Journal of Affective Disorders ▮ (▮▮▮▮) ▮▮▮–▮▮▮

Contents lists available at SciVerse ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

Preliminary communication

Novel surveillance of psychological distress during the great recession

John W. Ayers [a,b,c,*], Benjamin M. Althouse [d], Jon-Patrick Allem [e], Matthew A. Childers [f], Waleed Zafar [d], Carl Latkin [d], Kurt M. Ribisl [g,h], John S. Brownstein [a,b,c]

[a] Children's Hospital Informatics Program at the Harvard-MIT Division of Health Sciences and Technology, Boston, MA, USA
[b] Children's Hospital Boston, Boston, MA, USA
[c] Harvard Medical School, Boston, MA, USA
[d] Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA
[e] University of Southern California Keck School of Medicine, Los Angeles, CA, USA
[f] Division of Social Sciences, University of California, San Diego, La Jolla, CA, USA
[g] Gillings School of Global Public Health, University of North Carolina, Chapel Hill, NC, USA
[h] Lineberger Comprehensive Cancer Center, University of North Carolina, Chapel Hill, NC, USA

ARTICLE INFO

Article history:
Received 1 March 2012
Received in revised form
22 April 2012
Accepted 1 May 2012

Keywords:
Health surveillance
Mental health
Psychological distress
Health economics

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.

Result: 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 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 be informed by changes in PD query trends.

1. Introduction

Countercyclical associations between economic contraction and population nonspecific psychological distress (PD), defined as depressed or anxious 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 and Wooden, 2008; Zimmerman and 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

Abbreviations: United States (US), Psychological distress (PD)

* Corresponding author at: Children's Health Informatics Program at the Harvard-MIT Division of Health Sciences and Technology, 1 Autumn Street Boston, MA 02215, USA. Tel.: +1 4433886138.
E-mail addresses: john.ayers@childrens.harvard.edu, ayers.john.w@gmail.com (J.W. Ayers).

0165-0327/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.jad.2012.05.005

delinquency or foreclosure rose from 1% to 7% (Blumberg and 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 and 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.

2. 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 and Kohler, 2003). By searching online, individuals actively relay information about their identity, thoughts, and behaviors (Brownstein et al., 2009; Wilson and 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., 2010; 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 and Monge-Corella, 2010), dengue (Althouse et al., 2011; Chan et al., 2011), gastritis (Pelat et al., 2009), kidney stones (Breyer et al., 2011; Willard and Nguyen, 2011), listerosis (Wilson and 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 and Zimmermann, 2009; Breyer and Eisenberg, 2010; Goel et al., 2010; Yang et al., 2011; Ayers et al., 2011a,b; Ayers et al. 2012; Reis and 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. We hypothesize changes in PD-related queries may similarly capture population PD trends with fine temporal resolution to inform timely analyses.

2.1. Search volume

Trends were downloaded from *Google Insights for Search* (http://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 and Hanson, 1989). Absolute monthly volume, however, was estimated using *Google Adwords* (http://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.

2.2. 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 (Fig. 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 ($r=0.93$).

2.3. 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 day past due or

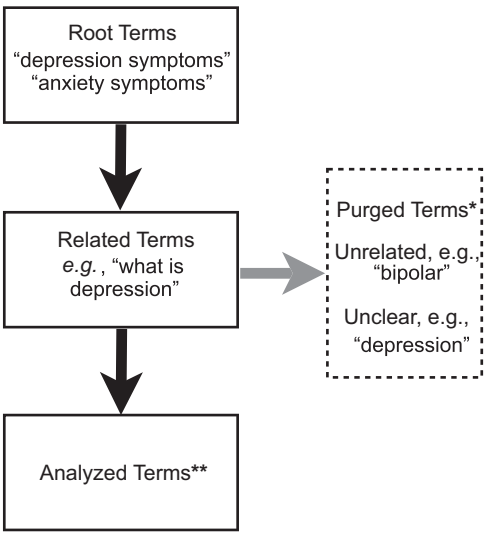

Fig. 1. *Search query selection strategy. Note*: ∗purged terms included: depression, bipolar, bipolar symptoms, bipolar depression, stress symptoms, bipolar depression symptoms, symptoms manic depression, manic depression, bipolar disorder, postpartum depression symptoms, postpartum depression, social 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.

Please cite this article as: Ayers, J.W., et al., Novel surveillance of psychological distress during the great recession. Journal of Affective Disorders (2012), http://dx.doi.org/10.1016/j.jad.2012.05.005

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 and 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.

2.4. 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 auto-correlation (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 Breusch–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 and Dobson, 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 & West, 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:Δsearches/Mean Searches$_{pre\text{-}GR}=0$). 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 (i.e.:, $\beta_{est} \sim \text{MVN}(\beta_{mle}, V(\beta_{mle}))$ here β_{mle} is the vector of ML estimates and $V(\beta_{mle})$ 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).

3. Results

PD query trends followed popular economic timelines, where economic contraction preceded increases in PD queries (Fig. 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 (Fig. 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 (Fig. 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

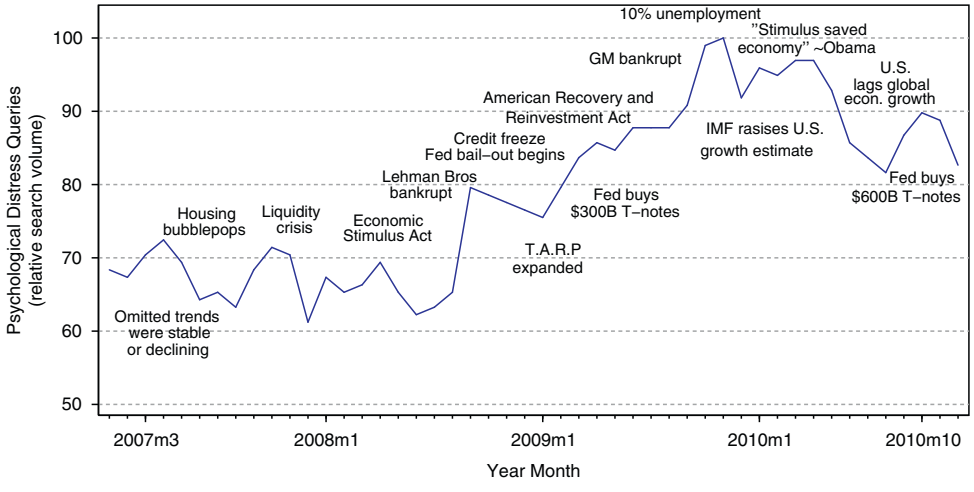

Fig. 2. *Psychological distress searches increased during the Great Recession. Note*: Monthly average trends for psychological distress like queries are shown with major economic events superimposed on the trend corresponding to the approximate date of the event. *Abbreviations*: T.A.R.P. is troubled asset relief program, *t-notes*: treasury notes.

Please cite this article as: Ayers, J.W., et al., Novel surveillance of psychological distress during the great recession. Journal of Affective Disorders (2012), http://dx.doi.org/10.1016/j.jad.2012.05.005

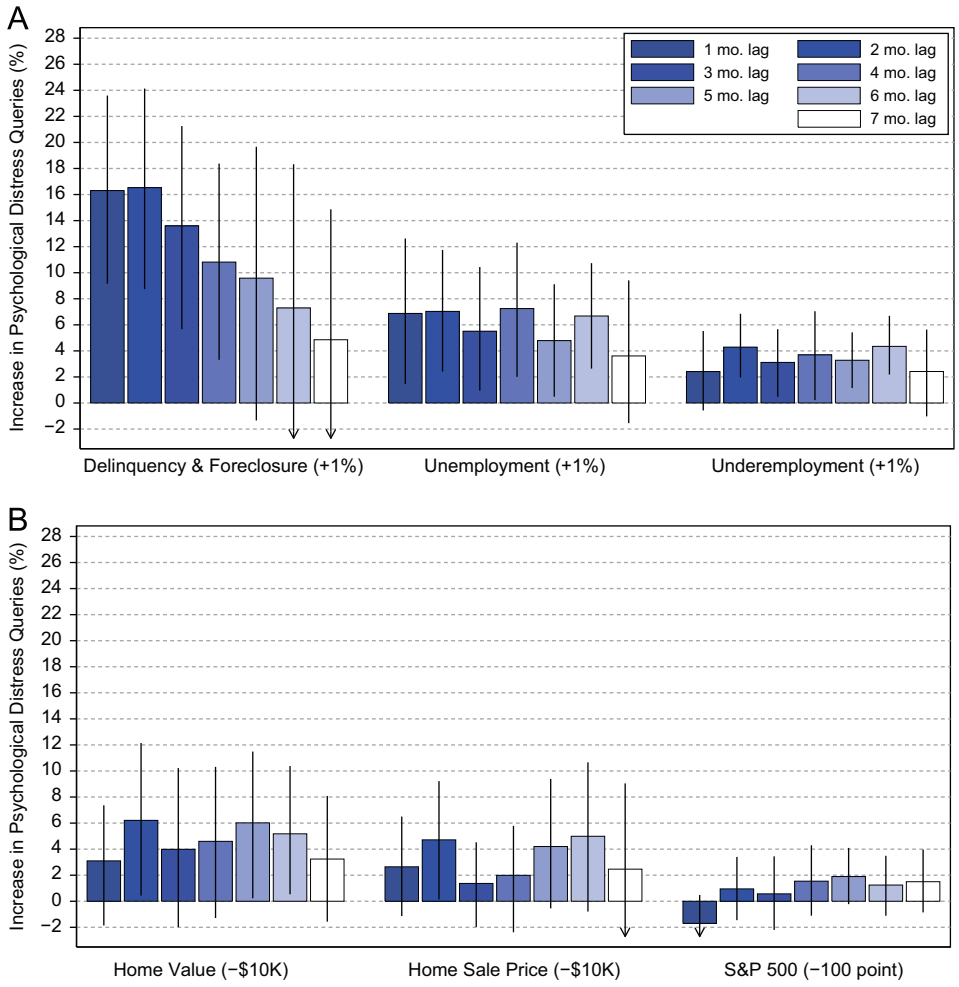

Fig. 3. *Mortgages in delinquency and foreclosure, unemployment and underemployment predict future increases in psychological distress queries. Note*: estimates show the percent increase in queries one to seven months into the future for (panel a) a 1% increase in unemployment, underemployment, or foreclosures; (panel b) a $10K decline in home values or sale prices, and a 100 point decline in the S&P 500 value.

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 $t-1$; $ß=18.0$, 95%CI, 9.7–26.4 versus $ß=10.5$, 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" (Fig. 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.

4. 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.

4.1. 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 and Feldman, 1992), especially where

Please cite this article as: Ayers, J.W., et al., Novel surveillance of psychological distress during the great recession. Journal of Affective Disorders (2012), http://dx.doi.org/10.1016/j.jad.2012.05.005

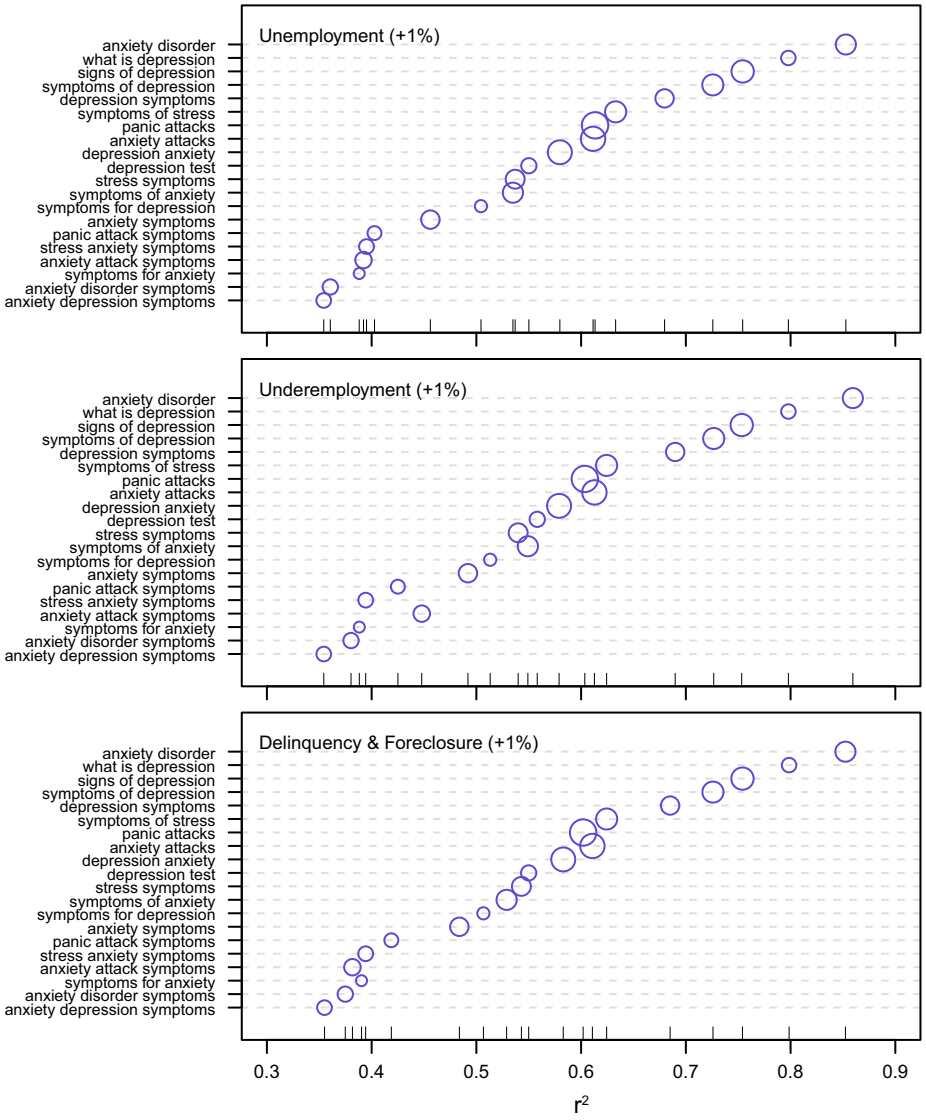

Fig. 4. *Mortgages in delinquency and foreclosure, unemployment and underemployment explain variance in individual psychological distress queries. Note*: each node is sized according to its search volume relative to the other queries. Estimates shown were derived from a three month lag, but were nearly identical lags ranging from one to four months.

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). 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 and Paradise, 2008). Stigma may also prevent those with physician access from discussing mental health problems (Link and 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 and 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 and Brownstein, 2009). One review of mental health surveillance said the aforementioned advantages would define an ideal "optimal surveillance system" (Freeman et al., 2011). However, query-based mental health surveillance is not designed to be a replacement for traditional survey-based or clinical-based diagnoses surveillance, and has its 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 and Gupta, 2004). However, recent work suggests individuals 60+ years of age and adolescents have similar tendencies to query online for health information (Ybarra and 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.

Please cite this article as: Ayers, J.W., et al., Novel surveillance of psychological distress during the great recession. Journal of Affective Disorders (2012), http://dx.doi.org/10.1016/j.jad.2012.05.005

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.

4.2. 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 and 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 and 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.

5. 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 and 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.

Role of funding source

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.

Conflict of interest

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.

Acknowledgements

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 and 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. We thank Larry Cheskin, Daniel Ford, Ken Mandl, and James Tonascia for their helpful criticisms.

References

Allard, R., 1998. Use of time-series analysis in infectious disease surveillance. Bulletin of the World Health Organization 76 (4), 327–333.

Alley, D.E., Lloyd, J., Pagán, J.A., Pollack, C.E., Shardell, M., Cannuscio, C., 2011. Mortgage delinquency and changes in access to health resources and depressive symptoms in a nationally representative cohort of Americans older than 50 years. American Journal of Public Health 101 (12), 2293–2298.

Althouse, B.M., Ng, Y.Y., Cummings, D.A., 2011. Prediction of dengue incidence using search query surveillance. PLoS Neglected Tropical Diseases 5 (8), e1258.

Andersson, G., 2009. Using the Internet to provide cognitive behaviour therapy. Behaviour Research and Therapy 47 (3), 175–180.

Askitas, N., Zimmermann, K.F., 2009. Google econometrics and unemployment forecasting. Applied Economics Quarterly 55 (2), 107–120.

Ayers, J.W., 2010. Measuring English proficiency and language preference: are self-reports valid? American Journal of Public Health 100 (8), 1364–1366.

Ayers, J.W., Ribisl, K., Brownstein, J.S., 2011a. Using search query surveillance to monitor tax avoidance and smoking cessation following the United States' 2009 "SCHIP" cigarette tax increase. PLoS One 6 (3), e16777.

Ayers, J.W., Ribisl, K.M., Brownstein, J.S., 2011b. Tracking the rise in popularity of electronic nicotine delivery systems (electronic cigarettes) using search query surveillance. American Journal of Preventive Medicine 40 (4), 448–453.

Ayers, J.W., Althouse, B.M., Allem, J., Ford, D.E., Ribisl, K.M., Cohen, J.E., 2012. A Novel Evaluation of World No Tobacco Day in Latin America. Journal of Medical and Internet Research 14 (3), e77.

Barnett, A.G., Dobson, Annette J., 2010. Analysing seasonal health data. Springer, Berlin.

Bennett, G.G., Glasgow, R.E., 2009. The delivery of public health interventions via the Internet: actualizing their potential. Annual Review of Public Health 30, 273–292.

Bennett, G.G., Scharoun-Lee, M., Tucker-Seeley, R., 2009. Will the public's health fall victim to the home foreclosure epidemic? PLoS Medicine 6 (6), e1000087.

Blumberg, D., O'Neal, C., 2010. TransUnion Finds National Mortgage Delinquencies Jumped 10.24 Percent at End of 2009.

Breyer, B.N., Eisenberg, M.L., 2010. Use of Google in study of noninfectious medical conditions. Epidemiology (Cambridge, Mass.) 21 (4), 584–585.

Breyer, B.N., Sen, S., Aaronson, D.S., Stoller, M.L., Erickson, B.A., Eisenberg, M.L., 2011. Use of Google Insights for Search to track seasonal and geographic kidney stone incidence in the United States. Urology 78 (2), 267–271.

Brownstein, J.S., Freifeld, C.C., Madoff, L.C., 2009. Digital disease detection—harnessing the Web for public health surveillance. The New England Journal of Medicine 360 (21), 2153–2155.

Catalano, R., 2009. Health, medical care, and economic crisis. New England Journal of Medicine 360 (8), 749.

Catalano, R., Goldman-Mellor, S., Saxton, K., Margerison-Zilko, C., Subbaraman, M., Lewinn, K., Anderson, E., 2011. The health effects of economic decline. Annual Review of Public Health, 32, 431–450.

Chan, E.H., Sahai, V., Conrad, C., Brownstein, J.S., 2011. Using web search query data to monitor dengue epidemics: a new model for neglected tropical disease surveillance. PLoS Neglected Tropical Diseases 5 (5), e1206.

Christensen, H., Griffiths, K.M., Jorm, A.F., 2004. Delivering interventions for depression by using the internet: randomised controlled trial. British Medical Journal (Clinical Research Ed.) 328 (7434), 265.

Cooper, B., 2011. Economic recession and mental health: an overview. Neuropsychiatry 25 (3), 113–117.

Cotten, S.R., Gupta, S.S., 2004. Characteristics of online and offline health information seekers and factors that discriminate between them. Social Science and Medicine (1982) 59 (9), 1795–1806.

Croft, J.B., Mokdad, A.H., Power, A.K., Greenlund, K.J., Giles, W.H., 2009. Public health surveillance of serious psychological distress in the United States. International Journal of Public Health 54 (Suppl. 1), 4–6.

Dohrenwend, B.P., Shrout, P.E., Egri, G., Mendelsohn, F.S., 1980. Nonspecific psychological distress and other dimensions of psychopathology. Measures for use in the general population. Archives of General Psychiatry 37 (11), 1229–1236.

Dooley, D., 2003. Unemployment, underemployment, and mental health: conceptualizing employment status as a continuum. American Journal of Community Psychology 32 (1–2), 9–20.

Druss, B.G., Wang, P.S., Sampson, N.A., Olfson, M., Pincus, H.A., Wells, K.B., Kessler, R.C., 2007. Understanding mental health treatment in persons without mental diagnoses: results from the national comorbidity survey replication. Archives of General Psychiatry 64 (10), 1196–1203.

Dugas, A.F., Hsieh, Y.H., Levin, S.R., Pines, J.M., Mareiniss, D.P., Mohareb, A., Gaydos, C.A., Perl, T.M., Rothman, R.E., 2012. Google Flu Trends: Correlation With Emergency Department Influenza Rates and Crowding Metrics, Clinical Infectious Diseases: An Official Publication of the Infectious Diseases Society of America.

Dukic, V.M., David, M.Z., Lauderdale, D.S., 2011. Internet queries and methicillin-resistant *Staphylococcus aureus* surveillance. Emerging Infectious Diseases 17 (6), 1068–1070.

Dutka, A.F., Hanson, H.H., 1989. Fundamentals of data normalization. Addison-Wesley Pub. Co., Reading, Mass.

Eysenbach, G., 2006. Infodemiology: tracking flu-related searches on the web for syndromic surveillance. AMIA Annual Symposium Proceedings/AMIA Symposium, 244–248.

Eysenbach, G., 2011. Infodemiology and infoveillance tracking online health information and cyberbehavior for public health. American Journal of Preventive Medicine 40 (5 Suppl. 2), S154–S158.

Eysenbach, G., Kohler, C.h., 2003. What is the prevalence of health-related searches on the World Wide Web? Qualitative and quantitative analysis of search engine queries on the internet. AMIA Annual Symposium proceedingsAMIA Symposium, 225–229.

Freeman, E.J., Colpe, L.J., Strine, T.W., Dhingra, S., McGuire, L.C., Elam-Evans, L.D., et al., 2010. Public health surveillance for mental health. Preventing Chronic Disease 7 (1) 〈http://www.cdc.gov/pcd/issues/2010/jan/09_0126.htm〉 (accessed 07.24.11).

Friesema, I.H., Koppeschaar, C.E., Donker, G.A., Dijkstra, F., van Noort, S.P., Smallenburg, R., van der Hoek, W., van der Sande, M.A., 2009. Internet-based monitoring of influenza-like illness in the general population: experience of five influenza seasons in The Netherlands. Vaccine 27 (45), 6353–6357.

Ginsberg, J., Mohebbi, M.H., Patel, R.S., Brammer, L., Smolinski, M.S., Brilliant, L., 2009. Detecting influenza epidemics using search engine query data. Nature 457 (7232), 1012–1014.

Goel, S., Hofman, J.M., Lahaie, S., Pennock, D.M., Watts, D.J., 2010. Predicting consumer behavior with Web search. Proceedings of the National Academy of Sciences of the United States of America 107 (41), 17486–17490.

Goldman-Mellor, S.J., Saxton, K.B., Catalano, R.C., 2010. Economic contraction and mental health. International Journal of Mental Health 39 (2), 6–31.

Hoffman, C., Paradise, J., 2008. Health insurance and access to health care in the United States. Annals of the New York Academy of Sciences 1136, 149–160.

Houston, T.K., Ford, D.E., 2008. A tailored Internet-delivered intervention for smoking cessation designed to encourage social support and treatment seeking: usability testing and user tracing. Informatics for Health and Social Care 33 (1), 5–19.

Hulth, A., Rydevik, G., Linde, A., 2009. Web queries as a source for syndromic surveillance. PLoS One 4 (2), e4378.

Iyengar, S., 1996. Framing responsibility for political issues. The Annals of the American Academy of Political and Social Science, 59–70.

Kessler, R.C., Andrews, G., Colpe, L.J., Hiripi, E., Mroczek, D.K., Normand, S.L., Walters, E.E., Zaslavsky, A.M., 2002. Short screening scales to monitor population prevalences and trends in non-specific psychological distress. Psychological Medicine 32 (6), 959–976.

King, G., Tomz, M., Wittenberg, J., 2000. Making the most of statistical analyses: improving interpretation and presentation. American Journal of Political Science 44 (2), 341–355.

Kroenke, K., Strine, T.W., Spitzer, R.L., Williams, J.B., Berry, J.T., Mokdad, A.H., 2009. The PHQ-8 as a measure of current depression in the general population. Journal of Affective Disorders 114 (1–3), 163–173.

Lazarus, R., Kleinman, K.P., Dashevsky, I., DeMaria, A., Platt, R., 2001. Using automated medical records for rapid identification of illness syndromes (syndromic surveillance): the example of lower respiratory infection. BMC Public Health 1, 9.

Lee, S., Guo, W.J., Tsang, A., Mak, A.D., Wu, J., Ng, K.L., Kwok, K., 2010. Evidence for the 2008 economic crisis exacerbating depression in Hong Kong. Journal of Affective Disorders 126 (1–2), 125–133.

Leonhardt, D., 2009. Broader Measure of US Unemployment Stands at 17.5%. New York Times.

Link, B.G., Phelan, J.C., 2006. Stigma and its public health implications. Lancet 367 (9509), 528.

Lütkepohl, H., 2006. New introduction to multiple time series analysis, illustrated ed. Birkhäuser, Berlin.

McCabe, T., 2011. The Street. 〈http://www.thestreet.com/story/10966578/bernanke-us-economic-recovery-5-years-away.html〉 (accessed Sep.2011).

McMullan, M., 2006. Patients using the Internet to obtain health information: how this affects the patient-health professional relationship. Patient Education and Counseling 63 (1–2), 24–28.

Miller, W.D., Pollack, C.E., Williams, D.R., 2011. Healthy homes and communities: putting the pieces together. American Journal of Preventive Medicine 40 (1 Suppl. 1), S48–S57.

Mossakowski, K.N., 2009. The influence of past unemployment duration on symptoms of depression among young women and men in the United States. American Journal of Public Health 99 (10), 1826–1832.

Murero, M., D'Ancona, G., Karamanoukian, H., 2001. Use of the Internet by patients before and after cardiac surgery: telephone survey. Journal of Medical Internet Research 3 (3), E27.

Newey, W.K., West, Kenneth D., 1987. A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. Econometrica 55 (3), 703–708.

Pelat, C., Turbelin, C., Bar-Hen, A., Flahault, A., Valleron, A., 2009. More diseases tracked by using Google Trends. Emerging Infectious Diseases 15 (8), 1327–1328.

Polgreen, P.M., Chen, Y., Pennock, D.M., Nelson, F.D., 2008. Using internet searches for influenza surveillance. Clinical Infectious Diseases: An Official Publication of the Infectious Diseases Society of America 47 (11), 1443–1448.

Pollack, C.E., Lynch, J., 2009. Health status of people undergoing foreclosure in the Philadelphia region. American Journal of Public Health 99 (10), 1833–1839.

Pollack, C.E., Kurd, S.K., Livshits, A., Weiner, M., Lynch, J., 2011. A case-control study of home foreclosure, health conditions, and health care utilization. Journal of Urban Health: Bulletin of the New York Academy of Medicine 88 (3), 469–478.

Portalseven.com, 2011. Unemployment Rate U-6. Portalseven.com. 〈http://portalseven.com/employment/unemployment_rate_u6.jsp〉 (accessed Dec.2011).

Powell, M., Martin, A., 2011. Foreclosure Aid Fell Short, and Is Fading. The New York Times.

Reeves, W.C., Strine, T.W., Pratt, L.A., Thompson, W., Ahluwalia, I., Dhingra, S.S., McKnight-Eily, L.R., Harrison, L., D'Angelo, D.V., Williams, L., Morrow, B., Gould, D., Safran, M.A.,Centers for Disease Control and Prevention (CDC), 2011. Mental Illness Surveillance Among Adults in the United States, MMWR. Surveillance Summaries: Morbidity and Mortality Weekly Report. Surveillance Summaries/CDC, 60 Suppl. 3, pp. 1–29.

Reis, B.Y., Brownstein, J.S., 2010. Measuring the impact of health policies using Internet search patterns: the case of abortion. BMC Public Health 10, 514.

Rice, R.E., 2006. Influences, usage, and outcomes of Internet health information searching: multivariate results from the Pew surveys. International Journal Of Medical Informatics 75 (1), 8–28.

Saft, J., 2011. Housing Raises U.S. Recession Alert. Reuters.com. 〈http://blogs.reuters.com/jim-saft/2011/03/24/housing-raises-us-recession-alert/〉 (accessed Dec.2011.).

Scutella, R., Wooden, M., 2008. The effects of household joblessness on mental health. Social Science and Medicine (1982) 67 (1), 88–100.

Please cite this article as: Ayers, J.W., et al., Novel surveillance of psychological distress during the great recession. Journal of Affective Disorders (2012), http://dx.doi.org/10.1016/j.jad.2012.05.005

Seifter, A., Schwarzwalder, A., Geis, K., Aucott, J., 2010. The utility of "Google Trends" for epidemiological research: Lyme disease as an example. Geospatial Health 4 (2), 135–137.

Skocpol, T., 1991. Targeting within universalism: politically viable policies to combat poverty in the United States. The Urban Underclass, pp. 411–436. Brookings Institution Press.

St. Louis Federal Reserve, 2011. Civilian Unemployment Rate (UNRATE), Monthly. Seasonally. Adjusted. 1948-01-01 to 2011-08-01.

Thomas, C., Benzeval, M., Stansfeld, S.A., 2005. Employment transitions and mental health: an analysis from the British household panel survey. Journal of Epidemiology and Community Health 59 (3), 243–249.

Valdivia, A., Monge-Corella, S., 2010. Diseases tracked by using Google trends, Spain. Emerging Infectious Diseases 16 (1), 168.

Willard, S.D., Nguyen, M.M., 2011. Internet search trends analysis tools can provide real-time data on kidney stone disease in the United States. Urology.

Wilson, K., Brownstein, J.S., 2009. Early detection of disease outbreaks using the Internet. CMAJ: Canadian Medical Association Journal=journal de l'Association medicale canadienne 180 (8), 829–831.

Woellert, L.,Gittelsohn, J., 2010. Fannie-Freddie Fix at $160 Billion with $1 Trillion Worst Case. Bloomberg.com.

Yang, A.C., Tsai, S.J., Huang, N.E., Peng, C.K., 2011. Association of Internet search trends with suicide death in Taipei City, Taiwan, 2004–2009. Journal of Affective Disorders.

Ybarra, M., Suman, M., 2008. Reasons, assessments and actions taken: sex and age differences in uses of Internet health information. Health Education Research 23 (3), 512–521.

Zaller, J., Feldman, S., 1992. A simple theory of the survey response: answering questions versus revealing preferences. American Journal of Political Science 36 (3), 579–616.

Zeng, Q.T., Kogan, S., Plovnick, R.M., Crowell, J., Lacroix, E.M., Greenes, R.A., 2004. Positive attitudes and failed queries: an exploration of the conundrums of consumer health information retrieval. International Journal of Medical Informatics 73 (1), 45–55.

Zillow.com. Real Estate Market Reports.

Zimmerman, F.J., Katon, W., 2005. Socioeconomic status, depression disparities, and financial strain: what lies behind the income-depression relationship. Health Economics 14 (12), 1197–1215.

Zivin, K., Paczkowski, M., Galea, S., 2011. Economic downturns and population mental health: research findings, gaps, challenges and priorities. Psychological Medicine 41 (7), 1343–1348.

Please cite this article as: Ayers, J.W., et al., Novel surveillance of psychological distress during the great recession. Journal of Affective Disorders (2012), http://dx.doi.org/10.1016/j.jad.2012.05.005