Use of Internet Search Data to Monitor Impact of Rotavirus Vaccination in the United States

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Google-based Internet query share (IQS) for rotavirus search terms correlated well with US rotavirus laboratory detections from 2004 to 2010 (r = 0.88; P < .001), capturing the reduction observed during postvaccine years (2008–2010). IQS analysis could become an inexpensive and reliable supplement for monitoring the impact of rotavirus vaccination in the United States.

Over the past 10 years, Internet use has increased dramatically, with the World Bank reporting 231 million Internet users in the United States and 47 million in the United Kingdom as of July 2010 [1]. The majority of users search for information through search engines, with Google attracting 68% of US and 91% of UK search engine market share [2]. Recent studies have shown that Google-based Internet search queries about health correlate strongly with public health surveillance data [3–8]. To our knowledge, Internet search data have not been used to date to monitor the impact of interventions, such as vaccination programs.

The implementation of routine childhood vaccination against rotavirus in 2006 has dramatically reduced severe rotavirus disease in US children [9]. To assess whether search engine data are able to capture the decline in rotavirus disease following vaccine implementation, we compared US Internet query share (IQS) trends for rotavirus-specific terms with national rotavirus laboratory surveillance data from the prevaccine (2004–2006) and postvaccine (2008–2010) years.

METHODS

Rotavirus testing data from sentinel US laboratories (n = 25) and UK laboratories (n = 187) were examined from 1 January 2004 through 30 December 2010. US laboratories are geographically dispersed (7 in the midwest, 9 in the south, 2 in the northeast, and 7 in the west) and processed an average of 13,208 samples (range, 8,979–16,031) annually. The total number of rotavirus tests processed in UK laboratories was unavailable; however, UK laboratories reported an average of 14,291 positive test results (range, 13,020–16,031) annually. The US weekly proportion of positive test results and the UK weekly number of positive test results were reviewed. Google Insights for Search is an Internet application that generates scaled weekly IQS data by dividing all searches performed for selected term(s) by all searches performed in defined regions, and then scaling the weekly IQS data to the highest weekly query share within a defined period [10] (Supplementary Table 1). We hypothesized that caregivers of patients with rotavirus disease would search the Internet for information and that IQS data for the term “rotavirus” and common misspellings identified by IQS (“rota virus,” “rotovirus,” “roto virus,” “rodo virus,” and “rhoda virus”) would correlate well with US and UK rotavirus laboratory detections.

Weekly IQS trends were aggregated for the 6 rotavirus-related search queries from 1 January 2004 through 30 December 2010 and were compared with national laboratory data in the prevaccine (2004–2006) and postvaccine (2008–2010) years; 2007 was a transitional year with limited vaccine uptake. During the early period after vaccine introduction, the National Immunization Survey does not offer data on uptake of new vaccines recommended for use in infancy. Estimates of rotavirus vaccine coverage are available from other data sources. On the basis of data from 4 US Immunization Information System sentinel sites, after introduction of rotavirus vaccine in February 2006, coverage with ≥1 vaccine dose among infants aged 5 months rose quickly to about 50%–60% within the first year (2007) and then steadily thereafter, to 74% by the second quarter of 2009. Pearson correlation coefficients were calculated for IQS data and national laboratory data in the United States and the United
Kingdom. We performed an interrupted time series analysis, using STATA software, release 11 (StataCorp; College Station, TX). The analysis assumed a negative binomial distribution of laboratory reports and controlled for background seasonality and secular trends of IQS by including an indicator variable for month and a sequential variable for time. A 2-tailed significance test (α = .05) was performed, and association coefficients and 95% confidence intervals (CIs) were estimated for a range of ±26-week lead and lag times. We identified the lead or lag time that maximized the association between laboratory detections and IQS data as measured by the incident rate ratio, which indicates the change in laboratory detections for a 1% IQS increase [11]. Ethics approval was not needed for this study.

RESULTS

Rotavirus IQS searches in the United States and United Kingdom correlated strongly with rotavirus laboratory detections (r = 0.88 [P < .001] and r = 0.80 [P < .001], respectively). Rotavirus IQS data peaked within 3 weeks of the peak in laboratory detections of rotavirus in 6 of 7 seasons in the United States (except in 2010, when the IQS peak was 11 weeks before the peak in laboratory detections) and in 6 of 7 seasons in the United Kingdom (except in 2008, when the IQS peak was 4 weeks after the peak in laboratory detections).

In the United States, compared with prevaccine years, the regression model estimated a 39% decrease (95% CI, 28%–48%; P < .001) in weekly IQS data and 24% decrease (95% CI, 4%–40%; P = .023) in weekly laboratory detections in postvaccine years (Figure 1). In postvaccine years in the United States, search volume and laboratory detections had the strongest association (IRR, 1.96 for a 1% increase in IQS; 95% CI, 1.73–2.23; P < .001) when a lead of 1 week was introduced into the IQS data (ie, IQS data from weekk+1 regressed onto rotavirus laboratory data from weekk). In the United Kingdom, compared with prevaccine years, the regression model estimated a 23% increase (95% CI, 1%–50%; P < .042) in weekly IQS data and a 38% increase (95% CI, 16%–65%; P < .001) in weekly laboratory detections in postvaccine years.

DISCUSSION

US and UK IQS data correlated strongly with rotavirus laboratory surveillance data, demonstrating a similar seasonal magnitude and peak week in both countries. Furthermore, US IQS data and US laboratory data showed a postvaccine decline that compares well with the well-documented decline in rotavirus disease following vaccine implementation [12]. However, rotavirus vaccine has not been adopted in the United Kingdom, and both UK IQS data and Health Protection Agency data did not show a decreasing trend, further supporting that the decline in rotavirus IQS and laboratory data in the United States after vaccine introduction are attributable to the effects of the vaccination program. Taken together, these findings demonstrate the utility of Internet search data in monitoring rotavirus disease trends and potentially assessing the impact of vaccination.

Rotavirus disease and testing are largely restricted to children younger than 5 years, so parents/guardians are likely performing rotavirus Internet searches. Increasing familiarity with the term “rotavirus” over time, in part due to vaccine introduction, may explain the higher year-round baseline of Internet searches. Optimal correlation between IQS data and laboratory data occurred when a 1-week lead time was included. This may be due to Internet queries being performed after clinical presentation and laboratory confirmation of disease. In the United Kingdom, increases in IQS data in postvaccine years may be attributable to more available information on the Internet about rotavirus subsequent to vaccine introduction. Rotavirus testing practices in the United Kingdom during prevaccine years have been demonstrated to be a consistently reliable indicator of rotavirus disease burden in the community [13]. However, the increase in laboratory detections in postvaccine years in the United Kingdom is difficult to interpret without corresponding information on total laboratory tests performed and may represent changes in testing or reporting practices.

In addition to healthcare-seeking behavior, some search queries may be responses to media or general information seeking. The most notable disconnect between rotavirus search trends and laboratory data occurred in the United States in spring 2010, when the media reported the presence of porcine circovirus genetic material in rotavirus vaccines [14]. In addition, 2010 was the only year in which the rotavirus IQS data did not peak within 3 weeks of the peak in laboratory detections. The discrepancy was a result of the diminished rotavirus season that made identification of a clear seasonal peak unreliable.

Rotavirus vaccine is known to be most effective at preventing severe disease [15–17], which may result in a trend toward fewer laboratory diagnostic evaluations and more outpatient management. If this shift is occurring, then laboratory surveillance data, which are largely based on testing on inpatients with rotavirus, will increasingly become an unreliable indicator of community rotavirus disease burden. Identifying the determinants of laboratory testing and the motivations for individuals to perform specific searches will be useful in understanding how IQS can serve as an adjunct to traditional rotavirus surveillance.

In conclusion, we show for the first time to our knowledge that Internet search data correlate well with trends in laboratory detections of rotavirus and could be used to assess declines in
rotavirus disease after vaccine implementation. Optimal association between IQS and laboratory data occurred with a 1-week IQS lead time, suggesting that Internet searches may occur soon after laboratory confirmation of disease. IQS may complement traditional surveillance systems by offering information that tracks rotavirus disease trends. However, because the availability, robustness, and quality of IQS data may differ by setting, additional validation of our findings in other countries using rotavirus vaccine is desirable.

**Supplementary Data**

Supplementary materials are available at *Clinical Infectious Diseases* online (http://www.oxfordjournals.org/our_journals/cid/). Supplementary materials consist of data provided by the author that are published to benefit the reader.
The posted materials are not copyedited. The contents of all supplementary data are the sole responsibility of the authors. Questions or messages regarding errors should be addressed to the author.

**Notes**

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**Disclaimer.** The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the CDC.

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**References**