Published in final edited form as:

J Affect Disord. 2012 December 15; 142(0): 323–330. doi:10.1016/j.jad.2012.05.005.

Novel Surveillance of Psychological Distress during the Great Recession

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Abstract

Background—Economic stressors have been retrospectively associated with net population increases in nonspecific psychological distress (PD). However, no sentinels exist to evaluate contemporaneous associations. Aggregate Internet search query surveillance was used to monitor population changes in PD around the United States' Great Recession.

Methods—Monthly PD query trends were compared with unemployment, underemployment, homes in delinquency and foreclosure, median home value or sale prices, and S&P 500 trends for 2004–2010. Time series analyses, where economic indicators predicted PD one to seven months into the future, were performed in 2011.

Results—PD queries surpassed 1,000,000 per month, of which 300,000 may be attributable to the Great Recession. A one percentage point increase in mortgage delinquencies and foreclosures

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Author Contributions: Designed research: JWA Performed research: JWA, BMA, JPA, MAC, WZ. Contributed reagents or analytic tools: JPA, MAC, WZ. Analyzed data: JWA, BMA. Wrote the paper: JWA, BMA, JPA, MAC, WZ, CAL, KMR, JSB.

Conflicts of Interests: JWA and BMA share an equity stake in a consulting group, Directing Medicine, that helps other clinician-scientists implement some of the ideas embodied in this work. The data generation procedures, however, are not proprietary and rely on public archives. There are no other conflicts of interest relevant to this study.

was associated with a 16% (95%CI, 9–24) increase in PD queries one-month, and 11% (95%CI, 3–18) four months later, in reference to a pre-Great Recession mean. Unemployment and underemployment had similar associations half and one-quarter the intensity. “Anxiety disorder,” “what is depression,” “signs of depression,” “depression symptoms,” and “symptoms of depression” were the queries exhibiting the strongest associations with mortgage delinquencies and foreclosures, unemployment or underemployment. Housing prices and S&P 500 trends were not associated with PD queries.

Limitations—A non-traditional measure of PD was used. It is unclear if actual clinically significant depression or anxiety increased during the Great Recession. Alternative explanations for strong associations between the Great Recession and PD queries, such as media, were explored and rejected.

Conclusions—Because the economy is constantly changing, this work not only provides a snapshot of recent associations between the economy and PD queries but also a framework and toolkit for real-time surveillance going forward. Health resources, clinician screening patterns, and policy debate may potentially be informed by changes in PD query trends.

Keywords

Health surveillance; mental health; psychological distress; health economics

Introduction

Countercyclical associations between economic contraction and population nonspecific psychological distress (PD), defined as depressed or anxiou2s mood,(Dohrenwend et al 1980; Kessler et al 2002) are accepted in medical science.(Catalano et al 2011; Zivin et al 2011) But most of this work used retrospective designs with few time measurements, cost-intensive data generation, and a single economic predictor or no specific economic measure at all. (Thomas et al 2005; Mossakowski 2009; Scutella, & Wooden 2008; Zimmerman, & Katon 2005) For example, a 2010 report found depressive episodes increased ~50% comparing two cross-sectional telephone surveys that happened to be collected before and after Hong Kong’s 2008 economic crisis.(Lee et al 2010)

The United States’ (US) economy fell into a “Great Recession” during 2008. Housing prices plummeted,(Saft 2011) homes in delinquency or foreclosure rose from 1% to 7%, (Blumberg, & O'Neal 2010), while labor and investment markets also experienced substantial declines.(Leonhardt 2009) Many Americans face uncertain financial futures, (McCabe 2011) but little is known about how the Great Recession has impacted population mental health because surveillance systems are not in place to estimate contemporaneous associations.(Goldman-Mellor et al 2010; Cooper 2011) Health professionals, instead, rely on community studies,(Pollack, & Lynch 2009; Pollack et al 2011) monitoring narrow subsets of the population(Alley et al 2011) or expert speculation,(Bennett et al 2009; Catalano 2009) that may not yield accurate extrapolation. Herein the utility of novel real-time aggregate Internet search query surveillance to capture changes in population PD and link these changes to multiple macro-economic features from 2004 through 2010 was explored.

Methods

The Internet is the world's most relied-on health resource,(Rice 2006; Zeng et al 2004; Murero et al 2001; Eysenbach 2011) with about 5% of all Internet search queries health related.(Eysenbach, & Kohler 2003) By searching online, individuals actively relay information about their identity, thoughts, and behaviors.(Brownstein et al 2009; Wilson, & Brownstein 2009; Eysenbach 2011) Monitoring query trends may then foreshadow changes in population health, *i.e.*, influenza-like queries have been used to model influenza epidemics,(Eysenbach 2006; Polgreen et al 2008; Friesema et al 2009; Hulth et al 2009; Goel et al 2010a; Dugas et al 2012) with *Google Flu Trends* providing valid geographically specific estimates of daily influenza-like illness.(Ginsberg et al 2009) Epidemiologists have since demonstrated the potential of queries for monitoring chickenpox,(Pelat et al 2009; Valdivia, & Monge-Corella 2010) dengue,(Althouse et al 2011; Chan et al 2011) gastritis, (Pelat et al 2009) kidney stones,(Breyer et al 2011; Willard, & Nguyen 2011) listerosis, (Wilson, & Brownstein 2009) lyme disease,(Seifter et al 2010) methicillin-resistant staphylococcus aureus,(Dukic et al 2011) and salmonella.(Brownstein et al 2009) Search query surveillance of non-acute diseases and health behaviors, however, are very rare. (Askitas, & Zimmermann 2009; Breyer, & Eisenberg 2010; Goel et al 2010a; Yang et al 2011; Ayers et al 2011a; Ayers et al 2011b; Reis, & Brownstein 2010) Still, in conjunction with other data, search query surveillance may improve population health forecasts and in the absence of other data search query surveillance may provide reliable population estimates for health behavior and chronic disease trends.(Goel et al 2010b) We hypothesize changes in PD-related queries may similarly capture population PD trends with fine temporal resolution to inform timely analyses.

Search volume

Trends were downloaded from *Google Insights for Search* (www.google.com/insights/search/), a regularly updated public database of aggregated search queries. PD query trends were analyzed on a relative search volume (RSV) scale each month, with queries normalized to the highest search proportion, *e.g.*, RSV=100 is the highest search proportion month and RSV=50 is 50% of the highest search proportion. This corrects for increases in absolute search volume for all queries.(Dutka, & Hanson 1989) Absolute monthly volume, however, was estimated using *Google Adwords* (www.adwords.google.com) to demonstrate the practical significance of PD search query trends. A monthly time-series was selected because many economic trends are only measured as monthly means.

Search term selection

Variability in PD query trends principally derive from primary (queries at the onset or during the course of illness by the affected person for self-diagnoses or treatment) and secondary (queries of family or friends of the affected person) sources. (Ginsberg et al 2009) For both, search sessions are iterative. Users go online, query, view links, and modify their search based on those links until they are satisfied. A self/surrogate-diagnosis query may occur later in search sessions than general symptomology queries but have stronger specificity. (Hulth et al 2009) First, two key terms, "depression symptoms" and "anxiety symptoms," were initially selected to identify self/surrogate PD diagnosis. Second, related

terms were identified using *Insight*'s "related terms" applet. Since some terms may have poor specificity because of multiple meanings, *e.g.*, "depression," or clearly unrelated meanings, *e.g.*, "great depression" these terms were omitted (Figure 1). Last, the list of terms was used to derive a single composite query trend in the US (2004–2010). The final composite trend was judged for internal consistency using a split-half procedure, where half the terms having the strongest and half the terms having the weakest association with the root terms (according to the *Google Insights* utility) with the two key terms had similar trends (r=0.93).

Economic measures

The unemployment rate captured the proportion of adults (16-year or older) available for work but not working in the prior month. (St. Louis Federal Reserve 2011) The underemployment rate captured the proportion of adults unemployed or employed part-time but seeking full-time work.(Portalseven.com 2011) Housing market trends were assessed by Zillow's median home value index and the median home sale price, both normalized to 2005 dollars. (Zillow.com) Delinquency and foreclosure rates, the proportion of conventional single-family loans 90 days past due or in the foreclosure process, were accessed from Fannie Mae and Freddie Mac, the nation's two largest mortgage backers holding 53% of residential mortgages.(Woellert, & Gittelsohn 2010) Trends were strongly consistent for Fannie and Freddie (r=0.99), so an average trend was estimated from the two data sources. Investment markets were judged by the S&P 500 index average monthly value.

Statistical Analysis

In principle, the statistical analysis involved the specification of time-series models where PD queries at any given month (t) were a function of the prior months' economic trends (t – i) after adjusting for overall trending in the data (the mean and variance of PD and the economic indicators change over time), seasonality (PD query trends may vary similarly year to year), and autocorrelation (measurements occurring closer in time are more similar than those further apart in time). The time-series were made stationary by taking the first difference (t – (t-1)) of both the outcome and each economic predictor, to make inferences independent of trending.(Allard 1998) An auto-regressive component was added by including a lagged PD search predictor, also differenced, so the association between PD and economic trends was in excesses of cyclical trends. The selection of a single auto-regressive process was confirmed by Breush-Godfrey tests.(Lütkepohl 2006) Monthly dummy indicators were included as additional covariates to account for seasonality. This method is assumption-free allowing seasonality to follow linear or non-linear patterns.(Barnett, & Dobson, Annette J. 2010) Autocorrelation patterns were reduced to a random pattern by these methods. Newey-West standard errors were used so the error variance estimates would be valid under regression assumption violations, yielding conservative estimates.(Newey, & Kenneth 1987) This analysis strategy produced valid estimates that overcome many of the limitations in less rigorous time-series models.

To assess general associations between the composite PD query trend and economic trends, separate time-series models for each economic predictor with varying lags, where PD query trends are a function of economic trends from one to six months prior, were estimated.

Regression coefficients for each economic indicator are reported as reflecting the percent increase in PD queries relative to a pre Great Recession mean (RSV=73) (Ho : $\Delta Searches$ / $Mean\ Searches_{preGR} = 0$). To address uncertainty in the estimates, the above ratio was calculated using 1000 randomly drawn sets of estimates from a multivariate normal sampling distribution with mean equal to the maximum-likelihood (ML) point estimates of the regression coefficients, and variance equal to the variance-covariance matrix of these estimates (ie: $\hat{\beta_{est}} \sim MVN\ (\hat{\beta_{mle}}, V(\hat{\beta_{mle}}))$, where $\hat{\beta_{mle}}$ is the vector of ML estimates and $V(\hat{\beta_{mle}})$ is the variance-covariance matrix from the regression).(King et al 2000) To assess the association between individual search term trends and economic indicators, terms were downloaded on their own scale and on a common scale. Each term was then individually modeled to each of the economic indicators using methods like that for the composite analysis and assessed through the amount of total variation explained by each individual term (r^2).

Results

PD query trends followed popular economic timelines, where economic contraction preceded increases in PD queries (Figure 2). For example, PD queries increased at the end of 2008 coinciding with the collapse of Lehman Brothers and the consequent stock market crises. The subsequent leveling off in PD queries concurred with modest economic stabilization but remained about 20% higher than before the Great Recession (~86 versus 73 RSV). There were more than 1,000,000 PD queries on Google per month in the US at the end of 2010. The absolute increases are dramatic, with about 300,000 queries attributable to the Great Recession at its peak (100 versus a pre-recession baseline of 73 RSV).

Statistical analysis suggested present unemployment, underemployment and mortgage delinquencies and foreclosure trends were associated with statistically significant increases in PD queries up to 6 months into the future (Figure 3A). On the other hand, the S&P 500, median home values, and home sale price trends were inconsistently associated with PD queries and usually statistically insignificant (Figure 3B). A one-percentage point increase in unemployment, for instance, was associated with a 7% (95% confidence interval [95%CI], 2–13) increase in PD queries the following month over a pre-Great Recession baseline. Unemployment had lasting associations with increases in unemployment consistently predicting PD queries increases 1 to 6 months into the future (lagged t-6; 7% 95%CI, 2–11). The association of underemployment with PD queries suggested a one-percentage point increase in underemployment was associated with a 3% (95%CI, 1–6) increase in PD queries 3-months later, for example. Mortgages in delinquency and foreclosure trends exhibited strong associations with PD trends. A one-percentage point increase in mortgages in delinquencies and foreclosure was associated with a 16% (95%CI, 9–24) increase in PD queries the following month, also reaching into the future predicting higher PD queries four months out (lagged t-4; 11% 95%CI, 3–18).

Standardized coefficients were computed to compare the relative magnitude of association across economic measures, given the variation in measurement units. Home mortgages in delinquencies and foreclosure, on average, had almost twice the leverage on PD queries as a similar increase in unemployment (lagged t-1; β=18.0, 95%CI, 9.7–26.4 versus β=10.5,

95%CI, 2.17–18.9), which was four times stronger than underemployment. These patterns suggest there was an equal step-down in strength of association moving from mortgages in delinquencies and foreclosure, to unemployment, to underemployment.

The top five individual PD search terms whose variance was best explained (highest r^2) by unemployment, underemployment and mortgages in delinquencies and foreclosure at a lag of 1 month (results were similar for other months) were “anxiety disorder”, “what is depression”, “signs of depression”, “depression symptoms”, and “symptoms of depression” (Figure 4). The associations were qualitatively similar across the three economic indicators. Unemployment, underemployment and, mortgages in delinquencies and foreclosure typically explained ~85% of total variance in the term “anxiety disorder”, ~80% for “what is depression”, ~75% for “signs of depression”, ~72% for “depression symptoms”, and ~68% for “symptoms of depression.” These terms were also relatively common compared to the other terms, being the 6th, 14th, 9th, 10th and 4th most queried terms out of the 20 terms analyzed.

Discussion

These results demonstrate the utility of PD search query surveillance, providing the first account of how multiple specific features of the Great Recession may be related to population mental health. A major problem in psychiatric epidemiology is how to assess mental health among individuals who do not present for treatment or cannot be reached with telephone surveys;(Croft et al 2009) monitoring Internet search queries may be one approach to address this problem. A query-based sentinel has many advantages over existing approaches and, as a result, has many implications for public health.(Brownstein et al 2009)

Strengths and Limitations

Self-reported survey responses are the principal surveillance for mental health problems, (Reeves et al 2011) with sets of questions designed to measure specific outcomes like severe psychological distress based on six questions (K-6 scale).(Kessler et al 2002) However, self-reports have strong social desirability biases,(Zaller, & Feldman 1992) especially where sensitive topics are discussed.(Ayers 2010) Telephone surveys also have high costs, meaning budgets can only support periodic data collection. For instance, the Behavioral Risk Factor Surveillance System (BRFSS) costs about $7 million each year, with mental health screeners only included periodically (e.g., the K6 severe psychological distress scale was only included in 2007 and 2009).(Department of Health and Human Services 2010) Physician-reports based on use of health services provide more timely and cost effective surveillance.(Lazarus et al 2001) but may have poor validity during economic contractions when lack of insurance or insurance deductibles and copayments impede access.(Hoffman, & Paradise 2008). Stigma may also prevent those with physician access from discussing mental health problems.(Link, & Phelan 2006) Both, self-reported and physician-reported sentinels have many restrictions on or delays for public access given that data streams often contain personal identifying information.(Wilson, & Brownstein 2009)

Query-based sentinels, in contrast, rely on anonymous data, bypass disclosures of socially undesirable information, and are freely available packaged in a continuous data stream.

These data streams may then be linked to a host of economic (and other macro) changes as they are occurring. Analyses of these data also afford greater transparency, as scientists may quickly replicate each others' work downloading data from a regularly updated online archive.(Wilson, & Brownstein 2009) One review of mental health surveillance said the aforementioned advantages would define an ideal "optimal surveillance system."(Freeman et al. 2010) However, query-based mental health surveillance is not designed to be a replacement for traditional survey-based or clinical-based diagnoses surveillance, and has it's own limitations. For instance, because queries are analyzed at the population level, they may not be used to infer the demography of those querying for PD like traditional surveillance. Changes in PD among the population of Google users must also closely correspond to the entire population. Traditional factors like younger age, more income, and more education have been associated with using the web as a health resource.(Cotten, & Gupta 2004) However, recent work suggests individuals 60+ years of age and adolescents have similar tendencies to query online for health information(Ybarra, & Suman 2008) and nearly all age-by-demographic breakdowns consume some health information online, (McMullan 2006) calling into question the assumption that Internet users differ dramatically from the entire population. Search query surveillance may not be as useful in resource poor settings, especially those with limited Internet access.

The larger limitation regards the validity of queries, specifically, are PD query trends indicative of changes in mental health problems including non-specific PD and/or specific depression or anxiety disorders? Unfortunately, unlike infectious disease surveillance where comparable criterions abound, there are no real-time or sufficiently granular mental health trends to compare with PD query trends. As a result, the queries monitored were not validated by comparison with traditional PD indicators, like the K-6. PD queries may not correspond to PD, however, they appear face valid. Moreover, alternative explanations for PD queries lack sufficient evidence to be compelling. PD queries may increase with PD media trends and the Great Recession may be motivating PD news and therefore PD queries. According to Google news archives, there were 21,800 articles on mental health in 2007 (before the Great Recession) and about 22,500 in 2008 (during the Great Recession) and 22,000 in 2009 (officially, after the Great Recession), suggesting increases in PD queries were not media driven. Still the analyses could be confounded. Confounding may have biased the results, but this would theoretically require an unobserved factor to cause both macro-economic decline and PD queries, and this is difficult to theorize. Where search query surveillance may have poor specificity, their sensitivity is likely strong, capturing subtle changes in mental health that may not be presented in clinical practice or discussed with others. As such, we assume PD queries indicate non-specific distress, but they may also indicate clinical/subclinical depression or clinical/subclinical anxiety. Therefore, our trends suggest Americans' mental health may be worsening during the Great Recession and this may inform efforts to improve population mental health.

Implications

PD query trends could be refined to guide the swift allocation of scarce health resources. Resources for mental health care may be released and clinicians can modify their screening practices to identify the subset of patients who may have clinically significant depression or

anxiety conditional on PD queries, by monitoring trends near their practice. The web is also a stigma-reducing and cost-reducing venue to reach patients who search for but do not discuss mental health problems with health care providers. Several web-based programs show promise for treating mental health problems,(Andersson 2009; Christensen et al 2004; Houston, & Ford 2008) even for those not meeting clinical thresholds like non-specific distress.(Druss et al 2007) Paid links appearing on the first page of PD search results may be a viable avenue to direct searchers to online and terrestrial care. For example, a “depression symptoms” searcher may be directed to a webpage and screened using several validated depression screeners, e.g. the Patient Health Questionnaire 8,(Kroenke et al 2009) and then linked to an online or terrestrial treatment program as needed.

Policymakers may use PD query trends to inform their debates, especially given their potential use for real-time surveillance. For instance, queries may be used to calculate health-related cost-offsets for economic stimuli. Policies targeting foreclosures may reduce PD but these have received less support than investment market stimuli. Over $700 billion was earmarked under TARP for banking and investment companies compared to $50 billion for foreclosure aid.(Powell, & Martin 2011) Policymakers are typically more willing to stimulate investment markets as investment trends are regularly updated and are logically connected to labor and housing markets (even if improvements was not the case during the Great Recession). Monitoring real-time PD queries may provide timely data to reframe labor and housing stimuli as ways to improve population health. These arguments may be ground for discussing the universal population health benefits of economic stimuli,(Skocpol 1991) rather than targeted benefits to the unemployed or those losing their home (who are often viewed as individually responsible for their loss).(Iyengar 1996) Such applications of PD query trends, may highlight the importance of public health, especially when it has been absent from current economic debates.

Conclusions

The Great Recession’s health implications have been widely speculated(Catalano 2009; Cooper 2011) but this was the first study to compare how various economic indicators are correlated with indicators of population health, including the first to associate underemployment(Dooley 2003), investment markets,(Catalano et al 2011) or homes in delinquency and foreclosure(Bennett, & Glasgow 2009; Miller et al 2011) with population mental health. Because the economy is constantly changing, this work not only provides a snapshot of recent associations between the economy and PD but also a framework and toolkit for real-time surveillance going forward. A query-based sentinel, in doing so, allows public health to move beyond accepted claims and demonstrate how current economic conditions may be linked to health in a manner that is relevant to clinicians, health advocates and policy makers to alleviate the high levels of PD Americans are likely enduring.

Acknowledgments

Role of Funding: Google.org, NLM, NICHHD, NSF and the Fullbright foundation had no role in the design and conduct of the study; in the collection, management, analysis, and interpretation of the data; or in the preparation, review, or approval of the manuscript.

Funding was received from *Google.org* to JWA, and the National Library of Medicine and *Google.org* to JSB. JWA was also supported by a National Institute of Child Health & Human Development Training Grant in Pediatric Emergency Medicine (5T32HD040128). A National Science Foundation Graduate Research Fellowship also supported BMA and a Fullbright fellowship also supported WZ. Google.org, NLM, NICHHD, NSF and the Fullbright foundation had no role in the design and conduct of the study; in the collection, management, analysis, and interpretation of the data; or in the preparation, review, or approval of the manuscript. We thank Larry Cheskin, Daniel Ford, Ken Mandl, and James Tonascia for their helpful criticisms.

Abbreviations

PD	Psychological distress
US	United States

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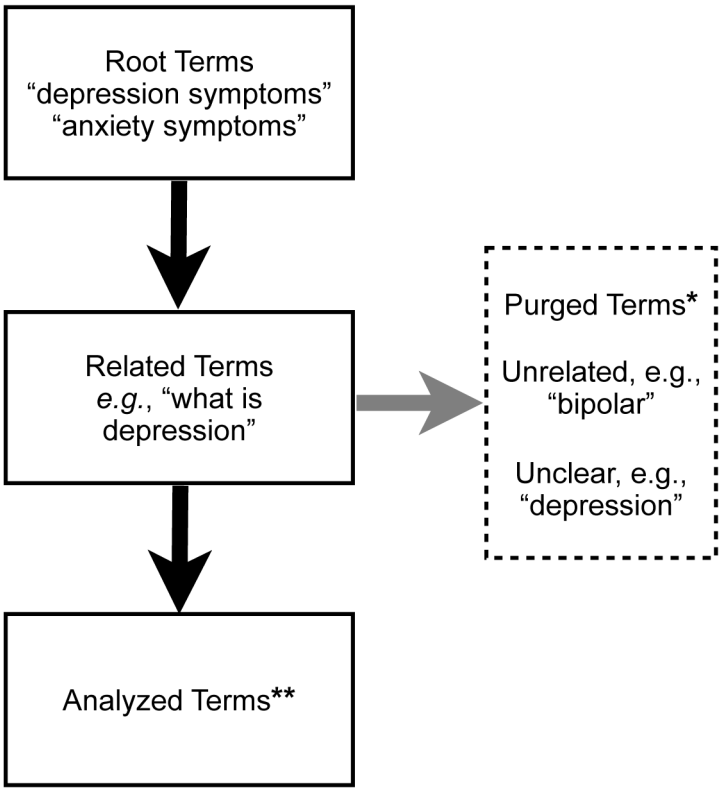

Figure 1. Search query selection strategy

Note: *Purged terms included: depression, bipolar, bipolar symptoms, bipolar depression, stress symptoms, bipolar depression symptoms, symptoms manic depression, manic depression, bipolar disorder, postpartum depression symptoms, postpartum depression, social anxiety symptoms and bipolar disorder symptoms, **Analyzed terms included: depression symptoms, anxiety symptoms, symptoms of depression, symptoms for anxiety, anxiety disorder symptoms, anxiety disorder, anxiety attacks, panic attacks, panic attack symptoms, depression anxiety, anxiety attack symptoms, symptoms for depression, stress symptoms, anxiety attacks symptoms, anxiety attacks, stress anxiety symptoms, signs of depression, depression test, depression and anxiety, symptoms of stress, , anxiety disorders.

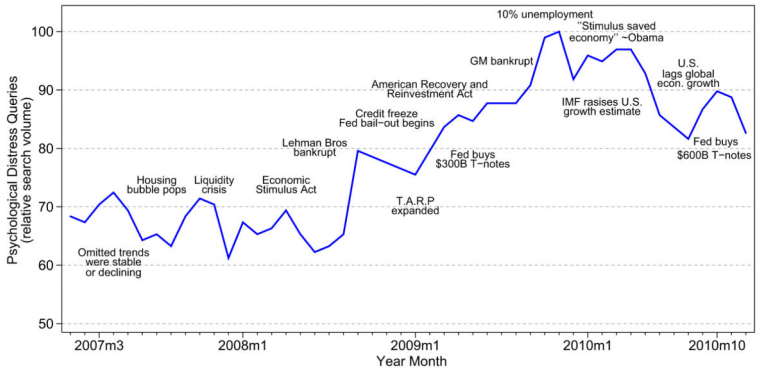

Figure 2. Psychological distress searches increased during the Great Recession

Note: Monthly average trends for psychological distress like queries are shown with major economic events superimposed on the trend corresponding to the approximate date of the event. Abbreviations: T.A.R.P. is troubled asset relief program, t-notes: treasury notes.

Figure 3A

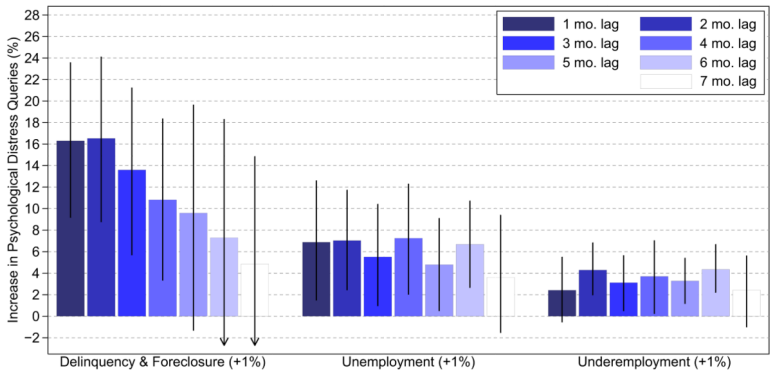

Figure 3b

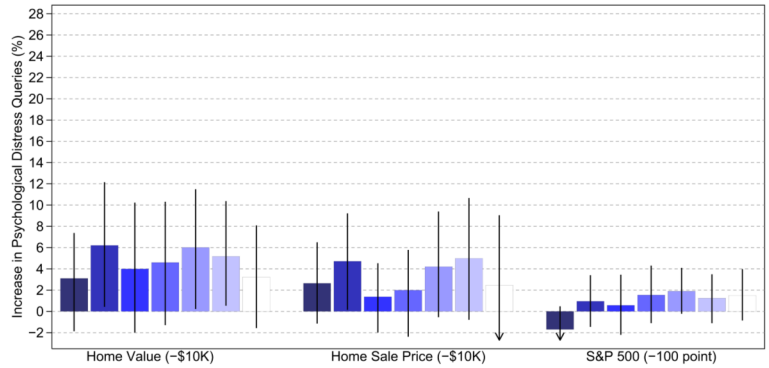

Figure 3. Mortgages in delinquency and foreclosure, unemployment and underemployment predict future increases in psychological distress queries

Note: Estimates show the percent increase in queries one to seven months into the future for (panel a) a 1% increase in unemployment, underemployment, or foreclosures; (panel b) a $10K decline in home values or sale prices, and a 100 point decline in the S&P 500 value.

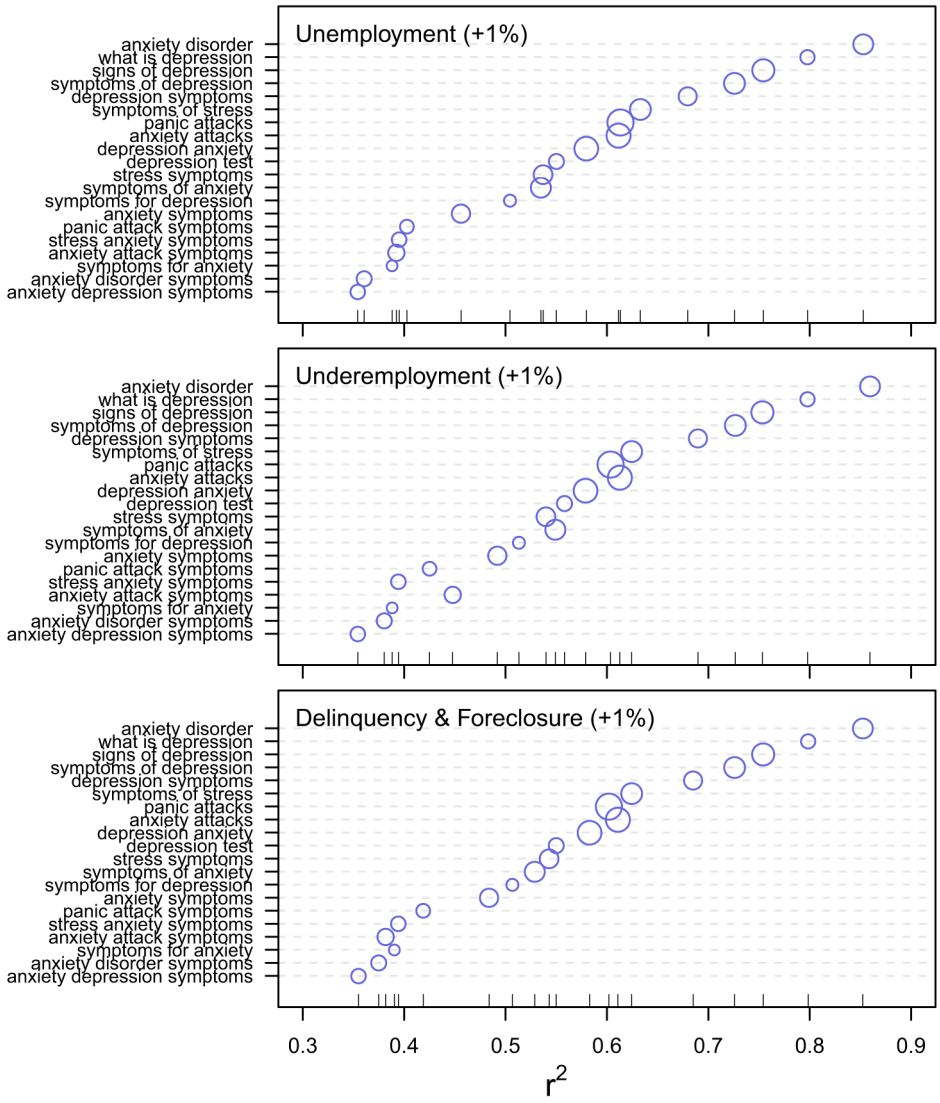

Figure 4. Mortgages in delinquency and foreclosure, unemployment and underemployment explain variance in individual psychological distress queries

Note: Each node is sized according to its search volume relative to the other queries. Estimates shown were derived from a three month lag, but were nearly identical lags ranging from one to four months.