



Practice of Epidemiology

Web-based Questionnaires: The Future in Epidemiology?

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The traditional epidemiologic modes of data collection, including paper-and-pencil questionnaires and interviews, have several limitations, such as decreasing response rates over the last decades and high costs in large study populations. The use of Web-based questionnaires may be an attractive alternative but is still scarce in epidemiologic research because of major concerns about selective nonresponse and reliability of the data obtained. The authors discuss advantages and disadvantages of Web-based questionnaires and current developments in this area. In addition, they focus on some practical issues and safety concerns involved in the application of Web-based questionnaires in epidemiologic research. They conclude that many problems related to the use of Web-based questionnaires have been solved or will most likely be solved in the near future and that this mode of data collection offers serious benefits. However, questionnaire design issues may have a major impact on response and completion rates and on reliability of the data. Theoretically, Web-based questionnaires could be considered an alternative or complementary mode in the range of epidemiologic methods of data collection. Practice and comparisons with the traditional survey techniques should reveal whether they can fulfill their expectations.

data collection; epidemiologic methods; health surveys; Internet; medical informatics; questionnaires

Systematic and thorough data collection plays an important role in every epidemiologic study, in which factors such as the characteristics of the target population, resources available, and sensitivity of the topic of interest determine the method of data collection chosen. Traditional approaches to gathering information from study subjects, including face-to-face and telephone interviews and paper-and-pencil questionnaires, increasingly fail to generate qualitatively good results within the financial parameters (1). Participation rates in epidemiologic studies gradually decreased approximately 1% per year over the past decades, with even sharper declines in recent years (2). A number of reasons for the growing rates of nonparticipation have recently been suggested, for example, a general decrease in volunteerism, higher demands for participation, oversurveying, and cell phone use (3).

In the late 1990s, additional approaches to data collection using the Internet were introduced, including Web-based data entry and direct mailing of online questionnaires (4, 5). Because of the limitations of conventional survey modes and declining participation rates, a major impact on survey

research was expected (6). Indeed, Web-based questionnaires are now frequently used in psychological studies and marketing research, but their use in epidemiologic studies was only 1% in recently published articles (Table 1). Nevertheless, the Internet may become an important tool in epidemiologic data collection in the near future, especially for recruitment and follow-up of large cohorts. A few successful examples of this approach are already available, including the Millennium Cohort Study (7), the Nurses and Midwives e-Cohort Study (8), and the Danish Web-based Pregnancy Planning Study (9).

Since Web-based questionnaires may be an attractive alternative to the traditional methods of data collection, epidemiologists need to become familiar with the possibilities and limitations of this relatively novel approach, especially since computer programmers instead of survey methodologists developed the various Web survey procedures (10). In this article, we discuss the latest developments concerning the advantages and disadvantages of Web-based questionnaires and address some practical issues involved in applying Web-based questionnaires in epidemiologic research.

Table 1. Modes of Data Collection Used in Analytic Epidemiologic Research Articles Published in 7 High-Impact General Medical and Epidemiologic Journals in 2008–2009^a

Journal Title	No. of Analytic Epidemiologic Articles	Mode of Data Collection, % ^b				
		Interview	PPQ	WBQ	Other ^c	Unknown
General medical journals	1,314	21.2	22.6	1.6	89.8	1.2
<i>The British Medical Journal</i>	310	27.4	34.8	1.9	78.1	0.0
<i>The Journal of the American Medical Association</i>	319	23.5	22.3	3.1	89.3	0.3
<i>The Lancet</i>	294	23.5	19.7	0.7	93.5	3.4
<i>The New England Journal of Medicine</i>	391	12.5	15.3	0.8	96.7	1.3
General epidemiologic journals	780	38.5	40.3	0.9	82.8	1.0
<i>American Journal of Epidemiology</i>	455	40.0	43.5	0.2	84.4	0.7
<i>Epidemiology</i>	138	31.9	34.1	1.4	78.3	0.0
<i>International Journal of Epidemiology</i> ^d	187	39.6	36.9	2.1	82.4	2.7
Total	2,094	27.6	29.2	1.3	87.2	1.1

Abbreviations: PPQ, paper-and-pencil questionnaire; WBQ, Web-based questionnaire.

^a All research articles were assessed by 2 independent reviewers. In case of inconsistencies, a third reviewer was consulted. If only “questionnaire” was stated as the method of data collection, it was assumed that a PPQ was used.

^b For some articles, multiple modes of data collection were used. Therefore, the percentages do not total 100%.

^c Other modes include use of medical records or registries, (psychological) tests, and biologic samples.

^d Cohort profiles were also included.

ADVANTAGES OF WEB-BASED QUESTIONNAIRES

Data collection using Web-based questionnaires generally improves data quality since validation checks can be incorporated with prompts that alert respondents when they enter implausible or incomplete answers. Even without forced-choice formats, item nonresponse and “don’t know” answers are reported to be less prevalent in Web-based questionnaires compared with postal questionnaires (11). Because data are entered electronically and may automatically be transformed into an analyzable format by common gateway interface (CGI) scripts (12), errors in the process of data entry and coding are avoided as well. Common gateway interface scripts can also be used to build in skip patterns to hide nonrelevant follow-up questions, order questions randomly, give personalized feedback, or randomize participants to different versions of the questionnaire. Visual and audio aids and pop-up windows providing additional information may be added to simplify responding, which is impossible in paper-and-pencil questionnaires. However, all these additional features will increase download time, which may contribute to nonresponse (13).

Experience shows that Web-based questionnaires are returned more rapidly than postal questionnaires, with most respondents completing the questionnaire within a few days (14, 15). Completing all questions in a Web-based questionnaire was estimated to take about half the time needed to answer the same number of questions in a telephone interview (16). Researchers are able to immediately adjust Web-based questionnaires to resolve unforeseen problems or to incorporate preliminary results or new developments (17). A data management system may be used to automatically send e-mail reminders and invitations for follow-up questionnaires to study participants, although follow-up

of “bounce-back” (undeliverable) e-mails will be time-consuming (18).

Although some authors state that the use of Web-based questionnaires results in substantial cost reductions (19–21), others conclude that the cost savings are currently unknown (1, 22). With Web-based questionnaires, costs for printing, postage, and data entry are avoided, but the set-up costs, including Web site and survey design, may be substantial, although the marginal costs for adding more participants to the study are relatively low (23). Therefore, the cost per response may be high when Web-based questionnaires are used in studies with small sample sizes or in populations with low response rates to Web surveys. Studies that invited participants through e-mail reported cost benefits associated with using Web-based questionnaires (14, 24, 25).

DISADVANTAGES OF WEB-BASED QUESTIONNAIRES

Two main disadvantages that may hamper the use of Web-based questionnaires in epidemiologic research were identified at the beginning of this century: 1) relatively high nonresponse rates compared with traditional modes of data collection and 2) concerns regarding the reliability and validity of the data obtained (17, 26). Reluctance to use Web-based questionnaires because of safety and confidentiality issues may also play a role.

Response rates

Response rates of less than 100% will lead to selection bias if the association between exposure and disease is different for participants than for all targeted subjects (27). Self-selection is a common cause of selection bias (28), but traditional modes of data collection have shown little

Table 2. Internet Access in Various Developed Countries in 2009

Country	Access to the Internet in 2009			Growth From 2000 to 2009, % (72)
	National Statistics		Internet World Stats, % (72)	
	%	Reference No.		
Australia	74	73	80.1	158.1
Canada			74.9	97.5
Denmark	83	74	84.2	137.4
France			69.3	407.1
Germany	73	75	65.9	126.0
The Netherlands	93	76	85.6	266.8
New Zealand			79.7	304.8
Norway	91 ^a	77	90.9	92.5
United Kingdom	76 ^a	78	76.4	203.1
United States	77	79	74.1	138.8

^a Used the Internet within the last 3 months.

bias resulting from nonparticipation (29, 30). Although higher response rates have been found in specific subgroups, such as the highly educated (25) and undergraduate students (31), response rates for Web-based questionnaires have generally been lower than for postal questionnaires (32, 33), particularly when Web-based questionnaires first became available. However, since Internet access is rapidly increasing in developed countries (Table 2), the coverage differential is decreasing and will probably soon disappear for the most part. Recent studies have already shown that subjects responding to a Web-based questionnaire are comparable to those responding to traditional modes of data collection in terms of age, gender, income, education, and health status (7, 34, 35). However, responders to Web-based questionnaires seem to be obese more often than responders to paper-and-pencil questionnaires or national probability-based samples, possibly because of a more sedentary lifestyle (7, 35).

Response to Web-based questionnaires may improve rapidly since recent studies reported that the overwhelming majority of respondents preferred the Web-based version to postal questionnaires and telephone interviews or had no preference (14, 36, 37). Many of the approaches known to increase response rates to postal questionnaires (38) are also applicable to Web-based questionnaires, but some methods cannot be used when study subjects are recruited electronically. Sending a monetary incentive, for instance, is impossible, but providing nonmonetary incentives, such as lottery participation and survey results, may improve response rates significantly (39). Approaches specifically pertaining to Web-based questionnaires, including providing a PDF version (40) and careful use of design elements (39), have shown some success in improving response rates. Questionnaire length does not seem to influence response rates or the amount of missing data (41).

By automatically collecting so-called paradata or meta-data, including date, time, and time to completion, Web-based questionnaires may provide useful insights into the answering process (42). These data could also be used to identify the best possible order of questions, which may

substantially increase completion rates (i.e., the number of subjects who submitted the last page of the questionnaire divided by the number of subjects who agreed to participate) (43). When a multiple-page design is used, partial responses may be used to identify survey questions that were difficult to answer. Subsequently, the researcher may adjust these questions, providing the opportunity to improve response rates and decrease item nonresponse.

Reliability and validity of the data

For various reasons, including simple errors such as subjects' not scrolling down to find all questions or answering options, bad questionnaire design, and faster reading by Internet users, Web-based questionnaires were suspected of yielding larger amounts of measurement error than the traditional methods of data collection (17, 44). The contrary seems to be true, however. Studies in various areas of health research have shown that traditional epidemiologic risk factors can be collected with equal or even better reliability in Web-based questionnaires compared with traditional approaches. The quality of data on anthropometry (37), perceived health status (45), oral contraceptive history (36), smoking (46), and alcohol use (47) was high when collected by Web-based questionnaires. Agreement for dietary history assessed with a Web-based questionnaire was reported to be moderate (36), but the repeatability and validity of Web-based dietary history questionnaires seem to be comparable to those of paper-and-pencil versions (48). Self-reported weight was shown to be a good proxy for weight measured by a trained professional (35), whereas health-related quality-of-life measures may reliably be collected using Web-based approaches as well (49).

A number of instruments used for psychological and psychiatric clinical and research applications, such as the Edinburgh Depression Scale (50), the Center for Epidemiological Studies Depression Scale (51), the Kessler Psychological Distress Scale (51), and the Obsessive Compulsive Inventory (52), have been validated for administration via the Internet. However, Web-based administration may yield slightly different results compared with paper-and-pencil assessments (51, 53). Therefore, it is questionable whether all of the scores obtained online can be compared with offline cutoff scores (54).

There are strong indications that Web-based questionnaires are less prone to social desirability bias than other methods of data collection (55–57), which makes them very suitable for research on sensitive topics such as sexual behaviors, weight, and illicit drug use. Computers may produce a situation in which respondents feel more anonymous and private and less concerned about how they appear to others (58), provided that they are alone when completing the questionnaire. Another prerequisite for obtaining less socially desirable answers is that the respondent be able to backtrack (i.e., adjust answers before submitting them) (59).

APPLICATION IN EPIDEMIOLOGIC RESEARCH

Although many software packages, ranging from free-of-charge programs with very limited possibilities to purchasable

but very extended packages, are available to create Web-based questionnaires, not all programs are suitable for epidemiologic research. Institutional review boards generally accept electronic data collection only if personal information is sent via a secure and encrypted connection and is stored behind a firewall, leaving most free and low-cost packages unsuitable for research purposes.

When a Web-based questionnaire is being created, many different issues may affect data quality and response rates. First of all, potential respondents use different hardware and software configurations, which will influence the presentation and thereby the validity of the questionnaire (60). Secondly, decisions should be made about a 1-page or a multiple-page design (44). If a 1-page design is used, all questions are presented on a single HyperText Markup Language (HTML) page. These questionnaires are identical for all participants and should be short, without complex skip patterns. Multiple-page designs, on the other hand, enable the application of, for instance, response validation, automatic skipping of questions, and random question order, usually by using common gateway interface scripts at the end of each HTML page. Placing 4 to 10 questions on a single page is recommended to avoid scrolling, but doing so comes with a trade-off: fewer questions per screen increases data quality and respondent satisfaction but increases completion time (61). When a questionnaire is presented on multiple pages, the respondent is not able to estimate the total length. As a solution, a progress indicator could be added, although it may decrease completion rates, especially in lengthy questionnaires (62).

Other more subtle design features may influence data quality as well. Closed-ended questions requesting a single answer, for example, may be presented with radio buttons or drop-down lists. Whatever format is used, showing only the first few answer options should be avoided to prevent respondents from not looking at the other options (63). For closed-ended questions that permit respondents to make multiple selections ("check all that apply"), matrices (a forced-choice format, in which respondents have to provide an answer for each item) are generally preferred over check boxes (64). However, respondents should not be forced to choose arbitrary answers.

To ensure that answers to open-ended questions are in acceptable formats, error messages are often built into questionnaires. These messages, however, may increase respondent frustration and thereby decrease completion rates (13), just as answer boxes of insufficient size do. Therefore, participants should be guided by visual elements to submit their answer in the desired format, such as by adjusting the size of the answer box to the number of digits expected, replacing the words "Month" and "Year" by "MM" and "YYYY" to reflect the desired number of digits, and placing the visual instructions in the natural reading path (65). Definitions can be clarified in multiple ways, although making them always visible on the screen will result in the highest chance of their being read. If doing so is not possible, a rollover strategy, in which the definition is obtained by simply positioning the mouse pointer on the term, is preferred over clicking to open a separate window (63).

Once a Web-based questionnaire has been created, participants can be recruited in 2 ways (66). Subjects in the

target population can be invited to participate in the study directly by general mail or e-mail, in which a link to the (password-protected) Web-based questionnaire is imbedded. Since a username is assigned to each individual with this approach, multiple entries from the same subject or questionnaire completions by others than the invited respondents are prevented and reminders may be sent to (partial) nonresponders (67). However, institutional review boards have been reluctant to allow recruitment by e-mail, whereas typing in the Web address, login, and password offered in a letter may act as a barrier to participation.

Alternatively, as in the Danish Web-based Pregnancy Planning Study (68), the questionnaire may be open to the public via recruitment strategies such as banners and advertisements. If this procedure is used, calculating a response rate is difficult and multiple completions from one participant cannot be prevented, although some strategies, such as recording Internet protocol addresses and personal data, may detect multiple submissions (69). In addition, it is very likely that a selective population, whose characteristics are different from those of the target population, will participate when an open recruitment strategy is used (21, 70), which may limit its use in quantitative studies but may not be an issue in qualitative research (71). Whatever recruitment strategy is used, informed consent will virtually always be required, via either Web-based or paper-based signed forms.

CONCLUSION

The current developments in the use of Web-based questionnaires as a mode of data collection in epidemiologic research are promising. They indicate that Web-based questionnaires, when carefully designed, could adequately be used in certain populations in developed countries, such as for college students and men and women of reproductive age. Because Internet access rates are rapidly increasing, the use of Web-based questionnaires should also be possible in other populations in the near future. Since Web-based questionnaires have scarcely been used in epidemiologic research so far, future studies in which this mode of data collection is used should determine the reliability of data obtained by this approach. Nevertheless, it should be kept in mind that no method of data collection is perfect. Theoretically, Web-based questionnaires are fully able to compete with traditional modes of data collection and should be considered as an alternative or complementary mode in the range of epidemiologic methods of data collection. In the coming years, practical application and comparison with more traditional survey techniques should reveal whether Web-based questionnaires can fulfill their expectations, but the first results look promising.

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