

## RESEARCH PAPER

# Assessment of nicotine dependence symptoms in adolescents: a comparison of five indicators

J O'Loughlin, J DiFranza, J Tarasuk, G Meshefedjian, E McMillan-Davey, G Paradis, R F Tyndale, P Clarke, J Hanley

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See end of article for authors' affiliations

Correspondence to:  
Jennifer O'Loughlin, PhD,  
Direction de santé publique  
de Montreal-Centre, 1301  
Sherbrooke Street East,  
Montreal, Quebec H2L  
1M3, Canada;  
jennifer.oloughlin@mcgill.ca

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**Objective:** To examine the psychometric properties, test-retest reliability, and convergent construct validity of five indicators of nicotine dependence (ND) symptoms in adolescents.

**Design:** Analysis of baseline data from a prospective study on the natural history of ND in 1264 adolescents aged 12–13 years.

**Setting:** Ten Montreal high schools.

**Subjects:** 233 grade 7 students who had smoked cigarettes one or more times in the three months preceding the baseline data collection.

**Main outcome measures:** Five indicators of ND symptoms including two that are multi-dimensional (a proxy measure of ICD-10 criteria for tobacco dependence; the Hooked on Nicotine Checklist (HONC)) and three new indicators of "symptom clusters" that emerged from principal component analysis (ND/cravings, withdrawal symptoms, self medication).

**Results:** All five indicators demonstrated acceptable internal and test-retest reliability. The correlation between the HONC and ND/cravings was 0.910. All other correlations between indicators ranged between 0.716–0.824. There was considerable overlap in the independent correlates identified for each indicator.

**Conclusions:** All five indicators performed well psychometrically. Until the meaning, relative importance, and usefulness of each scale is clarified in longitudinal work, decisions regarding which scale(s) are most informative will depend more on the content of the scales, the need for a multi- or uni-dimensional indicator, and whether or not the scale is theory based.

Contrary to prevailing theories advocating that nicotine dependence (ND) develops only after lengthy periods of regular or daily exposure to cigarettes,<sup>1</sup> recent evidence suggests that ND symptoms occur even with the irregular, sporadic smoking that characterises the early stages of smoking onset.<sup>2</sup> Increased understanding of the process by which ND is established is crucial to developing effective prevention and cessation strategies for adolescents, yet few studies to date have examined the natural history of ND. This relates in part to the lack of a widely accepted, theoretically derived, and psychometrically sound tool to measure ND in adolescents.<sup>3</sup> This article describes the derivation, and compares the psychometric properties, reliability, and convergent construct validity of five indicators of ND symptoms used in an ongoing prospective study investigating the development of ND symptoms in relation to the onset of smoking. Data for this analysis were drawn from the baseline data collection.

## METHODS

The McGill University study on the Natural History of Nicotine Dependence in Teens (NDIT study) is a prospective study of 1264 students initially aged 12–13 years, recruited from all grade 7 classes in a convenience sample of 10 Montreal secondary schools (seven English speaking and three French speaking schools). The primary objectives are to measure the onset of ND symptoms in relation to tobacco exposure, and to investigate the relative aetiological importance of environmental and genetic risk factors for ND. Secondary schools were selected in consultation with local schools boards and school principals, to include a mix of French and English speaking schools, urban, suburban, and rural schools, and schools located in high and low socioeconomic neighbourhoods. In addition all schools purportedly had a relatively low turnover

of students. All 13 schools approached agreed to participate; three schools were excluded, two because of a low return rate of consent forms, and one because school administrators could not guarantee cooperation over the entire study. All subjects and a parent/guardian provided signed informed consent. Over half (56.2%) of eligible students participated in the baseline data collection; the relatively low response is related in part to the need for blood draws for genetic analysis, and also to a labour dispute in Quebec that resulted in teachers in several schools refusing to collect consent forms.

Baseline data collection in the Fall (autumn) of 1999 comprised questionnaires and standardised anthropometric<sup>4</sup> and blood pressure measurements.<sup>5,6</sup> French or English questionnaires were administered according to the language used in each study school, either classroom by classroom or in the school cafeteria to groups of classes. In one school with 85 subjects, we repeated the baseline questionnaire administration one week later to examine test-retest reliability of the study variables.

The study population for the analyses described in this paper includes the 233 subjects from among the baseline sample of 1264 students, who had smoked one or more times, even just a puff, in the three months preceding the baseline questionnaire (201 of the 233 subjects (86.6%) had smoked one or more times in the past month (that is, were past-month smokers)).

**Abbreviations:** DSM-IV, *Diagnostic and statistical manual of mental disorders*, fourth edition; HONC, Hooked on Nicotine Checklist; ICD-10, *International statistical classification of diseases and related health problems*, 10th revision; ND, nicotine dependence; OR, odds ratio

**Table 1** Questionnaire items and response categories for five nicotine dependence (ND) symptom indicators**Hooked on Nicotine Checklist (HONC)**

1. In the past 3 months, did you seriously try to quit smoking completely and forever? (yes, I quit completely and have remained non-smoking ever since; I never tried to quit; yes, I tried to quit but failed)
  2. Do you smoke cigarettes now because it is really hard to quit? (other/I don't know/I smoke so little; I don't know because I have never tried to quit; no; sometimes; often/always)
  - 3a. How physically addicted to smoking cigarettes are you? (not at all, a little, quite, very)
  - 3b. How mentally addicted to smoking cigarettes are you? (not at all, a little, quite, very)
  4. Do you ever have strong cravings to smoke cigarettes? (no; not often/not strong; often/not strong or not often/strong; often/strong)
  5. How often have you felt like you really need a cigarette? (never, rarely, sometimes, often)
  6. Do you find it difficult not to smoke in places where it's not allowed (at a movie theatre, at home if your parents don't know you smoke)? (not at all difficult/I don't know, a bit difficult, very difficult)
- Think about the times you have cut down or stopped using cigarettes or when you haven't been able to smoke for a long period (like most of the day). How often did you experience the following . . . ? (never, rarely, sometimes, often)
7. Trouble concentrating
  8. Feeling irritable or angry
  9. Feeling a strong urge or need to smoke
  10. Feeling nervous, anxious or tense

**ICD-10 tobacco dependence syndrome**

(1) *A strong desire or sense of compulsion to take tobacco: (4 items)*

1. Have you ever had strong cravings to smoke cigarettes? (no, yes)
2. How physically/mentally addicted to smoking are you? (not at all addicted, a little addicted, quite addicted, very addicted)
3. How often have you felt like you really need a cigarette? (never, rarely, sometimes, often)
4. Do you find it difficult not to smoke in places where it's not allowed (at a movie theatre, at home if your parents don't know you smoke)? (not at all difficult/I don't know, a bit difficult, very difficult)

(2) *Difficulties in controlling tobacco taking behaviour in terms of its onset, termination, or levels of use: (2 items)*

1. In the past 3 months, did you seriously try to quit smoking completely and forever? (yes, I quit completely and have remained non-smoking ever since; I never tried to quit; yes, I tried to quit but failed)
2. Do you smoke cigarettes now because it is really hard to quit? (other/I don't know/I smoke so little; I don't know because I have never tried to quit; no; sometimes; often/always)

(3) *A physiological withdrawal state when tobacco use has ceased or been reduced, as evidenced by: the characteristic withdrawal syndrome for tobacco; or use of the same (or a closely related) substance with the intention of relieving or avoiding withdrawal symptoms: (4 items)*

Now think about the times when you have cut down or stopped using cigarettes or when you haven't been able to smoke for a long period (like most of the day). How often did you experience the following . . . ? (never, rarely, sometimes, often)

1. Feeling irritable or angry
2. Feeling restless/Feeling nervous, anxious or tense
3. Trouble concentrating
4. Feeling a strong urge or need to smoke

(4) *Evidence of tolerance, such that increased doses of tobacco are required in order to achieve effects originally produced by lower doses: (2 items)*

How true are each of the following statements for you?

1. Compared to when I first started smoking, I need to smoke a lot more now to be satisfied. (not at all true, a bit true, very true)
2. Compared to when I first started smoking, I can smoke much more now before I start to feel nauseated or ill. (I've never felt nauseated or ill from smoking, not at all true, a bit true, very true)

(5) *Progressive neglect of alternative pleasure or interests because of tobacco use, increased amount of time necessary to obtain or take the substance or to recover from its effects: (4 items)*

How true are each of the following statements for you? (not at all true, a bit true, very true):

1. I spend a lot of time getting cigarettes (going out of my way to a store where I know they will sell to me; trying to find someone who will buy them for me)
2. I've stopped hanging out with certain people because of my smoking
3. I avoid going to a friend's house where you're not allowed to smoke even though I might enjoy hanging out with him/her
4. I have cut down or stopped physical activities or sports because of my smoking

(6) *Persisting with tobacco use despite clear evidence of overtly harmful consequences, such as depressive mood states consequent to periods of heavy substance use, or drug related impairment of cognitive functioning; efforts should be made to determine that the user was actually, or could be expected to be, aware of the nature and extent of the harm: (2 items)*

How true are each of the following statements for you? (not at all true, a bit true, very true):

1. In situations where I need to go outside to smoke, it's worth it even in cold or rainy weather
2. If you are sick with a bad cold or sore throat, do you smoke? (no, I don't have to, I smoke so little; no, I stop smoking when I'm sick; yes, but I cut down on the amount I smoke; yes, I smoke the same amount as when I am sick)

**ND/cravings**

1. In the past 3 months, did you seriously try to quit smoking completely and forever? (yes, I quit completely and have remained non-smoking ever since; I never tried to quit; yes, I tried to quit but failed)
  2. How often do you have cravings to smoke cigarettes? (never, very rarely, sometimes, often, very often)
  3. How physically addicted to smoking cigarettes are you? (not at all, a little, quite, very)
  4. How mentally addicted to smoking cigarettes are you? (not at all, a little, quite, very)
  5. How often have you felt like you really need a cigarette? (never, rarely, sometimes, often)
  6. Do you find it difficult not to smoke in places where it's not allowed (at a movie theatre, at home if your parents don't know you smoke)? (not at all difficult/don't know, a bit difficult, very difficult)
  7. If you are sick with a bad cold or sore throat, do you smoke? (no, I don't have to, I smoke so little; no, I stop smoking when I'm sick; yes, but I cut down on the amount I smoke; yes, I smoke the same amount when I am sick)
  8. How deeply do you usually inhale the smoke? (into my mouth; into my throat; into my lungs shallow; into my lungs deep)
  9. How true is the following statement for you? Cigarettes are good for dealing with boredom (not at all true, a bit true, very true)
  10. Do you smoke cigarettes now because it is really hard to quit? (I don't know/I smoke so little/I quit; no, it is not hard to quit; never tried to quit/I don't want to quit; yes (sometimes, often/always))
  11. On the days that you smoke, when do you usually smoke your first cigarette of the day? (right when I wake up, in the morning, later or another time)
- How true are each of the following statements for you? (not at all true, a bit true, very true)
12. I often run out of cigarettes quicker than I thought I would
  13. I spend a lot of time getting cigarettes (going out of my way to a store where I know they will sell to me; trying to find someone who will buy them for me)
  14. I spend a lot of time smoking cigarettes (chain smoking, smoking a lot throughout the day)
  15. When you see other kids your age smoking cigarettes, how easy is it for you not to smoke? (very easy, quite easy, a bit difficult, very difficult)
  16. How often do you smoke cigarettes when you are alone? (never, sometimes, often/always)

**Table 1** continued

**Withdrawal symptoms:** Think about the times when you have cut down or stopped using cigarettes or when you haven't been able to smoke for a long period (like most of the day). How often did you experience the following? (never, rarely, sometimes, often)

1. Feeling irritable or angry
2. Feeling restless
3. Feeling nervous, anxious, or tense
4. Trouble concentrating
5. Feeling a strong urge or need to smoke
6. Trouble sleeping

**Self medication:** How true are each of the following statements for you? (not at all true, a bit true, very true)

1. I can function much better in the morning after I've had a cigarette
2. When I'm feeling down, a cigarette makes me feel good
3. A cigarette gives me energy when I'm tired
4. Smoking cigarettes calms me down when I feel nervous
5. Smoking cigarettes helps me concentrate on my homework
6. Smoking cigarettes relieves tension when I am stressed

### Description of variables

Sociodemographic data included student's date of birth, sex, language(s) spoken, main language spoken at home, country of birth of each of the student, biologic father and mother, number of years the students has lived in Canada, family composition, and family origin.

### Smoking behaviour

Lifetime smoking history was measured in five items including: (1) Have you ever IN YOUR LIFE smoked a cigarette, even just a puff (drag, hit, haul)?<sup>7</sup> (No; Yes, 1 or 2 times; Yes, 3 or 4 times; Yes, 5 to 10 times; Yes, more than 10 times); (2) Check the one box that describes you best<sup>7</sup> (I have never smoked a cigarette, even just a puff; I have smoked cigarettes (even just a puff), but not at all in the past 12 months; I smoked cigarettes once or a couple of times in the past 12 months; I smoke cigarettes once or a couple of times each month; I smoke cigarettes once or a couple of times each week; I smoke cigarettes every day); (3) How old were you when you smoked a whole cigarette (down to or close to the filter) for the first time; (4) How old were you when you first took cigarette smoke into your lungs for more than one puff; (5) Have you smoked 100 or more whole cigarettes in your life? (100 cigarettes = 4 packs of 25) (Yes; No).

Six items measured smoking in the past three months beginning with the month preceding questionnaire administration.<sup>8</sup> One item for each month measured the number of days on which the subject had smoked during the month, and one item for each month measured the number of cigarettes smoked per day on average (on the days subject had smoked) during that month.

The number of cigarettes smoked during the week preceding questionnaire administration was measured in a seven day recall<sup>9</sup> (one item). A measure of cigarette "single time exposure" was obtained by asking subjects how much of the cigarette he/she usually smokes (one or a few puffs; less than half of it; about half of it; most of the cigarette; right down to or near the filter; and I don't know (I smoke so little/this does not apply to me)). Finally, students reported how often during the past three months they smoked a cigar or cigarillo, or used chewing tobacco or snuff (never, a bit to try, once or a couple of times a month, once or a couple of times a week, usually every day).

For analysis, data on lifetime smoking history and number of cigarettes smoked in the week preceding baseline data collection were used to create four smoking status categories including "triers" (smoked only once or twice in lifetime), "sporadic smokers" (smoked more than twice in lifetime, but not daily and number of cigarettes smoked per week  $\leq$  1.0), "weekly smokers" (smoked more than twice in lifetime, but not daily, and number of cigarettes smoked per week  $>$  1.0), and "daily smokers" (smoked every day).

Quit attempts in the past three months were measured in one item: Did you seriously try to quit smoking completely and forever? (Yes, I quit completely and have remained non-smoking ever since; I never tried to quit; Yes, I tried to quit but failed).

### ND symptom items

A total of 46 items that measured numerous diverse ND symptoms in youth were included in the questionnaire, including the 10 items that comprise the Hooked on Nicotine Checklist (HONC).<sup>10</sup> The remaining items emerged from consultation with seven North American experts on youth smoking, and from six focus groups interviews with teenage smokers aged 14–17 years.<sup>11</sup> The item specific test-retest reliability and convergent construct validity of many of these items were reported in an earlier study.<sup>12</sup> In this current study, most items had multi-level response choices.

### Other variables

Tolerance was measured in three items: How true are each of the following statements for you? (not at all true, a bit true, very true): (1) Compared to when I first started smoking, I need to smoke a lot more now to be satisfied; (2) Compared to when I first started smoking, I can smoke much more now before I start to feel nauseated or ill; and (3) I get dizzy or nauseous when I smoke my usual amount of cigarettes.

Depression symptoms were measured in a six item scale that has been previously validated.<sup>13–16</sup> Subjects reported how often (never, rarely, sometimes, often) in the past three months they: (1) felt too tired to do things; (2) had trouble going to sleep or staying asleep; (3) felt unhappy, sad or depressed; (4) felt hopeless about the future; (5) felt nervous or tense; (6) worried too much about things. Responses were summed to create a depression symptom score (mean (SD) = 2.4 (0.7); median = 2.3; Cronbach's  $\alpha$  = 0.76 in past three month smokers). For analysis, scores were categorised into few (0–1), some (2–3), or many ( $\geq$  4) depression symptoms.

### ND symptom indicators

We studied five ND symptom indicators, including an existing multi-dimensional measure called the HONC,<sup>10</sup> an indicator based on the *International statistical classification of diseases and related health problems*, 10th revision (ICD-10) criteria for tobacco dependence,<sup>17</sup> and three new ND "symptom clusters" that emerged from principal component analysis of all the ND items in the questionnaire.

The HONC was derived from a theory based definition of ND, which postulates that a person is hooked when they have experienced a loss of autonomy over their use of nicotine.<sup>10</sup> It includes 10 dichotomous (yes, no) items that assess cravings,

**Table 2** Distribution, internal reliability, and one week test-retest reliability of indicators of nicotine dependence symptoms among grade 7 past three month smokers

| Indicator*      | n†  | Mean‡ (SD) | Median | Range | Internal reliability |                     | Test-retest reliability |               |                       |
|-----------------|-----|------------|--------|-------|----------------------|---------------------|-------------------------|---------------|-----------------------|
|                 |     |            |        |       | n‡                   | Cronbach's $\alpha$ | n§                      | Agreement (%) | ICC (lower 95% CI)    |
| ICD-10          | 233 | 1.2 (1.6)  | 1.0    | 0–6   | 183                  | 0.91                | 13                      | 100.0         | 0.49 ( $\geq -0.01$ ) |
| HONC            | 233 | 4.3 (3.4)  | 4.0    | 0–11  | 192                  | 0.87                | 14                      | 78.6          | 0.81 ( $\geq 0.51$ )  |
| ND/cravings     | 233 | 12.0 (9.5) | 9.6    | 0–38  | 168                  | 0.94                | 12                      | NA            | 0.91 ( $\geq 0.75$ )  |
| Withdrawal      | 214 | 3.4 (4.5)  | 1.0    | 0–18  | 206                  | 0.88                | 11                      | NA            | 0.78 ( $\geq 0.40$ )  |
| Self medication | 209 | 2.3 (2.9)  | 1.0    | 0–12  | 205                  | 0.85                | 9                       | NA            | 0.74 ( $\geq 0.27$ )  |

\*Analyses were conducted using continuous scores.

†Sample size varied because of missing values.

‡Means were calculated as the total score divided by the sum of the total number of items responded to.

§Among n=14 past three month smokers in one school with 85 subjects.

CI, confidence interval; HONC, Hooked on Nicotine Checklist; ICC, Intraclass correlation coefficient; ICD-10, International statistical classification of diseases and related health problems, 10th revision; NA, not applicable; ND, nicotine dependence.

loss of control, withdrawal symptoms, and psychological addiction. In a longitudinal study of adolescents, the endorsement of a single HONC item (indicating diminished autonomy) was associated with a failed attempt at cessation (odds ratio (OR) = 29), continued smoking until the end of follow up (OR = 44), and daily smoking (OR = 58). HONC scores correlated with the maximum amount smoked ( $r = 0.65$ ), and the maximum frequency of smoking ( $r = 0.79$ ). Internal reliability was 0.94 and a one factor solution explained 66% of the total variance.<sup>10</sup>

For this study, the HONC was modified slightly (table 1). Multiple response choices were provided for each item, allowing that the intensity of symptoms might reflect different degrees of lost autonomy. The question, "Have you ever tried to quit, but couldn't?" was replaced with, "In the past 3 months, did you seriously try to quit smoking completely and forever?" The question, "Have you ever felt like you were addicted to tobacco?" was replaced by two items, "How physically addicted to smoking cigarettes are you?" and "How mentally addicted to smoking cigarettes are you?". All of the items in the modified HONC indicate diminished autonomy over the use of tobacco as defined by the autonomy theory.<sup>10</sup> Endorsement of any affirmative response category of any HONC item (that is, a positive HONC) was considered to indicate a loss of autonomy. In addition, a continuous HONC score was calculated by summing the scores obtained for each item.

To create an indicator based on the six ICD-10 criteria for tobacco dependence,<sup>17</sup> ND related questionnaire items were selected to measure each criterion (table 1). An item was con-

sidered positive only if the most extreme response choice was endorsed; a criterion was considered positive if the subject endorsed any of its items (the withdrawal syndrome required that two items be endorsed). The subject was categorised as nicotine dependent if he/she met three or more of the six ICD-10 criteria, as defined by ICD-10. In addition, the number of positive criteria was summed to obtain a continuous score of ICD-10 tobacco dependence.

Finally, we used principal component analysis with orthogonal varimax rotation to identify parsimonious clusters of ND symptoms from among the ND items included in the questionnaire. The number of factors selected was based on the scree test and a minimum eigenvalue of 1.0. A factor loading of at least 0.40 was selected as the criterion for determining which items contributed to a given factor.<sup>18</sup> This analysis resulted in the creation of three new scales (table 1): (1) a 16 item general indicator of ND and cravings; (2) a six item indicator of withdrawal symptoms; and (3) a six item indicator of self medication to alleviate negative affect.

All HONC items, and nine of 16 ND/craving items, overlapped with items in the ICD-10. Seven ND/cravings and HONC items overlapped. Five withdrawal items overlapped with ICD-10 items, and four withdrawal items were also among HONC items. Items comprising the self medication score did not overlap with any items in the other four indicators.

### Data analysis

#### Internal and test-retest reliability

The internal consistency of the five ND symptom indicators was measured by Cronbach's  $\alpha$ . Values above 0.85 indicate

**Table 3** Mean score of five indicators of nicotine dependence symptoms by smoking status and quit attempts among grade 7 past three month smokers (n=233)

|                                    | n  | Median cig/week (n) | ICD-10 mean (SD) | HONC mean (SD) | ND/cravings mean (SD) | Self medication mean (SD) | Withdrawal mean (SD) |
|------------------------------------|----|---------------------|------------------|----------------|-----------------------|---------------------------|----------------------|
| Smoking status*                    |    |                     |                  |                |                       |                           |                      |
| Triers                             | 65 | 0.0                 | 0.3 (0.6)        | 1.6 (1.9)      | 4.1 (4.1)             | 0.4 (1.0)                 | 0.8 (1.4)            |
| Sporadic                           | 68 | 0.0                 | 0.6 (0.8)        | 3.6 (2.7)      | 8.6 (5.2)             | 1.4 (2.0)                 | 2.3 (3.3)            |
| Weekly                             | 55 | 5.0                 | 1.4 (1.2)        | 5.5 (2.6)      | 15.0 (6.1)            | 2.4 (2.3)                 | 3.5 (3.9)            |
| Daily                              | 43 | 30.0                | 3.4 (1.9)        | 8.4 (2.4)      | 25.8 (7.0)            | 5.7 (3.2)                 | 8.4 (5.2)            |
| p Value                            |    |                     | 0.0001           | 0.0001         | 0.0001                | 0.0001                    | 0.0001               |
| R <sup>2</sup> , %                 |    |                     | 50.2             | 49.3           | 66.1                  | 41.5                      | 35.0                 |
| Quit attempts†                     |    |                     |                  |                |                       |                           |                      |
| Tried, remained non-smoking        | 49 | 0                   | 0.2 (0.6)        | 2.0 (2.3)      | 5.0 (4.2)             | 1.0 (2.0)                 | 1.7 (3.0)            |
| Never tried to quit                | 70 | 0                   | 0.7 (1.4)        | 4.1 (2.9)      | 11.2 (8.7)            | 1.8 (2.8)                 | 2.8 (4.4)            |
| Tried to quit but failed           | 91 | 5                   | 2.3 (1.5)        | 6.5 (3.0)      | 18.2 (8.6)            | 3.3 (3.1)                 | 5.0 (4.7)            |
| p Value                            |    |                     | 0.0001           | 0.0001         | 0.0001                | 0.0001                    | 0.0001               |
| R <sup>2</sup> , %                 |    |                     | 32.5             | 29.4           | 31.5                  | 11.0                      | 9.4                  |
| Adjusted R <sup>2</sup> square, %‡ |    |                     | 49.1             | 50.7           | 65.1                  | 37.0                      | 30.0                 |

\*n=2 missing.

†n=23 missing.

‡Adjusted for smoking status.

**Table 4** Correlation\* between indicators of nicotine dependence symptoms among grade 7 past three month smokers (n=233)

| Indicator†      | ICD-10 | HONC  | ND/cravings | Self medication |
|-----------------|--------|-------|-------------|-----------------|
| HONC            | 0.741  | –     |             |                 |
| ND/cravings     | 0.824  | 0.910 | –           |                 |
| Self medication | 0.716  | 0.733 | 0.755       | –               |
| Withdrawal      | 0.721  | 0.821 | 0.750       | 0.756           |

\*Pearson product moment correlation coefficients.

†Correlation coefficients were computed using continuous scores.

acceptable internal consistency.<sup>19</sup> Test-retest reliability was examined in a subsample of past three month smokers from one school with 85 participating students. While patterns of smoking (and hence exposure to nicotine) are likely to be variable in this age group, a lapse of one week for the retest was judged to be optimal to minimise recall bias due to measures being too close in time, and to reduce the likelihood that patterns of smoking had changed substantially over time. We computed the intraclass correlation coefficient<sup>20</sup>; a “reliability of 0.75 is a fairly minimal requirement for a useful instrument”.<sup>21</sup>

### Convergent construct validity

Because no gold standard exists against which the criterion related validity of ND measures can be assessed, we examined convergent construct validity in three ways: (1) first, because evidence of convergent construct validity is provided if the indicator examined correlates as expected with other indicators known or thought to be related to the construct under investigation,<sup>21</sup> we tested the association between each indicator and smoking status, and then quit attempts (both of which are known to be associated with ND, at least in adults<sup>23</sup>); (2) next, we studied the correlation between the five ND symptom

indicators; and finally (3) we identified the independent correlates of each ND symptom indicator, from among measures of cigarette exposure and sociodemographic characteristics, in multivariate regression analyses. Similarity in the correlates identified could indicate that the indicators measure similar constructs. The independent correlates of the ICD-10 indicator, dichotomised into tobacco dependent (yes, no), were identified in logistic regression analyses. Scores for the other four indicators were divided into tertiles and independent correlates were identified in polychotomous logistic regression.

### RESULTS

Compared to 992 subjects in the baseline sample who had not smoked in the past three months, a higher proportion of past three month smokers were female (64.8% v 48.9%;  $p < 0.0001$ ), they were slightly older (mean (SD) age 12.5 (0.6) years v 12.2 (0.5) years;  $p < 0.0001$ ), there was a much higher proportion of Francophone subjects among past three month smokers (54.9% v 25.3%;  $p < 0.0001$ ), and fewer past three month smokers had been born outside Canada (4.7% v 8.4%;  $p = 0.062$ ). There was little difference in the proportion of subjects living in single parent families (12.5% of past three month smokers v 8.6% of subjects who had not smoked in the past three months,  $p = 0.093$ ).

Subjects reported a wide range of smoking experiences: 65 of 233 (28.1%) were triers; 29.4% were sporadic smokers; 23.8% were weekly smokers; and 18.6% smoked daily. The median number of cigarettes smoked per week was 1 (range 0–121). Triers, sporadic, weekly, and daily smokers smoked a median of 0, 0, 5, and 30 cigarettes per week, respectively. Subjects had first inhaled at age 11.3 (1.5) years on average, and this coincided closely with the mean age at which they had first smoked a whole cigarette (11.1 (1.3) years). A total of 140 smokers (67.0%) reported recent quit attempts, including 61.2%, 65.1%, 67.3%, and 76.2% of triers, sporadic, weekly, and

**Table 5** Independent correlates of five indicators of nicotine dependence symptoms among grade 7 past three month smokers (n=233)

| Independent correlate* (n)                      | HONC OR (95%CI)    | ND/cravings OR (95%CI) | ICD-10 OR (95%CI)  | Self medication OR (95%CI) | Withdrawal OR (95%CI) |
|-------------------------------------------------|--------------------|------------------------|--------------------|----------------------------|-----------------------|
| Sex                                             |                    |                        |                    |                            |                       |
| Male (82)                                       | Ref                | –†                     | –                  | Ref                        | Ref                   |
| Female (151)                                    | 2.8 (1.4 to 5.4)   |                        |                    | 2.4 (1.2 to 4.8)           | 2.3 (1.1 to 4.6)      |
| Number of cigarettes in past week               |                    |                        |                    |                            |                       |
| 0 (110)                                         | Ref                | Ref                    | Ref‡               | Ref                        | Ref                   |
| ≤1-6 (64)                                       | 2.6 (1.2 to 5.6)   | 2.2 (1.0 to 4.7)       | 5.5 (1.8 to 17.2)  | 2.0 (0.9 to 4.3)           | 2.7 (1.2 to 6.1)      |
| ≥7 (59)                                         | 10.9 (4.1 to 28.9) | 19.7 (6.5 to 59.4)     | 19.5 (5.4 to 69.8) | 5.2 (2.0 to 13.4)          | 3.1 (1.2 to 8.2)      |
| Chew tobacco                                    |                    |                        |                    |                            |                       |
| No (205)                                        | –                  | –                      | –                  | –                          | Ref                   |
| Yes (16)                                        |                    |                        |                    |                            | 7.8 (2.0 to 29.6)     |
| Depression symptoms                             |                    |                        |                    |                            |                       |
| Few (64)                                        | Ref                | Ref                    | –                  | Ref                        | Ref                   |
| Some (118)                                      | 2.7 (1.3 to 5.7)   | 2.1 (1.0 to 4.4)       |                    | 3.1 (1.4 to 6.7)           | 6.6 (2.9 to 15.3)     |
| Many (51)                                       | 4.8 (1.8 to 12.5)  | 2.6 (1.0 to 6.8)       |                    | 7.2 (2.6 to 19.5)          | 17.2 (5.9 to 50.1)    |
| Age smoked whole cigarette, y                   |                    |                        |                    |                            |                       |
| Don't know (59)                                 | –                  | Ref                    | –                  | Ref                        | –                     |
| 11–13 (126)                                     |                    | 2.7 (1.1 to 7.1)       |                    | 3.4 (1.1 to 10.4)          |                       |
| ≤10 (48)                                        |                    | 3.2 (1.0 to 10.4)      |                    | 5.4 (1.4 to 20.5)          |                       |
| How much of the cigarette is smoked             |                    |                        |                    |                            |                       |
| One or few puffs/don't know (78)                | Ref                | Ref                    | –                  | Ref                        | Ref                   |
| Less than half/about half (31)                  | 1.3 (0.5 to 3.4)   | 1.6 (0.6 to 4.3)       |                    | 2.3 (0.8 to 6.4)           | 1.6 (0.6 to 4.4)      |
| Most/all (109)                                  | 4.6 (2.0 to 10.4)  | 3.6 (1.4 to 8.8)       |                    | 3.6 (1.4 to 9.1)           | 3.2 (1.3 to 7.7)      |
| Need to smoke more now to be satisfied          |                    |                        |                    |                            |                       |
| Not at all true (133)                           | Ref                | Ref                    | Ref                | Ref                        | Ref                   |
| A bit true/very true (75)                       | 5.6 (2.6 to 12.3)  | 8.6 (3.6 to 20.6)      | 24.4 (6.5 to 92.0) | 3.5 (1.7 to 7.5)           | 5.3 (2.4 to 11.7)     |
| Need to smoke more now to feel nauseated or ill |                    |                        |                    |                            |                       |
| Not at all true (144)                           | –                  | –                      | –                  | –                          | Ref                   |
| A bit true/very true (56)                       |                    |                        |                    |                            | 2.2 (1.1 to 4.6)      |

\*In each model, the independent correlate predicts the risk of having more ND symptoms.

†Not significant.

‡Due to zero cells, the number of cigarettes smoked in the past week was categorised as 0–6, 7–24, and ≥25.

daily smokers, respectively. Among those who attempted to quit, 35.0% remained non-smoking (up until the current data collection), including 46.9%, 34.9%, 5.5%, and 2.4% of triers, sporadic, weekly, and daily smokers, respectively. According to our proxy ICD-10 measure, 17.3% of past three month smokers were tobacco dependent. Tobacco dependence increased notably with increased exposure to cigarettes, such that 0%, 1.5%, 18.2%, and 67.4% of triers, sporadic, weekly, and daily smokers, respectively, were tobacco dependent. Finally, 85.2% had a positive HONC including 61.5%, 89.7%, 100.0%, and 100.0% of triers, sporadic, weekly, and daily smokers, respectively.

### Psychometric properties

Table 2 describes the distributions of the scores on each ND symptom indicator. All five ND symptom indicators demonstrated acceptable internal reliability and test-retest reliability.

### Convergent construct validity

In univariate analyses, scores for each of the five ND indicators all increased with increased exposure to tobacco, and in addition could differentiate subjects who had tried to quit and failed, from those who had tried and remained non-smoking (table 3). The ND/cravings indicator, and the HONC, were highly correlated with each other; the correlations between the other indicators ranged between 0.716–0.824 (table 4). The independent correlates of the five indicators overlapped considerably: number of cigarettes smoked in the past week and the tolerance symptom, “need to smoke more now to be satisfied”, emerged strongly and consistently across all five models; depression symptoms and how much of the cigarette smoked were significant in four of the five models; and sex was significant in three of the five models (table 5). The finding that fewer correlates were identified in the ICD-10 model possibly reflects that the dependent variable was dichotomous.

## DISCUSSION

ND has been defined as the compulsive use of cigarettes to achieve pleasurable and other effects and to avoid withdrawal symptoms.<sup>23</sup> According to the *Diagnostic and statistical manual of mental disorders*, fourth edition (DSM-IV),<sup>24</sup> symptoms of ND include tolerance, withdrawal symptoms, use in larger amounts and over longer periods than intended, a persistent desire or unsuccessful attempts to cut down or control usage, a great deal of time spent in use related activities, social disruption caused by use, and continued use despite physical or psychological symptoms. Symptoms of nicotine withdrawal include dysphoria or depressed mood, insomnia, irritability, frustration or anger, difficulty concentrating, restlessness, decreased heart rate, and increased appetite, and cravings.<sup>22</sup> However, these definitions remain controversial, even in adults. For example, cravings are not included in the DSM-IV criteria, but are included in the ICD-10 criteria for tobacco dependence,<sup>17</sup> and the role of tolerance in ND is debated.<sup>25–26</sup>

In this analysis, all five indicators of ND symptoms demonstrated convergent construct validity against quit attempts and smoking status; all five were highly intercorrelated (in part because of the shared items); and there was considerable overlap in their independent correlates. Since the individual items comprising each indicator were developed based on expert opinion or qualitative inquiry among adolescents, these indicators also possess content validity. This analysis therefore cannot distinguish between these five indicators on the basis of psychometric performance or convergent construct and content validity. It could be that, in spite of their obvious content differences, all are relatively good indicators of ND symptoms, at least cross sectionally. This would be true if ND is indeed a multidimensional phenomenon that includes symptoms of withdrawal, self medication, cravings, and loss of

### What this paper adds

Few studies have examined the natural history of nicotine dependence (ND), in part because there is no widely accepted, theoretically derived, and psychometrically sound tool to measure ND in adolescents. This article compares the psychometric properties of five indicators of ND symptoms, including the multidimensional Hooked on Nicotine Checklist, an indicator based on the ICD-10 criteria for tobacco dependence, and three new ND “symptom clusters” measuring ND/cravings, withdrawal symptoms, and self medication to alleviate negative affect. All five indicators performed well psychometrically. Until the meaning, relative importance, and usefulness of each scale is clarified in longitudinal work, decisions regarding which scale is most useful in a given context will depend on its content, the need for a multi- or unidimensional indicator, and whether or not the scale is theory based.

autonomy. However, until the meaning, relative importance, timing of appearance, and usefulness of each indicator is clarified in longitudinal work, decisions regarding which scale(s) are most useful for a particular research project will depend on the context and objectives of the research, as well as the content of the scales, the need for a multi- or unidimensional indicator, and whether or not the scale is theory based.

### Limitations

These data were drawn from a convenience sample of grade 7 students (age 12–13 years), and are therefore not representative of the general population. However, the sample included adolescent smokers with a wide range of cigarette exposures. Range of exposure is arguably more important in a study examining reliability and validity, than the representativeness of the population. In addition, if the biological processes underlying the development of ND do not differ substantially between populations, then representativeness is not crucial in a measurement study.

The sample size of smokers was relatively small, but did not impede multivariate analysis, or result in overly wide confidence intervals or difficulties attaining statistically significant results. Finally, the sample included only smokers in early adolescence. It could be that the constellation of ND symptoms as well as the timing of the appearance of individual symptoms or symptom clusters differ in different age groups.

### Conclusion

All five ND indicators showed satisfactory psychometric properties and in addition were related as expected to other variables thought to be associated with ND. As such they each provide an informative measure for use in descriptive, analytic, or evaluative research on nicotine dependence in adolescence. However, until the meaning, relative importance, and usefulness of each scale in predicting failed cessation, continued smoking, or progression to higher levels of smoking is clarified in longitudinal work, decisions regarding which scale(s) to use will depend more on the content of the scales, the need for a multi- or unidimensional indicator, and whether or not the scale is theory based.

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#### Authors' affiliations

\***J O'Loughlin**, \***G Paradis**, **J Hanley**, Department of Epidemiology, McGill University, 1020 Pine Avenue West, Montreal, Quebec H3A 1A2, Canada

**J DiFranza**, Department of Family Medicine and Community Health, University of Massachusetts Medical School, 55 Lake Avenue, Worcester, Massachusetts 01655, USA

**J Tarasuk**, **G Meshefedjian**, **E McMillan-Davey**, Direction de santé publique de Montréal-Centre, 1301 Sherbrooke Street East, Montreal, Quebec H2L 1M3, Canada

**R F Tyndale**, University of Toronto, Department of Pharmacology and Centre for Addictions and Mental Health, 1 King's College Circle, Room 4336 MSB, Toronto, Ontario M5S 1A8, Canada

**P Clarke**, Department of Pharmacology and Therapeutics, McGill University, 3655 Drummond Street, Room 1325, Montreal, Quebec H3G 1Y6, Canada

\*Also Direction de santé publique de Montréal-Centre

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