Comparative Appraisal of Randomized Response Technique vs. Direct Interview Method in Assessment of Burden of Tobacco and Alcohol Use among Adolescents in India

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Abstract

Background: In countries like India, the major source of error in reporting of sensitive events (e.g., tobacco and alcohol use) among adolescents is deliberate misreporting. To estimate its burden, the commonly used direct interview method involves problems in reporting. To cope up, randomized response technique (RRT) is an alternative approach which uses a random device for providing more privacy to respondents. So, it may be worthwhile to compare RRT with direct interview method in assessment of burden of ever tobacco and alcohol use among Indian adolescents.

Methods: A cross-sectional survey on ever tobacco and alcohol use among adolescents was conducted on 796 (401: RRT; 395: Direct interview) 9th to 12th class students from purposively selected three schools of Delhi/National Capital Region, during November-2014 to November-2016. As per conventional use of RRT, two types of questions, one related to “sensitive attribute” and other “an unrelated question” was used to estimate ever tobacco and alcohol use. For the first time, a new random device (i.e., randomly arranged questionnaires) was proposed and used under RRT which is user friendly and appropriate for time-bound application. For comparison, the estimates of both, ever tobacco use and ever alcohol use, were obtained which could also facilitate comparative change in effect size with increasing sensitivity.

Results: The prevalence of ever tobacco use under RRT approach and Direct Interview method was 18.6% (95% CI: 13.33-24.01) and 10.1% (95% CI:7.15-13.10) respectively, where as that of ever alcohol use was 22.8% (95%CI: 17.08-28.5) and 9.1% (95% CI: 6.27-11.95) respectively.
Further, comparative results showed that as contents in used substance become more sensitive, under estimation of burden under direct interview method may become higher [i.e., Ever tobacco use: 8.5% (95% CI: 3.43-13.65); Ever alcohol use: 13.6% (95% CI: 8.34-19.03)]. The proposed new random device under RRT, as a set of randomly arranged questionnaires containing either sensitive or unrelated questions, consists of most of its recommended properties.

Conclusions: The findings under the present study suggest that the randomized response technique may serve as a versatile method for gaining access to more accurate information on sensitive topics.

Keywords: Randomized response technique, Direct Interview method, Ever tobacco use, Ever alcohol use, Prevalence

Background

There is ample evidence in the related literature that tobacco and harmful alcohol use are major leading threats for various non-communicable diseases and death globally. There are numerous diseases like different types of cancer, respiratory diseases, and heart diseases, which are known to be caused and get further deteriorated by use of such substances. As a matter of fact, these bad practices are major modifiable causes of morbidity and mortality. Further, their uses among adolescents are likely to have many grisly impacts on their future life, and society. Also, tobacco and alcohol use are called as gateway regarding initiation of illicit drug like amphetamine, cocaine, hallucinogens or heroin [1]. Hence, the time to time assessment of the burden of substance use, like tobacco and alcohol use, among adolescents becomes more important. However, such tasks among adolescents are often tedious and some time controversial. The
surveys using direct interview methods on sensitive personal practices (e.g., tobacco use, alcohol use, sexual activity) especially among adolescents generally involve huge non-response, or, responses which are not true. Intuitively, disclosure of identity or embarrassment due to unveiling of identity may be main concerns regarding non response or false response. Such responses may cause mainly two problems: first, systematically biased estimate of the burden of tobacco use and alcohol use; and second, distortion in the association between covariates and the use of tobacco/alcohol [2].

To overcome above problems, Warner [3] suggested a randomized response technique for estimating the proportion of responses on sensitive issues like tobacco use and alcohol use. As such, the randomized response technique (RRT) provides privacy to respondents by virtually using a randomized device to ask the answer of the sensitive question from them. In addition, this random device plays a pivotal role in concealing the subject’s response; and also avoiding the possibility of hiding true response on sensitive issues and also non-cooperation from respondents. Further, according to Diekmann Hglinger, the considered random device needs to have easiness to use, availability, friendly to handle, trustworthiness, and involvement of less time [4]. Most of the random devices used earlier were not easy to use [5-7]; friendly to handle [8] and appropriate for time-bound application [6,7]. Hence, as an alternative approach regarding large survey on such sensitive topics, it is worthwhile to explore innovative random devices under RRT which may be easier to use and understandable by both, respondents and surveyors. The tobacco and alcohol use among adolescents in India is still considered as a transgression. Thus, this study aimed to explore user friendly random devices for practical utility in large scale field survey while comparing randomized response technique with direct interview method especially on sensitive topics like tobacco use and alcohol use among adolescents.
Methods

The randomized response technique (RRT) suggested by Warner[3] for estimating the proportion of responses on sensitive issues have certain limitations and for this reason several modifications have been proposed in the literature[9]. As one of the improvements, Simmons[10] suggested a use of a RRT involving an unrelated question whose theoretical framework was given by Greenberg [9]. Under this design, the respondents are asked to answer if they belong to a specific group which is unrelated to motive of survey. This survey technique conventionally contains two types of questions, one related to sensitive attribute, e.g., “Did you ever use tobacco?”, and other unrelated question, e.g., “Were you born in January or February?” Further, a random device is used in such survey to decide about type of questions to be answered by respondents; and thus helps in concealing the subject’s response and privacy. So, it plays pivotal role in avoiding the possibility of hiding true response on sensitive issues and also non-cooperation from respondents. This method can be done in two conditions, first when prevalence of characteristics of unrelated question is unknown, and second, when prevalence is known. However, it is also reported that efficiency of RRT involving known prevalence of unrelated question in the population is better than that in case of unknown prevalence[9,10]. They found this approach better than even Warner’s randomized response technique. Further, random device used under RRT, should be easy to use, friendly to handle and appropriate for time-bound application.

The prevalence of tobacco use under RRT [9] with known prevalence of unrelated question may be estimated as:

\[
p(T_{RRT}^\wedge) = \frac{p(D) - [1 - p(C)]*p(B)}{p(C)}
\]

(1)
Where: T: Tobacco use; B: Born in January or February; C: Use of questionnaire on ever tobacco use; and D: Cumulative yes answer in survey; P (T) = probability of tobacco use among students; P (B) = probability of student actually born in January or February; P (C) = probability of getting questionnaire on ever tobacco use; 1-p (C) = probability of getting questionnaire on born in January or February; and p(D)=probability of getting yes answer among total respondents.

The sampling variance of the above estimator may be given as[9]:

\[
V\left[p\left(\frac{\sum_{i=1}^{n}}{n}\right)\right] = \frac{p(D)(1-p(D))}{n[p(C)]^2}
\]  \hspace{1cm} (2)

For larger n, confidence interval of estimated proportion is given as:

\[
[p(\hat{T}_{RRT}) \pm z_{1-\alpha/2} \sqrt{V[p(\hat{T}_{RRT})]}]
\]  \hspace{1cm} (3)

Where, under standard normal distribution $z_{1-\alpha/2}$ at 95% confidence level is 1.96.

Moors [11] reported that randomized response technique had better efficiency if ratio of sensitive question vs. unrelated question is 7:3. So keeping this in view, proportion of students responding question on ever tobacco use i.e., proportion of students who answered questionnaire related to ever tobacco use was taken as 0.70. Likewise, in case of ever alcohol use also, this proportion remained same.

Direct Interview survey method is a method where interviewer enquires the required information directly from interviewee. If D is the number of students who had given yes for ever using tobacco in direct interview among n respondents, then the proportion of tobacco user $p(Di)$ is defined as:
\[ p(T_{DI}) = \frac{D}{n} \]  

(4)

For larger \( n \), confidence interval (C.I.) of estimated proportion is given as:

\[
\left[ p(T_{DI}) \pm z_{1-\alpha/2} \sqrt{\frac{p(T_{DI})(1-p(T_{DI}))}{n}} \right]
\]

(5)

Where, under standard normal distribution \( z_{1-\alpha/2} \) at 95% confidence level is 1.96. The difference of estimate of proportion of ever tobacco use (\( \Delta p_{ETU} \)) Difference between proportions of ever tobacco (\( \Delta p_{ETU} \)) used observed in RRT and Direct Interview methods calculated as:

\[
\Delta p_{ETU} = P(T_{RRT}) - P(T_{DI})
\]

(6)

and it one sided 95% confidence interval (LCL, UCL) was calculated as:

\[
\Delta p_{ETU} - 1.64 \sqrt{(s.e_{RRT})^2 + (s.e_{DI})^2}, \Delta p_{ETU} + 1.64 \sqrt{(s.e_{RRT})^2 + (s.e_{DI})^2}
\]

(7)

**Definition of Ever Tobacco Use and Ever Alcohol Use**

Ever tobacco use was considered as at least one time ever use of tobacco like smoking of Cigarette, Cigar, Hooka, Beedi; and Khaini Gutkha, Panmasala containing tobacco, by the student. Ever alcohol use was considered as at least one time use of alcoholic material like Beer Breezers, Desi sharab, Wine, Whisky, Rum, and Vodka, by the student.

**Sample Size**

For tobacco use, considering prevalence among adolescents (NFHS-3[12]) under direct method as 13% and its expected level as 20 percent under randomized response technique, at 95% level of confidence and 80% power of study, minimum sample size required in each group came as 347 students. For alcohol use, considering prevalence among adolescents (NFHS-3[12]) under
direct method as 5% and its expected level as 12 percent under randomized response technique, at 95% level of confidence and 80% power of study, sample size required in each group came as 200 students. Accordingly, a target to cover at least 350 in each group was fixed.

**Data collection**

The primary data was collected though cross-sectional survey exclusively developed for this study. Survey was conducted among students of 9\textsuperscript{th} to 12\textsuperscript{th} class from purposively selected three schools of Delhi/National Capital Region (N.C.R), during November-2014 to November-2016. Before conducting survey, the permission from concerned school authority like New Delhi Municipal Cooperation (N.D.M.C) or principal or both was taken. From ethical point of view, name of school and name of interviewed individual students will not be disclosed here. Among these three schools, School-A was public school from Ghaziabad U.P, (Delhi NCR), and other two schools (i.e., School-B and School-C) were government schools from Delhi. Students of ninth class of two schools (i.e., School-A and School-C) were not included because principal of concerned schools did not give permission for surveys in those classes. Before conducting the study, it was approved by the Institute Ethics Committee, All India Institute of Medical Sciences (AIIMS), New Delhi.

During survey, strength of students (total number) in each class was obtained from each school and participant information sheet, consent from parents and assent form containing information about date of birth from students, was distributed. During next visit, students present in the class on that day and gave written consent and assent in each class/section were first divided in two groups using simple random allocation list (1:1) with the help of random number table and serial listing of students in the class. One group was considered under RRT and another under direct interview method.
Under randomized response technique, as stated earlier, framework of unrelated question (9) with known or guessable prevalence of unrelated question among surveyed subjects was utilized. Randomized response technique for ever tobacco use survey consists of either of two questions, first was related to sensitive attribute, i.e., “Did you ever use tobacco like smoking of Cigarette, Cigar, Hooka, Beedi; and Khaini, Gulkha, Panmasala containing tobacco?” (S1); and second was unrelated question, e.g., “Were you born in January or February?” (S2) Likewise, under ever alcohol use survey, either of two questions was utilized, i.e., “Did you ever drink alcohol like Beer Breezers, Desi sharab, Wine, Whisky, Rum, and Vodka?” (S3) Or Unrelated attribute “Were you born on 1\textsuperscript{st}, 2\textsuperscript{nd}, 3\textsuperscript{rd}, 4\textsuperscript{th}, 5\textsuperscript{th} day of any calendar months of the year?” (S4). In each of the two studies on ever tobacco use and ever alcohol use, randomly arranged both questionnaires (ratio of sensitive question vs. unrelated question as 7:3) served as a random device.

Before conducting survey, under randomized response technique, each of the above mentioned two questions under studies on tobacco/alcohol surveys was printed separately on similar looking papers/questionnaires in ratio of sensitive question vs. unrelated question as 7:3. Further, using random number table, these two questionnaires were arranged in unpredictable sequence for each class/each section of a class and sealed accordingly in opaque envelops to ensure concealment of questionnaires. Finally, this randomly arranged questionnaire sequence served as random device in our survey. Similar arrangement was done in case of ever alcohol use survey under RRT method.

The students covered under RRT were instructed that they should neither discuss about questions among them, nor put any identification mark on answer sheet. Further, after writing only either “Yes” or “No” as answer, they should drop answer sheet into the container kept outside
classroom. After above instructions, students selected to be covered under RRT were shifted to other room one by one where randomly arranged questionnaire set was kept. Each of the students picked up one questionnaire sequentially available on his turn. One of the research team member, totally unknown to students, was present in the room for smooth conduct of survey by maintaining desired rule and guiding students if they had problem. The answer sheets were collected in above instructed manner. After completing first survey on ever tobacco use, another survey for ever alcohol use under RRT was conducted on same students using second set of questionnaires arranged independently in described manner earlier.

Under direct interview method (D.I), direct interview was taken on both sensitive questions, i.e., ever tobacco use and ever alcohol use. Both surveys were conducted on same students who were allocated under direct interview method in each section/class. For this, a researcher totally unknown to students interviewed each student one by one. Under ever tobacco use survey, he asked sensitive question “Did you ever use tobacco like smoking of Cigarette, Cigar, Hooka, Beedi; and Khaini, Gutkha, and Panmasala containing tobacco?”, whereas under ever alcohol use survey, he asked question “Did you ever drink alcohol like Beer Breezers, Desi sharab Wine, Whisky, Rum, and Vodka?”, directly to each of the respondent.

Out of 999 students in three schools, who were eligible for survey, 938 (93.9%) had given assent and consent. Among them, only 796 (84.9%) were present at time of survey and took part in the study. Details of school-wise and class-wise distribution of covered 796 students are given in Appendix-1.
Results

Out of 796 covered students, 401 students were surveyed through randomised response technique (RRT) and 395 through Direct Interview method for both, ever tobacco use and ever alcohol use. Among 401 students, as extracted from assent forms, 62 (15.5%) students were born in month of January or February (i.e., \( p(B) = 0.155 \)). As stated earlier, for better efficiency, the ratio of questionnaires with sensitive question (ever tobacco use) vs. unrelated question (born in month of January or February) was 7:3; hence, \( p(C) = 0.70 \). Under RRT survey, total “yes” answered by surveyed students in tobacco survey i.e., yes answers to either of two questions (sensitive and unrelated), was by 71 (17.7%) students. Accordingly, probability of getting yes answer among total respondents becomes 0.177, that is, \( p(D) = 0.177 \). So using equations (1&3), derived estimated percentage of ever tobacco users under RRT survey came as 18.6% (95% C.I.: 13.33, 24.01) In other words, RRT approach revealed prevalence of ever tobacco use as about 19% and its 95 interval estimate as 13% to 24%. Further, among 395 surveyed through direct (face to Face) interview method, 40 students reported that they had used tobacco products once or more until the day of survey. So, percentage of ever tobacco users in surveyed students was 10.1% (95% CI: 7.15, 13.10). In other words, under direct interview method, prevalence of ever tobacco use emerged to be about 10% and its 95% interval estimate as 7% to 13%.

Likewise under ever alcohol use survey using RRT, as extracted from assent forms of 401 surveyed students, 70(17.5%) were born on 1\(^{st}\), 2\(^{nd}\), 3\(^{rd}\), 4\(^{th}\) & 5\(^{th}\) day of any calendar months of the year, that is, \( p(B) = 0.175 \). As reported in case of ever tobacco use survey using RRT, \( p(C) = 0.70 \). Further, since 85(21.2%) students had given yes answer in survey to either of two questions, probability of getting yes answer among total respondents becomes 0.0.212, that is, \( p(D) = 0.212 \). So derived estimated proportion of ever alcohol users, using equations
(1&3), and 95% C.I., was 22.8% (17.09, 28.51). In other words, RRT approach revealed prevalence of ever alcohol use as about 23% and its 95 interval estimate as 17% to 29%. Under direct interview method, 36 (9.1%) students reported that they had used alcoholic products once or more until the day of interview (95% C.I.: 06.27, 11.95). In other words, under direct interview method, prevalence of ever alcohol use emerged to be about 9% and its 95% interval estimate as 6% to 12%.

Table 1: Comparison of Prevalence under Two Methods (RRT vs. Direct Interview)

| Survey            | Prevalence (95% C.I.) | Difference (95% C.I. one sided) |
|-------------------|-----------------------|---------------------------------|
|                   | RRT                   | Direct Interview                |                                |
| Ever tobacco use  | 18.6 (13.33-24.01)    | 10.1 (7.15-13.10)               | 8.5 (3.43-13.65)               |
| Ever alcohol use  | 22.8 (17.08-28.51)    | 9.1 (6.27-11.95)                | 13.6 (8.34-19.03)              |

As evident from table-1, the direct interview method underreported the prevalence of ever tobacco use by 8.5% (95% CI: 3.43-13.65) in comparison to RRT method. Sample size calculation was calculated by assuming that there may be at least seven percent underreporting by direct interview method, i.e., Null Hypothesis: H₀ ≤ 7; & Alternative Hypothesis: H₁ > 7. Although, direct interview underreported the prevalence of ever tobacco use but it is not statistically significant because 95% confidence interval includes 7 i.e., Null hypothesis cannot be rejected. However, under ever alcohol use survey, direct interview method underreported prevalence of ever alcohol use by 13.6% (95% CI: 8.34-19.03) as compared to RRT survey which is statistically significant. Further, comparative results on ever tobacco use and ever alcohol use
suggest that under estimation by direct interview method was more regarding alcohol use than tobacco use. In other words, under estimation increased with increase of sensitivity of the topics.

Discussion

In the present study, the used random device under RRT approach is proposed in the form of a set of randomly arranged questionnaires containing either sensitive or unrelated questions. It is easy to handle and understandable by the researchers. The principal characteristics of a random device under RRT have been reported as ease of use, trustworthy, and easily available [4]. The present random device is intuitively handy and researchers may be able to carry out the randomisation quickly and without too much effort. Also, this random device may obviously ensure to obtain response to sensitive questions with more accuracy and in unbiased manner. Further, this device may easily be developed regarding any study on sensitive topics. As such, to the best of our knowledge, the present study is first to propose and use such random device.

The data collected on ever tobacco use among adolescents using randomised response technique (RRT) revealed its prevalence as 18.6% (95% CI: 13.33-24.01); and that using direct interview or face to face interview method as 10.1% (95% CI:7.15-13.10)%. Further, it was observed that direct interview method underreported the prevalence by 8.5% (95% CI: 3.43-13.65). However, one sided confidence interval did not show this as statistically significant. Similar result was reported by other studies [7, 13]. The ever alcohol use survey among adolescents using randomised response technique (RRT), prevalence of ever alcohol use came as 22.8% (95% CI: 17.08-28.5); whereas that under direct interview method as 9.1% (95% CI: 6.27-11.95). As observed in case of ever tobacco use, in comparison to RRT, direct interview method underreported the prevalence of ever alcohol use by 13.6% (95% CI: 8.34-19.03).
However, in contrary to ever tobacco use, one sided confidence interval of difference in prevalence under both methods shows this as statistically significant. The results obtained in present study are in line with those reported by earlier studies [7,8,14] The key finding under present study is that estimates of both, prevalence of ever tobacco use and ever alcohol use, among adolescents were higher under RRT approach in comparison to direct interview (face to face interview) method. Further, the variability associated with RRT estimates was considerably higher. Further, comparative results between two methods on ever tobacco use and ever alcohol use suggest that extent of underreporting by direct interview method was more in case of alcohol use than tobacco use. In other words, as contents of used substance become more sensitive, under reporting of burden under direct interview method is pushed higher side. Similar finding is also reported under earlier studies [7].

Conclusion

In comparison to RRT, the direct interview method may provide underreporting of sensitive events which may be pushed further higher side in case of highly sensitive events. The present study has amply shown that assuring privacy of information through use of a random device under RRT will result into more accurate reporting of socially unacceptable behaviours like ever tobacco use and ever alcohol use among adolescents. Further, the findings under the present study has confirmed the utility of the randomized response technique as a versatile method for gaining access to more accurate information on sensitive social problems. As such, the present study has shown the path regarding possible use of such approach (RRT) in estimating prevailing burden in relation to sensitive topics more accurately. This may however require further exploration regarding feasibility of its use under large scale surveys on the sensitive topics.
**List of abbreviations**

A.I.I.M.S: All India Institute of Medical Sciences; DI: Direct Interview Method; ETU: Ever Tobacco Use; N.C.R: National Capital Region; N.D.M.C: New Delhi Municipal Cooperation; N.F.H.S: National Family Health Survey; RRT: Randomized Response Technique; s.e.: Standard Error.

**Declarations**

**Ethics approval and consent to participate**

The present study was approved by Ethics Committee for Post graduate research, All India Institute of Medical Sciences, New Delhi, India. A written assent from participants and written consent from their parents was taken before collection of data.

**Consent for publication**

Not applicable

**Availability of data and material:**

Study data may be made available on demand by the first author.

**Competing interests:**

The authors declared that they have no competing interests.

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**Authors' contributions:**
Ashish Datt and Sada Nand conceived and designed the study. Ashish Datt conducted the survey, collected data and did the analysis under supervision of corresponding author, Sada Nand. All the authors were involved in interpretation of the results. The final draft of the manuscript was prepared by First author, Ashish Datt, under supervision of corresponding author, Sada Nand. All authors read and approved the final manuscript.

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First author is a Ph.D. student under the guidance of corresponding author and co-guidance of other authors. Corresponding author is Professor of Biostatistics; third author is Professor of Psychiatry; whereas fourth author is ex- Professor of Biostatistics, All India Institute of Medical Sciences (AIIMS), New Delhi, India.
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Appendix- 1: Socio-demographic Characteristics of Respondents under RRT and Direct interview Surveys

| Characteristics | Under RRT n=401 | Under Direct interview (DI) n=395 | p-value |
|-----------------|-----------------|----------------------------------|---------|
| Age (yrs)#      | 16.70±1.97      | 16.45±1.90                       | 0.069   |
| School@         |                 |                                  |         |
| School-A        | 131 (32.7)      | 124 (31.4)                       | 0.89    |
| School-B        | 191 (47.6)      | 189 (47.8)                       |         |
| School-C        | 79 (19.7)       | 82 (20.8)                        |         |
| Type of Schools@|                 |                                  |         |
| Private         | 131 (32.7)      | 124 (31.4)                       | 0.700   |
| Government      | 270 (67.3)      | 271 (68.6)                       |         |
| Gender@         |                 |                                  |         |
| Male            | 266 (66.3)      | 273 (69.1)                       | 0.402   |
| Female          | 135 (33.7)      | 122 (30.9)                       |         |
| Class@          |                 |                                  |         |
| 9th             | 25 (6.2)        | 26 (6.6)                         |         |
| 10th            | 105 (26.2)      | 105 (26.6)                       | 0.912   |
| 11th            | 171 (42.7)      | 159 (40.3)                       |         |
| 12th            | 100 (24.9)      | 105 (26.5)                       |         |

@: Data as presented as frequency (%) and Chi-square test applied
#
#: Presented as mean (±S.D) and unpaired t-test applied