downtrend of COVID-19 cases in the subsequent two waves, increased anxiety search trends were happening. It appeared that affected individuals isolated at home looked for a way to understand their emotional condition or to seek self-help strategies to cope with the ongoing lockdown experiences. The different peaks of Anxiety searches appeared during every wave of peak COVID-19 cases, including the expression of general life dissatisfaction[24].

Furthermore, an increase of 90% in the incidence of depression rates even prior to the pandemic announcement by World Health Organization[19]. During those times, speculations still have it on COVID-19 infections affecting most known territories and countries, not just Saudi Arabia. A recent study showed a generally increased incidence of loneliness and anxiety that seemed to affect those with "less wealth" or low-income households[25]. Female, urban dwellers showed

statistical significance to higher level of depression among participants[26]. All three waves of increased COVID-19 cases in Saudi Arabia were accompanied by a positive trend of searches except the last wave, as the positive increase in search trend happened just after the peak. Incidentally, every drastic increase in COVID-19 cases health institutions implemented even steeper lockdowns. These lockdowns were seen to have a significant association with depressive symptom development and actual depression among affected individuals[27][28][29]. In a more favorable finding, a study identified that the vulnerable individuals, especially the elderlies and guardians of larger families, showed "*relatively low depression levels*".

Panic is a normal emotional response when individual is faced with incredible dangers or issues such as this COVID-19 pandemic with all its challenges and hardships[30]. This initial response will deliver a way to cope or adapt to an unfamiliar or sudden dangerous situation, either perceived or actual. This study's results manifested the highest panic experience at the start of March 2020, way earlier than when the first wave of COVID-19 cases increased drastically. During this time of the pandemic period, a study even produced an estimate of about 79.6% statistical significance among their respondents in predicting panic from age, education, and civil status, e.g., older than 30 years old, educated and married[31]. Though there was a general decline in panic trend throughout the same period, consistent but intermittent spikes appeared during the second and third wave experiences. The Saudi netizens' panic response could have been a next-to-real reflection of their conditions. The "*COVID-19 Pandemic-induced panic disorder*" even was introduced in the earlier pandemic times as a case report[32] emphasizing panic response was and is until the present from not just Saudi netizens but to world residents as well.

Interestingly, a new concept was introduced that triggered mental health issues like depression and anxiety. This concept is called "infodemic factors" defined as *information consumption during COVID-19 outbreaks from different media sources resulting in information overload and confusion from a mixture of accurate and inaccurate data*[33][34]. Somehow, individuals or groups but also institutional panic accelerated implementation and evaluation of interventions like premature drug approvals appearing in frequent press releases[35]. Alternatively, the COVID-19 pandemic seemed to have been ascribed to as propaganda delivered to us through mass media[36][37] riddled with inaccurate information. It exaggerated responses made worse by the internet superhighway making its spread faster than the SARS-CoV-2 virus raising unnecessary panic and fear.

Utilizing the time series analysis and model, generalization from a single study like this might not present a solid and conclusive statement but also offers that certain leeway for an independent study like this. Though Google Trends and information gathered from the site can be considered secure and unbiased, it is still open to possible external manipulation and threats through nefarious individuals or organizations with views opposing prevailing ones, political or otherwise. With the use of gross trending analysis made with much care and professionalism and influenced by the author's background and biases, it might still be open to alternative and opposing interpretations. Furthermore, Google Trends and Google as a whole is an AI-driven (Artificial Intelligence) site with different applications. Artificial intelligence is dependent on the coding styles and surely will change as it learns from past and present situations and considerations.

5. Summary and Conclusion

In conclusion, the COVID-19 Pandemic experience in Saudi Arabia reflected three waves of peak incidences of varied length and intensity. It clearly influenced their behaviors expressed through their search terms depression, anxiety, and panic

observed during 2020 until the first quarter of 2022. The mental health search trend presented a positive appreciation when compared with the trend set by COVID-19 cases, while for the other search terms of depression, anxiety, and panic, showed consistent downtrends. This might be Saudi netizens' manifestation of adaptability to the said "*new normal*" as while the over-all pandemic situation winds down.

Lastly, this study proved (even partially) alternative criteria for understanding cyber behavior. Additionally, continued surveillance and monitoring of public mental health may now be done through available cyber trends as provided by AI-assisted applications (like Google Trends) to aid in any initiatives and programs affecting policies, plans, and strategies on public health now guided by this alternative basis.

Limitations of the Study

Utilizing the time series analysis and model, generalization from a single study like this might not present a solid and conclusive statement but also offers that certain leeway for an independent study like this. Though Google Trends and information gathered from the site can be considered secure and unbiased, it is still open to possible external manipulation and threats through nefarious individuals or organizations with views opposing prevailing ones, political or otherwise. With the use of gross trending analysis made with much care and professionalism and influenced by the author's background and biases, it might still be open to alternative and opposing interpretations. Further and more in-depth studies might be done to ensure more valid and relevant outcomes, whether supportive of the present results or contrary.

Statements and Declarations

Data Availability

Though source of data were described already in the previous appropriate manuscript parts, availability and further clarifications may be supplemented and supplied if properly requested from the corresponding author.

Conflicts of Interest

The author declares no conflict of interest in preparing this article.

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