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Original article

Self-reported smoking among adolescents: How accurate is it with the urine cotinine strip test?

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ABSTRACT

Background & Objective: In the local setting, the prevalence of smoking among adolescents varies, as it is based only on self-reporting without biomarker validation. The objective of the present study was to determine the accuracy of self-reported smoking among adolescents as compared to that of the urine cotinine strip test.

Methods: We performed a cross-sectional study of 314 adolescents aged 16 years from February 2015 to April 2015 in Putrajaya, Malaysia. The accuracy of self-reporting was assessed using a data collection sheet and was validated by the urine cotinine strip test. Three schools were chosen by the simple random method, where all Form 4 students constituted the sample unit. The kappa statistic was used for determining agreement between self-reporting and urine cotinine strip testing.

Results: There was a substantial agreement between self-reporting and the urine cotinine strip test (kappa = 0.757, 95% confidence interval [CI]: 0.63, 0.88); there was 95.86% overall agreement. The prevalence of self-reported smoking was 8% (95% CI: 7.47, 8.53) and that of urine cotinine strip testing was 10.8% (95% CI: 10.20, 11.41). There was a discrepancy with the results of the urine cotinine strip test in 8% of self-reported smokers and 3.8% of self-reported nonsmokers. Self-reporting had 67.6% sensitivity and 99.3% specificity as compared to those of urine cotinine strip testing and had 92% positive predictive value and 96.2% negative predictive value.

Conclusion: Self-reporting can be used to assess smoking status but should be used with care among adolescents. Urine cotinine strip test validation of self-reporting enables the measurement of the true prevalence of smoking among adolescents.

1. Introduction

Worldwide, the prevalence of smoking among adolescents ranges from 13% in the United States, 21% in England and 45% in Greenland [1]. In Malaysia, the most recent National Health and Morbidity Survey III (NHMS III) in 2006 reported an 8.7% prevalence of smoking among adolescents; [2] this finding is inconsistent with that of local studies conducted between 2000 and 2011, which showed that the prevalence of adolescent smokers was from 14%, [3,4] 29%, [5] 32.8%, [6] 35%, [7] to 37% [8].

The above studies used only self-reporting to determine the prevalence of smoking. The authors have pointed out a limitation that the self-reporting was not verified using biomarkers, which could have resulted in underestimation of the actual prevalence of smoking [4,5]. Self-reporting may have underestimated the actual prevalence of cigarette smoking by up to 4% in some populations [9,10].

There is often skepticism regarding the validity of self-reported smoking, as it is widely believed that smokers are inclined to underestimate the amount smoked [11,12] or to deny smoking entirely [13,14]. The validity of self-reported smoking among adolescents has also been questioned, as socially unacceptable behavior would likely be unreported [15]. If a respondent experiences pressure because of social and medical disapproval, then self-reporting can

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be unreliable [16].

Biochemical verification is therefore recommended to ensure that self-reporting is accurate, as significant misclassification or deception has been reported [17]. The commonly used biomarkers or tools for determining active smoking status are expired carbon monoxide, thiocyanate, nicotine, and cotinine [18]. The availability, cost, and ease of administration of these measures and biomarkers differ widely. It is easier to determine carbon monoxide and thiocyanate levels, but time of day, diet, exposure to pollution, and physical activity may influence their levels [19,20]. Nicotine measurement has the advantage of being specific to tobacco but requires expensive laboratory instruments [18]. It is also unsuitable, as its half-life in the blood is relatively short, that is, 2 h [21]. The sensitivity and specificity of cotinine are higher than those of other biochemical tests. Therefore, it is considered the best indicator of tobacco smoke exposure [18,22].

The half-life of cotinine is 20 h, enabling detection for up to 1 week from the last smoking episode [23]. The advantage of cotinine is that it is nicotine-specific, has a long half-life (15–40 h), and is directly proportional to the quantity of nicotine absorbed [24]. Cotinine is possibly the best marker when accuracy is paramount; [25] it is a more specific and sensitive measure of tobacco and can be measured in urine, saliva, and plasma [26].

An evaluation of the accuracy of urinary cotinine strips suggested that they appear to determine smoking status reasonably accurately [27]. Another study that used a urinary cotinine test strip showed that the test is a rapid and simple method for detecting urine cotinine [28].

To the best of our knowledge, no study in the local setting has compared smoking status based on self-reporting and urine cotinine testing, whether in adolescents or in other age groups or populations. We hope that this study will shed light on the issue and determine whether the current approach of self-reported smoking is sufficient and accurate enough to be used in schools to differentiate adolescent smokers and nonsmokers.

This study would enable accurate measurement of the true prevalence of smoking in adolescents. The limitation of the previous prevalence studies can be overcome, as the subject's smoking status would be accurately measured by the biomarker. Therefore, we aimed to establish the accuracy of self-reported smoking in adolescents as compared to that of urine cotinine strip testing and to identify and predict factors associated with the discrepancy between self-reporting and urine cotinine strip testing.

2. Methodology

2.1. Study design

This was a cross-sectional validation study performed from February 2015 to April 2015. The study involved Form 4 students in secondary schools in Putrajaya, a federal territory of Malaysia that is recognized as 100% urbanized.

2.2. Study population and sampling

The target population was adolescents aged 16 years. The sample population was Form 4 students from secondary schools in Putrajaya. From the 11 schools there, three schools namely, Sekolah Menengah Putrajaya Presint 8, Sekolah Menengah Putrajaya Presint 14, and Sekolah Menengah Putrajaya Presint 9, were selected for inclusion in the study by the simple random method. The inclusion criterion was all Form 4 students, and therefore, all Form 4 students in the three schools formed the sampling frame of the study. Students were excluded if they refused to participate (no parental consent as they are > 18 years old), failed to return their urine sample, were unable to read and write, and were absent on the day of the study.

Based on the study objectives, the largest sample size was calculated from the two proportions of discrepancy formula using Power and Sample Size (PASS) version 3.1.2, [29] which yielded a value of 299. By adding 10%, we determined that the final sample size was 329. However, during data collection, only 314 students were eligible respondents, i.e., 95.4% of the response rate, after considering the inclusion and exclusion criteria.

2.3. Study tools

The two study tools used were the standardized data collection sheet and the urine cotinine strip test. The data collection sheet was used to assess the self-reported smoking status of the respondents. The sheet is divided into three major domains: the respondent's sociodemographic factors, the parents' factors, and the respondent's smoking status ("Yes" or "No"). The respondents were considered as smokers if they smoke through any mode such as cigarette, e-cigarettes, and shisha.

The students were later asked to provide a urine sample, which was then tested with the urine cotinine strip test [Cotinine COT Rapid Test Device (Urine), Innovacon, Inc., San Diego, CA, USA], a rapid visual immunoassay for detecting cotinine in human urine qualitatively and presumptively at the cut-off of 200 ng/m. Urine cotinine levels of <100 ng/mL in passive smokers are not detected as positive by this device [30]. Cotinine is detected visually by interpreting color development on the device.

We compared and checked the accuracy of the device against a commercially available test with the same cut-off threshold value. There was >99.9% agreement between the tests, and the device had 99% sensitivity [31]. The device has a very high specificity of 96%, yielding a positive result in less than 5 min when the urine cotinine concentration is 200 ng/mL.

2.4. Variable definition

In the data collection sheet, self-reported smoker status was defined as having smoked for the past 7 days and self-reported non-smoker status was defined as not having smoked in the past 7 days. In the urine cotinine test, smoker status was defined as a positive strip test result for the presence of cotinine and nonsmoker status was defined as a negative strip test result for the presence of cotinine. Discrepancy was defined as a difference in the smoking status between self-reporting and urine cotinine testing, either when the respondents self-reported as non-smokers but had a positive urine cotinine test result or vice versa.

For family characteristics, high education level was defined as STPM (Sijil Tinggi Persekolahan Malaysia, equivalent to GCE Advanced levels), certificate, diploma, degree, master's, and onwards from higher education institutes, while low education was defined as primary and secondary school level up to SPM (Sijil Pelajaran Malaysia, equivalent to GCSE or GCE Ordinary level). High, middle, and low income was defined as a total family income of ≥RM10,000, RM3,000–9,999, and <RM3,000, respectively. This was based on the Report of Household Income and Basic Facilities 2012 [32].

2.5. Statistical analysis

Descriptive analysis of all relevant data was performed first, and the results are reported as number and percentage. Kappa statistic was used for determining agreement between self-reporting results and urine cotinine testing results. Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS)

version 22.0.

2.6. Ethical consideration

Participation in the study was voluntary. Parents and students were informed that no personal identification of the students would be collected on any occasion and the students' smoking status would remain anonymous. The researcher was blinded to the smokers' identities, and the parents were informed of these details. The respondents and parents received a Patient (Respondent) Information Sheet with Informed Consent before the data collection. Only consenting students were included in the study. Ethical approval was obtained from the Universiti Kebangsaan Malaysia (UKM) Ethics Committee (UKM 1.5.3.5/244/FF-2015-072) and the Malaysian Ministry of Education [KP(BPPDP)603/5/JLD.10] before the study commenced.

3. Results

3.1. Respondents' characteristics

Of the 314 respondents in the study, 171 (54.5%) were male and 143 (45.5%) were female; all respondents were Malay. No girls were smokers as determined by either self-reporting or urine cotinine testing. Self-reporting showed that 8% of respondents had smoked in the previous 7 days (95% confidence interval [CI]: 7.47, 8.53), whereas urine cotinine testing showed that the prevalence was 10.8% (95% CI: 10.20, 11.41). Table 1 shows the respondents' family characteristics.

3.2. Agreement between self-reporting and urine cotinine testing

The accuracy of self-reported smoking status as compared with that of the gold standard of urine cotinine testing was determined depending on the agreement between the two modalities. There was substantial agreement between self-reporting and urine cotinine testing (kappa = 0.757, $P < .001$, 95% CI: 0.63, 0.88); overall agreement was 95.86%. Table 2 shows the agreement table.

There was discrepancy with the urine cotinine strip test result in 8% of self-reported smokers and 3.8% of self-reported nonsmokers. Self-reporting had 67.6% sensitivity and 99.3% specificity compared to those of urine cotinine testing and 92% positive predictive value (PPV) and 96.2% negative predictive value (NPV).

The kappa agreement was analyzed according to the respondents' family characteristics to investigate whether the agreement became stronger or weaker among the group. Kappa agreement was higher or very good (kappa >0.8) in fathers with nonprofessional jobs, fathers and mothers with low education, nonsmoker fathers, and middle-income families. Table 3 shows the agreement between self-reporting and urine cotinine testing according to family characteristics.

Table 1
Characteristics of the respondents' family.

Characteristics	Frequency, n (%)
Father's Occupation	
Professional	105 (33.4)
Nonprofessional	76 (24.2)
Not working	1 (0.3)
Father's Education Level	
High Education Level	181 (57.6)
Low Education level	102 (32.5)
Mother's Occupation	
Professional	86 (27.4)
Nonprofessional	58 (18.5)
Not working	79 (25.2)
Mother's Education Level	
High Education Level	167 (53.2)
Low education Level	105 (33.4)
Family Financial Income	
High Income	70 (22.3)
Middle Income	140 (44.6)
Low Income	37 (11.8)
Father's smoking status	
Smoker	119 (37.9)
Nonsmoker	150 (47.8)
Ex-smoker	42 (13.4)
Mother's smoking status	
Smoker	0 (0.0)
Non-smoker	306 (97.5)
Ex-smoker	2 (0.6)

Notes: Because of missing values of the covariates, the n was different from one another.

4. Discussion

Our results indicate substantial agreement between self-reporting and the urine cotinine strip test (kappa = 0.757, $P < .001$, 95% CI: 0.63, 0.88). This kappa value is much lower than that in two previous studies that used the same methods but which involved adults, where the kappa value was 0.92 (95% CI: 0.87, 0.97)[33] and 0.85 (95% CI: 0.88, 1.00) [34]. The stronger agreement in the two studies suggests that the self-reported smoking status of adolescents is not highly reliable. However, there has been no study of adolescents based on the kappa statistic against which our results can be compared.

Here, self-reporting had higher specificity (99.3%) than sensitivity (67.6%) compared to those of urine cotinine testing. A previous study using the same methods but involving adults reported 97.4% specificity and 95% sensitivity [27]. The comparatively lower sensitivity of self-reporting in the present study could be explained by the different age groups of respondents. This supports the results of the Canadian study that reported lower sensitivity in the younger age group than in the older age group [35].

In the present study, there was 8% discrepancy between self-reported smoking results and positive urine cotinine test results. For comparison with respondents in the same age group, a study that used saliva cotinine as the biomarker showed 7% discrepancy, [15] which supports the present findings. Studies of adults have reported 3.9% and 6% discrepancy [36,37]. This gives the impression that the discrepancy is smaller among adults than among adolescents.

In the present study, the self-reported prevalence of smoking in the previous 7 days was 8% (95% CI: 7.47, 8.53) and that of urine cotinine testing was 10.8% (95% CI: 10.2, 11.41), which is 2.8% higher than the self-reported prevalence. This 2.8% difference in prevalence is slightly higher than that of only 0.8% reported in a study involving adults [38]. This again supports the earlier assumption that there is a higher chance that adolescents would be dishonest about their smoking status, as they would face much greater social disapproval.

Table 2
Agreement of self-reported smoking status with the Urinary Cotinine Strip Test result.

Self-reported smoking	Urinary Cotinine Strip Test Result		Total
	Smoker (Positive)	Nonsmoker (Negative)	
Smoker	23	2	25
Non-smoker	11	278	289
Total	34	280	314

Kappa: 0.757, $P < .001$.

Table 3
Agreement of self-reported smoking status with urine cotinine strip test result by Kappa value.

Characteristics	n (%)	Agreement of self-reported smoker with Urine Cotinine strip test (%)	Agreement of self-reported Non-smoker with Urine Cotinine strip test (%)	Kappa value (95% CI)
Father's Occupation				
Professional	105 (58.0)	100.0	97.1	0.653 (0.29, 1.03)
Nonprofessional	76 (42.0)	87.5	97.1	0.801 (0.58, 1.00)
Father's Education Level				
High Education Level	181 (64.0)	81.8	95.3	0.614 (0.40, 0.83)
Low Education level	102 (36.0)	100.0	96.8	0.826 (0.64, 1.00)
Mother's Occupation				
Professional	86 (59.7)	100.0	97.6	0.491 (−0.11, 1.00)
Nonprofessional	58 (40.3)	75.0	96.3	0.639 (0.26, 1.00)
Mother's Education Level				
High Education Level	167 (61.4)	75.0	96.9	0.484 (0.13, 0.84)
Low education Level	105 (38.6)	92.3	95.7	0.800 (0.63, 0.97)
Family Financial Income				
High Income	70 (28.3)	100.0	94.2	0.317 (−0.16, 0.79)
Middle Income	140 (56.7)	90.9	99.2	0.901 (0.77, 1.00)
Low Income	37 (15.0)	100.0	88.6	0.456 (0.03, 0.88)
Father's smoking status				
Smoker	119 (44.3)	85.7	92.4	0.659 (0.47, 0.85)
Nonsmoker	150 (55.7)	100.0	97.9	0.847 (0.68, 1.00)
Mother's smoking status	306 (100)			
Smoker		–	–	–
Nonsmoker		92	96.8	0.788 (0.67, 0.91)

Kappa statistic, $P < .001$

For family characteristics, the two modalities had differing kappa values. The kappa value was higher for nonprofessional fathers, both mothers and fathers with lower education levels, nonsmoker fathers, and middle-income families. As there are few such studies on adolescents, our findings cannot be compared with those of other studies, as it involves family characteristics. Therefore, we may assume that the father's characteristic has more influence on agreement between self-reporting and urine cotinine testing. We may also assume that a respondent with a nonprofessional father, a father with lower education, or a smoker father would be more afraid of their father; thus, agreement between self-reporting and urine cotinine testing in such respondents would be much stronger than that in other respondents.

To the best of our knowledge and in the literature, there has been no study on the validation of self-reported smoking in Malaysia thus far. This could be the strongest aspect of the present study. Although Western researchers have questioned the accuracy of self-reported smoking status, they have focused more on high-risk groups such as pregnant women, [36] patients with lung cancer, [34] and other adults [33]. The present study is one of the few limited studies focusing on adolescents.

One limitation of our study is that it focused on an urban area, where the respondents could have highly similar family backgrounds. We suggest that a study involving a rural area in Malaysia would yield different results. A suggestion for future investigation is to perform the same study, but with a comparative approach, in two sets of respondents, namely, those from urban and rural areas. Another limitation is that respondent characteristics such as race and sex were not explored thoroughly.

5. Conclusion

Self-reporting can be used to assess smoking status, but it should be used with care in adolescents. Validating the self-reported smoking status with urine cotinine strip testing enables measurement of the true prevalence of smoking in adolescents. The respondents' family characteristics do not appear to be a predictive factor of discrepancy between self-reported and urine cotinine strip-tested smoking status. The urinary cotinine strip test appears promising as an inexpensive, noninvasive, rapid, and easy-to-use method for validating smoking status in adolescents and may be suitable for use in the school setting. The present study is the first validation study in the local setting and hopefully will be a benchmark for further studies on smoking and the validity of self-reporting.

Ethical consideration

Participation in this study was voluntary. Parents and students were informed that no personal identification of the students would be collected on any occasion and the smoking status of the students would remain anonymous. The researcher was blinded to the smokers' identities, and these details were informed to the parents. Patient (Respondent) Information Sheet with informed consent was given to the respondents and parents before data collection. Only the consented students were involved in this study. Ethical approval was obtained from the UKM Ethics committee (UKM 1.5.3.5/244/FF-2015-072) and the Malaysian Ministry of Education (KP(BPPDP)603/5/JLD.10) before the study commenced.

Declaration of interest

The authors declare that they have no competing interest.

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