The Feasibility of Using Self-Generated Identification Codes in Longitudinal Research with Military Personnel

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The views expressed are those of the authors and do not reflect the official views or policy of the Department of Defense or its Components.
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Introduction

Subject-generated identification codes (SGIC) have grown in popularity in recent years to overcome methodological challenges plaguing longitudinal research. Namely, protecting participant anonymity while enhancing the validity of collected data on sensitive topics (Yurek, Vasey, & Sullivan Havens, 2008). SGIC often consist of a set of questions that have stable answers over time in order to enable a respondent's answers to be matched across repeated time points. The use of SGIC allows for individual data to be linked longitudinally, while preserving participant anonymity. As such, SGIC have the potential to produce more accurate estimates of potentially sensitive information (e.g., illicit substance abuse) or among participants with fewer privacy protections (e.g., military personnel), where the participant's confidence in the anonymity and confidentiality of the data is key to the validity of the findings (Kristjansson, Sigfusdottir, Sigfusson, & Allegrante, 2014).

SGIC have mainly been used with adolescents to measure sensitive topics such as alcohol use (Morgenstern, Wiborg, Isensee, & Hanewinkel, 2009), substance abuse and violence prevention (Griffin, Holliday, Frazier, & Braithwaite, 2009), and sexual habits (Mellanby, Newcombe, Rees, & Tripp, 2001). Match rates using the SGIC technique have varied, but recent longitudinal research in student samples over a 12 month follow-up range from 42.5% - 75% for exact (i.e., codes repeated identically across all items at both time points)match rates (Galanti et al., 2007; Kearney, Hopkins, Mauss, & Weisheit, 1984; Kristjansson et al., 2014). Research in military populations using the SGIC technique to collect sensitive information is limited, but one study of active duty populations reported an 80.4% match rate across time (Cigrang et al., 2014).

However, this study only used a three-variable code, which resulted in a high level of error and the investigators had to use other measured variables to reliably link participants over time. This labor-intensive process may not be realistic for large samples with repeated measures. Additionally, studies reporting the results of SGIC typically do not provide information on the non-matched group in terms of the health risk behaviors, nor do they compare the health risks of data collected in a truly anonymous method. As such, it is unclear whether SGIC are a valid methodological tool for collecting sensitive information longitudinally (Kristjansson et al., 2014). Improving the application of SGIC for sensitive information data collection within military settings, or other settings where stigmatized behaviors may be underreported such as illicit substance use, would enable more reliable tracking of important health-related behaviors among individuals.

In the military, commanding officers have access to research files for participants on a need to know basis. Therefore, the same privacy protections that civilians enjoy do not apply to military personnel. In the unlikely event that a commander gain access to sensitive information about a particular participant, like underage drinking, they have the ability to take administrative action against the participant for the admission of behaviors that violate the Uniformed Code of Military Justice. Research has shown that additional factors such as differential treatment from unit leaders, lost confidence from peers, and barriers to promotion and advancement opportunities further hinder the disclosure of sensitive information among military personnel (Hom, Stanley, Schneider, & Joiner, 2017; Vogt, 2011). While anonymous reporting allows military personnel to respond to assessments with fewer concerns regarding the impact of their responding, data collected anonymously cannot be used to analyze longitudinal within-person

changes, which is needed to accurately assess the effectiveness of interventions aimed at reducing risky behaviors, such as alcohol misuse.

Problematic alcohol use among active duty military personnel results in an estimated loss of 320,000 workdays and 34,400 arrests per year, half of which are for driving under the influence (Schumm & Chard, 2012). Moreover, alcohol misuse by military members results in an annual cost of $425 million in medical expenditures, as well as approximately 10,400 service members being placed on medically non-deployable status and 2,200 separations from active duty per year (Schumm & Chard, 2012). However, as mentioned above, admission of serious problems such as alcohol misuse could result in negative consequences for military personnel. Thus, service members are often reluctant to report any difficulties if they are personally identifiable for fear of punitive action (Hom et al., 2017; Vogt, 2011). Yet, without accurate reports of behavior over time, it is difficult to both identify the kinds of problems that military personnel are facing and to subsequently assess the effectiveness for primary prevention strategies designed to address the identified problems. A reliable and valid SGIC could overcome these barriers by providing military researchers with an avenue for collecting longitudinal sensitive information from military personnel in order to reduce problem behaviors, such as alcohol misuse, that are historically underreported and lack efficacious prevention and treatment interventions.

The Current Research

This paper will present the results of two studies with military personnel to assess the feasibility, reliability and validity of using a SGIC to collect longitudinal sensitive participant data. The first study was highly controlled to determine the feasibility of using a SGIC to match

participant data over time, while the second study compared two data collected methodologies (anonymous versus SGIC) to determine the reliability and validity of the SGIC.

Study 1

Methods

Participants and Procedures. Air Force Technical Trainees (N=105) were recruited from Joint Base San Antonio – Lackland Air Force Base, during their first week of Technical Training, as part of a study testing the effects of a brief alcohol intervention. Airmen were informed about the study and were allowed to ask questions in either a group or private setting, if requested. Participants in this study were part of the same team, and thus began and ended Technical Training at the same time and had the same training experiences, allowing for a highly controlled study. Participants were at least 18 years of age. Study procedures were approved by the 59th Medical Wing Institutional Review Board.

Airmen who agreed to participate were asked to complete an assessment that contained 10 items to generate a SGIC and questions about alcohol use. The assessment was given in a group setting to the teams at three time points over the course of their 12-week training: week 1, week 4, and week 12. Participants were informed that the SGIC was designed to link their responses over time without collecting personal identifying information. The SGIC was created using questions that only the participant could replicate (e.g., first 2 letters of your mother's maiden name; see Table 1 for a list of SGIC items). Airmen provided passive consent by choosing to complete the anonymous assessment.

Data Analysis. To link the SGICs between two timepoints, we used a macro that compared Levenshtein string distances between each SGIC at the first timepoint and each SGIC at the second (Schnell, Bachteler, & Reiher, 2010; Schnell & Rukasz, 2019). The Levenshtein

measures the distance between 2 strings by the minimum number of single character edits (e.g. insertions, deletions, substitutions) required to transform the first string into the second. The Privacy Preserving Record Linkage (PPRL) library rates each comparison as a potential match or non-match, and calculates a score based on the calculated distance (Schnell & Rukasz, 2019). Among potential matches, when a record in one dataset matched to multiple records in the second data set, only the closest match was retained. In the current study, optimal matching was defined as greater than 90% of tests matching(Galanti et al., 2007). All analyses were conducted in R v4.0.2 (R Foundation for Statistical Computing, Vienna, Austria.)

Results. There were 105 participants that completed a SGIC at week 0, 91 participants at week 4, and 91 at week 12. Shoe size was found to be an unreliable source item, and therefore excluded from the SGIC. We achieved optimal matching (i.e., greater than 90% match rate) between the week 1 and week 4, and week 1 and week 12 data collection time points. Specifically, at week 4, we matched 84 (92.3%) of the 91 week 4 participants to week 1 using the Levenshtein method. Of these matches, 26.2% matched exactly across all SGIC items. At week 12, 80 (87.9%) participants were matched to their week1 assessment using the SGIC; of these matches 21.2% were matched exactly across all questions (see Table 2).

Study 2

Methods

Participants and Procedures. Air Force Technical Training students were recruited from Joint Base San Antonio – Fort Sam Houston as part of a larger study to assess the effects of a brief alcohol intervention to reduce problematic drinking (Derefinko et al., 2017; Klesges et al., 2013). From March through July 2017, participants were recruited to participate in the Control Group. The Control group provided information related to their alcohol use anonymously. Once the Control group was enrolled, the second group, the SGIC group, was recruited to participate.

From March 2018 to September 2018, participants were recruited to participate in the SGIC group, in which they were surveyed at two time points (time point 1 at the beginning of their Technical Training, and time point 2 at the end of their Technical Training [approximately 26 weeks later]), using a SGIC which allowed their repeated measures to be linked over time. Both groups of Airmen were approached in groups of approximately 50 to. Participants in the SGIC group were informed that the SGIC was designed to link their responses over time without collecting personal identifying information, while participants in the Control group were told that their answers would remain completely anonymous. Participants were at least 18 years of age. Study procedures were approved by the 59th Medical Wing Institutional Review Board. Airmen provided passive consent by choosing to complete the anonymous assessment. *Time Point 1.* At time point 1, of the 1,864 Airmen who were approached to participate in the study, 97.5% (N=1,844) agreed to participate (n=788 in the SGIC group and n=1056 in the Control group). Participants in both groups completed an assessment prior to receiving the brief alcohol intervention that assessed their average number of drinks per week and the Alcohol Use Disorders Identification Test (AUDIT) (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001). The assessment given to participants in the Control group was anonymous, while participants in the SGIC group completed the same assessment with the addition of the 10 items used to generate the SGIC (see Table 1 for list of SGIC items). The AUDIT contains 10-items to assess excessive alcohol use, alcohol dependence, and harmful alcohol use which are scored to create a total score with higher numbers reflecting more harmful or hazardous drinking behavior. Average number of drinks was measured by asking participants how much alcohol they typically consumed on each day of the week prior to Basic Military Training (Collins, Parks, & Marlatt, 1985). Responses were summed to create an average score reflecting weekly number of drinks.

At time point 1, Airmen were under a period of enforced alcohol abstinence, and thus all items assessed alcohol use prior to Basic Military Training (roughly 8 ½ weeks earlier).

Following the intervention, participants in the SGIC group were given an additional anonymous post-assessment which contained the items to generate the SGIC and 4 questions about their beliefs about using a SGIC to report sensitive information confidentially and anonymously. These questions assessed their willingness to disclose sensitive information with an SGIC, perceptions of how honest other Airmen would be in disclosing sensitive information with a SGIC, confidence in the SGIC to keep their information confidential and anonymous, and worry that the information they provided would negatively impact their career. Belief questions were measured using a 5-point likert scale (1 = not at all to 5 = very). The pre and post surveys contained a unique identifier in order to match the surveys and determine the reliability of the SGIC. These survey identifiers were not associated with participant identifiers in any way.

Time point 2. At time point 2, participants in the SGIC group were given an end-of-training assessment that anonymously assessed their number of drinks per week and the AUDIT. Participants in the SGIC group were also asked the 10 items to create the SGIC and the 4 beliefs items. Due to the anonymous nature of the SGIC, it was impossible to know at time point 2 who had participated in the time point 1 assessment until after the data was collected and the matching macro was used to identify match rates over time. Therefore, at time point 2, all Airmen were given the opportunity to participate in the study. Of the 857 approached, 88.8% (n= 761) agreed to participate.

Data Analysis. For participants in the SGIC group, the same macro used in Study 1 for determining the Levenshtein distance between the sources string and target string, was used to create the SGIC. Shoe size was again found to be unreliable and excluded from the SGIC.

Survey codes on the pre- and post-assessments were used to determine the reliability of the match rate of the codes. Within the SGIC group, a two-sample t-test was run to compare scores on the belief questions between matched and unmatched surveys using the SGIC at time point 1 and time point 2. Next, a mixed regression model was run to detect mean differences in the belief questions between time point 1 and time point 2 between matched and unmatched samples. Finally, group comparisons between the Control and SGIC group were calculated for number of drinks per week and AUDIT scores using Wilcoxon's rank sum test. For each group, results were calculated for the overall sample, under age 21, and age 21 and older.

Results. Of the 788 participants in the SGIC group who completed a pre and immediate post-assessment, 774 (98.2%) post- to pre-assessments were matched using the Levenshtein method, indicating an optimal match rate. Of these, 64.9% were exact matches across all items (excluding shoe size). Of the 774 matched pre- and post-assessments using the SGIC, 771 (99.6%) were confirmed with the unique identifier that was pre-printed on the assessment. Of the 761 end-of-training assessments completed by the SGIC group, we matched 434 post- to the end-of-training assessments (57%) using the Levenshtein method. Of these, 12.2% were exact matches across all items (excluding shoe size; see Table 2).

There were no statistically significant differences in beliefs about SGIC between matched and unmatched participants in the SGIC at time points 1 and 2 (all p's > 0.05; see Table 3). When comparing the overall sample at time point 1 to time point 2, participants at time point 1 were more willing to disclose sensitive information, more confident that their responses would remain confidential and anonymous, and believed that Airmen would be more in honest disclosing sensitive information using a SGIC than participants at time point 2 (p's < 0.0001).

There were no observed differences in concern that information provided using the SGIC could negatively impact their careers ($p = 0.4095$; see Table 3).

Group differences in median drinks per week and AUDIT total scores between the Control and SGIC groups are found in Table 4. Overall, the Control group reported drinking more median drinks per week and higher AUDIT scores compared to the SGIC group (p's < 0.05).

Discussion

The current study examined both the feasibility, reliability and validity of using a SGIC to match sensitive information over time across two studies with military personnel. In the first study, results demonstrated that a 10-item SGIC produced optimal matching over a 12-week follow-up. In the second study, while the matching rate declined, there were no observed differences in matched and non-matched participants' beliefs about the use of a SGIC. Additionally, using the Levenshtein distance proved a reliable method to match participants overtime; concordance between pre-printed survey codes on the pre- and post-assessments and the SGIC was 99.6%. However, there were differences in reported alcohol use behaviors across the Control group (assessed anonymously) and the SGIC group, with the Control group reporting significantly higher levels of drinks per week and AUDIT scores. These findings raise potential concern over reporting of highly sensitive information through a SGIC among this population.

Using the Levenshtein distance method, the matching rate in the first study was 97.9%, over the 90% optimal threshold, compared to 57% in the second study. This discrepancy is expected, given that the first study was conducted under more ideal conditions, where the same group of participants were seen over three time periods. The second study was conducted to determine how well the SGIC matching performed under real world conditions. In this design,

participants were recruited to participate in the assessment at the beginning and end of their training. However, unlike Study 1 participants, participants in Study 2 were a heterogeneous group of participants with varying lengths of training based on their specific career field. While every effort was made to survey all participants who participated in time point 1 assessment again at the end of training for the time point 2 assessment, it is possible that some Airmen were still in training at the end of the study and thus were not given the opportunity to participate in the time point 2 assessment. Conversely, some Airmen who had not participated in the time point 1 assessment, may have chosen to participate in the time point 2 survey, as there was no record of study participants. Given these design constraints, we would not expect to achieve as high of a match rate in Study 2 as we did in Study 1.

Another factor that may account for some of the observed difference in match rate across the two studies was the length of time between the two assessments. The follow-up window between time point 1 and time point 2 in Study 2 was 26 weeks compared to 12 weeks in Study 1. Previous studies have found that the rate of matching decreases in proportion to the length of time between measure points (Schnell et al., 2010; Yurek et al., 2008). However, it should be pointed out that in Study 1 as the length of time between follow-up assessments increased, the matching rate also increased (from 92.3% to 97.9%), contrary to previous studies

While the match rate in Study 2 was not optimal, for the reasons outline above, the code was found to be reliable when compared to the pre-printed code on the pre- and post-assessments. The concordance rate between these two codes was 99.6%, suggesting that the Levenshtein distance macro is a reliable method for matching participants using a SGIC. However, in both studies, the exact match rate between the assessments was low, highlighting potential issues with the SGIC source items. Previous studies with youth have reported issues

with students recalling particular source items (e.g., grandmother's name) at repeated assessments (Galanti et al., 2007). The fact that there was only a 64.9% observed exact match rate on a pre- and post-assessment given 45 minutes apart in Study 2, confirms that participants either had trouble remembering the answers they gave to particular source items, or they purposely misrepresented their answers. In this same study, there were no differences in terms of beliefs about the use of a SGIC to confidentially and anonymously collect sensitive information from matched and non-matched participants. This finding suggests that unmatched participants may not have deliberately answered the SGIC questions incorrectly, but rather had issues with the source items. Further supporting this idea, overall beliefs about the SGIC were positive. From the analyses, shoe size was found to be an unreliable source item. Because shoe size can vary based on type or brand of shoes, and slight variations in a response (e.g., size 9.5 versus 10), are considered completely different string distances in the SGIC, shoe size was deemed to be inconsistent over time, a key feature of any source item. To increase the reliability of a SGIC, more research is needed to find source items that can be accurately recalled, while maintaining a participant's feeling of anonymity.

Significant differences in reported alcohol use behaviors across the Control group (assessed anonymously) and the SGIC group were observed in Study 2, with individuals in the Control group reporting significantly higher levels of drinks per week and AUDIT scores. Previous studies with youth have found significantly higher rates of risky behaviors such as cannabis use, tobacco use and binge drinking in unmatched groups compared to matched groups (Kristjansson et al., 2014; Morgenstern et al., 2009; Pérez, Ariza, Sánchez-Martínez, & Nebot, 2010). Further supporting this idea, overall participants' beliefs about the confidentiality and anonymity of using a SGIC to collect sensitive information from participants decreased between

time point 1 and time point 2, suggesting that there could have been underreporting of highly sensitive information using the SGIC in this sample at time point 2, or misreporting of the source items for the SGIC due to distrust of the SGIC process. Future studies are needed to disentangle whether participants are purposely misreporting their answers to the source items, or whether the source items need to be improved.

While the potential underreporting of problem behaviors using a SGIC has implications for epidemiological assessments of highly sensitive problem behaviors, it should not affect the use of SGIC to evaluate behavior change or group differences in clinical trials. If both the intervention and control group are surveyed using the SGIC, then any underestimation of the behavior would be consistent both across conditions and over time within subjects. Therefore, any changes in the problem behavior, such as alcohol use, would be accurate, albeit an underestimate of the true severity of the problem.

These findings should be interpreted in light of several limitations. First, participants were not randomly assigned to the Control and SGIC groups in Study 2. As such, it is possible that individuals in these groups differed in terms of alcohol use behaviors and therefore the observed differences between the SGIC and Control groups were not a result of the type of assessment (anonymous versus SGIC), but rather due to differences between participants. Future studies should explore differences between those reporting sensitive information via a SGIC versus a truly anonymous response using a strong study design, such as a randomized clinical trial where individual differences can be controlled. Additionally, as mentioned previously, it was not possible to ensure that all participants in Study 2 had the opportunity to take the time point 2 assessment. Therefore, it is not possible to say whether the low rate of matching was due to misreporting or the nature of the survey design. However, to overcome this bias, Study 1 was

conducted using a tightly controlled study design. Given the high rate of matching observed over a 12-week follow-up, results support the use of a SGIC to anonymously track participants over time.

In conclusion, using a SGIC to collect highly sensitive behaviors in a sample of military personnel was found to produce optimal match rates. While future studies should explore the validity of highly sensitive data obtained through a SGIC, our results support the use of a SGIC to reliably track participants anonymously over time to determine individual behavior change.

Disclosures

The views expressed are those of the authors and do not reflect the official views or policy of the Department of Defense or its components. The voluntary, fully informed consent of the subjects used in this research was obtained as required by 32 CFR 219 and DODI 3216.02_AFI 40-402. The authors declare no conflict of interest. This study is a collaborative endeavor between the U.S. Air Force and the University of Virginia via a Cooperative Research and Development Agreement (CRADA 17-361-59MDW-C18003). None of the original material contained in the manuscript has been submitted for consideration, nor will any of it be published elsewhere except in abstract form in connection with scientific meetings. This data has not been disseminated in any other form. The authors gratefully acknowledge the support of the Second Air Force, the leadership branch of training in the U.S. Air Force. This work was supported by a grant from the Congressionally Directed Medical Research Program (W81XWH-14-1-0367). All authors contributed to the conduction of the current research and writing of the manuscript. All authors have read and approved the final manuscript.

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Table 1. Subject-Generated Identification Code (SGIC) and Question Set

Question	Example Answer	SGIC
Select the first 2 letters of your mother's maiden name. If not applicable, select N/A.	AB	
Select the 2-letter abbreviation for the state in which you were born. If not applicable, select N/A.	VA	
Select the first 2 letters of the name of the school where you began 9th grade. If not applicable, select N/A.	PO	
Select the date of your date of birth.	29	
How many older siblings, alive or deceased, do you have?	1	
What is your natural hair color?	Brown (coded as 1)	
Select the first 2 letters of the name of your favorite NFL team when you were in BMT. If not applicable select N/A.	ST	
What is your typical shoes size?	7	
How many siblings, alive or deceased, does your mother have?	3	
Select the first 2 letters of your father's first name. If not applicable, select N/A.	FR	
SGIC		**ABVAPO291ST73FR**

Table 2.
Proportion (%) of successfully linked SGIC among participants at time point 1 and time point 2 across studies, by number of digits

Study	Duration between Assessments	All* 9 digits (exact matches)	Levenshtein Distance Method
Study 1			
Week 1 to Week 4	4 weeks	26.2%	92.3%
Week 1 to Week 12	12 weeks	21.2%	97.9%
Study 2			
Pre- to Post-assessment	45 min	64.9%	98.2%
Time point 1 to Time point 2	26 weeks	12.2%	57%

*Shoe size was not included in the analyses because it was found to be unreliable.

Table 3. Average responses to belief questions using a SGIC among matched and unmatched codes at time points 1 and 2.

	Time point 1 Mean (SD)				Time point 2 Mean (SD)			
	Total Sample (n=788)	Matched Codes (n=774)	Unmatched Codes (n=14)	p-value	Total Sample (n=761)	Matched Codes (n=434)	Unmatched Codes (n=327)	p-value
How willing are you to disclose sensitive or private information using an anonymous survey with a SGIC?	3.8 (1.3)	3.8 (1.3)	3.8 (1.6)	0.8577	3.5 (1.4)*	3.5 (1.4)	3.4 (1.5)	0.2856
How honest do you think Airmen would be disclosing sensitive or private information using an anonymous survey with a SGIC?	3.2 (1.2)	3.2 (1.2)	3.7 (1.5)	0.2899	2.8 (1.3)*	2.9 (1.2)	2.8 (1.3)	0.1651
How confident are you that the information you provided today will remain confidential and anonymous and not shared with your chain of command?	3.9 (1.3)	3.9 (1.2)	3.8 (1.7)	0.8801	3.4 (1.4)*	3.4 (1.4)	3.4 (1.4)	0.5119
How worried are you that the information you provided, regarding alcohol use, may negatively impact your career?	1.5 (1.1)	1.5 (1.1)	2.2 (1.7)	0.1569	1.6 (1.1)	1.6 (1.1)	1.5 (1.1)	0.5537

Note. Response options ranged from 'Not at all' = 1 to 'Very' = 5.

*Denotes statistically significant differences in overall means between time point 1 and time point 2 at p <.0001

Table 4. Median number drinks per week and AUDIT total scores among a group that did not use a SGIC and a group that did use the SGIC prior to answering alcohol-related questions.

	Control Group		SGIC Group		
	N	Median (Q1, Q3)	*N*	Median (Q1, Q3)	*P*-value
Median drinks per week					
Total	1056	1 (0,8)	750	0 (0,5)	<.0001
Under 21	491	0 (0,5)	348	0 (0,0)	0.0015
Age 21 and over	531	4 (0,10)	375	3 (0,7)	0.0011
AUDIT total score					
Total	1056	2 (0,5)	750	1 (0,4)	<.0001
Under 21	491	0 (0,4)	348	0 (0,2)	<.0001
Age 21 and over	531	3 (1,6)	375	3 (1,5)	0.0036

Note. 34 participants in the Control Group and 38 participants in the SGIC Group were excluded due to missing age.