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Science Website Traffic in Earthquakes

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ABSTRACT

Science communication in natural disasters is important to society but rarely informed by quantitative analysis of website traffic patterns. Analysis of science website traffic during the 2010–2012 Canterbury earthquake sequence in New Zealand reveals near-instantaneous traffic surges after strong earthquakes followed by heavy-tailed power-law temporal decay consistent with Omori law for aftershocks. Traffic perturbations scale with earthquake magnitude and population exposure to strong shaking. Traffic also increases in response to public communications by the affiliated website operator. Website traffic decays with increasing seismic sequence duration but is ultimately sustained at levels 800%–1400% larger than pre-event traffic, revealing sustained public utilization of science websites that outlast the duration of the associated natural disaster. Science websites with diverse sources and content exhibit similarly scaled traffic volume patterns. This study provides a clear, quantitatively justified motive for scientists of all affiliations to prioritize timely science communication with the public following time-critical natural phenomena and disasters. Science website traffic for other natural disasters, including volcanic eruptions, cyclones, heatwaves, typhoons, and bushfires are similarly fit by power laws.

Electronic Supplement: Tables of Akaike information criterion and Omori-law parameters for Heaviside step function, and figures of daily seismicity rates and website visits and comparison of fits of Omori-law, exponential, and power-law distributions to website traffic data.

INTRODUCTION

Science websites are important vehicles for aiding in disaster readiness, response, and recovery, enhancing public understanding of the value of science, enabling research collaborations and data transfer, and providing effective communication and educational pathways between scientists, policy makers, emergency managers, stakeholders, and the general public (e.g., White *et al.*, 2009; Bossu *et al.*, 2012; Wald *et al.*, 2012). Social media such as Twitter (Earle *et al.*, 2012) and science website visitor IP addresses (Bossu *et al.*, 2012, 2014) record traffic surges and decays following earthquakes and have been used to rapidly locate and assess earthquake damage. The rate of public subscriptions to earthquake electronic mailing lists also increases above background rates for approximately two weeks following major earthquakes (Schwarz, 2004). We are unaware of a prior circumstance where website traffic has been monitored across several science websites before and throughout a protracted (i.e., multi-year duration) natural disaster and has been published in the peer-reviewed literature. This circumstance could enable investigation of how the characteristics of the website and the associated natural disaster influence when, where, how often, and for how long the general public seeks scientific information on the Internet.

In this study, we obtain and compare website visitor traffic data prior to and throughout the 2010–2012 Canterbury earthquake sequence (CES) in New Zealand for four diverse earth science websites with different pre-CES traffic volumes, data provisions, and *modus operandi* (Table 1). The CES initiated with the 4 September 2010 (New Zealand Standard Time [NZST]) Darfield earthquake and included 36 $M_L \geq 5.0$ and 3 $M_w \geq 6.0$ aftershocks in the following 16 months (Fig. 1a). The 22 February 2011 M_w 6.2 Christchurch earthquake (aftershock) caused 185 fatalities and extensive building and infrastructural damage. Strong ground motions in central Christchurch during this earthquake and related aftershocks are the highest instrumentally recorded in an urban environment in New Zealand (Bradley *et al.*, 2014). The Canterbury earthquakes caused >40 billion NZD damage (> 20% of New Zealand's gross domestic product [GDP]) and represent the most expensive natural disaster to affect New Zealand. The largest earthquakes in the sequence received media coverage worldwide and generated large national media coverage and surges in social media traffic (Bruns and Burgess, 2012; Gledhill *et al.*, 2010). The exposure of the regional populace to repeated strong ground shaking, land and infrastructural damage, and severe social and professional disruptions over a protracted period induced adverse mental health impacts (Fergusson *et al.*, 2014; Spittlehouse *et al.*, 2014). Thousands of affected residents immediately turned to the Internet for scientific information on aftershocks, future seismic risk, and general scientific explanations of earthquakes. We explore the statistical elements and implications of this phenomenon herein.

METHODS

CES earthquake data including epicentral locations, Richter magnitudes (M_L) and processed geometric mean peak

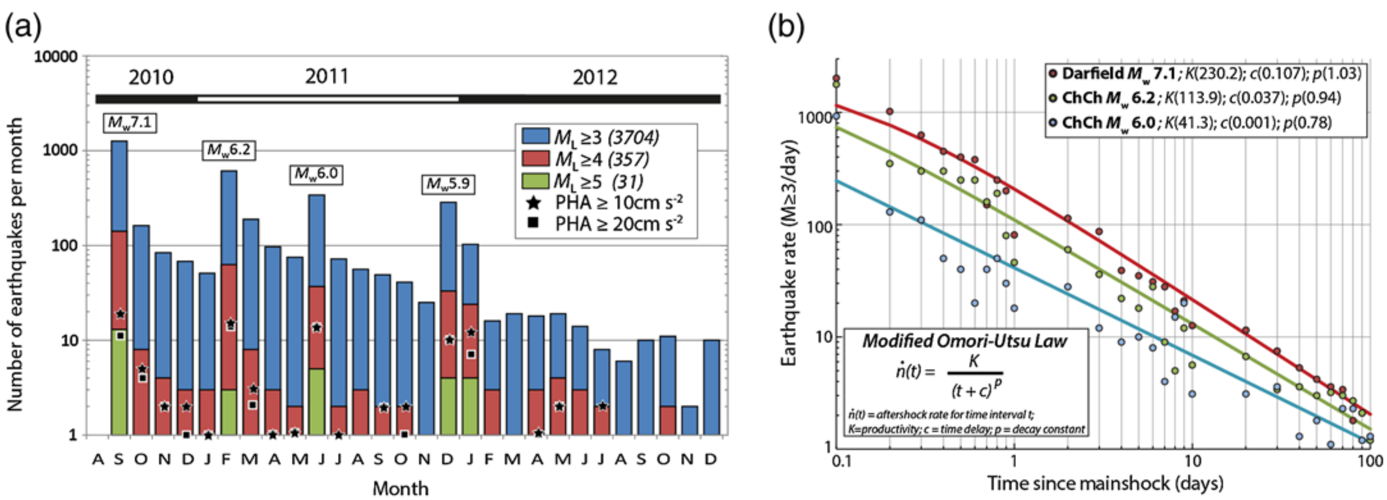
doi: 10.1785/0220160172

Table 1
Science Websites Analyzed in This Study

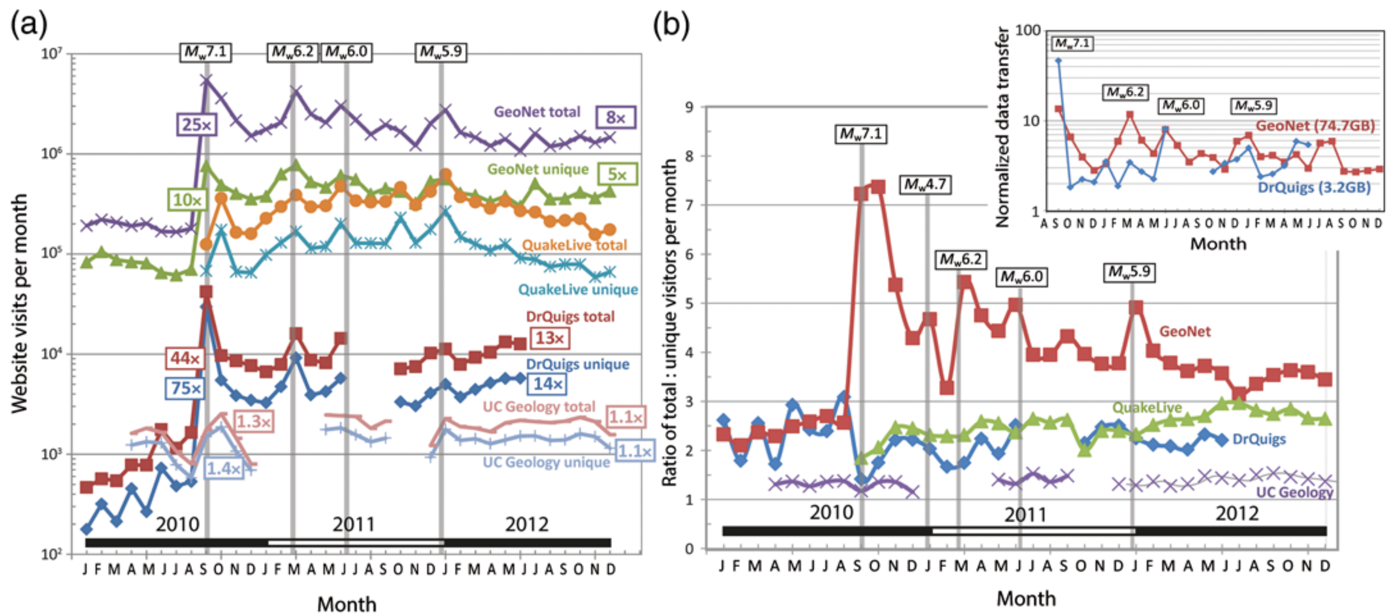
Website Names*	Details	Established	Darfield Earthquake Response Date (Postevent Time Lapse)	Traffic Monitor
GeoNet	New Zealand's primary geological hazard monitoring website, designed and maintained by the governmental science agency *GNS Science* and funded by the Earthquake Commission	March 2001	4 September 2010 (< 1 min)	Amazon webservices
DrQuigs	Self-funded, personal science website designed and maintained by a local university-based academic to provide scientific information and publications relating to the CES	May 2007	4 September 2010 (3 hrs)	AWStats
Canterbury QuakeLive	Self-funded independent science website set up by a local individual to provide earthquake data obtained from GeoNet in an alternative format	September 2010	16 September 2010 (12 days)	Google analytics
UC Geology Department	Small suite of webpages hosted within the earthquake region at the Department of Geological Sciences at University of Canterbury to provide earthquake information	Pre-2000, updated October 2010	23 September 2010 (19 days)	Google analytics

CES, Canterbury earthquake sequence.
*See Data and Resources for the details of the websites.

horizontal ground accelerations (PHA) at the Christchurch Hospital (located in central Christchurch at −43.5359°, 172.6275°) were downloaded in August 2015 from the updated GeoNet earthquake catalog (see Data and Resources). Earthquakes were binned by month, magnitude exceedances, and cm s^{-2} PHA exceedances (Fig. 1a). Daily rates of $M_L \geq 3.0$ earthquakes were binned by 0.1-day increments from days 0–1, 1-day increments from days 1-10, and 10-day increments from



▲ **Figure 1.** (a) Monthly binned Richter magnitude (M_L) ≥3.0 earthquake magnitude–frequency distributions from September 2010 to December 2012 for the spatial domain framed by −43.096° to −43.964° latitude and 171.947° to 174.303° longitude. Magnitude–frequency distributions during the Canterbury earthquake sequence (CES) follow Gutenberg–Richter scaling with $b \approx 1$ (Quigley *et al.*, 2016), with the number of earthquakes in each magnitude bin shown in parentheses. Stars and boxes denote the number of earthquakes per month with peak horizontal accelerations (PHAs) recorded in central Christchurch equal to or in excess of 10 and 20 cm s^{-2}, respectively. Collectively, the data indicate stronger and more frequent earthquakes in Christchurch occurred in close temporal proximity to the Darfield earthquake and largest aftershocks in February, June, and December 2011. (b) Earthquake rates per day binned by 0.1 days from 0 to 1, 1 day from 1 to 10, and 10 days from 10 to 100 days after the mainshock for the 3 September 2010, 21 February 2011, and 13 June 2011 events. Lines are maximum-likelihood estimates (MLEs) of the modified Omori-law relationship. Parameters for the Omori law are shown in the top right. The color version of this figure is available only in the electronic edition.



▲ **Figure 2.** (a) Monthly binned science website traffic statistics (unique and total visits) prior to and throughout the 2010–2011 CES. Unique and total website visits in September 2010 increased on GeoNet (10×, 25×) and DrQuigs (75×, 40×) (boxed numbers on the left side of diagram) relative to pre-earthquake monthly means. Subsequent website traffic increased episodically during months with increased seismicity (see Fig. 1a) and remained at elevated levels (GeoNet 5×, 8×; DrQuigs 13×, 14×) at the close of the analytical period (boxed numbers on the right side of diagram). (b) Comparison of total-to-unique visitor ratios prior to and throughout the 2010–2011 CES. Prior to the Darfield earthquake, both GeoNet and DrQuigs averaged ~2.4 visits per unique visitor; these ratios diverged dramatically in September 2010. (Inset) Post-Darfield earthquake ratios of monthly data transfer-to-pre-earthquake monthly mean data transfer. Pre-earthquake monthly mean data transfer values are shown in GB in parentheses beside website labels. Monthly data transfer increased 13× (GeoNet) and 46× (DrQuigs) relative to pre-earthquake levels in September 2010 due to the Darfield earthquake. Subsequent strong earthquakes caused additional surges in data transfer. Because these data are normalized to pre-earthquake data transfer volumes, it is relevant for bandwidth planning for possible natural disaster effects on website traffic on other science websites. The color version of this figure is available only in the electronic edition.

days 10 to 100 after the Darfield earthquake and two largest aftershocks (Fig. 1b). We fit earthquake frequency data to the modified Omori law for aftershock decay

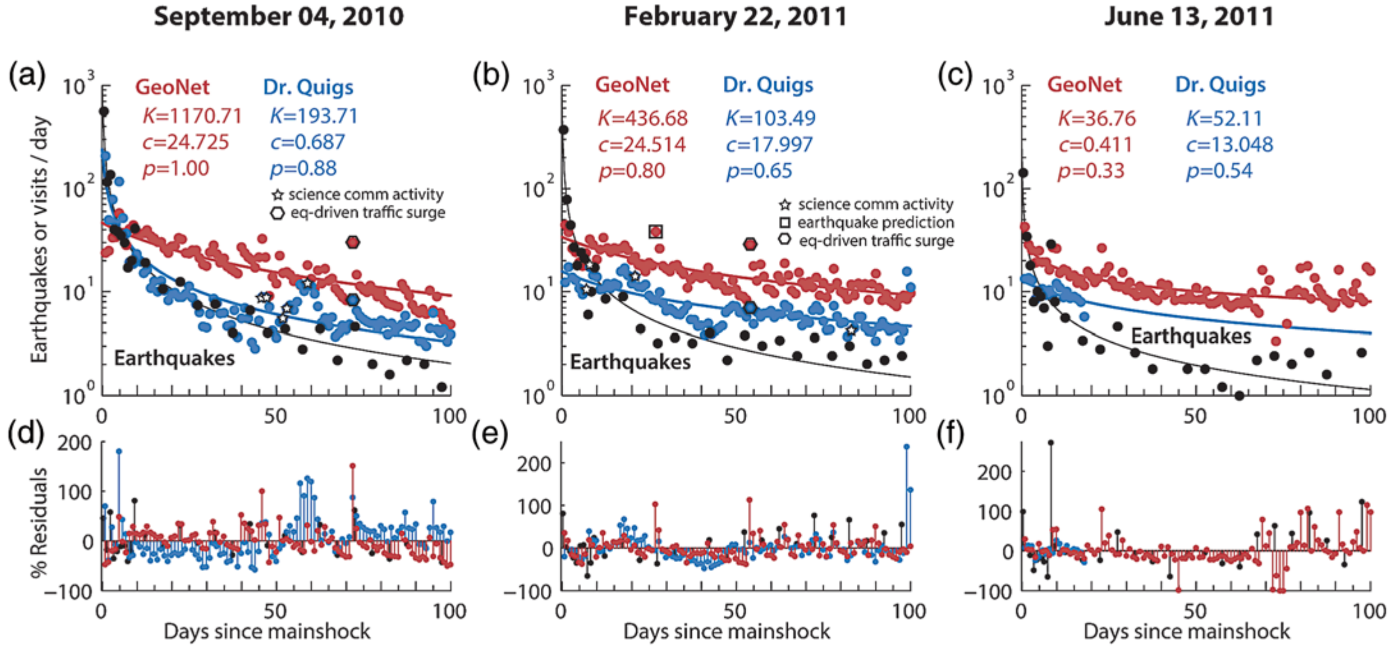
$$r(\leq m_c, t) = dN/dt = K/(t+p)^c \qquad (1)$$

(Omori, 1894; Utsu, 1961), in which we modeled the rate of earthquakes (r) with a minimum cutoff of M_L 3.0 (m_c) for a given time interval after the mainshock (t) using the maximum-likelihood estimation (MLE) method (Ogata, 1983) to derive Omori-law parameters K, c, and p (Fig. 1b; see Ⓔ electronic supplement to this article).

We obtained daily and monthly unique and total visitor statistics and monthly data transfer rates (GB) prior to and throughout the CES recorded by web analytical tools for four science websites (Table 1). The time stamps for daily website and earthquake data were corrected to UTC to enable derivation of time since mainshock, but the dates referred to in the article are NZST. Periods of data disruption or unavailability include: (1) a temporary crash of both the governmentally sanctioned New Zealand natural disaster science website, GeoNet (see Data and Resources) and local earthquake science website, DrQuigs (see Data and Resources) due to inadequate bandwidth coping capacity during a surge in website traffic following the 2010 Darfield earthquake, (2) intermittent monthly hiatuses in traffic data for the University of Canterbury Geological Sciences (henceforth UCGeol) website in 2011 due to incomplete traffic data capture by the tracking tool, and (3) a malware-induced crash of DrQuigs from June–September 2011. The Canterbury Quake Live website (henceforth QuakeLive) was established after the Darfield earthquake and thus has no pre-CES traffic data.

We compute monthly traffic and data transfer averaged over five (UCGeol) to eight months (DrQuigs and GeoNet) prior to the CES to compare to the month of the Darfield earthquake (September 2010) and the month at the end of the observation period (December 2012) (Fig. 2a,c). Monthly visits to unique visitor ratios are estimated and plotted in Figure 2b.

We use the MLE method to fit Omori law to the daily binned website traffic data for DrQuigs and GeoNet (see Ⓔ electronic supplement). Because the data are binned into 24 hr increments, we do not quantitatively consider time of day in our analyses. As a result, we cannot analyze traffic surges on subdaily temporal scales (e.g., seconds to hours) that could provide finer resolution of the timing of perturbations with respect to the associated earthquakes.



▲ **Figure 3.** (a–c) Daily earthquake data and website traffic (normalized by background rates) following the three largest earthquakes in the CES. Solid curves show best-fit Omori-law curves derived from the MLE method. The largest derivations from Omori-law curves (see also d–e) that can be clearly linked to changes in earthquake rate (Darfield, 22 February and 13 June earthquakes, and other aftershocks delineated by hexagons) or other phenomena are delineated by different symbols. For example, increased traffic at DrQuigs during days of science communication activities that did not correspond with increased seismicity are linked to science communication activities (star). Increased traffic at GeoNet corresponding to the date of a pseudoscientific earthquake prediction (20 March 2011) rather than increased earthquake or science communication activities shown by box. (d–f) Corresponding percentage residuals between Omori-law daily prediction and observed daily values. The color version of this figure is available only in the electronic edition.

Goodness of fit of the modified Omori law is compared with general power-law and exponential fits to the website data, using both visual comparison and Akaike information criterion (Akaike, 1974; see Ⓔ electronic supplement). To remove scale-dependent effects on K that prohibit meaningful comparison of website and earthquake data, we normalize CES daily website traffic to earthquake daily means for 3 months (DrQuigs) and 9 months (GeoNet) prior to the Darfield earthquake and recalculate Omori-law fits using MLE (Fig. 3a–c). We calculate percentage residuals by comparing empirical daily traffic with predicted estimates from Omori law (Fig. 3d–f). The dates of DrQuigs major science communication activities (public talks, print media, and television) were obtained from *Stuff* (see Data and Resources) and plotted as stars in Figure 3a,b.

To explore the relationship between earthquake M_L, PHA in central Christchurch, and GeoNet earthquake-normalized website traffic rate change (K parameter in Omori law), we calculate a combined M_L-PHA metric (see Ⓔ electronic supplement) and plot M_L and M_L-PHA against earthquake-normalized GeoNet K (Fig. 4a). To capture GeoNet traffic patterns with higher precision, we identify earthquakes that generated large K responses and associated Omori-law decays and generate a continuous Heaviside step function (Fig. 4b; see Ⓔ electronic supplement) of the form

$$r(t) = \frac{H(t-t_1) \times K_1}{(c_1 + (t-t_1))^{p_1}} + \frac{H(t-t_n) \times K_n}{(c_n + (t-t_n))^{p_n}} + \ldots, \tag{2}$$

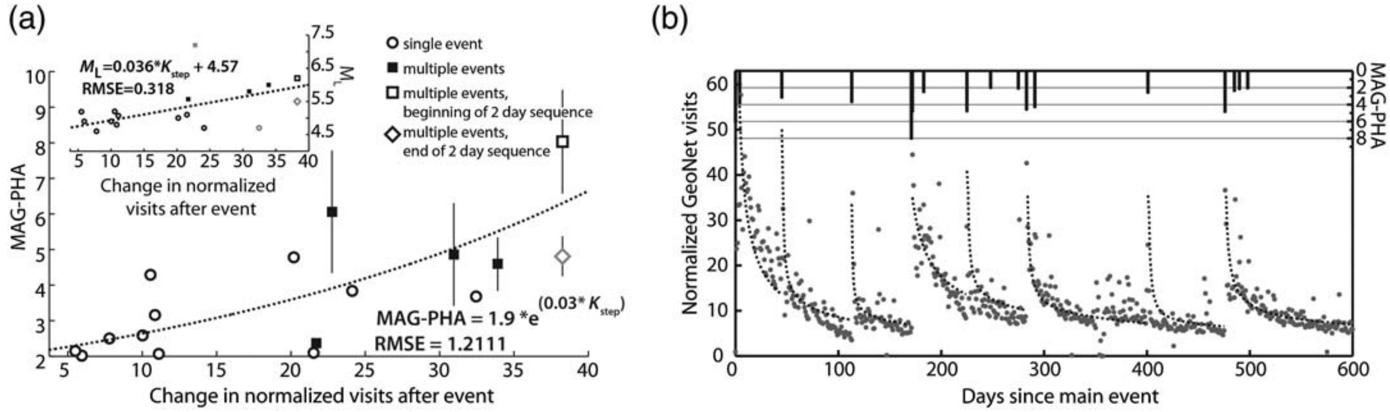
in which $r(t)$ is the normalized daily visits with time, K_n, c_n, and p_n are the modified Omori-law parameters for individual events, t is the total time series, t_n is the start of a new aftershock sequence, and $H(t-t_n)$ is the Heaviside step function, defined as

$$H(x) = \begin{cases} 0, & x < 0 \\ 1, & x \geq 0 \end{cases}. \tag{3}$$

Finally, we obtained website traffic statistics for individual science articles pertaining to a diverse range of natural disasters from *The Conversation* (see Data and Resources) and used MLE to derive exponential, power-law, and Omori-law fits to daily traffic (Fig. 5).

RESULTS

Earthquake frequency–magnitude distributions adhere to Gutenberg–Richter scaling ($b \sim 1$) when considered over the duration of the CES and in subgroups following large ($M_w > 5.9$) aftershocks (Fig. 1a; Shcherbakov *et al.*, 2012). The frequency of earthquakes causing strong shaking in central



▲ **Figure 4.** MAG-PHA values versus GeoNet K. (a; inset) Change in normalized GeoNet website visits (K) versus associated earthquake magnitude (M_L). (b) Heaviside step function results for normalized GeoNet daily website traffic and corresponding MAG-PHA values.

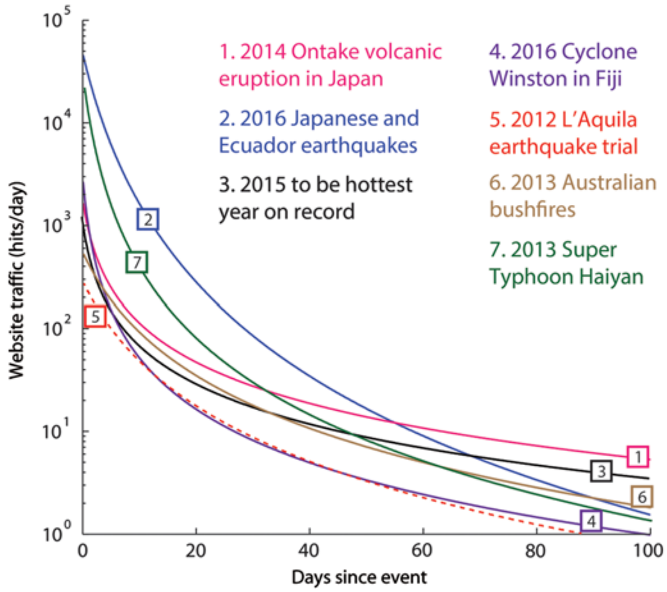
Christchurch is the highest in months with the largest aftershocks (Fig. 1a). Daily earthquake rates following the 2010 Darfield and the 2011 February and 2011 June Christchurch earthquakes adhere to Omori law with K, c, and p parameters consistent with other earthquake sequences (Fig. 1b; Utsu *et al.*, 1995; Holschneider *et al.*, 2012).

Monthly binned unique and total website visits indicate large (10–75×) spikes in website traffic for GeoNet and DrQuigs following the Darfield earthquake (Fig. 2a). Website traffic subsequently decreased with decreasing seismicity and increased in months with increased seismicity (Fig. 2a). Website traffic stabilizes at rates significantly higher than pre-mainshock traffic (GeoNet 5×, 8×; DrQuigs 13×, 14×) over the last 6–12 months of the analytical period. UC Geology traffic was comparably unaffected by the Darfield earthquake (+1.4×) or subsequent large aftershocks (+1.1×). The concomitant traffic surges and heavy right tails of GeoNet, DrQuigs, and *QuakeLive* data suggest scale invariance in website traffic patterns for these sites, despite their diverse contents and provenance. GeoNet and DrQuigs responded rapidly (within hours) to the Darfield earthquake, and subsequent aftershocks and their operators (*GNS Science* and *M. Quigley*, respectively) featured regularly in the media; we attribute these attributes to their large peak response and sustained traffic. *QuakeLive* was established 12 days after the Darfield earthquake but provided near instantaneous earthquake data updates throughout the CES once established, therein providing an alternative and easily accessed source of rapid information. *UC Geology* responded 19 days after the Darfield earthquake but was not regularly updated and did not provide specific earthquake data. The lack of seismic excitation in *UC Geology* traffic is interpreted to reflect the initial delay in providing information and lack of specific seismic data provisions thereafter, thus reducing the Internet visibility of this site throughout the CES. *UC Geology* thus provides a baseline reference with which to compare traffic patterns observed from the other sites.

Ratios of total-to-unique visitors for GeoNet and DrQuigs exhibit antithetical behaviors that we attribute to differences in website content (Fig. 2b). GeoNet monthly total-to-unique visitor ratios increased in months of strong local earthquakes and increased seismicity rate due to repeated site visits to check epicenter locations, hypocentral depths, and magnitudes after strongly felt earthquakes. In contrast, DrQuigs total-to-unique visitor ratios are typically <2.5 and generally trend downward during intervals of increased seismic activity, due to a surge of unique visitors wanting more general information about the earthquake sequence, earthquakes in general, or perhaps the website operator. The absence of specific information on individual earthquakes may have discouraged recurrent visits to DrQuigs. *QuakeLive* exhibited similar traffic patterns to DrQuigs. We suggest that both of these sites may have appealed more to a certain type of visitor (one seeking multiple information sources about earthquakes) rather than visitors repeatedly visiting the same source (GeoNet) for specific earthquake locations, magnitudes, and other source information.

Monthly data transfer on GeoNet and DrQuigs surged dramatically in the month of the Darfield earthquake (Fig. 2c) and after strong local earthquakes and related increases in seismicity rate. Data transfer plateaued at rates ~10–50× greater than the pre-event monthly data transfer volumes by the end of the observation period. Daily data transfer within 24–48 hrs of the triggering event is significantly larger than daily averages over a month; for example, the data transfer on DrQuigs on 4 September 2010 was $>340\times$ the average daily transfer over the prior month, causing the website to crash due to exceedance of bandwidth capacity.

Omori-law parameters K and c for daily website traffic exceed earthquake K and c by orders of magnitude due to larger volumes of website visits and longer delays between the onset of traffic decay and aftershocks, respectively (see Ⓔ electronic supplement). Website p-values vary primarily between 0.84 and 1.3, consistent with global compilations of empirical p-values for earthquakes (Utsu *et al.*, 1995). Normalized website K-values (Fig. 3a–c) decrease with decreasing earthquake K; DrQuigs K estimates are very similar to earthquake K, and all website p-values are less than earthquake p. The increase



▲ **Figure 5.** Examples of science article reads on *The Conversation* (see Data and Resources) science website for diverse natural disasters, showing near instantaneous spikes followed by Omori-law-type decay. Associated Omori-law and power-law fit parameters for individual items are presented in the Ⓔ electronic supplement to this article. The color version of this figure is available only in the electronic edition.

in Δp (earthquake p minus normalized website p) with time indicates that aftershock frequency declined more rapidly than website traffic with increasing sequence duration. Normalized residuals for daily website data are consistent with residuals for earthquakes (Fig. 3d–f), implying Omori law is as precise in predicting normalized website traffic as it is earthquakes. The causal relationship between earthquake frequency and website traffic is evident in the temporally coincident step increases in earthquakes and website visits, which trigger their own Omori-law decay sequences inset into the more general form that fits the 0–100 day data (e.g., Fig. 3a; day 72). An anomalous increase in DrQuigs traffic from day 50–60 (preceded by an additional spike on day 47) after the Darfield earthquake (Fig. 3a) coincides with an antithetic decrease in seismicity and GeoNet traffic. The DrQuigs operator conducted two large public lectures in Christchurch on day 46 (public attendance ~600, with an additional ~600 people turned away) and day 60 (public attendance ~1000) and featured prominently in the media (newspapers, television, and radio) during the lead-up to the second public lecture (e.g., extensive media coverage on days 47, 52, 56, and 60). The anomalous traffic increase is therefore attributed to the concurrent increase in public science communication and media coverage. DrQuigs traffic returned to seismically modulated behavior but at an elevated rate (manifested as a shift to positive residuals for remainder of analytical period) following this traffic surge; this is interpreted to reflect a science communication-induced step change to a traffic pattern generally dominated by seismic activity. Science media-induced traffic perturbations were also identified in DrQuigs traffic after the Christchurch earthquake (Fig. 3b). A traffic surge at GeoNet on 20 March 2011 (Fig. 3b) accompanied an M_L 4.5 earthquake; we attribute the strength of the traffic perturbation to a strongly publicized earthquake prediction by an astrologer (see Data and Resources) that amplified local tensions in the weeks prior to 20 March (Gluckman, 2014).

CES earthquakes with larger M_L and PHA in central Christchurch generated the largest website traffic spikes at GeoNet (Fig. 4a). M_L versus normalized GeoNet K yields a tight linear fit (root mean square error [rmse] ≈ 0.3) for K versus M_L (Fig. 4a, inset). The MAG-PHA function yields a higher rmse but increases tightness of fit for some comparably low M_L events that generated high local PHA and associated large K due to earthquake proximity to central Christchurch.

The MAG-PHA versus K function is used with the Heaviside step function to predict traffic surges and decays for eight distinct steps in normalized GeoNet (Fig. 4b). The goodness of fit between the Omori-law traffic decay (with K predicted from earthquake data; dotted line) and observed traffic suggests that earthquake M_L and PHA in central Christchurch enable prediction of future GeoNet traffic perturbations induced by future CES events. For any random event with MAG-PHA ≥ 2, we predict a separate spike and decay perturbation of website traffic to be nested within the generalized pattern of postmainshock Omori-law decay. The MAG-PHA versus K relationship allows estimation of future GeoNet traffic spikes induced by CES events using seismological input data. Further testing of these functions against other earthquakes would be beneficial but is beyond the scope of this study.

Daily website traffic for individual science articles on volcanic eruptions, earthquakes, heatwaves, cyclones, bushfires, and typhoons exhibits power-law decay similar to that observed following the CES events (Fig. 5; see also Ⓔ electronic supplement).

DISCUSSION AND CONCLUSIONS

Like geological fault systems (Main, 1996), the Internet is a complex fractal network with a self-organizing hierarchical structure. Network connectivity (Barabási and Albert, 1999), links (Albert *et al.*, 1999), webpages (Huberman and Adamic, 1999), and download rates (Sumiyoshi and Suzuki, 2003) can be characterized by power laws consistent with Gutenberg–Richter earthquake frequency–magnitude (M_L) scaling (Gutenberg and Richter, 1956). Individual website traffic (this study) and Internet traffic in general (Abe and Suzuki, 2003) exhibit time-dependent characteristics including burstiness, volatility, and decay that are consistent with Omori law for aftershocks.

The occurrence of a natural disaster such as an earthquake provides a stimulus (the hazard) and a market (a populace seeking science information on the Internet) that may be directed toward science websites that have a prominent predisaster

Internet presence (e.g., an official government-sanctioned source of hazard information) and/or that feature prominently in the media (e.g., print, television, radio, social media) after the disaster onset. The severity and spatiotemporal nature of the hazard, the exposure of a populace to it, and the frequency and reach of science media communications therefore all have the potential to exert strong influence on science website traffic patterns. For recurrent or prolonged natural disasters affecting the same populace, quantitative relationships between website traffic, population and population density, and hazard attributes (e.g., earthquake magnitude and shaking intensity) could be coupled to short-term forecast models of future events (e.g., Gerstenberger *et al.*, 2005) to predict future traffic surges.

Two data aspects we observe herein are particularly encouraging for fostering a transparent, equitable, and autonomous science environment, whereby all scientists who wish to contribute to natural disaster science (e.g., scientific data, damage reporting, future risks, policy) may be able to achieve a public audience. First, similarly scaled traffic patterns on the organization-operated, government-sanctioned GeoNet and the privately operated, independent DrQuigs sites should encourage more scientists to engage with science communications during disasters, irrespective of the size or nature of their host institutions or areas of scientific expertise. Unfortunately, the Internet also provides opportunity for proliferation of pseudoscientific or otherwise speculative information that may incite public panic or confusion. A large public information request that is not promptly and directly answered by the scientific community might influence the public trust and the scientific credibility in the operating organization and turn information seekers to less-reliable websites or other media channels (Bossu *et al.*, 2012). In response, and perhaps proactively, scientists should use the Internet to openly and constructively criticize unjustified information and provide more credible alternatives. It is clear that interest in science websites (e.g., GeoNet) can increase during periods of enhanced media interest in an associated topic (e.g., earthquake prediction) irrespective of the origin or scientific credibility of the stimulus (Fig. 3b).

Second, the prolonged nature of elevated traffic to the sites studied herein provides clear evidence for sustained public interest that outlasts the disaster onset and response phase. Scientists may capitalize on this phenomenon to undertake further public science education initiatives, to provide open access to publicly funded scientific research, to ensure that science maintains a priority during disaster recovery and policy discussions, to provide alternatives to mainstream journalistic media, and to enhance the public appreciation of the value of science. The operators of science websites have an ethical responsibility to ensure the quality, honesty, and integrity of the science they present and to clearly delineate fact from opinion and knowledge brokerage from advocacy (Gluckman, 2014; Science Council of Japan, 2013). Events such as the 2009 L'Aquila earthquake and associated trial of scientists highlight how science communication under extreme duress, through journalistic channels, and by nonexperts might convey unintended messages to the public (Cocco *et al.*, 2015). The Internet provides many opportunities for scientists to carefully improve these types of situations, and we encourage our colleagues to increasingly prioritize this important component of science practice.

DATA AND RESOURCES

Seismologic data used in this study are available from GeoNet (www.geonet.org.nz, last accessed February 2016). All of the raw and processed DrQuigs website traffic data presented in this study are freely available upon request (M. C. Q.). Raw data for websites other than DrQuigs.com may be obtained by contacting Kevin Fenaughty, Chris Crowe, and Anekant Wandres. The data for this article are also obtained from https://theconversation.com/au (last accessed June 2016), www.stuff.co.nz (last accessed June 2016), and http://www.nbr.co.nz/article/scientists-side-campbell-moon-man-quake-prediction-dispute-ck-87208 (last accessed June 2016).

ACKNOWLEDGMENTS

Funding for this work was provided to M. Q. through the 2011 New Zealand Prime Minister's Prize for Science Communication. We thank Kevin Fenaughty for provision and discussion of GeoNet data, Chris Crowe for provision of Canterbury *QuakeLive* data, James McPherson and Nik Devidas for provision of DrQuigs data, and the University of Canterbury and Anekant Wandres for provision of *UC Geology* data. We dedicate this work to the earthquake affected residents of Canterbury, New Zealand.

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Published Online 1 March 2017