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Reliability and Validity of a Life Course Passive Smoke Exposure Questionnaire in an Australian Cohort From Childhood to Adulthood

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Objectives: Life course exposure to passive smoke may predict health, but there are few validated measures. We tested the reliability and validity of a retrospective life course passive smoking questionnaire.

Methods: Participants from the third follow-up of the Childhood Determinants of Adult Health study (2014-2019, ages 36-49 years) retrospectively reported mother/father/other household member smoking when living at home during childhood, including duration (years) and smoking location (never/sometimes/always inside house). The severity of exposure index (SEI; sum of mother/father/other years smoked multiplied by smoking location), cumulative years of exposure (CYE; sum of mother/father/other years), and total household smokers (THS) were derived. The reliability of retrospective passive smoking reports was examined with intraclass correlation coefficients (ICCs) using household smoking reported 34 years earlier in 1985 by participants when aged 7-15 years. Construct validity was examined by correlating retrospective passive smoking with participants' smoking in adulthood and lung function in childhood and adulthood.

Results: Among 2082 participants (mean±standard deviation [SD], 45.0±2.5 years; 55.2% females), THS ranged from 0 to 5 (mean±SD, 0.9±1.0), CYE ranged from 0 to 106 (mean±SD, 10.5±13.9), and SEI ranged from 0 to 318 (mean±SD, 24.4±36.0). Retrospective measures showed moderate agreement with total household smokers reported in childhood (ICC, 0.58 to 0.62). The retrospective measures were weakly but significantly ($p<0.05$) correlated with participants' smoking ($r=0.13$ to 0.15) and lung function ($r=$ -0.05 to -0.06).

Conclusions: The retrospective passive smoking questionnaire showed reasonable reliability and validity. This measure may be useful for epidemiological studies.

Key words: Reliability and validity, Passive smoking, Cohort studies

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INTRODUCTION

Passive smoke exposure increases the risk of various diseases, including lower respiratory infections in infancy, lung and cervical cancer, and stroke [1]. The frequency and duration of exposure to passive smoking influence its adverse effects [2,3]. We have found that prospectively reported childhood measures of passive smoke exposure from parents were associated

with greater carotid intima-media thickness [4] and increased risk of carotid atherosclerotic plaque [5]. There is increasing recognition of the importance of exposures across the life course from childhood to adulthood [6], but examining relationships between exposures in childhood and health outcomes in adulthood requires measurements of exposures over time. Existing questionnaires on passive smoking in children and adults measure short-term exposure to passive smoking, ranging from 24 hours to a few weeks [7-10]. Some measures of passive smoking have attempted to retrospectively capture prolonged passive smoke exposure across childhood with demonstrated reliability (mostly intra-rater reliability) using repeated assessments in adulthood. Few researchers have examined the validity of these measures, possibly due to the lack of a gold standard [11].

The Childhood Determinants of Adult Health (CDAH) study is a follow-up of the cardiovascular health of participants in the Australian Schools Health and Fitness Survey (ASHFS), which was a nationally representative cross-sectional study of the health and fitness of Australian schoolchildren in 1985. The aim of this study was to assess the reliability and validity of a retrospective life course passive smoking questionnaire making use of rich data on childhood and adulthood social, demographic, and health-related factors captured across the life course.

METHODS

Study Participants

The participants were drawn from the CDAH study, a follow-up of the 8498 7-year-old to 15-year-old children who participated in the ASHFS in 1985 after 2-staged random sampling, first of schools and then of children within schools [12]. The response proportion in the ASHFS was 67.5%. After the first follow-up in 2004-2006 (CDAH-1; response proportion, 47.0%), subsequent follow-up was conducted in 2009-2011 (CDAH-2; response proportion, 36.0%) and 2014-2019 (CDAH-3; response proportion, 25.0%).

Study Measures

Self-reported exposure to passive smoking

In CDAH-3, participants completed face-to-face assessments, along with questionnaires on health and lifestyle, diet, and physical activity when they were aged 36-49 years. Data on exposure to passive smoke during childhood were collected with a questionnaire (Supplemental Material 1) including the number of household members who smoked (mother, father, and other), environments where the exposure occurred (car and house), and the duration of the exposure for each household member (years). Responses were truncated to the period when the person lived at home with their parents.

The questionnaires were used to derive 3 retrospective passive smoke exposure variables described below, based on an approach reported for adults in the literature [13]:

Total household smokers: This represents the sum of the total number of household members who were regular smokers, lived with the participant, and smoked inside the house. Parental smoking in CDAH-3 was categorized as "none," "either parent smoked," and "both parents smoked."

Cumulative years of exposure: This was derived from summing the total number of years that participants were exposed to passive smoke from each household member with whom he or she lived. Cumulative years of exposure was also categorized by tertiles (no exposure, 1-20 years, and 21 years and above).

Severity of exposure index: The frequency of exposure inside the house from each household member was scored as "never" (=1), "sometimes" (=2), and "always" (=3). An index of severity of exposure was calculated by multiplying the years of exposure from each household member by the frequency of the exposure, summed over all household members for each participant [13]. The severity of exposure index was also categorized into quartiles: no exposure, 1-30, 31-60, and >60.

Other measurements

A range of measurements in the same participants taken in childhood during the ASHFS and at adult follow-ups (CDAH-1 and CDAH-3) were used to explore the reliability and validity of the retrospective passive smoke exposure questionnaire administered as part of CDAH-3.

Baseline: Australian Schools Health and Fitness Survey in 1985

The measures included gender, age group (7-9, 10-12, and 13-15 years), area-level socioeconomic status according to the postcode of residence (quartiles of a continuous measure: high, medium-high, medium-low, and low); smoking experimentation in childhood (one, a few puffs, yes, <10 in my life, yes, >10 in my life); total household smokers; parental smoking categorized as "none," "either parent smoked," and "both par-

ents smoked"; and lung function using a Vitalograph single-breath wedge spirometer to estimate the forced expiratory volume in 1 second (FEV1) and forced vital capacity (FVC) [14].

Childhood Determinants of Adult Health-1 in 2004-2006

Lung function was measured using a portable electronic spirometer and included FEV1 and FVC [14]. The mean values of lung function measures were used as cut points for descriptive analyses.

Childhood Determinants of Adult Health-3 in 2014-2019

The measures taken included physical activity level (low, moderate, and high) from the total minutes of physical activity per week using the International Physical Activity Questionnaire [15], employment status (not working, studying, or working) and own smoking status (never, former smoker, or current smoker) in adulthood. The main occupation of participants was categorized into occupation types: A (e.g., managers, administrators, or professionals); B (e.g., tradespersons, clerical or service workers); and C (e.g., production or transport workers, labourers, unemployed).

Statistical Analysis

We explored the descriptive summary statistics of the 3 derived passive smoking exposure measures according to their range, mean, and standard deviation (SD).

Reliability

We assessed internal reliability or consistency using Cronbach's alpha [16]. Consistency between each of the 3 derived exposure variables with their component items (e.g., individual exposure from mother, father, and other household smokers) was tested using Cronbach's alpha, and a score of 0.7 was deemed acceptable [16].

We used the intraclass correlation coefficient (ICC) to examine agreement in passive smoking exposures from childhood to adulthood [17]. We used one-way random-effects ICCs to examine absolute agreement between the 3 retrospective derived measures of passive smoking and parental smoking from CDAH-3 with the childhood (ASHFS) assessment of parental smoking and total number of smokers in the home. An ICC of <0.5 is accepted as indicating poor agreement, 0.50 to 0.75 as moderate agreement; 0.75 to 0.90 as good agreement and >0.90 as excellent agreement [17].

Validity

As there is no gold standard for validating prolonged passive smoking questionnaires, we used a range of variables from ASHFS, CDAH-1, and CDAH-3 to examine aspects of construct validity of the retrospective passive smoke exposure questionnaire. Tests included the *t*-test and one-way analysis of variance to examine how passive smoke exposure varied by different childhood (e.g., socioeconomic status and smoking experimentation) and adulthood (e.g., employment and smoking status) characteristics, addressing aspects of convergent validity.

We also examined the convergent validity of the 3 derived passive exposure variables and parental smoking in CDAH-3 with participants' own smoking status at CDAH-3 and lung function tests (FEV1 and FVC) from CDAH-1 and ASHFS using Spearman's or Pearson's correlation coefficients, as appropriate based on the distribution of variables [18]. Similarly, an analysis was performed with total household smokers and parental smoking in ASHFS in place of the 3 derived passive exposure variables and parental smoking in CDAH-3. All analyses were conducted with Stata version 16 (StataCorp., College Station, TX, USA).

Ethics Statement

Institutional ethics approval was obtained from the Tasmania Health and Medical Human Research Ethics Committee and participants provided written informed consent.

RESULTS

There were 2082 participants in CDAH-3 (Supplemental Material 2). The number of household smokers ranged from 0 to 5 (mean $\pm$ SD, 0.9 ± 1.0); cumulative years of exposure range from 0 to 106 (mean $\pm$ SD, 10.5 ± 13.9) and severity of exposure ranged from 0 to 318 (mean $\pm$ SD, 24.4 ± 36.0).

Reliability

The Cronbach's alpha values illustrated good internal consistency for the severity of exposure index (Cronbach's $\alpha=0.70$), cumulative years of exposure (Cronbach's $\alpha=0.70$) and total household smokers (Cronbach's $\alpha=0.75$).

ICCs demonstrated mostly moderate agreement between the derived measures of passive smoking in CDAH-3 and parental smoking and total household smokers in ASHFS (Table 1). For example, the highest agreement was between retrospectively reported parental smoking in CDAH-3 and parental smok-

Table 1. ICCs of the CDAH-3 measures of passive smoking with similar measures of passive smoking in the ASHFS

Variables	Prospective passive smoke exposure (ASHFS)			
	Total household smokers in ASHFS (1985)		Parental smoking in ASHFS (1985)	
	No. of observations	ICC (95% CI)	No. of observations	ICC (95% CI)
Retrospective passive smoke exposure (CDAH-3)				
Total household smokers	1603	0.58 (0.55, 0.61)	1613	0.47 (0.43, 0.51)
Cumulative years of exposure	1604	0.62 (0.59, 0.65)	1613	0.64 (0.61, 0.67)
Severity of exposure index	1604	0.59 (0.56, 0.62)	1613	0.54 (0.50, 0.57)
Parental smoking	1586	0.55 (0.52, 0.59)	1596	0.65 (0.62, 0.68)

ICC, intraclass correlation coefficients; CDAH, Childhood Determinants of Adult Health; ASHFS, Australian Schools Health and Fitness Survey; CI, confidence interval.

Table 2. Convergent validity of the measures of passive smoking using CDAH-3 smoking status and CDAH-1 lung function

Variables	Adulthood (CDAH-3 and CDAH-1)					
	Participant smoking status[1]		FEV1[2]		FVC[2]	
	r	*p*-value	*r*	*p*-value	*r*	*p*-value
Retrospective passive smoke exposure (CDAH-3)						
Total household smokers	0.15	<0.001	-0.06	0.032	-0.04	0.110
Cumulative years of exposure	0.13	<0.001	-0.05	0.054	-0.03	0.237
Severity of exposure index	0.14	<0.001	-0.06	0.019	-0.04	0.107
Parental smoking	0.13	<0.001	-0.05	0.064	-0.04	0.185
Passive smoke exposure (ASHFS)						
Total household smokers	0.16	<0.001	-0.05	0.054	-0.03	0.155
Parental smoking	0.11	<0.001	-0.05	0.021	-0.04	0.087

CDAH, Childhood Determinants of Adult Health; ASHFS, Australian Schools Health and Fitness Survey; FEV1, forced expiratory volume in 1 second; FVC, forced vital capacity.
[1]Spearman's correlation.
[2]Pearson's or Spearman's correlation.

ing in ASHFS (ICC, 0.65; 95% confidence interval [CI], 0.62 to 0.68). There was lower agreement with less similar items, such as for total household smokers assessed retrospectively with parental smoking in ASHFS (ICC, 0.47; 95% CI, 0.43 to 0.51).

Construct Validity

As shown by the mean of the 3 derived measures of exposure according to childhood and adulthood factors (Supplemental Material 3), demographic factors varied by exposure to passive smoking. Analyses repeated using non-parametric tests confirmed these results (data not shown).

There was a weak but statistically significant positive correlation of retrospective passive smoking measures with participants' own smoking (CDAH-3) and a significant, negative association with lung function in adulthood (Table 2). Similar results were also obtained between the ASHFS measures of passive smoking and participants' own smoking and lung function in adulthood. Significant positive correlations were found between retrospective passive smoking measures (CDAH-3) and lung function in childhood, but this was found to be influenced by age (Supplemental Material 4). For total retrospective household smokers, correlations were positive in younger children but negative in older children. Parental smoking in ASHFS was also negatively correlated with lung function in childhood, although this correlation was not statistically significant.

DISCUSSION

This study aimed to establish the reliability and validity of a retrospective questionnaire on prolonged passive smoking exposure in childhood. The 3 derived measures showed good internal consistency and moderate agreement with similar measures reported prospectively in childhood. The 3 retrospective measures in adulthood were weakly but significantly correlated in the expected direction with a number of variables, suggesting that the instrument is valid. Similar results were also observed with childhood exposure measures. The passive smoke exposure questionnaire was therefore found to be reliable and valid in the measurement of prolonged passive smoke exposure.

The retrospective passive smoking measure was found to be reliable. The ICCs are broadly supported by findings in another study with a reference standard using answers from surrogates

for the number of years exposed (ICC, 0.89), number of smokers at home (ICC, 0.79) and childhood exposure severity index (ICC, 0.74) [13]. While our ICCs were of smaller magnitude, this could reflect the difficulties in measuring prolonged exposure with reference standards measured more than 30 years ago. Further, the prospective questions were referenced to the current behaviour within the household, whereas the retrospective questions encompassed the entirety of childhood. Therefore, complete agreement would be unlikely given the dynamic nature of smoking behaviour over time.

The retrospective passive smoking measures were found to have reasonable validity. Some other investigators validated their self-reported questionnaires on passive smoking with airborne nicotine concentrations [9] and cotinine levels in urine [8]. However, our measures were validated more indirectly with participants' own demographic and health-related factors, which included lung function and participants' own smoking. There were some unexpected positive correlations between passive smoke exposure from retrospective and prospective reports with childhood lung function. This may reflect the proximity of these measures to the single measure of lung function and the need for exposure to accumulate before there are effects on lung health, as well as uncontrolled confounding. We sought to validate prolonged passive smoke exposure instead of recent exposure, and this cannot be done with cotinine and nicotine concentration measurements. There is no gold standard for measuring prolonged passive smoke exposure, as seen in the use of cotinine measurements to validate questionnaires on recent exposure to passive smoking [8]. Our reference standards for convergent validity were selected because they have been associated with sustained or prolonged passive smoking exposure (e.g., decrease in lung function) [19]. Furthermore, exposure to parental smoking in childhood increased the risk of being a current smoker in adulthood [20].

Evidence was found for the reliability and validity of the passive smoking instrument, suggesting that it can be used to measure prolonged passive smoking. Our finding supports the use of exposure from different close contacts, years of exposure, and the intensity of exposure to represent passive smoke exposure across childhood. These holistic data on this exposure will be useful to understand the frequency, determinants, and outcomes of passive smoking exposure.

The limitations of this study are that there is no gold standard measure of prolonged passive smoke exposure that we could use to validate the instrument. Questions on passive smoking were asked differently for the 2 periods. In ASHFS participants were asked, "Does your mother/father smoke at home?" while in CDAH-3 they were asked, "Was your mother/father ever a regular smoker?" Although subtle, these differences in the questions may have affected recall of smoking status and therefore the assessments of reliability.

In conclusion, our sample was relatively large and contained a range of factors with which to validate the prolonged passive smoking exposure questionnaire. The cohort showed heterogeneity in passive smoke exposure and the variables used to examine validity.

SUPPLEMENTAL MATERIALS

Supplemental materials are available at https://doi.org/10.3961/jpmph.20.559.

CONFLICT OF INTEREST

The authors have no conflicts of interest associated with the material presented in this paper.

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AUTHOR CONTRIBUTIONS

Conceptualization: CE, SG. Data curation: CE, CGM, ALN, MJB, TD, AV, SG. Formal analysis: CE, CGM, ALN, MJB, TD, AV, SG. Funding acquisition: CGM, TD, AV, SG. Methodology: CE, CGM, ALN, MJB, TD, AV, SG. Project administration: CE, CGM, ALN, MJB, TD, AV, SG. Visualization: CE, CGM, ALN, MJB, TD, AV, SG. Writing – original draft: CE, SG. Writing – review & editing: CE, CGM, ALN, MJB, TD, AV, SG.

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