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Online population control surveys: A new method for investigating foodborne outbreaks

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Abstract

In foodborne outbreak investigations, case-control and cohort studies are used to test hypotheses and identify a source, but these studies are resource-intensive and may have challenges of representativeness, temporality or accessibility. We used online surveys to collect population control data for two foodborne outbreaks and compared the data collected to our cases and existing population exposure data. Online survey population controls were comparable to cases based on age and sex. Exposure data collected through online surveys were more precise than existing control data, represented the disease-specific exposure period and could be easily modified. In one outbreak the online control exposure data differed from established population data. In both outbreaks, the information from the online population control survey supported the hypothesis of the investigation. Our findings demonstrate that online surveys were a rapid and representative way to collect responses from controls during outbreak investigations.

In foodborne outbreak investigations, case-control and cohort studies are considered the gold standard epidemiological methods for hypothesis testing to identify a source. However, the resources required to conduct them are often prohibitive and recruiting appropriate controls is challenging [1, 2].

Over the last decade, there has been a shift to using other methods such as population-based food consumption surveys including the use of binomial calculation and case–case analysis to generate or test a hypothesis [3–7]. These methods have their own challenges. Population survey data may not provide a representative control population, match temporally or include sufficient food product precision and can become outdated. Case–case analysis can only be conducted if comparable cases are accessible and the binomial calculation requires a background exposure value.

Online surveys can increase recruitment of controls in outbreak investigations, but these have typically been used with known exposed population cohorts [1, 8–11]. Online surveys to recruit controls in a non-targeted group of individuals (e.g. community at large) could potentially also increase timeliness and efficacy of recruitment. Our objective is to demonstrate the application, benefits and limitations of online surveys to collect data from community-level controls in real-time to better assess epidemiological data to generate and test hypotheses for foodborne outbreak investigations.

Online surveys for these outbreak investigations were developed using SurveyMonkey [12]. When individuals visited the British Columbia Centre for Disease Control (BCCDC) website (http://www.bccdc.ca), they were asked if they would like to participate in a survey to help solve an outbreak via a pop-up window. Between May and October 2018, this website received an average of 341 visits/day. If visitors agreed to participate, they were asked province of residence and whether they had experienced gastro-intestinal (GI) symptoms. Participants were included if: they were a resident of British Columbia (BC) and they had not experienced GI symptoms during the relevant exposure period (14 days for *Cyclospora* and 7 days for *Salmonella*). They were asked whether they had consumed two to three foods of interest, described using commodity name, their gender, age and city of residence. No further details on the foods of interest were collected. Personal identifiers were not collected.

Data from online surveys were compared to outbreak cases and population control data from Foodbook Canada [13]. Odds ratios (unadjusted) and *P*-values were calculated using Epi Info [14].

Outbreaks of locally acquired *Cyclospora* occur annually in BC during the spring and summer [15]. A source has not been identified in recent years, although previous investigations identified blackberries, cilantro or raspberries as leading hypotheses. The purpose of the online survey conducted during the 2018 *Cyclospora* outbreak was to test the leading hypotheses from previous investigations.

The first survey was posted from 4 May to 31 August 2018, at the onset of the 2018 *Cyclospora* outbreak. The survey initially asked about exposure to cilantro, blackberries and

Table 1. Demographic and exposure comparison between *Cyclospora* outbreak cases and control populations, British Columbia (BC), May–June 2018

	Cases	Controls	Controls
	Cyclospora 2018 BC outbreak cases ($n = 16$), May–June, 2018	Online survey responses from May–June, BC, 2018 ($n = 757$)	Foodbook Canada-BC responses from May and June, 2014–15 ($n = 421$)
Gender	62.5% F	80.1% F	56.6% F
Age	Max: 75 years	Max: 80 years	Max:96 years
	Min: 19 years	Min: 10 years	Min: 1 year
	Median: 43 years	Median: 41 years	Median: 44 years
Exposures %			
Cilantro	40.0%	39.3%	36.2%
Blackberries	37.5%	17.8%	2.2%
Raspberries	33.0%	34.6%	28.8%

raspberries. Preliminary analyses of outbreak case data suggested low exposure to raspberries (18%), but a high exposure to spinach (58%). On 26 June, raspberry was removed and spinach was added to the survey.

A total of 1687 responses were received and 1403 (83.2%) met the inclusion criteria. The online controls were similar to the cases in age, gender ($P = 0.078$) (Table 1) and geographic distribution (data not shown).

For cilantro, raspberries and spinach, the control populations showed similar exposure proportions to each other and to the cases. For blackberries, the control populations showed different exposure proportions, 17.8% in the online survey and 2.2% in Foodbook, for the same time period of May and June and were lower than the cases (37.5%). The difference between the two control groups may be due to different exposure periods (14 days in the online survey *vs.* 7 days in Foodbook) or changes in food preferences over time (Foodbook data were collected in 2014).

Cases had non-significantly higher odds of consuming blackberries than the online controls (OR 2.3, CI 0.76–6.77 $P = 0.1$). This epidemiological information led to the review of blackberry import data and to traceback of implicated blackberries based on case purchase data. While the source of the outbreak was not confirmed to a single supplier or source of blackberries, blackberries were the leading hypothesis.

The second survey was set up during a national outbreak investigation of *Salmonella* Infantis with the majority of cases ($N = 47$) reported in BC. While English cucumbers had been hypothesised as a possible source, other exposures were also frequently reported by cases. This survey objective was to test the leading hypothesis that English cucumbers were the source of illness. This specific exposure was not available in Foodbook population control data for comparison purposes. The online survey was posted from 16 October 2018 to 2 November 2018.

A total of 286 responses were received and 253 (88.5%) responses met the inclusion criteria. The population in this online survey was very similar to that of the *Cyclospora* online survey. Online survey controls were more likely to be female ($P = <0.005$) and had a similar age profile to the *Salmonella* cases (Table 2). The online survey controls were less likely to have English cucumber exposure (40.2%) than cases (60.0%) ($P = 0.007$). Exposure results for English cucumbers directed traceback activities which identified a common supplier and confirmed the hypothesis.

During this investigation, we also conducted a case–case analysis using concurrent *Salmonella* cases infected with other serotypes (excluding Typhi, Paratyphi and Infantis) as controls. Outbreak cases had a similar exposure to cucumber (69.0% compared to 54.8%, $P = 0.1$) as other *Salmonella* cases. While this method allowed for rapid comparison, we were only able to compare cucumber exposure, not English cucumbers, as that is not asked during routine investigations of *Salmonella* cases in BC.

The use of online surveys in both outbreaks was a rapid and useful way to collect control data from a non-targeted population during outbreak investigations to support the epidemiological investigation. This type of online control offers advantages and limitations compared to traditional control recruitment tools and datasets.

Unlike traditional recruitment for controls, online surveys can be prepared quickly with few resources and can lead to a large number of respondents. Accessing existing population control survey data can also be done rapidly. It took most individuals less than a minute to complete the survey and there were regular responses submitted when the surveys were open. The BCCDC website gets a large number of visitors each day and approximately 4% of visitors participated in the online survey. Design of the initial questionnaire took less than 24 h. Once designed, it was revised and posted in less than an hour. Unlike other online control surveys for cohort studies, this method can increase recruitment for controls in the broader community and did not require access to a known list of individuals. Accessing the data could be done by the investigators in real-time.

Like case-control and case–case studies, this tool allows querying the control population about the same exposure period as cases. This was not possible using existing population control survey data where respondents were asked about a single exposure period (e.g. 7 days). Similarly to case–case studies, online data collection on controls occurs simultaneously as cases occur once an outbreak investigation has been launched. We collected online controls during the same period as cases in the *Cyclospora* outbreak because we anticipated this investigation and had predetermined hypotheses. However, for the *Salmonella* investigation, collection of online control data occurred after a hypothesis had been identified. In case-control studies, controls are recruited after cases have occurred; they may suffer from recall bias. Using concurrent online controls limits the impact that changes in food consumption may have, whereas existing population

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Table 2. Demographic and exposure comparison between *Salmonella* Infantis outbreak cases and control populations, British Columbia (BC), June–October 2018

	Cases	Controls	Controls
	S. Infantis BC cases ($n = 47$), 22 June–13 October 2018	Online BC survey responses ($n = 253$), 16 October–2 November 2018	Foodbook Canada-BC responses ($n = 456$), July–October 2014–15
Gender	52.0% F	80.4% F	52.9% F
Age	Max: 89 years	Max: 84 years	Max: 98 years
	Min: 1 year	Min: 12 years	Min: <1 year
	Median: 42 years	Median: 40 years	Median: 41 years
Exposures (%)			
Any cucumber	75.0%	NA	75.2%
English cucumber	60.0%	40.2%	NA

NA, not available.

control survey data can become outdated when surveys are conducted several years before the current investigation.

This method allows for both collection of precise information and flexibility in the exposure data collected. We were able to add and remove exposures of interest in the online survey in real-time. However, we need to ensure that these changes to the exposures of interest are not made too frequently and that when we have appropriate power to look for associations. This tool also allowed us to collect data on a precise exposure (e.g. English cucumber) that was not available through other sources such as established population controls or case–case studies. While we did not provide product descriptions or photos in the online survey, these could be added so that controls can identify the specific food products being asked about.

This method also has potential limitations and biases. In our study, all controls were enrolled when accessing a health agency website. Such internet users are more likely to be older and female and have a higher socio-economic status and education level than the general population [16]. To address these limitations, respondents could be restricted or data could be stratified to create a subset of controls representative of the cases as required. We did not collect personal identifiers and did not restrict the same person from contributing as a control multiple times. This limitation could be minimised by requesting people only to participate once or using technology to block the survey from appearing if a person uses the same IP address. While this could have occurred during our outbreaks, we do not feel it had a significant impact on the composition of our control population as it varied in demographic characteristics and geographical locations, and a substantial number of people participated.

Identification of controls through using this method may not be appropriate when the community at large is not impacted. If cases are clustered geographically, controls could be limited to those communities or local websites could be used. If the outbreak was limited to an event or facility, relying on facility lists of residents or attendees to an event would be most appropriate. In addition, this method can only be used if investigators have access to an electronic survey tool and have control over a website where people will easily access the survey to provide responses.

To date, we have not used this method to test a hypothesis where we identify a specific brand given this is a public tool and there are potential confidentiality risks to disclosing that information if the hypothesis is incorrect. However, this could be overcome by asking about various brands of the same product. This method to recruit controls and obtain control data in a foodborne outbreak has benefited the epidemiological component of outbreak investigations. However, investigations rely on the weight of evidence from epidemiological, food safety and laboratory investigations [17]. In our experience, the use of online controls provided the epidemiological information required to support the other components of the investigation in order to conclude the final source of an outbreak.

All control methods have strengths and limitations and each one may be most practical in different contexts. Controls should be recruited from the same population that cases arose from and should have the same risk of being exposed to the source of interest as cases do. Based on our experience, we will continue to use this method for future outbreak investigations. We will continue to evaluate its usefulness compared to other methods and establish population controls.

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Conflict of interest. None.

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