



## Research report

## Association of Internet search trends with suicide death in Taipei City, Taiwan, 2004–2009

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## ABSTRACT

**Background:** Although Internet has become an important source for affected people seeking suicide information, the connection between Internet searches for suicide information and suicidal death remains largely unknown. This study aims to evaluate the association between suicide and Internet searches trends for 37 suicide-related terms representing major known risks of suicide.

**Methods:** This study analyzes suicide death data in Taipei City, Taiwan and corresponding local Internet search trend data provided by Google Insights for Search during the period from January 2004 to December 2009. The investigation uses cross correlation analysis to estimate the temporal relationship between suicide and Internet search trends and multiple linear regression analysis to identify significant factors associated with suicide from a pool of search trend data that either coincides or precedes the suicide death.

**Results:** Results show that a set of suicide-related search terms, the trends of which either temporally coincided or preceded trends of suicide data, were associated with suicide death. These search factors varied among different suicide samples. Searches for “major depression” and “divorce” accounted for, at most, 30.2% of the variance in suicide data. When considering only leading suicide trends, searches for “divorce” and the pro-suicide term “complete guide of suicide,” accounted for 22.7% of variance in suicide data.

**Conclusions:** Appropriate filtering and detection of potentially harmful source in keyword-driven search results by search engine providers may be a reasonable strategy to reduce suicide deaths.

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## 1. Introduction

Prevention of suicide has long been complicated by its multidimensional nature (Maris, 2002). Studies have identified many risk factors for suicide in the general population. Nevertheless, even with standardized measurement of suicide risks, recognition of suicidal individuals is still difficult and preventive intervention is often too late. Persons with suicidal

intentions may not seek medical/psychiatric attention, but rather seek information regarding the means of suicide.

In recent years, the Internet has become an essential medium for people seeking health information, yet the Internet includes both helpful and harmful sources. One study demonstrates that suicide-risk individuals who went online for suicide information were likely to visit pro-suicide sites (i.e., websites providing a guide to suicide) (Harris et al., 2009). Pro-suicide websites are easily accessed through searches and may be implicated in completed suicides (Biddle et al., 2008; Prior, 2004; Recupero et al., 2008). Unfortunately, how the public perceives and utilizes suicide information is still largely unknown. A better understanding of Internet

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search behavior in relation to suicide may help design efficient suicide prevention programs.

Analysis of Internet searches has proven to be useful for predicting infectious disease outbreaks (Ginsberg et al., 2009; Hulth et al., 2009; Polgreen et al., 2008; Seifter et al., 2010; Wilson and Brownstein, 2009), yet limited mental health studies have been reported using Internet search data. We recently found that Internet searches for depression have seasonality, and the degree of seasonality is latitude-dependent (Yang et al., 2010). A pilot study suggests that annually averaged Google search activity for “suicide” correlates to yearly suicide rate data in the United States (McCarthy, 2010). To the best of our knowledge, no previous study has examined the association between Internet searches and suicide death in more detailed time scale.

Because suicide has multidimensional risk factors, we hypothesize that suicide trend data may be associated with Internet search trend from search terms related to suicide-risk factors in a broad sense. The aims of this study are (1) to evaluate the association between suicide and Internet trend data, and (2) to identify search trend data that coincides or precedes the fluctuations in suicide death counts. This study analyzes suicide death registers in Taipei City, Taiwan and corresponding local search trend data from Google Insights for Search, a free service provided by the Google Corporation that allows researchers to examine trends of certain search keywords. Using cross correlation analysis and multiple linear regression with a stepwise method, this investigation comprehensively evaluates the association between suicide and Internet search trends from a pool of search trend data based on 37 suicide-related queries.

## 2. Materials and methods

### 2.1. Suicide data

Data on all suicide deaths in the Taipei City, Taiwan from January 1 2004 to December 31 2009 was provided by the Department of Health, Taiwan. This period was selected to match with available search trend data. This study chose the record of suicide deaths in Taipei City as the study target instead of nationwide data because Internet search volumes in Taiwan are largely represented by Taipei City, the largest metropolitan area in Taiwan.

A total of 2342 suicide cases were included in this study (65.8% male, mean age =  $49.9 \pm 17.5$  years, range = 12–97). The demographic variables in this data include gender, age, date of death, marital state, and means of suicide by International Classification of Disease (ICD-9-CM). All data were provided in electronic format. The study chose monthly counts of suicide as the time series using ecological study design. Suicide data was further stratified by age, gender, and suicide means to generate different suicide models.

### 2.2. Internet search data

The Internet search trend data from Taipei City was retrieved from the Chinese version of Google Insights for Search ([www.google.com/insights/search/](http://www.google.com/insights/search/)), a web-based service providing de-identified, normalized weekly search volume data for a keyword. To investigate the association between suicide death and Internet search trends systemically, 37 search terms were selected to reflect a broad sense of suicide risks covering five

**Table 1**  
List of search terms.

Category	Search terms <sup>a</sup>
Psychiatric terms	Suicide; major depression; bipolar disorder; schizophrenia; anxiety disorder; stress; illicit drugs; alcohol; drunkenness; alcohol abstinence; insomnia; hypnotics; antidepressant; psychiatric service
Medical terms	Asthma; allergy; pain; headache; cancer; chronic illness
Familial terms	Marriage; divorce; abuse; domestic violence; relationship breakup
Socioeconomic terms	Job; unemployment; social welfare; social benefits; religious belief; stock market; Taiwan economy; lawsuit
Pro-suicide terms	Hanging, jumping from a height, charcoal burning, complete guide of suicide

<sup>a</sup> Search terms are shown in their English equivalent. See Table A1 for original search terms in Chinese language.

categories, including psychiatric, medical, familial, socioeconomic factors, and pro-suicide terms. These terms were selected to best represent the meaning underlying suicide risks and contain both positive (e.g., social welfare) and negative information (e.g., pro-suicide terms). Of note, this study included a specific pro-suicide term, “complete guide of suicide”, which is a forbidden but popular pro-suicide book in Taiwan and Japan. Table 1 lists standard English translations of these search terms (see Table A1 for original Chinese search terms).

Search terms with an insufficient search volume were excluded (i.e., incomplete or absence of search trends results returned by Google). Retrieved search trend data were averaged on a monthly basis. None of the search data in this study contains personal information or individualized records of Internet search history. Because Google also returns results of popular keywords associated with a given search term, the study screened these keywords to avoid queries containing unexpected meanings, thus ensuring that our selected search terms can best represent the risks of suicide.

### 2.3. Statistical analysis

SPSS for Windows Version 15.0 (Chicago, IL; SPSS Inc.) software was used for statistical analyses. A two-stage modeling process was used to assess the association between suicide and Internet search trends. In the first stage, we applied cross correlation analysis to estimate the temporal relationship between suicide and Internet search trends derived from each search term. The cross correlation analysis served two purposes in this study: (1) to adjust time lag between suicide and Internet search trends; and (2) to reduce spurious correlations in the subsequent regression analysis by excluding irrelevant Internet search trends. Those search terms that lack statistically significant correlations or a definite time lag or lead pattern were excluded. The remaining search terms were then used in the second stage of regression analysis, applying lag or lead models based on cross correlation analysis results.

Using monthly suicide counts as the dependent variable and identified Internet search trends as predictors, this investigation applied multiple linear regression analysis with a stepwise method to identify significant factors associated with suicide and to estimate how much of the total variation in the monthly suicide counts could be explained by these factors. The stepwise method was chosen to avoid collinearity because the Internet

**Table 2**  
Cross correlation analysis of suicide and Internet search trends.

Search terms	Lags (month)						
	-3	-2	-1	0	1	2	3
<i>Internet search trends that coincided with suicide data</i>							
Major Depression	0.212	0.282	0.402	0.477	0.241	0.137	-0.073
Suicide	0.190	0.254	0.385	0.430	0.170	0.104	0.082
Domestic Violence	0.224	0.338	0.351	0.419	0.401	0.312	0.175
Anxiety Disorder	0.028	0.320	0.164	0.394	0.071	0.077	-0.060
Psychiatric Service	0.153	0.309	0.313	0.322	0.106	0.080	-0.003
Lawsuit	0.150	0.062	0.303	0.318	0.238	0.082	-0.109
Stress	0.078	0.270	0.273	0.299	0.088	-0.057	-0.104
Marriage	0.068	0.139	0.197	0.293	0.092	-0.096	-0.148
<i>Internet search trends that preceded suicide data for one month</i>							
Complete Guide of Suicide	0.273	0.344	0.350	0.165	0.139	0.129	0.286
Bipolar Disorder	0.170	0.294	0.332	0.212	0.123	-0.040	0.015
Alcohol Abstinence	0.133	0.093	0.329	0.214	0.094	0.200	0.146
Taiwan Economy	0.233	0.249	0.328	0.298	0.139	0.015	-0.094
Insomnia	0.106	0.183	0.313	0.220	0.197	0.143	0.081
Allergy	0.154	0.193	0.300	0.243	0.232	0.092	0.007
Religious Belief	0.007	0.224	0.295	0.234	0.160	-0.045	-0.062
<i>Internet search trends that preceded suicide data for two months</i>							
Asthma	0.216	0.276	0.206	0.154	0.091	0.027	0.124
Divorce	0.178	0.275	0.272	0.210	0.212	0.143	0.164
Asthma	0.142	0.269	0.215	0.213	0.022	-0.108	0.014

<sup>a</sup>Values represent cross correlation coefficient.

<sup>b</sup>Search terms of hypnotics, antidepressant, hanging, jumping from a height, and charcoal burning were excluded due to insufficient search volumes.

<sup>c</sup>Search terms of schizophrenia, illicit drugs, alcohol, drunkenness, pain, headache, cancer, chronic illness, abuse, relationship breakup, job, unemployment, social benefits and stock market were excluded due to insignificant cross correlation coefficients.

<sup>d</sup>Gray-filled values indicate the maximum of cross correlation coefficient.

search trends may be inter-correlated. The variance inflation factor (VIF) was estimated for all Internet search trends and a VIF value of 10 or greater is considered to be an indication of significant collinearity. The study analyzed different suicide models, in which suicide data was stratified based on age, gender, and means of suicide. Partial correlations between suicide and predictors, and a summary for each regression model are reported. A two-tailed *p* value of less than 0.05 was required for statistical significance in all analyses.

### 3. Results

#### 3.1. Baseline characteristics of suicide data

Of the 2342 persons who committed suicide, 1827 (78.0%) were adults (age  $\geq 20$  and age  $\leq 65$ ), 478 (20.4%) were elderly

(age  $> 65$ ), and 37 (1.6%) were adolescents (age  $< 20$ ). 1385 (59.1%) deaths were by violent means, such as hanging or jumping from heights (ICD-9-CM codes: E953-E957), 883 (37.7%) were by non-violent means, such as poisoning (ICD-9-CM codes: E950-E952), and 74 (3.2%) were unclassified. Regarding marital status, 901 (38.5%) were married, 733 (31.3%) were single, 498 (21.3%) were divorced, 198 (8.5%) were widows/widowers, and 12 (0.5%) were unknown.

#### 3.2. Temporal relationship between suicide and Internet search trends

The first stage of analysis applied a cross correlation analysis to identify the temporal relationship between suicide data and search terms (i.e., a lag or lead pattern). This stage excluded nineteen search terms, and Table 2 shows the remaining eighteen terms. No search trends lagged behind the suicide data. Gray indicates the lead patterns of search terms associated with suicide data. Search terms such as “major depression” ( $r = 0.477$ ,  $p < 0.001$ ), “suicide” ( $r = 0.430$ ,  $p < 0.001$ ), or “domestic violence” ( $r = 0.419$ ,  $p < 0.001$ ) coincided with suicide data. Trends of other search terms, such as “complete guide of suicide” ( $r = 0.350$ ,  $p = 0.003$ ), “bipolar disorder” ( $r = 0.332$ ,  $p = 0.004$ ), and “alcohol abstinence” ( $r = 0.329$ ,  $p = 0.005$ ), led suicide data for one month. Trends of “asthma” ( $r = 0.276$ ,  $p = 0.009$ ), “divorce” ( $r = 0.275$ ,  $p = 0.008$ ), and “social welfare” ( $r = 0.269$ ,  $p = 0.011$ ) led suicide data for two months. Fig. 1 illustrates the temporal relationship between suicide data and Internet searches for “major depression” and “suicide”. Visual inspection suggests that searches for depression and suicide coincided considerably with monthly suicide count data.

#### 3.3. Identify Internet search trends associated with suicide

Applying lead models to search trend data, this study used multiple regression analysis to identify factors of suicide, as Table 3 shows. Searches for “major depression” ( $r = 0.512$ ,  $p < 0.001$ ) and “divorce” ( $r = 0.319$ ,  $p = 0.008$ ) accounted for 30.2% of variance in all suicide count data ( $p < 0.001$ ). These two factors also explained 28.3% and 30.0% of variance in male and adult suicide models (both  $p < 0.001$ ). Of note, female suicide ( $R^2 = 0.114$ ,  $p = 0.003$ ) was associated with searches for “anxiety” ( $r = 0.356$ ,  $p = 0.003$ ). The study derived no significant model from elderly suicide data. When stratifying suicide data according to the means of suicide, major depression searches ( $r = 0.421$ ,  $p < 0.001$ ) were the single factor associated with violent suicide cases

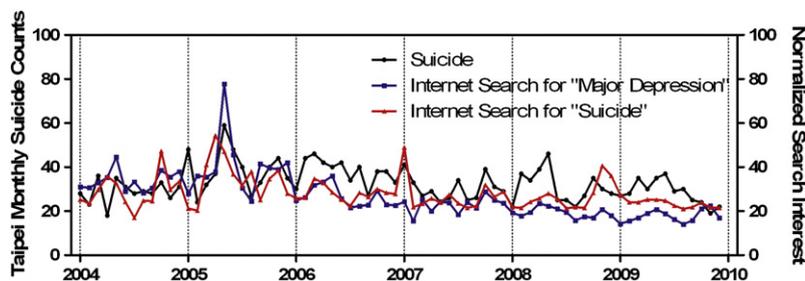


Fig. 1. Comparison of monthly suicide counts (black) and Internet search trends of terms “major depression” (blue) and “suicide” (red).

( $R^2 = 0.165$ ,  $p < 0.001$ ). “Domestic violence” ( $r = 0.377$ ,  $p = 0.001$ ) and “insomnia” ( $r = 0.274$ ,  $p = 0.022$ ) were associated with non-violent suicide ( $R^2 = 0.209$ ,  $p < 0.001$ ).

Because Internet search interests concerning suicide-related terms may be confounded by public attention to suicide cases in the media (Chen et al., 2010; Cheng et al., 2007), this investigation conducted a separate regression analysis by excluding search trends that coincided with suicide time series and focused only on those search trends that preceded suicide data (i.e., based on cross correlation analysis in Table 2). Table 4 shows that “divorce,” leading suicide data for two months, and “complete guide of suicide,” leading suicide data for one month, were consistently associated with data comprised of all suicide counts ( $R^2 = 0.227$ ,  $p < 0.001$ ), and with violent and male suicide. Other search terms, including “Taiwan economy,” “bipolar disorder,” and “religious belief,” were associated with subtypes of suicide.

#### 4. Discussion

This analysis identifies significant associations between suicide death and a set of suicide-related search terms. Search trends for these terms either temporally coincided with or preceded suicide data trends. Searches for “major depression” and “divorce” accounted for, at most, 30.2% of the variance in suicide data. When considering only leading suicide trends, searches for “divorce” and the pro-suicide term “complete guide of suicide,” accounted for 22.7% of the variance in suicide data. To our knowledge, this is the first study that has used a design that allowed the comprehensive evaluation of suicide risks based on Internet search data.

Risk factors of suicide tend to interact and potentiate each other. Although Internet search volume data represent a collective phenomenon, the temporal relationship between

**Table 3**

Stepwise regression model of suicide and all Internet search trends.

Search terms	Model summary			
	Standardized $\beta$	SE	Partial correlation	$P$
<i>Total suicide (adjusted <math>R^2 = 0.302</math>, <math>F = 15.93</math>, <math>p &lt; 0.001</math>)</i>				
Major depression	0.491	0.076	0.512	<0.001
Divorce (lead 2 months)	0.277	0.098	0.319	0.008
<i>Violent suicide (adjusted <math>R^2 = 0.165</math>, <math>F = 14.66</math>, <math>p &lt; 0.001</math>)</i>				
Major depression	0.421	0.051	0.421	<0.001
<i>Non-violent suicide (adjusted <math>R^2 = 0.209</math>, <math>F = 10.11</math>, <math>p &lt; 0.001</math>)</i>				
Domestic violence	0.363	0.062	0.377	0.001
Insomnia (lead 1 month)	0.255	0.064	0.274	0.022
<i>Male suicide (adjusted <math>R^2 = 0.283</math>, <math>F = 14.63</math>, <math>p &lt; 0.001</math>)</i>				
Major depression	0.449	0.062	0.474	<0.001
Divorce (lead 2 months)	0.313	0.079	0.351	0.003
<i>Female suicide (adjusted <math>R^2 = 0.114</math>, <math>F = 9.85</math>, <math>p = 0.003</math>)</i>				
Anxiety disorder	0.356	0.029	0.356	0.003
<i>Adult suicide (adjusted <math>R^2 = 0.300</math>, <math>F = 15.75</math>, <math>p &lt; 0.001</math>)</i>				
Major depression	0.483	0.071	0.505	0.000
Divorce (lead 2 months)	0.288	0.091	0.329	0.006
Elderly suicide – no significant model was derived				

Note: All search terms identified in Table 2 were used in regression models.

**Table 4**

Stepwise regression model of suicide and Internet search trends that lead to suicide.

Search terms	Model summary			
	Standardized $\beta$	SE	Partial correlation	$P$
<i>Total suicide (adjusted <math>R^2 = 0.227</math>, <math>F = 11.15</math>, <math>p &lt; 0.001</math>)</i>				
Complete guide of suicide (lead 1 month)	0.412	0.046	0.428	<0.001
Divorce (lead 2 months)	0.314	0.103	0.340	0.004
<i>Violent suicide (adjusted <math>R^2 = 0.163</math>, <math>F = 7.72</math>, <math>p = 0.001</math>)</i>				
Complete guide of suicide (lead 1 month)	0.386	0.030	0.393	0.001
Divorce (lead 2 months)	0.225	0.066	0.242	0.045
<i>Non-violent suicide (adjusted <math>R^2 = 0.142</math>, <math>F = 6.70</math>, <math>p = 0.002</math>)</i>				
Taiwan economy (lead 1 month)	0.302	0.043	0.313	0.009
Divorce (lead 2 months)	0.243	0.064	0.256	0.034
<i>Male suicide (adjusted <math>R^2 = 0.245</math>, <math>F = 8.45</math>, <math>p &lt; 0.001</math>)</i>				
Religious belief (lead 1 month)	0.223	0.060	0.234	0.055
Divorce (lead 2 months)	0.305	0.083	0.331	0.006
Complete guide of suicide (lead 1 month)	0.285	0.039	0.297	0.014
<i>Female suicide – no significant model was derived</i>				
<i>Adult suicide (adjusted <math>R^2 = 0.227</math>, <math>F = 11.12</math>, <math>p &lt; 0.001</math>)</i>				
Bipolar disorder (lead 1 month)	0.403	0.044	0.422	0.000
Divorce (lead 2 months)	0.287	0.095	0.315	0.008
<i>Elderly suicide – no significant model was derived</i>				

Note: Only search terms that led suicide cases were used in regression models.

Internet search trends and suicide data may shed light on sequential acts of suicidal behaviors. This study shows that searches for most medical, familial, and socioeconomic terms preceded suicide deaths and most searches for psychiatric-related terms coincided with suicide data (see Table 2). For example, searches for divorce preceded suicide for two months, and searches for complete guide of suicide led suicide for one month. Both factors were significantly associated with suicide trend data.

Internet search trends were associated with the means of suicide differently. Results show that non-violent suicide was associated with searches for domestic violence and insomnia. One possible explanation is that non-violent suicide is usually associated more with female than male gender (Maes et al., 1993). Women frequently suffer from domestic violence. Findings regarding violent suicide are worth noting. The search trend for the term “complete guide of suicide,” which preceded the suicide trend for one month, was associated with violent and male suicide data. The suicide means introduced in “complete guide of suicide” are mostly violent. This finding provides preliminary evidence that searches for pro-suicide information is associated with suicide death.

Gender appears to have different risk profiles in this study. Researchers have recognized divorce as an important risk factor for suicide (Moscicki, 2001). The exclusive association of searches for divorce and male suicide agrees with prior

studies showing that men are more likely to commit suicide after divorce (Kposowa, 2000). This study also found that male suicide is associated with searches for major depression, whereas female suicide is associated with searches for anxiety. This finding is consistent with prior reports showing that suicide attempts related to anxiety disorders appear to be more frequent in women than in men (Allgulander and Lavori, 1991; Johnson et al., 1990). In terms of age effect, this study did not find an association between elderly suicide and Internet searches. This finding is likely due to an insufficient elderly suicide sample or low Internet use in this population.

For physical symptoms associated with suicide, this study found that the search for insomnia, leading suicide data for one month, was associated with non-violent suicide. Prior research has suggested that poor sleep quality in depressive patients correlates with the presence of suicidal ideas (Agarun et al., 1997). Other research shows that insomnia is an independent factor associated with suicide (Bernert et al., 2005; Liu, 2004). This study also found that searches for allergy and asthma were associated with suicide. The search rate for allergy is greater in patients with depression (Goodwin et al., 2006), and thus increased suicide (Postolache et al., 2008). Studies have recently implicated asthma in suicide, particularly in young populations (Kuo et al., 2010). Certain medications (e.g., systemic steroids) used to treat allergies and asthma can exacerbate suicide-risk factors and even triggering suicide (Chan and Shaw, 2009).

Strength of this study is the use of Internet search trends to study suicide data. Taiwan is one of the leading countries in computer science industries and Internet searches have been popular for years without restrictions, enhancing the reliability of search trend data and the validity of study results. Several limitations should be considered in interpreting these data. First, charcoal burning has emerged as a novel suicide method in Taiwan, particular in the young populations (Chang et al., 2010; Lin and Lu, 2008; Pan et al., 2009). After sufficient search data has accumulated on this suicide method, further research is needed to investigate youth suicide and searches for “charcoal burning.” Second, the Internet-suicide correlation found in this study does not exclusively represent searches from affected individuals. Similar to studies using search queries for predicting disease outbreaks (Ginsberg et al., 2009; Hulth et al., 2009; Polgreen et al., 2008; Seifter et al., 2010; Wilson and Brownstein, 2009), use of Internet searches as an indicator of suicide should be careful about surges in queries due to unrelated events. Third, age bias may exist between online users and deceased persons in this study. Future research should consider the differences between demographic profiles of online users and suicide. Fourth, search terms used in this study were empirical. Search terms related to suicide risks may be varied in different time and geographical regions. With the aid of the search engine provider, automatic screening of millions of search terms may help identify current and local suicide risks.

Finally, in the public health point of view, because Internet has increasingly become important sources of pro-suicide information, appropriate filtering and detection of potentially harmful source in keyword-driven search results by search engine providers may be a reasonable strategy to reduce suicide deaths.

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#### Conflict of interest

All authors declare that they have no conflicts of interest.

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#### Appendix Table A1. List of Chinese search terms and their English equivalent.

English equivalent	Original Chinese search terms*
<i>Psychiatric terms</i>	
Suicide	自殺
Major depression	憂鬱症
Bipolar disorder	躁鬱症
Schizophrenia	精神分裂症
Anxiety disorder	焦慮
Stress	壓力
Illicit drugs	毒品
Alcohol	酒
Drunkenness	酒醉
Alcohol abstinence	戒酒
Insomnia	失眠
Hypnotics	安眠藥
Antidepressant	抗憂鬱藥
Psychiatric service	精神科
<i>Medical terms</i>	
Asthma	氣喘
Allergy	過敏
Pain	痛
Headache	頭痛
Cancer	癌症
Chronic illness	慢性病
<i>Familial terms</i>	
Marriage	婚姻
Divorce	離婚
Abuse	虐待
Domestic violence	家暴
Relationship breakup	分手
<i>Socioeconomic terms</i>	
Job	工作
Unemployment	失業
Social welfare	社會福利
Social benefits	救濟
Religious belief	信仰
Stock market	股市
Taiwan economy	台灣經濟
Lawsuit	訴訟
<i>Pro-suicide terms</i>	
Hanging	上吊
Jumping from a height	跳樓
Charcoal burning	燒炭
Complete guide of suicide	完全自殺手冊

\*Traditional Chinese characters were used in Taiwan. Search terms in English equivalent may need modifications for English-based search trends.

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