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Evaluation of Estimated Survey Duration Equations Using a Health Risk Assessment

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Survey duration—the time it takes to complete a survey—affects response and completion rates. Estimated survey duration equations may be used to estimate survey duration, however, there are no studies assessing their use. The objective of this study is to evaluate estimated survey duration equations using a health risk assessment. Six existing estimated survey duration equations were identified. Using health risk assessment data from January 1, 2018 to December 31, 2018, an average respondent profile was built to inform the inputs into the estimated survey duration equations. Estimated survey duration of the health risk assessment ranged from 7.64 minutes to 39.6 minutes. Using the same health risk assessment dataset, the estimated survey duration was compared to the actual completion time of the health risk assessment. The average completion time of the health risk assessment was 13.99 minutes. The estimated survey duration equations either under- or overestimated the completion time of the health risk assessment. The equation that is based on word count, number of questions, decisions, and open text boxes is recommended for use to estimate the duration of a health risk assessment although it was an overestimate. Using estimated survey duration equations appear to be a suitable alternative to pilot testing but future studies are needed to further evaluate these equations.

Keywords: health risk assessment; survey; completion time; duration; accuracy; percent error

1 Introduction

Getting people to start and complete a survey is one of the biggest challenges survey developers and administrators face. Typically, a good response rate is above 70% but studies have shown that survey response rates are usually less than 40% (Fincham, 2008; Poynton, DeFouw, & Morizio, 2019; Sykes, Walker, Ngwakongnwi, & Quan, 2010). One reason an individual may not start or complete a survey is its duration—the amount of time it takes to complete the survey. Factors that contribute to survey duration include, but are not limited to, the survey's mode of delivery, the characteristics of the individual taking the survey, the length of the questions, the types of questions, and the number of questions. Previous studies have found that surveys that can be taken in less than 15–20 minutes have higher response rates (Liu & Wronski, 2018; Porter, 2004; Revilla & Ochoa, 2017; Rolstad, Adler, & Rydén, 2011; Saleh & Bista, 2017).

Survey duration is typically estimated through pilot testing the survey among a group of individuals who are naïve to the survey. This may give a close estimate to how long it should take a member of the general population to complete the survey, however, there are several limitations to this approach. The group of individuals who pilot the survey, for example, may not be representative of the broader population who will be taking the survey. It also takes a large diverse sample size to have more confidence in the results and generalizability. Pilot testing is also time consuming and uses valuable, and possibly limited, resources to determine whether a survey may take too long to complete. There are also direct economic costs of pilot testing surveys if incentives or rewards are provided for those participating in the pilot testing. In addition, there may be modifications to the survey during its development to further refine it which subsequently requires multiple rounds of pilot testing to accurately estimate the final duration time.

An alternative to pilot testing surveys to estimate its duration is to use estimated survey duration equations. These equations use characteristics of the survey that contribute to

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its duration such as the word count, and number and types of questions. Currently, there are no studies assessing the accuracy or use of these equations. The objective of this study is to evaluate existing estimated survey duration equations using a health risk assessment.

2 Data and Methods

2.1 Health Risk Assessment

This study evaluated estimated survey duration equations using the Wellcomplete Health Risk Assessment for the Workforce (Wellsource®). The Wellcomplete Health Risk Assessment for the Workforce collects information on an individuals' health and lifestyle behaviors to estimate risk across seven health areas (cardiovascular disease, diabetes, obesity, cancer, mental health, physical activity, and nutrition). The health risk assessment includes 133 possible questions including 100 single-choice questions and 33 questions with short open-text boxes for the respondent to enter data. A single respondent, however, would never see all questions available.

The Wellcomplete Health Risk Assessment for the Workforce is dynamic, where questions and answers change, become hidden, and/or are displayed based on how the respondent answers previous questions or based on the respondent's age or sex (called branching or skip logic). For example, someone who uses tobacco would see an additional question about types of tobacco used while a non-tobacco user would not, while a male respondent would not be asked if he was pregnant. There are 42 questions that are contingent on branching logic operations in the health risk assessment.

The Wellcomplete Health Risk Assessment for the Workforce can be delivered via paper, electronically (i.e., web-based), or telephonically and is mobile-friendly. The health risk assessment is a custom-built application, composed of both server-side web services and a browser-based user interface (UI) application, based on Microsoft .NET framework (Microsoft Corporation, Redmond, WA) and other industry-standard development platforms.

The sample of health risk assessments used in this study is a non-probability sample of all health risk assessments completed between January 1, 2018 and December 31, 2018 (Wellsource, 2018). This study uses proprietary data of Wellsource.[1]

2.2 Estimating Survey Duration Equations

Six existing equations used to estimate survey duration (Table 1) were identified through a non-systematic literature search of peer-reviewed publications and grey literature (Lopez, 2019; Puleston, 2012; The Versta Team, 2011). Equations A–E use various combinations of the word count, number of questions, number of decisions, number of open text boxes, and/or number of rows in the survey to estimate survey duration (Lopez, 2019; Puleston, 2012). Equation F uses a point system based on number and type of questions in the survey (The Versta Team, 2011).

2.3 Defining the Average Respondent

Since the Wellcomplete Health Risk Assessment for the Workforce uses branching logic, the estimated survey duration equations require the inputs to be based on an average respondent's experience (Puleston, 2012). The average respondent profile was created using deidentified data from health risk assessments completed by 81,876 individuals between January 1, 2018 and December 31, 2018 (Wellsource, 2018). These respondents include both those naïve and familiar with the health risk assessment.

For each question in the health risk assessment that required a numeric response, such as age and number of hours sleeping, the average was calculated across all health risk assessments. For each question that required a categorical response, such as stress level or self-rated health, the frequency of responses was calculated across all health risk assessments. The average for numeric responses and the most frequent categorical responses were used to create the average respondent profile. These responses informed the questions-including those contingent on branching logic-that would have been answered by the average respondent which subsequently informed the inputs into the estimated survey duration equations.

Due to the proprietary nature of the health risk assessment, the data used to inform the average respondent profile is not publicly available.

2.4 Definitions for Equation Inputs

The estimated survey duration equations provided definitions for each of the inputs. These definitions, however, required further interpretation based on their use to estimate the duration of the health risk assessment. These interpretations were created by the study investigators without consulting the equation developers. Only questions, answers, and instructions that would be seen by the average respondent were included in the calculation of inputs.

Word count (W) was defined as the number of words in the assessment including instructions, questions, and options (i.e., answers) (Puleston, 2012). The word count from section headers (e.g., "My Activities"), help text (as it required clicking on an icon to appear), and other content (e.g., real-time reporting of answer) that were not specifically questions, answers, or instructions in the health risk assessment were excluded.

The number of questions (Q) were those that required an action by the respondent such as selecting an answer op-

[1]This study uses proprietary data of Wellsource and is not publicly available.

Table 1
Estimated Survey Duration Equations

Equation Name	Equation
A (Puleston, 2012)	$(W/5 + 5 \cdot Q + 2(D - Q) + 15 \cdot T)/60$
B (Puleston, 2012)	$(W/5 + R \cdot 1.8)/60$
C (Puleston, 2012)	$W/150$
D (Puleston, 2012)	$Q/2.5$
E (Lopez, 2019)	$Q/4$
F (The Versta Team, 2011)	$P/8$

Abbreviations: D = number of decisions; P = number of points; Q = number of questions; R = number of rows; T = number of open text boxes; W = word count

tion or entering data into an open text box (Puleston, 2012). Question set headers in the health risk assessment such as "During the past month, have you often:" were counted once as part of the first sub-question that required an action.

The number of decisions (D) a respondent had to make were based on the question type (Puleston, 2012). A single choice answer counted as one decision, a multi-select question (i.e., choose all that apply) counted as 0.5 per answer option, and each row in a question grid was counted as one decision (Puleston, 2012). Open-ended text box questions were excluded from the decision count as this was a separate variable in the equation (Puleston, 2012). All questions in the health risk assessment that were not open-text questions required a single choice answer.

The number of open-ended text box questions (T) were those that required a respondent to fill-in an answer response by typing (Puleston, 2012). All open-text questions in the health risk assessment were included except the section regarding the respondent's biometrics (other than weight, height, and waist circumference as there were separately asked questions). The biometrics section in the health risk assessment requires manual entry of biometric values, including but not limited to systolic blood pressure, total cholesterol, and hemoglobin A1c, and is optional to complete. This section was counted as one open text box question as the average respondent did not enter data into these text boxes; however, it is assumed the average respondent likely spent time briefly reading the question and biometrics labels, but not answering them. In addition, one question in the health risk assessment —"How tall are you?"— required data entry into two text boxes (i.e., feet and inches). This question was counted as two text boxes.

The number of rows (R) was defined as the "total number of row options" (Puleston, 2012). This was interpreted as the number of times a respondent must move down to a new line of text in the web browser version of the assessment. Wrapping questions were not counted as multiple rows. The number of rows in the health risk assessment as if it were being taken by the average respondent was counted using Google Chrome™as the web browser on March 31, 2020 by one study investigator.

And finally, the point system (Equation F) was based on the total points assigned to question types: short/simple survey question (1 point), grid format question (1 point for each row), multiple-select questions (0.5 per answer option), mental calculation (2 points), short open-ended (3 points), lengthy instructions or questions that have a lot of words (1 point for every 3 sentences) (The Versta Team, 2011). One question in the health risk assessment —"How tall are you?"—required data entry into two text boxes (i.e., feet and inches); this question was counted as one short open-ended question.

Questions about the individual's identifying information (e.g., first and last name, date of birth, contact information) were excluded from all inputs as these were often prepopulated by the health risk assessment administrator for their population base. Additional questions asked of the respondent by the survey administrator beyond of those provided in the health risk assessment were also excluded from inputs.

2.5 Evaluating the Estimated Survey Duration

To evaluate the estimated survey duration equations, the completion time of respondents who took the Wellcomplete Health Risk Assessment for the Workforce was compared to the estimated survey duration based on the average respondent profile.

Completion time was calculated as the difference between the timestamp the health risk assessment was completed and the timestamp the health risk assessment was started, rounded to the nearest one-hundredth. The timestamps were created by the server. Completion times were derived from health risk assessments completed between January 1, 2018 and December 31, 2018 (Wellsource, 2018). Since the health risk assessment is primarily designed to be completed electronically by the individual, assessments that were completed on paper which required subsequent manual entry of responses into the database and those that were completed

telephonically or by a proxy were excluded as the completion times of these assessments would not represent the health risk assessment's intended mode of delivery (electronically). Health risk assessments with additional questions as required by the survey administrator were also excluded as these would have lengthened the completion time. Health risk assessments identified as those used in product demonstrations, quality assurance testing, or usability testing were excluded as these did not represent the completion time of a real user experience. Health risk assessments with completion times greater than 120 minutes were also excluded; this completion time threshold was selected arbitrarily as the maximum allowable time to complete the health risk assessment by design.

The difference between the estimated survey duration and the completion time was calculated for each respondent. The percent error of the estimated survey duration was also calculated by taking the difference between the estimated survey duration and the completion time and dividing it by the completion time, then multiplying by 100 to get a percent. Descriptive statistics (i.e., mean, median, and range) were reported. A one-sample t-test was used to compare the estimated survey duration and the completion time, as well as the log-transformed values, of the health risk assessment. Mean difference, 95% confidence intervals (CI), and p-values were reported. A statistically significant test result was defined as a p-value less than 0.05.

A subgroup analysis excluding outliers identified among health risk assessments with eligible completion times was conducted. Outliers were defined using Tukey's definition, commonly referred to the 1.5 interquartile range (IQR) rule, where any data point that falls beyond one and a half IQRs below the first quartile or above the third quartile in a dataset are considered outliers (P. R. Jones, 2019). A separate analysis evaluating estimated survey duration and completion time among health risk assessment respondents who matched the average respondent profile—that is, would have seen the same questions—was also conducted.

All data were managed in and analyzed using SPSS® statistical software (IBM®, Armonk, NJ).

3 Results

Based on 81,876 individuals who completed the Wellcomplete Health Risk Assessment for the Workforce, the profile of the average respondent is a non-pregnant 43-year-old working female. She drinks alcohol and does not use tobacco. She reports some levels of stress, but not enough that it causes her distress. She eats breakfast and is physically active. She left her clinical biometric values blank and thus, selected "bucket" answers (e.g., normal, high, don't know) that best described her blood pressure, cholesterol, and glucose levels. Due to the proprietary nature of the health risk assessment, detailed characteristics of all the responses that informed the profile of the average respondent is not provided.

Based on this profile, the average respondent would answer 99 questions (Q), read 1,146 words (W), make 82 decisions on short/simple survey questions (D), and enter data in 18 text boxes (T) across 159 rows (R) for a total of 133 points (P). The estimated survey duration of the health risk assessment for the average respondent ranged from 7.64 minutes to 39.6 minutes (Table 2).

Among all health risk assessments with an eligible completion time, the mean completion time was 13.99 minutes (range, 1.45 to 119.41 minutes) and the median completion time was 10.52 minutes (Figure 1).

The mean difference between the estimated survey duration of the six equations and the completion time of the health risk assessment ranged from −6.35 minutes to 25.61 minutes (Table 2). The percent error ranged from −23.35% to 297.28% (data not shown). One sample t-tests showed all estimated survey durations were statistically significantly different from completion times of the health risk assessment ($p < 0.01$) even when log-transformed values were used (data not shown).

When outliers were excluded (i.e., completion times greater than or equal to 27.3 minutes), the mean completion time of the health risk assessment was 11.27 minutes (range, 1.45 to 27.29 minutes) and median completion time was 10.01 minutes. The mean difference between the estimated survey duration of the six equations and the completion time of the health risk assessment ranged from −3.63 minutes to 28.33 minutes (Table 2). The differences remained statistically significant.

In the subgroup analysis among 66 respondents who matched the average respondent profile, the mean completion time was 10.80 minutes (range, 4.00 to 61.00 minutes). The mean difference between the estimated survey duration of the six equations and the completion time of the health risk assessment ranged from −3.16 minutes to 28.80 minutes (Table 3). The differences remained statistically significant for all estimated survey durations except that of Equation B which underestimated duration by an average of 2.21 minutes ($p = 0.075$). Similar results were seen when outliers within this subgroup were excluded (i.e., completion times greater than or equal to 20 minutes) with the exception that the estimated survey duration by Equation C was no longer statistically significantly different from the completion time of the health risk assessment ($p = 0.175$) (Table 3).

4 Discussion

In this study, estimated survey duration equations either over- or underestimated the actual completion time of the Wellcomplete Health Risk Assessment for the Workforce. The estimate closest to the average completion time of the health risk assessment (13.99 minutes) was Equation A at

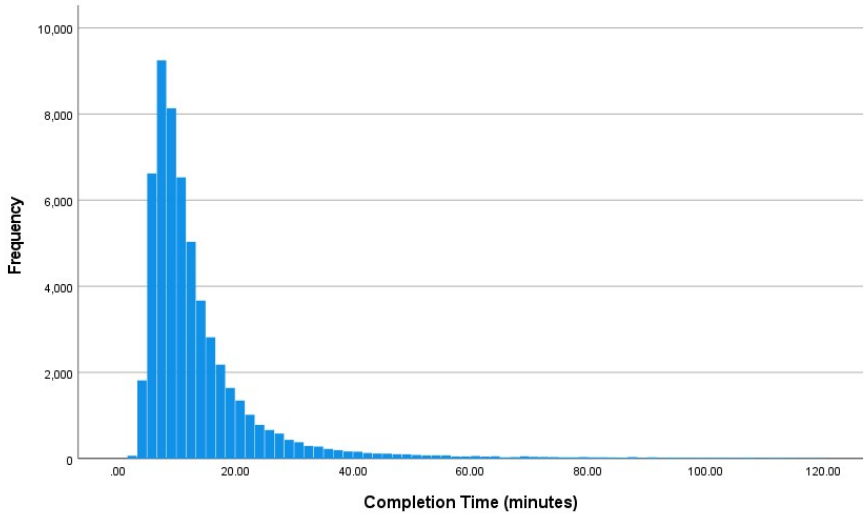

Figure 1. Histogram of Completion Times

Table 2

Mean Difference of Estimated Survey Duration When Compared to Completion Times of the Wellcomplete Health Risk Assessment for the Workforce

		All HRAs (n=56,108)					Excluding Outliers (n=51,795)				
			95% CI		Range			95% CI		Range	
Eqn	Duration	Mean	Lower	Upper	Lower	Upper	Mean	Lower	Upper	Lower	Upper
A	16.003	2.01*	1.92	2.12	−103.41	14.55	4.74*	4.69	4.78	−11.29	14.55
B	8.590	−5.40*	−5.50	−5.30	−110.82	7.14	−2.68*	−2.72	−2.63	−18.70	7.14
C	7.640	−6.35*	−6.45	−6.25	−111.77	6.19	−3.63*	−3.67	−3.58	−19.65	6.19
D	39.600	25.61*	25.51	25.71	−79.81	38.15	28.33*	28.29	28.38	12.31	38.15
E	24.750	10.76*	10.66	10.86	−94.66	23.30	13.48*	13.44	13.53	−2.54	23.30
F	16.625	2.64*	2.54	2.74	−102.78	15.18	5.36*	5.32	5.40	−10.66	15.18

Abbreviations: CI = confidence interval; Eqn = equation; HRA = health risk assessment

* One sample t-test, $p < .05$

Table 3

Mean Difference of Estimated Survey Duration When Compared to Completion Times of the Wellcomplete Health Risk Assessment for the Workforce Among 66 Respondents Who Matched the Average Participant Profile

		All HRAs (n=66)			Excluding Outliers (n=60)		
			95% CI			95% CI	
Eqn	Duration	Mean	Lower	Upper	Mean	Lower	Upper
A	16.003	5.20*	2.76	7.64	7.82*	7.03	8.61
B	8.590	−2.21	−4.66	0.23	−0.41	−0.39	1.20
C	7.640	−3.16*	−5.61	−0.72	−0.54	−1.34	0.25
D	39.600	28.80*	26.35	31.24	31.42*	30.62	32.21
E	24.750	13.95*	11.50	16.39	5.77*	4.97	6.56
F	16.625	5.82*	3.38	8.27	8.44*	7.65	9.23

Abbreviations: CI = confidence interval; Eqn = eqn; HRA = health risk assessments

* One sample t-test, $p < 0.05$

16.003 minutes. This equation used the word count, and the number of questions, decisions, and open text boxes. The next best estimate was Equation F at 16.625 minutes which was based on a point system by types of question. Both, however, were overestimates. When outliers were excluded, the estimate closest to the average completion time of the health risk assessment (11.27 minutes) was Equation B, that used word count and the number of rows of text, at 8.59 minutes; this was an underestimate.

Given the diverse experiences among respondents who take a dynamic health risk assessment, we recommend erring on the side of overestimating survey duration and thus suggest using Equation A for estimating the duration of a health risk assessment. Although Equation A, on average, overestimated the health risk assessment completion time by 2.01 minutes, we find it better to overestimate survey duration to build trust in the individual and their survey experience. Presurvey communications typically include the estimated time to complete the survey as a motivator for an individual to start the survey. If the respondent is taking longer than the estimated time provided in the communication, they may not complete the survey or rush through the survey resulting in answers that may not be honest or accurate (Mirzaee, 2009). With overestimating, a respondent may feel better that they were able to complete the assessment in less time that it said it would take to complete. On the other hand, overestimating survey duration may cause individuals to not start the assessment as it appears too long as well as increasing any direct costs associated with incentivizing longer surveys. Future studies are needed to determine which estimate (over- or under-) is best to tell individuals in pre-survey communications that results in improved participation rates.

When initially creating a survey, it is best to refer to survey design methodology as there are many techniques to employ that will decrease survey duration while maintaining validity and reliability (Andres, 2012; T. Jones, Baxter, & Khanduja, 2013; Kelley, Clark, Brown, & Sitzia, 2003). For example, offering a variety of question types and providing answers such as those in a drop-down list are effective methods for reducing response burden. Minimizing the use of open text boxes also alleviates response burden and decreases completion time as each open text box takes an average of 15 seconds to complete (Puleston, 2012). If the questionnaire is electronic based, use branching logic to move a respondent more quickly through the question set as this approach tailors the questionnaire to the respondent making it more relevant and engaging to them, thus resulting in shorter completion times and higher completion rates.

Using estimated survey duration equations appear to be a suitable alternative to pilot testing especially in the early phases of development before refining the final survey. Pilot testing is still useful to get a more accurate idea of how long it takes for the survey to be completed especially once the survey has been finalized. A survey may have few questions with few words and thus a shorter estimated duration, but it may take longer to complete than what was calculated. Pilot testing will help correct the estimate used in pre-survey communications to individuals to hopefully improve response and completion rates. Future studies should compare pilot testing times to estimated survey duration equations to determine if one performs better than the other. This comparison was not made in this study because pilot testing was not conducted during the development of the health risk assessment.

There are limitations to this study. The first, being the estimated survey duration equations themselves. These equations are not widely used in practice as evidenced by the lack of studies or guidance on their use. There may be many reasons for their nonuse including the industry not being able to agree on the definition of inputs or which inputs to include in the equations. The six equations used in this study were as simple as using word count only to as complex as scoring the number and type of questions. None, however, considered the delivery mode of the assessment, or who was taking or giving the assessment, as well as other survey characteristics such as the use of sliders or drop-down lists. These are all factors that contribute to survey duration. In addition, the inputs to be used in the estimated survey duration equations had to be further defined to fit estimating the duration of a health risk assessment. These interpretations may not be accurate or capture what was originally intended leading to the over- or underestimation of duration. We also did not contact the developers of the equations for further clarification of the inputs.

Second, the inputs used in the estimated survey duration equations were based on the average respondent profile who took the health risk assessment. The assumption that using the average respondent would deal with the difficulty of branching logic in surveys was made by the developers of the equations (Puleston, 2012). This assumption may make the equations less reliable as it does not reflect the various experiences a diverse population would have when taking a survey with branching logic. For example, someone taking the health risk assessment could answer a minimum of 83 questions or a maximum of 116 questions. When the estimated survey durations were compared to the completion times among 66 respondents who matched the average respondent profile, all estimates except one (Equation B) remained statistically significantly different which may indicate this assumption is not reliable. Each unique experience induces changes to all inputs used the equations leading to longer or shorter estimated survey durations. In addition, the approach we used to create the average respondent profile may have not been the best method especially since some assumptions were made about the average respondent's experience. We also did not limit the average respondent profile to those with an eligible completion time as we wanted to

truly have an accurate profile of everyone who has taken the health risk assessment. Completion times should be compared to the estimated survey duration based on inputs of other respondent profiles, inputs for each unique experience, as well as inputs using different approaches to determining the average respondent's profile, all of which was not done in this study.

Third, the completion time of some of the health risk assessments may have been shorter or longer than others. We were not able to exclude health risk assessments where the respondents had to complete parts of or the entire intake form. The intake form is typically pre-filled by the survey administers, however, if a respondent had to complete some or all parts, it could have added to the completion time. We were also unable to exclude health risk assessments where clinical biometrics were pre-uploaded. This would have potentially modified the biometrics-related questions a respondent would have had to answer resulting in fewer questions and thus a shorter completion time. If a respondent took breaks while taking the health risk assessment, the completion time does not omit inactivity. The health risk assessment is designed to automatically sign out after 10 minutes of inactivity, but this setting can be turned off by survey administrators. We were also limited to a maximum allowable completion time of 120 minutes. And finally, we were unable to determine which device (e.g., desktop, mobile) was used to complete the health risk assessment as completion times may have varied by type of device used. Although timestamps are based on the server side, there may be slight variances pertaining to the client's time, but these are likely miniscule.

And finally, these results may not be generalizable as this is a use case with a non-probability sample where we compared the survey duration estimations produced by different equations with the actual completion time of a single survey-a health risk assessment. It is possible one equation performs better for one type of survey, such as a health risk assessment, while another equation performs better in another type. It is also possible that one equation works best for the Wellcomplete Health Risk Assessment for the Workforce while another equation would work best for a different health risk assessment.

Overall, imprecise or inaccurate estimated survey duration and completion times will lead to incorrect calculations of their differences, and thus the possible reliance on the wrong equation. And low generalizability limits the results of the study. These limitations emphasize the need for future research to confirm which survey duration equation is best to use and for which types of surveys. Survey developers are encouraged to evaluate these equations with their own surveys to determine which may be best and disseminate their findings.

It is important to estimate survey duration for a multitude of reasons. First, it will help obtain adequate participation and completion rates. As mentioned previously, questionnaires lasting no longer than 15—20 minutes have the best response rates. Estimating survey duration will allow survey developers to reduce development costs by minimizing pilot testing efforts. It will also help in the better estimation of other costs as time is money. Longer surveys mean longer time out in the field to collect the data, longer time analyzing the data, and larger compensation to respondents for their participation if completing the survey is incentivized.

In the end, using estimated survey duration equations appear to be a suitable alternative to pilot testing especially in the early phases of development before refining the final survey. It is best practice to use existing survey development methodology to design a valid and reliable survey to minimize its duration to improve response and completion rates, and reduce costs. Future research on using estimated survey duration equations is greatly needed.

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