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Title: Amplification of perceived risk among users of a national travel health website during the 2013-2016 West African Ebola Virus outbreak

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Keywords: Infections, Epidemiology, Surveillance, Prevention, Health services

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Abstract: Timely outbreak information was paramount to public health bodies issuing travel advisories during the 2013-2016 West Africa Ebola virus (EBV) outbreak.

This paper explores the potential for a syndromic system/Shewhart control chart based on the online interaction with a national travel health website in comparison to searches on the Google UK search engine. The study showed an amplification of perceived risk among users of a national travel health website months before the World Health Organization declared the outbreak a Public Health Emergency of International Concern (PHEIC) and the initial surge in public interest on Google UK in August 2014.

London, 7 November 2017

American Journal of Infection Control

Dear Prof. Elaine L. Larson,

We are delighted by the positive outcome of the review. Please find our responses to the editorial requirements and reviewer comments below.

On behalf of the author team and with many regards,

Jakob Petersen

### **RESPONSE TO EDITORIAL REQUIREMENTS AND REVIEWER COMMENTS**

Ms. Ref. No.: AJIC-D-17-00642

Title: Amplification of perceived risk among users of a national travel health website during the 2013-2016 West African Ebola Virus outbreak

#### **Editorial requirement**

Reviewers have now commented on your paper, and have suggested its publication in AJIC, pending satisfactory completion of revisions. We receive many more manuscripts than we can possibly consider so we ask authors to be as concise as possible. Therefore, would you kindly try to revise this as a Brief Report of a maximum of 1000 words, a 2-3 sentence unstructured abstract, and a maximum of two tables/figures? Many thanks for your consideration.

#### ***Response***

*We have revised the manuscript in accordance with the author guidelines for Brief Reports and feel that the study findings are presented more clearly as a result.*

#### **Reviewer comment 1**

A very good paper on the use of internet queries to detect subtle changes in demand for health information as a proxy for an impending outbreak.

#### ***Response***

*Thank you.*

#### **Reviewer comment 2**

Literature is needed on risk perception and risk amplification. One or two references from risk perception and risk amplification literature may clarify the context of its use in the article and justify the conclusion.

#### ***Response***

*We have rewritten the first paragraph of the discussion explaining the underlying risk amplification mechanism. It now reads:*

*“Online information seeking activity has been shown to wax and wane as new information on threats becomes available and satisfy gaps in knowledge. The mechanism behind the initial bursts of information seeking has been termed the social amplification of risk (SAR) (Reintjes et al. 2016). Several studies have explored the SAR mechanism for early detection of disease outbreaks using online information sources including search engines....”.*

### **Reviewer comment 3**

More clarity on Sentinel surveillance versus syndromic surveillance:

CDC ... in practice, certain syndromic surveillance systems collect surrogate data ... Alternative data sources have potential problems ... the optimal system might be one that integrates data from multiple sources (<https://www.cdc.gov/mmwr/preview/mmwrhtml/su5301a3.htm> )

WHO ... a sentinel surveillance system is used when high-quality data are needed about a particular disease that cannot be obtained through a passive system.

[http://www.who.int/immunization/monitoring\\_surveillance/burden/vpd/surveillance\\_type/sentinel/en/](http://www.who.int/immunization/monitoring_surveillance/burden/vpd/surveillance_type/sentinel/en/)

It appears the paper is more in the field of syndromic than sentinel. There may be an alternative explanation from the researchers though, on the preference for sentinel. Sentinel means to be on the lookout to prevent a surprise.

### **Response**

*We agree with the reviewer that the term syndromic is more appropriate here. The use of infodemiological data for syndromic surveillance is acknowledged in the seminal paper by Eysenbach (2011) cited in the paper.*

### **Reviewer comment 4**

The comparison between Google UK and NaTHNaC website may have also indicated that people turn more to professional websites than a general one when in search of health information. If the authors confirm this, it adds another finding to the study.

### **Response**

*This is a very interesting point. We are aware that the visits to the national website show weekday highs and weekend lows, which suggest that it is mainly used by professionals, but unfortunately we do not know the background of users directly.*

### **Reviewer comment 5**

Line 28: "The aim of this paper is to examine the potential value of a sentinel surveillance system in predicting periods of high demand on travel health services based on the traffic to a national travel health website."

I found this a bit difficult to understand. Is this statement the same as ... "The aim of this paper is the potential value of demand on travel health services, the ebb and flow in traffic at a national travel health website, as a sentinel surveillance system."

**Response**

*We have now revised the aim in response to this and reviewer comment 7, so that it now reads:*

*"The aim of this paper is to explore the potential value of a syndromic surveillance system for early identification of incidents, allowing timely preparation of public and travel health messages to prevent under capacity when there is a sudden surge in demand".*

**Reviewer comment 6**

Line 96: ZIKV (16, 19, 25) ... Is this ZIKA (16, 19, 25)

**Response**

*That is correct; now changed to "Zika virus". Thank you.*

**Reviewer comment 7**

Line 145 to 147:

"Such tools may facilitate early identification of incidents and allowing the timely preparation of appropriate public and travel health messages at a time when routine capability of services could be exceeded."

If the authors are inclined to rephrase this, maybe as "Such tools may facilitate early identification of incidents, allowing the timely preparation of appropriate public and travel health messages to prevent under capacity when there is a sudden surge in demand"

I think the word "prevention" is critical, this is a suggestion.

**Response**

*We agree with the reviewer that this would be more precise and have now rephrased accordingly.*

**Title**

Amplification of Perceived Risk among Users of a National Travel Health Website during the 2013-2016 West African Ebola Virus Outbreak

**Authors** (\* corresponding)

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**Title**

Amplification of Perceived Risk among Users of a National Travel Health Website during the 2013-2016 West African Ebola Virus Outbreak

**Abstract**

Timely outbreak information was paramount to public health bodies issuing travel advisories during the 2013-2016 West Africa Ebola virus (EBV) outbreak.

This paper explores the potential for a syndromic system/Shewhart control chart based on the online interaction with a national travel health website in comparison to searches on the Google UK search engine.

The study showed an amplification of perceived risk among users of a national travel health website months before the World Health Organization declared the outbreak a Public Health Emergency of International Concern (PHEIC) and the initial surge in public interest on Google UK in August 2014.

**Keywords**

Infections, Epidemiology, Surveillance, Prevention, Health services

**Highlights**

- Timely information was key to the travel health sector during the EBV outbreak
- Data on information seeking behaviours carry potential for surveillance
- Traffic to a travel health website showed early/sustained interest in the outbreak
- This suggests a potential for a syndromic surveillance system

## 1 Introduction

2 The 2013-2016 West African Ebola virus (EBV) disease outbreak was unprecedented in  
3 terms of the sheer numbers of cases and deaths, the countries affected, the spread between  
4 neighbouring countries and further afield through air traffic, the time scale to contain the  
5 disease and the intensity of human-human transmission in urban environments where only  
6 smaller and more confined outbreaks in rural environments had been observed previously (1).

7 Authoritative, accurate, and timely information about the spread of EBV was key to the work  
8 of public health bodies issuing travel advisories during the outbreak. This was important, to  
9 reduce international spread, avoid harm in travellers, to provide optimal support for travel  
10 health services, and to disseminate appropriate public health messages while media attention  
11 was high (2).

12 Data on online behaviours carry rich potentials for surveillance in the field of infodemiology,  
13 i.e. the science of distribution and determinants of online information with the aim of  
14 informing public health and public policy (3–6).

15 The aim of this paper is to explore the potential value of a syndromic surveillance system for  
16 early identification of incidents, allowing timely preparation of public and travel health  
17 messages to prevent under capacity when there is a sudden surge in demand.

## 18 Methods

19 The National Travel Health Network and Centre (NaTHNaC) is a government body  
20 supporting travel health services in England, Wales, and Northern Ireland. The main  
21 information channel is its website, [TravelHealthPro.org.uk](http://TravelHealthPro.org.uk) (7).

22 In total, NaTHNaC issued 28 EBV-related travel advisories between 24 March 2014 and 9  
23 January 2015.

24 Weekly counts of unique pageviews ('views' from here on) of EBV-related pages versus all  
25 pages were extracted from Google Analytics March 2013 through December 2014. The  
26 relative search volumes for "Ebola" were obtained from Google Trends UK

27 (<https://www.google.co.uk/trends>; country: UK) as a measure of interest from the public.

28 A Shewhart control chart was created for the proportion of EBV-related views relative to  
29 total views (8). The same time period in the previous year was used as a baseline (mean +/- 3  
30 standard deviations). Both numerators and denominators were logarithmically transformed.

## 31 Results

32 The time trend of EBV-related searches showed an earlier interest on the professional website  
33 compared to Google UK (Figure 1). The Shewhart chart showed all weeks from 30 March to  
34 31 December 2014 as "out-of-control" relative to the baseline (Figure 2).

35

36 **Figure 1** Ebola virus-related searches on a professional travel health website,  
37 [www.TravelHealthPro.uk](http://www.TravelHealthPro.uk), and searches on Google UK, 23 March to 31 December 2014.  
38 Vertical line: week of WHO PHEIC on 8 August 2014.

39

40 **Figure 2** Shewhart control chart of weekly Ebola-related page views relative to total views  
41 with end of March to end of December 2013 as baseline. Out-of-control data points were  
42 defined as being three standard deviations above the baseline mean. Vertical line: week of  
43 WHO PHEIC on 8 August 2014.



## 44 Discussion

45 Online information seeking activity has been shown to wax and wane as new information on  
46 threats becomes available and satisfy gaps in knowledge. The mechanism behind the initial  
47 bursts of information seeking has been termed the social amplification of risk (SAR) (2).  
48 Several studies have explored the SAR mechanism for early detection of disease outbreaks  
49 using online information sources including search engines (9–13), social media networks  
50 such as Twitter (10,11,14,15), the online encyclopaedia, Wikipedia (16), media newsrooms  
51 and news aggregators (2,9,17,18), professional networks such as Program for Monitoring  
52 Emerging Diseases (ProMED) (19), and traffic to professional travel health websites (20).  
53 Particular diseases of interest have been swine / seasonal flu (2,17,18), Ebola virus disease  
54 (9,10,13,15,19), dengue (12), and most recently, Zika virus (11,14,20).

55 The time trend of EBV-related searches on Google UK was characterised by three distinct  
56 spikes (Figure 1). The first spike in late July/early August 2014 coincided with the WHO  
57 PHEIC. The second and largest spike coincided with news on 30 September 2014 of the first  
58 US EBV case in a Liberian resident, who travelled to Texas and infected two healthcare  
59 workers before being diagnosed (1). The third spike at the end of December 2014 coincided  
60 with the EBV diagnosis of a British aid worker on 29 December 2014. In comparison, the  
61 activity on the professional website also showed an early interest at the end of March and in  
62 the lead up to the PHEIC four months later (Figure 1). Compared to the baseline of the  
63 Shewhart chart, this represented a clear and significant change. This study thus demonstrates  
64 a potential for early detection of, not the outbreak itself, but the interest among users of a  
65 national travel health website.

66 A syndromic surveillance system as outlined in this study could have benefits in terms of  
67 alerting public health organisations about outbreaks early. As with any surveillance system it

68 would by design have to qualify on a number of auditable criteria such as acceptability, cost-  
69 effectiveness, data quality, flexibility, positive predictive value, representativeness, security,  
70 sensitivity, simplicity, stability, standards use, and timeliness (21,22). The crux of the system  
71 would be its predictive value and specificity, which can easily be evaluated against the timing  
72 of reports from WHO and other leading public health agencies as well as surges in interest in  
73 social media and on internet search engines as provisionally demonstrated in this study.  
74 Another clear strength of such a system would be that the data are naturally occurring and the  
75 costs of setting and running it would be minimal. There are known limitations to systems  
76 based on online activity, e.g. not all searches are performed by humans with genuine  
77 concerns about diseases and it has not been possible to rule out whether some searches could  
78 have been carried out by robots designed to boost traffic to other websites for commercial  
79 gains (23). The fact that the NaTHNaC website, TravelHealthPro.org.uk, is specialised and  
80 has a relatively small following (7), however, make this less likely to be an issue.

## 81 **Conclusions**

82 The study showed an amplification of perceived risk among users of a national travel health  
83 website months before the PHEIC and the initial surge in public interest on Google UK in  
84 August. This suggests a potential for tools predicting periods of high demand on travel health  
85 services by detecting changes in online information seeking behaviours. Such tools may  
86 facilitate early identification of incidents, allowing the timely preparation of appropriate  
87 public and travel health messages to prevent under capacity when there is a sudden surge in  
88 demand.

89

## 90 **Author contributions**

91 JP, HS, and DP were closely involved with the design, conduct, analysis, presentation, and  
 92 interpretation of the study findings.

### 93 **Sources of funding**

94 This research did not receive any specific grant from funding agencies in the public,  
 95 commercial, or not-for-profit sectors.

### 96 **Competing interests**

97 None of the authors have any competing interests in the manuscript.

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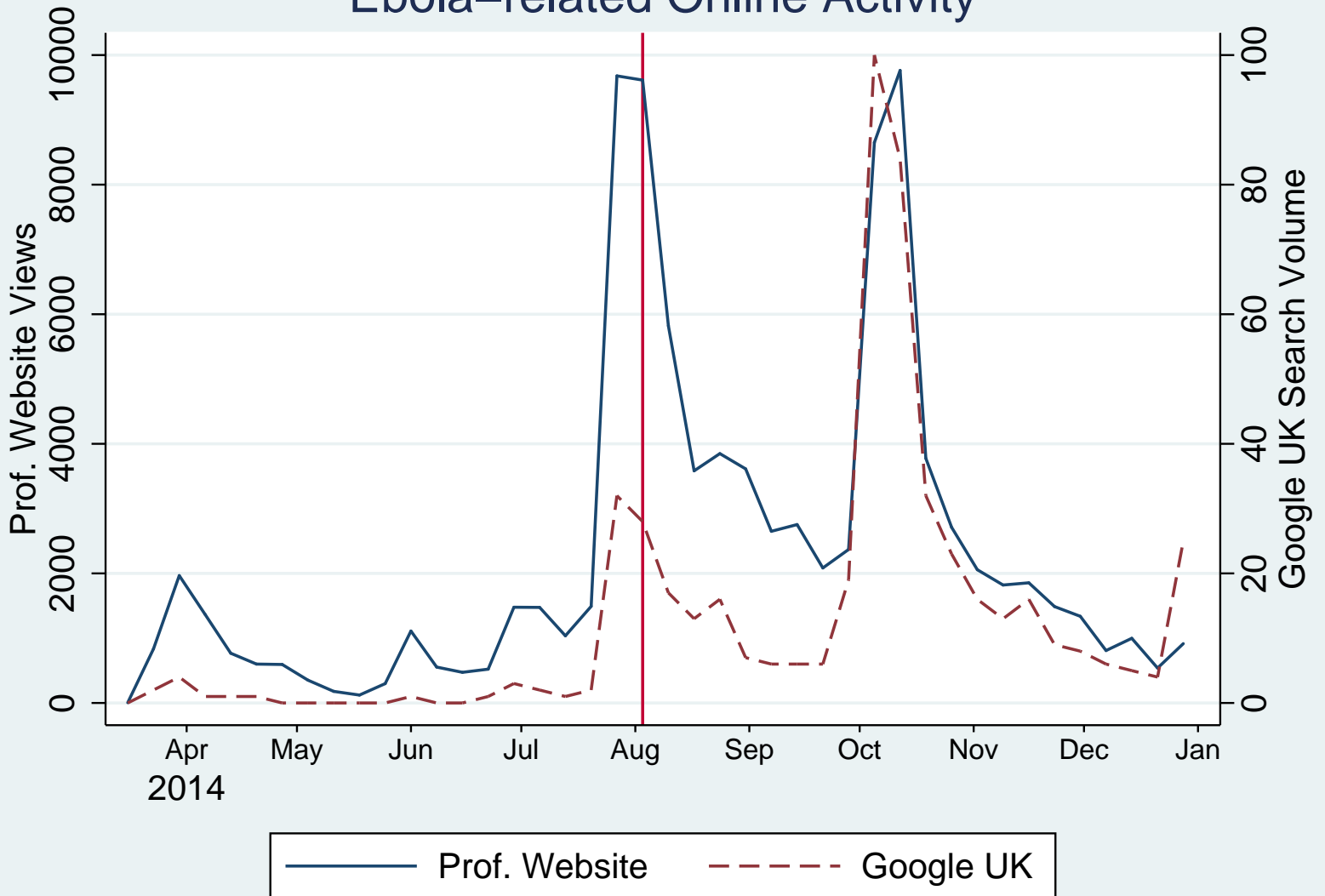
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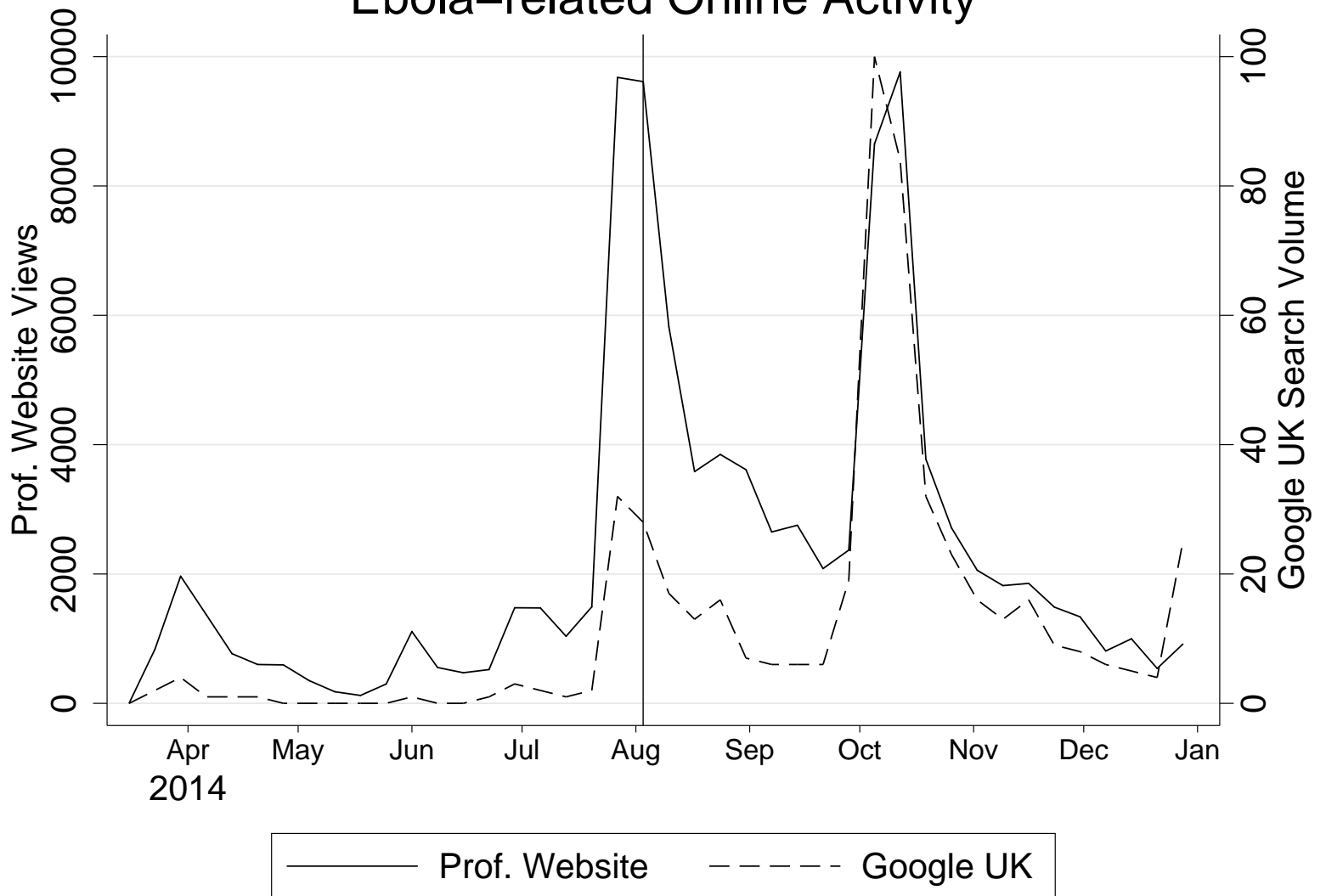
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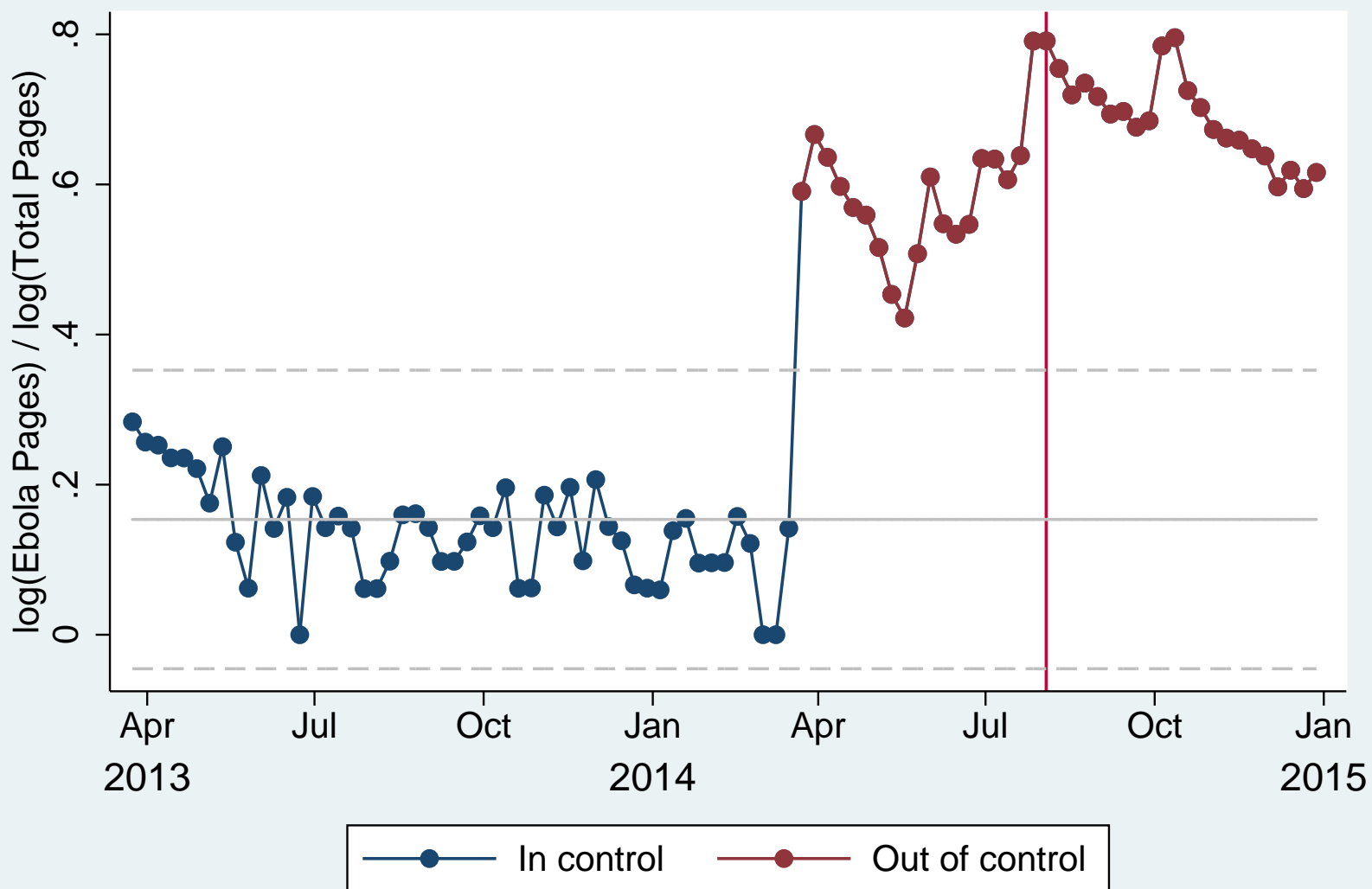
### Ebola-related Online Activity



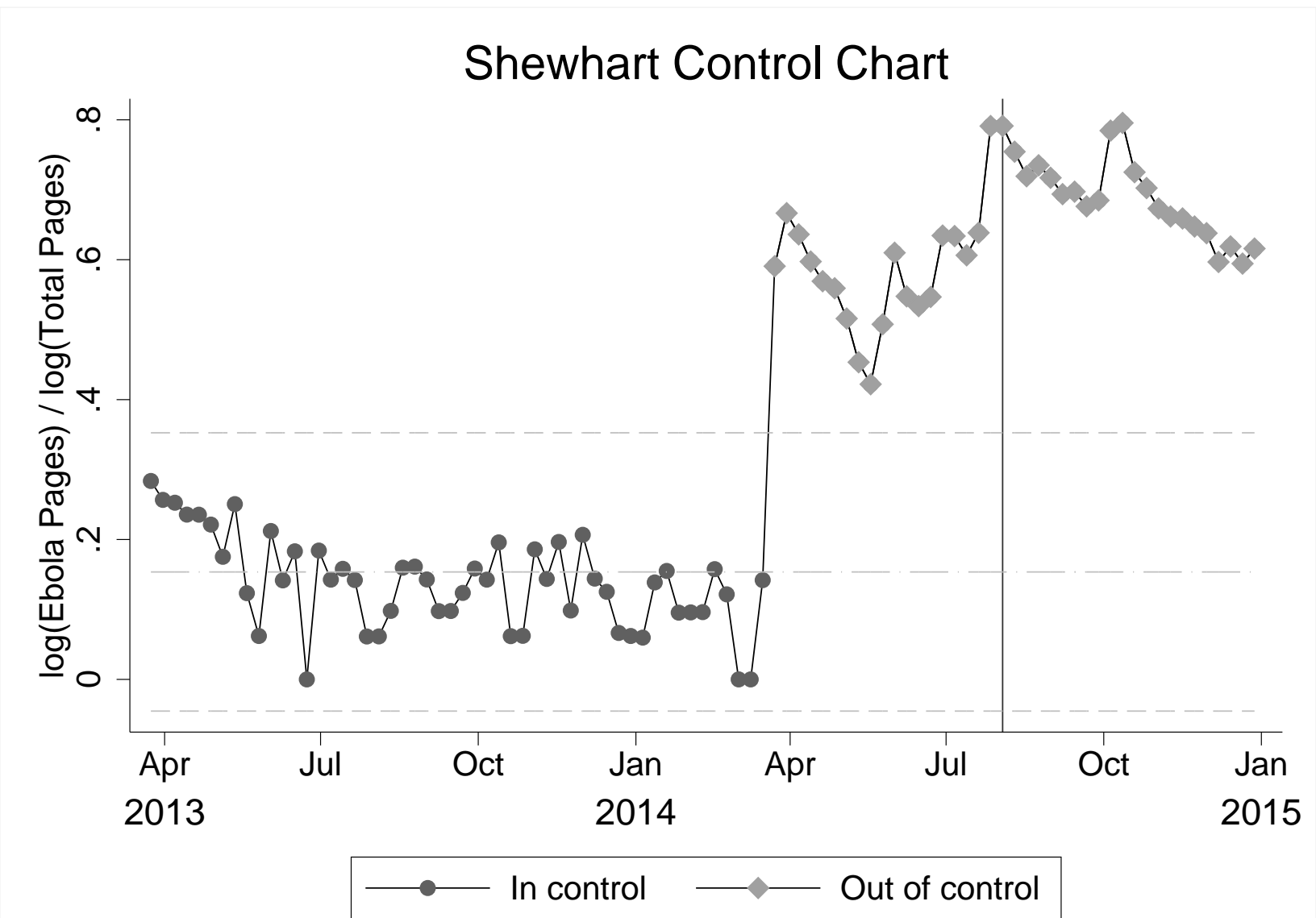
### Ebola-related Online Activity



## Shewhart Control Chart







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