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Sensor recorded changes in rates of hand washing with soap in response to the media reports of the H1N1 pandemic in Britain

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ABSTRACT

Objectives: To examine how the frequency of information regarding a real disease threat influences hand washing with soap.

Design and setting: The authors installed wireless devices in highway service station lavatories in England to record the proportion of individuals washing hands with soap from May 2009 to January 2010.

Participants: Participants were users of men's and women's toilets. Combined there was an average of 6800 participant entrances into the lavatories daily.

Primary outcome measure: The primary outcome measure is the proportion of soap usage to the number of entries into the lavatories.

Results: Hand-washing rates were positively related to both H1NI coverage in blogs and the news; however, these relationships were stronger for men than for women.

Conclusions: Hand washing with soap increases proportionally to the frequency of media key words related to H1N1. Women's hand washing was more strongly associated with incidence of media keywords than men's.

ARTICLE SUMMARY

Article focus

- How does hand washing change as a function of media messages regarding the severity of a contagious disease?
- Do men and women wash hands to different degrees as a function of media regarding contagious disease?
- Do conventional media sources or weblogs better track hand-washing behaviour?

Key messages

- Hand washing with soap increased as a function of the frequency of media about H1N1.
- For women, there was a stronger relationship between media and hand washing.
- Blogs more closely tracked hand washing as opposed to conventional media sources.

Strengths and limitations of this study

- The study used a sensor system rather than self-report or observation.
- The study could have benefited from recording hand washing before the media regarding H1N1 began.
- Some gaps in data collection occurred in one set of toilets in the fall.

Do people modify their behaviour during an epidemic? Changes in hygiene or social contact patterns can influence the dynamics and outcome of an epidemic, yet at present relatively little is known about how people react to this kind of infection threat outside of self-report. The influenza A (H1N1) pandemic that reached the UK in April 2009 provided social scientists and epidemiologists with a valuable opportunity to study the effect of a pandemic on health-related behaviours in real time.[1 2] Here, we add to this literature, showing for the first time that actual rates of a recommended precautionary behaviour, hand washing with soap, correlated with media focus on the pandemic.

HAND WASHING WITH SOAP AND RESPIRATORY INFECTION

Many lines of evidence point to the efficacy of hand washing for preventing contagion especially during outbreaks of respiratory infection. Hands are known to be disease vectors carrying respiratory pathogens shed from the mouth or nose to the nasal mucosa, conjunctiva[3] or mouth[4] of new hosts, and microbiological studies have identified respiratory pathogens on hands.[5–8] It is well known that viruses and bacteria can be cleansed from hands by washing with soap[9–14] or other cleansers. Hand washing is also known to reduce respiratory infections

in hospital settings[15–18] but has been shown to be effective in a variety of other settings as well.[19] More specific to the topic of this paper, washing with soap has been shown to significantly reduce influenza A on human hands.[20]

H1N1 OUTBREAK, MEDIA, ATTITUDES AND HEALTH BEHAVIOURS

Mass media focused a great deal on influenza A (H1N1) during the months following the outbreak with variable rates of news coverage. All major news outlets reported the potential impact of the pandemic with just over 10% of articles conveying an alarmist tone.[21] Precautionary behaviours such as vaccination and hand washing with soap as well as behaviours to limit contagion when coughing and sneezing ('catch it, bin it, kill it') were also a focus of media reports and government publications. In the end, the epidemic was less severe than feared. In the UK, case death is estimated to have been 0.026%.[22] The 1918 epidemic, by comparison, had a case death ratio of 2%–3%. Nevertheless, transmissibility of the virus was higher than that of normal seasonal influenza,[1] and 784 000 cases are estimated to have occurred in England alone.

Although media attention related to H1N1 was very high, researchers surveying the public generally found that levels of anxiety and concern were low. Goodwin *et al*[23] found that only 5% of Europeans reported being 'very concerned' about becoming a victim of H1N1 as opposed to 42% of Malaysians. Rubin *et al*[24] also found that levels of public concern were relatively low with only 2% of UK participants reporting high levels of anxiety due to the pandemic. A longitudinal study conducted by Rubin *et al*[2] found that the proportion of people who reported worrying about the possibility of catching swine flu had two peaks of only 19.3% and 32.9%. They also found that higher levels of worry did not coincide with any particular media foci as measured through specific keywords (eg, vaccinations, children) but with more media coverage generally.

A number of studies have found that people report that they are more likely to wash hands as a consequence of the H1N1 pandemic. Indeed, two studies[1 24] found that washing with soap was the most frequently mentioned response to the infection threat. A web-based study conducted in the early stages of the outbreak (27 April to 5 May) found that almost 80% of participants reported an intention to 'wash hands more often, given the current state of the epidemic'.[1] A telephone-based study conducted in the UK between the 8 and 12 May 2010 found 28% of people reported washing hands with soap and water more often over the past 4 days due to swine flu.[24] In early May, the UK government released a leaflet about H1N1 and strategies to avoid contagion. Comparing respondent who had and had not read the leaflet, Rubin *et al*[23] found no significant difference in intention to engage in hand washing or other recommended behaviours. A study conducted jointly in Europe and Malaysia found that 1/3 of participants spontaneously mentioned hand washing as a way to avoid the disease.[24] However, in focus groups conducted in the fall of 2009, only 8 of 73 participants (which included purposive sampling of older adults and 'at risk' individuals, eg, pregnant women) believed that they had increased their hand-washing behaviour since the pandemic began.[25]

Taken together, previous research indicates a low level of anxiety regarding swine flu and a minority of individuals reporting actually increasing their hand-washing behaviour. However, reported behaviour has been shown in many instances to be a poor measure for actual behaviour, particularly for sensitive subjects like hygiene and hand washing.[26 27] Hand washing with soap has been a key behaviour in efforts to reduce child mortality due to diarrhoea. Researchers in this area have found that self-report is often a poor predictor of actual hand-washing rates.[26–29] Approaches using unobtrusive electronic monitoring circumvent many of these problems and offer a more ecologically valid and reliable method for measuring behaviour. To this end, we installed a set of electronic sensors in a UK service station that allow measurement of the proportion of toilet users that also use soap.[30] Given the unreliability of self-report, the high rates of media coverage, and the low levels of worry and concern about the H1N1 pandemic, it remains unclear if people did indeed change their behaviour. The current study examines the question of whether or not public hand washing did in fact change in reaction to the H1N1 outbreak and whether or not the intensity of media coverage moderated this effect.

METHOD

The toilets of a motorway service station in England were the naturalistic setting in which hand washing with soap was monitored via sensors. Wireless devices were installed in the service station lavatories to record the number of entries and the number of times soap was used in the men's and women's toilets. Between 21 May 2009 and 4 January 2010, the ratio of entries to soap usage by men and women daily was recorded. Daily, the mean number of male toilet users was 3694 (579) and the mean number of female users was 3098 (1132). Average number of hand-washing episodes per day for men's toilet users was 1292 (479) and for women's toilet users was 2075 (946). This study spanned a period including the winter holidays and bank holidays (days in which the majority of the population has the day off work or school). Thus, during this time, service station users included families, tour groups (including groups of children, adults and elderly people) as well as regular business travellers—a wide subsample of the English travelling public. The data for this study spans over 1 million lavatory uses. The door sensors occasionally malfunctioned such that we were not able to calculate number of entrances/exits. This malfunction and the waiting period for the replacement parts account for the major gaps in data collection.

We used Meltwater media monitoring (http://www.meltwater.com/products/meltwater-news/) to calculate how many articles contained a variety of keywords during those months. Meltwater is a service that tracks keywords and phrases from 115 000 sources globally each day. We acquired daily counts of full articles originating in the UK with the words 'H1N1' or 'Swine Flu' in the title, as well as monitoring blog posts (web-based logs and journals usually written by ordinary citizens, not in the media) originating in England for these key words. Thus, the counts used in the data analysis represent number of articles and blog posts, respectively. The sum total of blogs recorded is 2115 with a daily mean of 9.24 (5.08). The sum total of news articles recorded is 70 078 with a daily mean of 306.2 (20.85). We surmised that while news represented the initial presentation of the information, blogs might represent more naturalistic information dispersal because they spread information from person to person in a way that better approximates ordinary non-web-based communication. The objective was to determine whether people responded to perceived threat of infection via various media announcements by increasing their rate of hand washing with soap.

The study obtained ethical approval from the Ethics Committee at the London School of Hygiene and Tropical Medicine, with approval code A89/5258. The researchers also received local approval for the study from the management of the motorway service station. According to ethical guidelines, a sign saying that 'the frequency of use of facilities in this toilet is being recorded for research purposes' was put up in the toilets, along with the contact details of the researcher, in case anyone had any questions or concerns. As the behavioural data were not linkable to any particular information, including personal information, individual consent was not required.

RESULTS

Hand-washing rates (soap count/door count) for men's and women's lavatories were calculated separately to form a single daily index of hand washing. Missing data (due to sensor malfunction) from the men's or women's toilets were replaced with data from the other functioning toilet. At no point did both toilets malfunction simultaneously. These hand-washing indices were standardised (z-scored) along with the daily counts for blog and news reports of swine flu.

To smooth each of these six standardised variables, a 3-week (21-day) moving average (eg, a datum for 21 July would represent the average of all days between 1 and 21 July, a datum for 22 July would represent the average of all days between 2 and 22 July, etc) was used. Using a multiple of 7 days helped to remove any day-of-week effects. Sex differences in hand washing were calculated using a difference score (women's rates minus men's rates). We then calculated both zero-order correlations among these moving averages and partial correlations, controlling for time (ie, daily effects) over the course of the study (table 1).

Controlling for time was important because time can be confounded with either the independent or dependent variables or both. For example, imagine variables x and y are collected five times, where x has values 1, 2, 3, 5 and 5 and y has values 1, 1, 3, 4 and 5 over time. Both x and y are correlated with time 0.97 ($p<0.01$). Ignoring time, the zero-order x–y correlation is 0.95 ($p=0.01$); however, controlling for time, the partial x–y correlation is only 0.14 ($p=0.86$). In other words, the x–y relationship is largely spurious because it is confounded with time (or one or more other variables also associated with time). For this reason, the partial correlations we report are likely more robust than the zero-order correlations.

On average, hand washing increased during the period of time in which H1N1 featured prominently in blogs and in the news (table 1; figure 1). Although both men's and women's hand washing were significantly related to H1N1 media coverage (figures 2 and 3, respectively), this effect was stronger for women than for men on average, as shown by the significant positive correlations between the sex difference score for the frequency of hand washing and frequencies of blog and news reports (table 1; figure 4). We also examined this sex difference by comparing the strength of the

Table 1 Zero-order correlations (above the diagonal) and partial correlations controlling for day (below the diagonal) for 21-day moving averages of hand-washing behaviour and H1N1 media coverage (21 May 2009 to 4 January 2010)

	Wash	Men	Women	Sex difference	Blogs	News
1. Day	−0.47	−0.14	−0.60	−0.66	−0.68	−0.57
2. Wash	–	0.75	0.89	0.63	0.61	0.59
3. Men	0.78	–	0.56	0.09_{ns}	0.35	0.40
4. Women	0.87	0.60	–	0.87	0.74	0.68
5. Sex difference	0.49	-0.01_{ns}	0.79	–	0.58	0.51
6. Blogs	0.45	0.35	0.56	0.23	–	0.92
7. News	0.44	0.39	0.51	0.22	0.89	–

Day, day of study; Wash, proportion of hand washing averaged across men and women; Men, proportion of hand-washing men; Women, proportion of hand-washing women; Sex difference, women − men. *ns*, 209 except for correlations involving female washing, *ns*=154; by this, we mean that all correlations in this matrix are based on 209 days of data except for the rows and column labelled 'Women', which are based on 154 days of data. All correlations and partial correlations are significantly different from zero at the $p<0.05$ level (two tailed) except *ns*. Correlations based on both men and women's data are for days on which we have both sets of data.

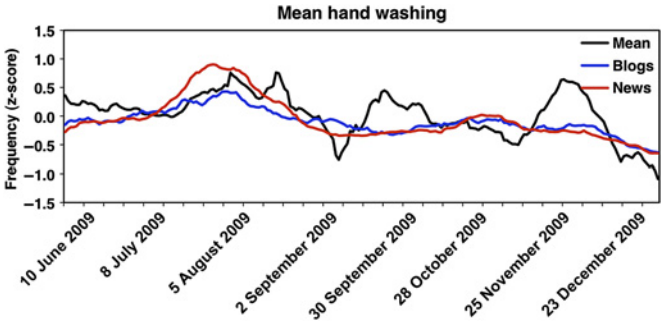

Figure 1 Frequencies of hand washing (mean of men's and women's rates or only men's in the gap) and two sources of swine flu media exposure (blogs and news; all variables represent *z*-scored 21-day moving averages) as a function of time (day), 21 May 2009 to 4 January 2010.

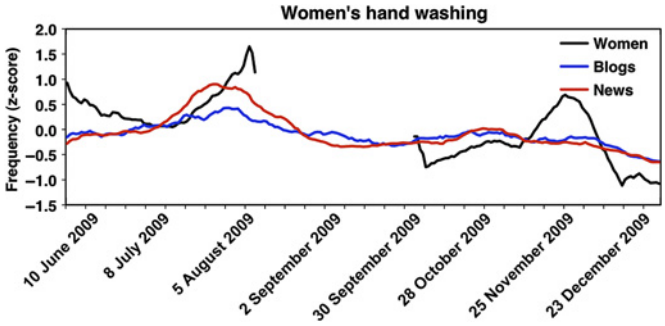

Figure 3 Frequencies of women's hand washing and two sources of swine flu media exposure (blogs and news; all variables represent *z*-scored 21-day moving averages) as a function of time (day), 21 May 2009 to 4 January 2010.

correlations between men and women for days which both had data.[31] On average, women had higher hand washing correlations than men for both blogs (0.74 vs 0.52, t_{151}=4.09, ps<0.01) and news (0.68 vs 0.51, t_{151}=2.92, ps <0.01). Blogs and news did not have a differential relationship with men's hand washing (0.52 vs 51, t_{151}= 0.40, p=0.69); however, women's hand washing was more strongly related to blogs than to news (0.74 vs 0.68, t_{151}=3.02, p<0.01).

DISCUSSION

This study supports the hypotheses that the general public increased rates of hand washing with soap during the H1N1 pandemic. The increase in hand washing was limited in scope to the period of time after which hand washing dropped off steeply to the lowest levels in the 6-month period before finally rising again to a 'baseline' level. There was a significant effect of sex on the correlation between media keywords and hand-washing rates. Additionally, blog keyword rather than news keyword frequency seemed to more closely mirror changes in hand washing for women but there was no difference between these for men.

The chief limitation of this study has to do with the timing of initial data collection. The best comparisons could have been done if hand washing had been monitored before the pandemic. Because we began a month afterward, our inferences about hand washing increasing are all in relation to the period of time several months after the pandemic began, although a previous use of this methodology[30] shows baseline hand washing close to the levels found at the end of this study's monitoring period. In particular, it would have been interesting to compare hand washing before and after the government's information leaflet had been dispensed. In addition, the number of new cases of H1N1 or deaths over time may have had an effect on washing rate, although this information was probably disseminated by media and blogs.

Although Judah *et al*[30] found sex differences in baseline rates of hand washing, we cannot be certain that the relationship between H1N1 keywords and men and women's hand washing is not due to gaps in data collection causing differences in sampling. In addition, there is no way to know if gaps in data collection, though random, overlapped with time periods in which our hypotheses would not have been supported. Other factors could have also been at play. Sex difference may in part be attributable to women bringing their infants and children into the lavatories and using soap on their hands.

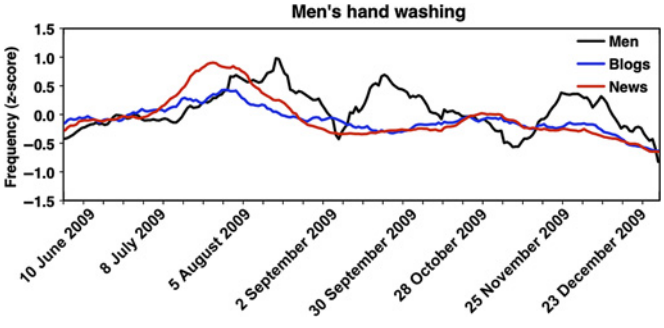

Figure 2 Frequencies of men's hand washing and two sources of swine flu media exposure (blogs and news; all variables represent *z*-scored 21-day moving averages) as a function of time (day), 21 May 2009 to 4 January 2010.

Figure 4 Frequencies of sex differences in hand washing (women's rates minus men's rates) and two sources of swine flu media exposure (blogs and news; all variables represent *z*-scored 21-day moving averages) as a function of time (day), 21 May 2009 to 4 January 2010.

Presuming that disease cues have a greater influence on women's hand washing, there are a number of possible interpretations. Women have a higher baseline rate of hand washing and thus may be more sensitive to messages related to disease-limiting norms especially hand washing.[30] Women also report greater disgust sensitivity which may indicate a greater sensitivity to messages related to disease cues[32] Finally, one study found that women engage in more contagion-limiting behaviours in public toilets, including hand washing, as vulnerability to infectious disease increases[33] thus indicating that the behaviour of hand washing and disease threat may be linked.

The way in which we sampled keywords (counting articles and blog posts that had H1N1 or 'swine flu' in the title) is an inexact means of operationalising media cues because articles with these words in the title do not necessarily represent information about transmission and prevention of contagion but could, for example, be criticisms of vaccine production, government readiness somewhat tangential to communicating disease threat. A more detailed analysis of keywords and tone of article such as Hilton and Hunt[21] could have revealed separate factors influencing the frequency of hand washing.

We did find a connection between our measure of communication of disease threat and hand washing which might not have been predicted from the minority of individuals who reported actually changing their hand-washing behaviour and the low levels of anxiety in the population.[23–25] The link between disease threat and hand washing is, however, still tenuous. Although changes in the prevalence of germ awareness mediated by media may have influenced hand washing, other research[34] did not find that increasing germ awareness led to an increase in hand washing. We cannot be sure if messages relating to disease prevalence or other messages reinforcing norms of hand washing and limiting contagion had a bigger role moderating behaviour change.

The data revealed a differential relationship between blogs and mainstream news on hand washing. For women, blogs had a stronger relationship with hand washing. Nardi *et al*[35] found that the majority of blogs are akin to online diaries and represent an open way for individuals to connect with people they know. Thus, the strong relationship between blogs and hand washing for women is probably not because women were reading the specific blogs we monitored but because blogs mirror the frequency of information that is related through interpersonal networks. Future research may monitor more naturalistic forms of communication, such as through sampling the content of phone and face-to-face communication with volunteers (eg, the EAR[36]).

The data in this study are correlational and thus necessarily cannot show a causal relationship. However, by controlling for time, we can at least be fairly certain that concomitant changes in both media exposure and hand washing are not the result of a spurious correlation with seasonal trends. While we were unable to monitor specific individual responses to disease threat, future research can hopefully address how disease reminder and contagion limiting norms mutually influence hand washing and other health behaviours.

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Competing interests All authors have completed the Unified Competing Interest form at http://www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare that (1) DSF, VC, RA, GJ and MdB have support from Unilever Plc for the submitted work; (2) GDW has no relationships with Unilever that might have an interest in the submitted work in the previous 3 years; (3) their spouses, partners or children have no financial relationships that may be relevant to the submitted work and (4) all authors have no non-financial interests that may be relevant to the submitted work.

Ethics approval Ethics approval was provided by London School of Hygiene and Tropical Medicine.

Contributors VC, RA and GJ conceived the study; VC, RA, DSF and MdB designed this study; RA, GJ and VC designed the data collection system; GJ and DSF collected the data; GDW analysed the data; DSF drafted the manuscript; VC, RA, MdB, GDW and GJ redrafted the manuscript. VC acts as guarantor for the study.

Provenance and peer review Not commissioned; externally peer reviewed.

Data Sharing statement Raw sensor data are available upon request from the first author for the months of June 2009 to January 2010.

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Correction

Fleischman DS, Webster GD, Judah G, *et al*. Sensor recorded changes in rates of handwashing with soap in response to the media reports of the H1N1 pandemic in Britain. *BMJ Open* 2011;1:e000127.

The Results section of the Abstract should read: "Hand-washing rates were positively related to both H1NI coverage in blogs and the news; however, these relationships were stronger for women than for men."

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STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-7
Objectives	3	State specific objectives, including any pre-specified hypotheses	4-7
Methods			
Study design	4	Present key elements of study design early in the paper	6-8
Setting and Participants	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-9
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	8-9
		(*c*) Explain how missing data were addressed	8-9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7-9
		(b) Give reasons for non-participation at each stage	7

		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	
		(b) Indicate number of participants with missing data for each variable of interest	7
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-9
Discussion			
Key results	18	Summarise key results with reference to study objectives	9-11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	9-11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9-11
Generalisability	21	Discuss the generalisability (external validity) of the study results	9-11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.