How search engines may help reduce drug-related suicides

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A B S T R A C T

Background and aims: Numbers of drug-overdose deaths, both intentionally and unintentionally, have been increasing in the United States. Of interest, Google spotlights counselling services as helpful resources when users query for suicide-related search terms. However, the search engine does so at varying display rates, depending on terms used. Display rates in the drug-overdose deaths domain are unknown.
Methods: We emulated suicide-related potentially harmful searches at large scale across the U.S. to explore Google's response to search queries including or excluding additional drug-related terms. Employing agent-based testing we conducted 215,999 search requests with varying combinations of search terms.
Results: Counseling services such as helpline telephone numbers were displayed at high rates after suicide-related potentially harmful search queries (e.g., "how to commit suicide"). While this is a desirable outcome, display rates were substantially lower when drug-related terms, indicative of users' suicidal overdosing tendencies, were added (e.g., "how to commit suicide fentanyl"). Importantly, the addition of any drug-related search term to the suicide-related queries decreased the display frequency of helpful prevention-related resources substantially.
Conclusions: Search queries such as "easy way to commit suicide fentanyl" may indicate acute suicidal crises. Helpful resources should be displayed right in such search moments. Search engines should adjust their algorithms to increase these display rates to direct users to such resources. By doing this, search engines may contribute to the prevention of drug-related suicides.

1. Introduction

The number of drug-overdose deaths in the United States has drastically increased over the past two decades (Rudd et al., 2016) and the U. S. "opioid crisis" has been shown to largely contribute to this increase with 49,860 opioid-related registered deaths in 2019 alone (Mattson et al., 2021). Latest driver of these deaths were heroin as well as synthetic opioids, mainly fentanyl (Rudd et al., 2016; Manchikanti et al., 2018), the use of which peaked, again, only recently during the early months of the COVID-19 pandemic (U.S. Department of Health and Human Services, 2020). Importantly, causes for the opioid crisis in the U.S. can only partially be attributed to the common narrative of an increased availability of prescription opioids, but instead point to social and economic upheavals yielding "interconnected trends in fatal drug overdose, alcohol-related disease, and suicide" (p. 183) (Dasgupta et al., 2018).

Drugs contribute to national death rates through increasing numbers of substance-overdose deaths, both intentionally and unintentionally (Oquendo and Volkow, 2018). Behind the devastating numbers of deaths with a drug addiction, people who unintentionally overdosed with prescription pain killers or illicit opioids including heroin or fentanyl, may mix with an unknown number of suicidal people who intentionally took their own lives. While 26 percent of substance-overdose deaths happen on purpose, specific overdosing with opiates or sedatives usually comes with stronger intentions to die (around 39 %). Although suicides and suicide attempts remain an unknown figure without explicit indicators, suicides have been emphasized as a 'silent contributor' to substance-overdose deaths (Bohnert et al., 2018).

The media operate in two ways in this regard. The so-called "Werther effect" has described the media repeatedly as an additional risk factor for suicidality through copycat effects, especially by means of celebrity-suicide news (Phillips, 1974; Stack, 2005; Niederkrotenthaler et al., 2012). Conversely, the media has also been shown to act as a preventive impediment by raising awareness for counselling services via telephone or chat, a phenomenon usually referred to as "Papageno effect" (Lester

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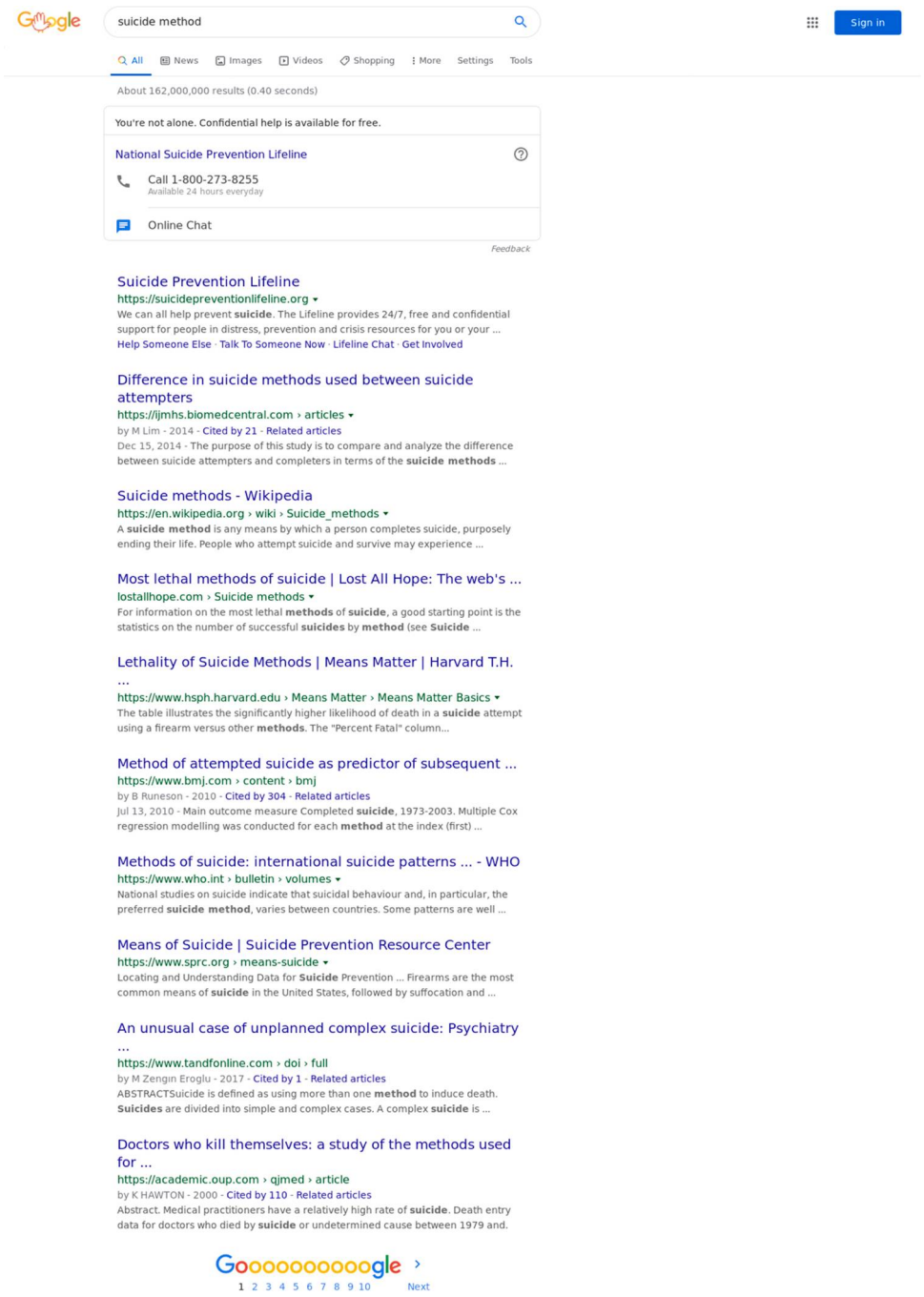

Fig. 1. Screenshot of a suicide-prevention result (SPR) at the top of Google's search results.

and Rogers, 2012; Niederkrotenthaler and Sonneck, 2007; Wasserman, 2016). Relatedly, these findings have found their way into policy considerations, WHO suggestions, and national press guidelines (Schäfer and Quiring, 2014).

Since 2010, Google Search spotlights counselling services to overcome suicidality including country-specific helpline telephone numbers, websites, and/or chats (Fig. 1) as part of an info box termed the "suicide-prevention result" (SPR). According to Google, for "certain search queries" (Zeiger, 2010), users are presented with the SPR at the top of Google's search results depicting resources to help overcome acute suicidality, right in the moment when suicide-related search terms are used. Suicide-related search queries (e.g., "how to commit suicide") can be indicative of acute suicidality in vulnerable users (Arendt and Scherr, 2017). Importantly, while the display of the SPR has been shown to not raise subsequent searches for suicide prevention (Cheng and Yom-Tov, 2019), Google's display of the SPR has been shown to increase the number of calls to helpline services (Zeiger, 2010), which in turn have been shown to help reducing suicidality (Gould et al., 2018). Thus, high display rates of the SPR are desirable and potentially help to save lives.

Yet, display rates of the SPR vary across different search queries with algorithmic mechanisms remaining largely unknown. Previous research has pointed out that the SPR is geared toward specific keywords and that it is not determined by prior individual user behavior (Haim et al., 2017). Moreover, the SPR is displayed more often after suicide-related potentially harmful search terms (e.g., "painless suicide") as compared to search terms indicative of seeking for help (e.g., "overcoming suicidal thoughts") (Haim et al., 2017; Scherr et al., 2019; Arendt et al., 2020). Recently, it has been shown that the display rates of the SPR not only

vary across countries and the language that is used for the web searches, but also that the display rates drop massively if additional words are added to the search term. For example, when the names of celebrities who died from suicide are added to a potentially harmful search term (e.g., "how to commit suicide robin williams"), the SPR's display rate declined drastically as compared to the potentially harmful search term alone (e.g., "how to commit suicide") (Arendt et al., 2020). This is problematic given that especially the reports of celebrity suicides tend to elicit substantial increases in societal suicide rates as seminally described by the aforementioned "Werther effect" (Niederkrotenthaler et al., 2012). Such less-than-ideal, algorithmic decision-making might not only reduce the display frequency of help resources after suicide-related search terms when combined with additional celebrity names, but also in combination with drug-related search terms. Hence, we questioned whether the combination of suicide-related and drug-related search terms reduces the SPR display rate relative to the SPR display rate after suicide-related search terms alone.

2. Materials and methods

To answer this question, we looked at determinants of Google's SPR's display frequency through the lens of agent-based testing (Haim, 2019, 2020). As such, we emulated real human search behavior over two weeks in late 2019 through virtual agents. Just like prior studies using a similar methodology (Haim et al., 2017; Scherr et al., 2019; Arendt et al., 2020), we set up multiple servers at different locations across the U.S., specifically in California, Ohio, Oregon, and Virginia. In order to control for the technical environment, we relied upon Amazon Web Services (AWS) and set up two servers in each of AWS' four locations available for the United States. Apart from provider-dependent assignments, the servers' IP addresses were kept constant to equalize possible mediating effects. A central database was used to maintain and orchestrate the various servers and agents.

We followed an experimental setup consisting of five groups. That is, we emulated searches using lists of queries (i.e., independent variable) which built on (a) suicide-related potentially harmful terms, (b) drug-related terms, (c) the combination of these two groups, (d) control terms, and (e) the combination of control and suicide-related potentially harmful terms. Suicide-related and control terms were used in concordance with previous studies (Haim et al., 2017; Scherr et al., 2019; Arendt et al., 2020). Drug-related terms were compiled from the CDC in conjunction with Google Trends data as an indicator for public-health debates. A complete list of terms is available in the Appendix. Apart from the individual search terms, virtual agents in all five experimental groups followed the same instructions (i.e., recipe). After each performed search, the display of the suicide-prevention result (SPR) was stored as the main (binary) outcome (i.e., dependent variable).

For actual search emulations we used the freely available "ScrapeBot" (Haim, 2019). This collection of Python scripts builds on Selenium for Firefox to repeatedly run so-called "recipes"—accurate instructions on what to do—on a distributed set of servers. Thereby and for every run, ScrapeBot sets up a fresh environment employing visual desktop-display settings, accurate language and location specifications, as well as real browser signatures. It also accounts for human behavior through randomly slow typing, waits, and scrolling. Each recipe, then, followed the same procedure. First, virtual agents navigated to https://www.google.com/. Second, one search term was randomly drawn from the agent's experimental group's list of search terms and typed into Google's query-input box before the search form was submitted. Third, in five percent of all runs per recipe, a screenshot was captured for visual inspection of the functionality of our approach. Fourth, all information boxes, including the SPR, were captured and stored as clear text. Fifth, all organic search results' links from the first result page as well as the first result page's source code were stored for backup reasons.

We created nine distinct agent recipes. Following our experimental setup, each of the five experimental groups was translated into a recipe. As per all recipes, we employed the pre-defined lists of search terms, all typed in lowercase. For each search query, one search term was randomly drawn from the respective list of search terms. In addition, we wanted to ensure that our setup yielded enough searches for statistical analyses of the latest drivers of the "opioid crisis," fentanyl and heroin; that is, we created separate drug-related recipes for the search terms and combinations of search terms with fentanyl and/or heroin. However, as no additional insights were found, these separate recipes were later re-integrated back into their corresponding drug-related groups, thus representing the five original experimental groups (Table 1).

Data collection took place from November 27 until December 9 of 2019 (end dates included). On all servers the ScrapeBot was initiated every two minutes. Each ScrapeBot then randomly picked recipes from the central database to run. During runtime, ScrapeBot logs its behavior excessively to ensure constant monitoring. For data analysis, due to the strong stability of the SPR display frequencies (Haim et al., 2017), we used the daily share of searches for which the SPR had been displayed in percent. All data, code, recipes, and the appendix are available at OSF under https://osf.io/qvr67/.

3. Results

First, we focus on the display frequencies of the SPR in the U.S. for suicide-related potentially harmful search terms as taken from previous studies (e.g., "how to commit suicide"), and compare it with the SPR's display rate for various drug-related (e.g., "heroin," "fentanyl") and control (e.g., "dachshund") search terms as well as combinations thereof (e.g., "how to commit suicide fentanyl"). Based on 215,999 emulated

Table 1
Overview of agent-based testing runs (i.e., searches) per location (California, Ohio, Oregon, or Virginia) and recipe, the latter being ascribed to one of the five experimental groups.

Recipe	Sample Terms	CA	OH	OR	VA
(a) Suicide-Related Potentially Harmful Terms					
1-harmful	best method for suicide, ways to commit suicide	6285	5983	6066	6249
(b) Drug-Related Terms					
2-drug	alprazolam, codeine	6185	5822	5954	6166
3-heroin	heroin	5882	5618	5694	5831
4-fentanyl	fentanyl	5875	5611	5791	5824
(c) Combination of Suicide-Related Potentially Harmful and Drug-Related Terms					
5-harmful-drug	best method for suicide alprazolam, painless suicide codeine	6146	5951	5918	6159
6-harmful-heroin	best method for suicide heroin, how to commit suicide heroin	6182	5943	6018	6279
7-harmful-fentanyl	best method for suicide fentanyl, quick suicide fentanyl	6269	5972	6003	6189
(d) Control Terms					
8-control	appetite, principal, tractor	6106	5725	5891	6009
(e) Combination of Control and Suicide-Related Potentially Harmful Terms					
9-harmful-control	best method for suicide appetite, easy way to commit suicide tractor	6219	5974	6027	6183

Note. The full list of search terms used can be found in the Appendix.

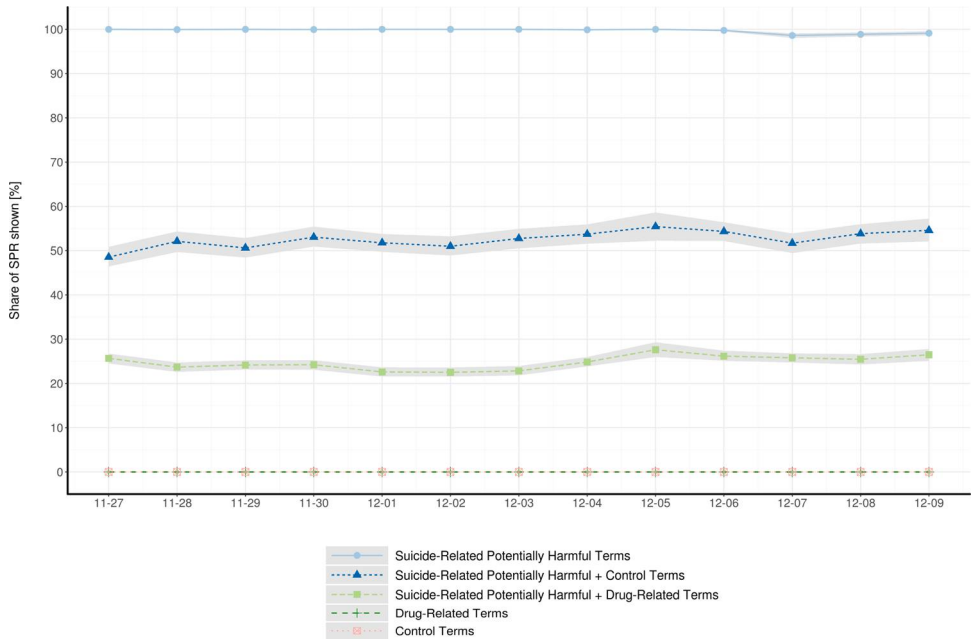

Fig. 2. Share of search queries over time, for which the suicide-prevention result (SPR) was displayed. The used search terms varied per group of agents. Grey areas present percentile-bootstrapped 95 % confidence bands of SPR display frequencies based on 1000 replications.

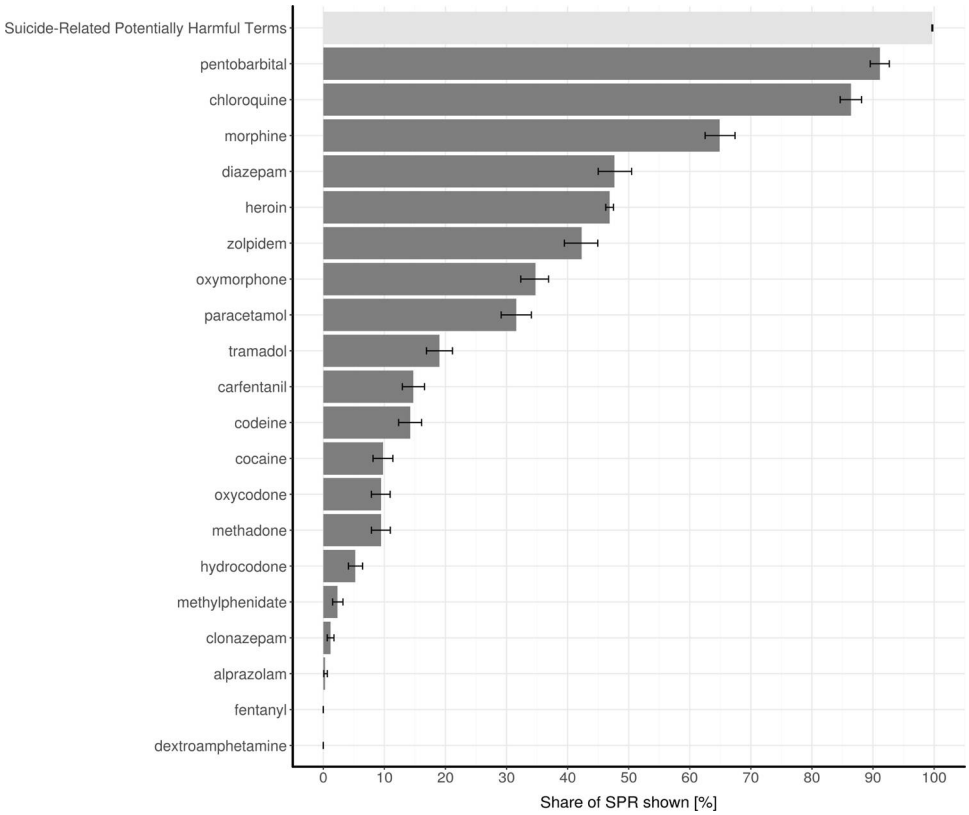

Fig. 3. Share of drug-related search-query additions to suicide-related potentially harmful terms (baseline in light grey on top), for which the suicide-prevention result was shown. Compared to suicide-related potentially harmful terms (e.g., "how to commit suicide"), the addition of any drug-related search term (e.g., "how to commit suicide fentanyl") reduces the SPR display frequency. Error bars present percentile-bootstrapped 95 % confidence intervals of SPR display frequencies based on 1000 replications.

searches, we report the mean percentage of conducted searches for which the SPR was displayed and the respective 95 % confidence interval (*CI*) around the mean (Fig. 2). We found the SPR to be shown atop Google's search results in almost every case of suicide-related potentially harmful search terms (n = 24,583; M = 99.7; 95 % *CI* [99.6, 99.8])—a higher SPR display frequency for the same search terms in the U.S. as compared to previous findings (Scherr et al., 2019). Conversely, the combination of a drug-related search term with a suicide-related potentially harmful search term decreased the display frequency by more than 75 % (n = 73,029; M = 24.6; 95 % *CI* [24.3, 24.9]). Moreover, the addition of a control term significantly decreased the chance of being presented with the SPR as well—although to a lesser extent (n = 24,403; M = 52.4; 95 % *CI* [51.7, 53.0]). Importantly for the present study, only using either a control (n = 23,731) or a drug-related (n = 70,253) search

term did not yield any displays of the SPR (i.e., $M = 0.0$; 95 % *CI* [0.0, 0.0]). These findings neither varied significantly over time nor across the different locations (see Appendix Fig. A1).

Second, additional analyses focused specifically on drug-related additions to searches, including "heroin" and "fentanyl." Building on the 73,029 emulated searches employing drug-related search-term combinations (Fig. 3), the display frequencies of the SPR continuously drop when appending one of twenty specific drug-related terms to a suicide-related potentially harmful search term. Compared to suicide-related terms alone (e.g., "how to commit suicide"), the addition of any drug-related search term (e.g., "how to commit suicide fentanyl") reduces the SPR display frequency. Notably, while the addition of, for example, pentobarbital ($n = 1309$; $M = 91.1$; 95 % *CI* [89.5, 92.5]) and chloroquine ($n = 1405$; $M = 86.4$; 95 % *CI* [84.7, 88.2]) still yields the SPR in (almost) nine-in-ten cases, including substances such as oxycodone ($n = 1371$; $M = 9.5$; 95 % *CI* [8.0, 11.1]) or hydrocodone ($n = 1336$; $M = 5.2$; 95 % *CI* [4.1, 6.4]) results in the SPR to be displayed in less than a tenth of the searches. Importantly, heroin decreases the chances of being presented with helpline information by half ($n = 24{,}422$; $M = 46.9$; 95 % *CI* [46.3, 47.6]) whereas fentanyl completely suppresses the display of the SPR and its helpful resources (i.e., $n = 24{,}433$; $M = 0.0$; 95 % *CI* [0.0, 0.0]). Given that recent data indicate a disturbing increase in the illicit use of fentanyl, this is an especially important finding. Again, results did not vary significantly across locations (see Appendix Fig. A2).

4. Conclusion

These findings are intriguing. For the U.S., a SPR is now displayed after English suicide-related potentially harmful search queries in a laudably high frequency, but the addition of any other search term decreases the display frequency of these helpful resources substantially. While this might be reflective of algorithmic semantic contextualization (Caliskan et al., 2017), Google is still acting behind closed doors in these matters.

This is particularly worrisome as search engines have room for maneuver when it comes to their role for public health, which not only unfolds in people's search queries (Cheng and Yom-Tov, 2019) but would also profit from the depiction of resources for prevention or rehabilitation. For people in potentially acute, suicidal crises as may be indicated by search queries such as "easy way to commit suicide fentanyl," information about where to find help in a suicidal crisis should be displayed right in that search moment, especially since the costs of false positives (i.e., presenting helpful resources to users not in need) seem negligible. A higher display frequency may better contribute to the prevention of unnecessary deaths of vulnerable individuals in the current overdose death crisis.

Contributors

Mario Haim: Conception of the work, data collection, analysis, interpretation of data, first draft, revising draft.

Sebastian Scherr: Conception of the work, interpretation of data, first draft, revising draft.

Florian Arendt: Conception of the work, interpretation of data, first draft, revising draft.

All authors have approved the final article.

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Declaration of competing interest

The authors report no declarations of interest.

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