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Role of Individual-Housing Based Socioeconomic Status Measure in Relation to Smoking Status among Late Adolescents with Asthma

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Abstract

Purpose—We aimed to assess whether smoking status among individuals in late adolescence (19–22 years) with asthma was associated with socioeconomic status (SES) defined by HOUSES, an individual housing based SES measure.

Methods—A population-based cross-sectional study was conducted among the 1988–1989 Olmsted County, Minnesota Birth Cohort, with physician-diagnosed asthma and that lived in the community during the study period (November 1, 2008–October 31, 2012). Using a z-score for housing value, actual square footage, and numbers of bedrooms and bathrooms, HOUSES was formulated and categorized into quartiles. Smoking status (both current and past smoker) was compared among subjects with different SES as measured by HOUSES using logistic regression, adjusting for age and sex.

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Results—Among 289 eligible subjects, 287 (99%) were successfully geo-coded to real property data for HOUSES. Of the 257 subjects whose smoke exposure was recorded, 70 (27%) had smoking status. An inverse association was observed between HOUSES and smoking status after accounting for age, gender, and General Medical Exam status. (adjusted OR: 0.39, 95% CI: 0.18-0.87 for comparing highest vs. lowest HOUSES in quartile; overall $p=0.02$).

Conclusions—A significant proportion of individuals with asthma in late adolescence were smokers during the study period, disproportionately affecting those with lower SES.

Keywords

Smoking; Asthma; Social Class; Preventive Medicine; Adolescent; Young Adult

Introduction

Asthma is the most common chronic illness in childhood and a major cause of morbidity in adults. Although a recent report showed overall childhood asthma prevalence increased from 2001 to 2009 followed by a plateau then a decline in 2013, this pattern varies with age, region, race, and socioeconomic status (SES).(1) Identifying factors associated with persistence of childhood asthma into adulthood is important for patients, their families, and health care providers, and some factors related to asthma remission have been suggested. (2-4) Tai et al. in his longitudinal prospective study up to age 50 years reported that asthma remission occurred most commonly between the age 14 and 21 years.(5) The late adolescence (age of 19-22 years), as a transitioning time from childhood to adulthood, may be important in terms of asthma remission and risk of new onset of asthma (i.e., adulthood asthma) by controlling modifiable risk factors such as smoking.(5, 6)

Smoking has been a well-known risk factor for asthma development and asthma outcomes. (6-15) Unfortunately, adolescents with asthma have higher or similar smoking prevalence than those without asthma.(16-20) While one might expect adolescents with asthma to quit smoking earlier than those without asthma, literature suggests that adolescents as well as adults with asthma were significantly less likely to quit smoking than their peers without asthma.(21, 22) Further, cigarette smoking is more prevalent among those with low SES and quit attempts are less likely to be successful, compared to those with higher SES.(23) However, little is known about whether or not SES is associated with smoking rate among late adolescents with asthma.

Despite the potential relationship of SES to smoking rate among those with asthma, socioeconomic data are often unavailable in data sets used in clinical research, such as administrative data and medical records.(24-26) The neighborhood SES (e.g., Census data) are often used as a proxy of individual SES, but literature has found the use of area-based proxies for individual-level measures resulted in over- or underestimates of socioeconomic gradients in health.(27-31) Also, it has been reported that individual-level socioeconomic measures are more strongly associated with smoking history than area-level measures among late adolescents.(32)

Our research team recently developed individual-level HOUSing-based SocioEconomic Status measure (*termed HOUSES*) based on real property data and reported HOUSES predicts health outcomes (e.g. asthma exacerbation) as well as risk factors for health outcomes (e.g., smoking exposure at home).(33-39) As SES is associated with risk of asthma (although the result in the literature is inconsistent),(40-44) it is important to further investigate the association of SES with smoking rate among late adolescents with asthma. We hypothesized SES as measured by HOUSES is associated with history of smoking among late adolescents with asthma.

Material and methods

Study setting

The study was approved by the Institutional Review Boards at both Mayo Clinic and Olmsted County Medical Center. Health care in Olmsted County, Minnesota is virtually self-contained within the community. When patients register with any health care provider in the community, they are asked whether they authorize use of their medical records for research. If one grants the authorization (95%) for using medical record for research, each patient is assigned a unique identifier under the auspices of the Rochester Epidemiology Project (REP),(45-49) which has been continuously funded by the NIH since 1960. All clinical diagnoses and information from every episode of care are contained within detailed patient-based medical records. This unique longitudinal population-based resource has been the source of over 2000 publications.(50) During the study period, characteristics of the City of Rochester and Olmsted County populations were similar to those of the U.S. Caucasian population, with the exception of a higher proportion of the working population employed in the health care industry.(51-53) Using REP resources, we previously demonstrated that incidence rates of asthma for this community are similar to other communities.(54)

Study design and subjects

This present study utilized a previous unpublished population-based cross-sectional study which was designed for assessing the H1N1 and the Pneumococcal Polysaccharide Vaccine 23-valent (PPV23) vaccine uptake rate among individuals with asthma and conducted among the Olmsted County Birth Cohort born between January 1, 1988- September 30, 1989 that lived in the community during the study period (November 1, 2008-October 31, 2012) with asthma ever (n=371). Individuals who did not grant authorization for using medical records for research or non-Olmsted County, MN resident as of October 1, 2009 were excluded (n=89). In this present study, we assessed the association of SES measured by HOUSES with smoking rate among late adolescents with asthma using the original study data. Asthma status was defined by physician-diagnosed asthma by ICD-9 code (493). Active asthma status (vs. inactive) was defined by any asthma-related symptom, medication, or medical visits documented during the past 12 months.

Smoking status

We comprehensively reviewed individual's medical records to ascertain tobacco smoking status for within 6 months before the time of chart review (i.e., past smoker, current smoker, passive smoker, non-smoker, and unknown). We then grouped individuals with regard to

history of tobacco smoke exposure; past or current smoker (i.e., smoker) vs. passive or non-smoker (i.e., non-smoker)) as we were interested in smoking behavior among late adolescents with asthma rather than biological effects of smoking.

Socioeconomic status (SES)

To determine if socioeconomic status (SES) is associated with smoke exposure, we used the REP Database and a SES index derived from housing characteristics (HOUSES). HOUSES was developed for health disparities research utilizing retrospective datasets and real property data.(33, 34) Address-linked real property data was obtained from the Assessor's Office and matched to the subject's address in the medical record. Real property datasets are maintained by the Assessor's Office of the Olmsted County government for the purposes of property taxation and publicly available. Information from these datasets were used to formulate the HOUSES index, which includes: 1) ownership status, 2) lot size of the housing unit, 3) square footage of the housing unit, 4) residential status (whether a housing unit is in a residential zoning), 5) number of bathrooms, 6) number of bedrooms, 7) building value (assessor's estimate), and 8) neighborhood SES (Census block-group level). Based on the principal component factor analysis, we formulated a standardized-HOUSES index score by summing all variables of each factor (i.e., housing value, actual square footage, and numbers of bedrooms and bathrooms) after transforming variables to z-scores, and the z-score is then categorized into quartiles. The reason why we chose quartiles in this study was to keep the consistency with our previous report and to allow us to measure a dose-response relationship between exposure (ie, HOUSES) and outcome (ie, smoking status). Higher HOUSES is associated with greater SES. HOUSES correlates with several health risks, such as tobacco smoke exposure at home among children and adolescents.(34)

Other variables

We collected from medical records other relevant variables such as occupational status (student vs. employment as of October 1, 2009), educational attainment (high school graduate or less vs. some college or greater), vaccination status (Human Papillomavirus (HPV), seasonal influenza, Pneumococcal Polysaccharide Vaccine 23-valent (PPV23)), and presence of general medical exam (GME) visit during study period to assess the association with smoking rate.

Statistical analysis

Each variable was assessed for the association with smoking status (smoker vs. non-smoker), using logistic regression models, and odds ratios (OR) and their corresponding 95% confidence Intervals (95% CIs) were presented. SES measured by HOUSES was treated as categorical variable (quartiles). In addition, logistic regression models were used to test the independent effect of modifiable variables (GME or vaccination status) in the presence of HOUSES. We did not include education and employment in the multivariable analysis as education and employment are collinear with HOUSES as SES measure. All analyses were performed using SAS statistical software package (Ver 9.3; SAS Institute, Inc, Cary, NC).

Results

Characteristics of study subjects

Among 289 eligible subjects with asthma who were enrolled in the study, nearly all of them (287, 99%) were successfully geo-coded to real property data in order to be classified by HOUSES. Of the 257 subjects whose smoke exposure was recorded and available for this study, 239 (93%) study subjects were of White race, 144 (56%) were female and the median age (Interquartile range) was 20.0 years (19.5-20.4).

Association between HOUSES and smoking status

Among 70 subjects (27%) with smoking status, 58 (82%) were current smokers. An inverse association was observed between HOUSES and smoking status ($p=0.02$). Smoking rates were 35%, 28%, 16% and 21% during the study period in the first (the lowest SES and reference), second (OR: 0.77, 95%CI: 0.37-1.63 compared to the first), third (OR: 0.31, 95%CI: 0.13-0.70 compared to the first), and fourth quartile (OR: 0.42, 95%CI: 0.19-0.91 compared to the first) of HOUSES, respectively (Table 1). This association of smoking status with HOUSES remained significant after accounting for age, gender, and GME (overall $p=0.02$). When limiting to current smoker, the result was similar 35% (Q1), 26% (Q2), 19% (Q3), and 19% (Q4); overall p -value: .086).

Association between other variables and history of smoking

Lower educational level (i.e., high school graduate or less) and employment status (i.e., having a job) were also significantly associated with higher smoking rate ($p<0.01$ in both) while 17-22% of data on educational level and employment status were missing. HOUSES showed strong association with both educational level and employment status ($p<0.001$ in both). For example, we have proportion of being employed of 35%, 29%, 10% and 7% and students of 35%, 48%, 71%, and 76% for Q1 (the lowest SES), Q2, Q3, and Q4 of HOUSES, respectively.

Smoking rate did not differ by active asthma ($p=0.48$), asthma medication use ($p=0.64$), other atopic conditions such as atopic dermatitis or allergic rhinitis ($p=0.59$), a family history of asthma ($p=0.90$), influenza vaccine rate ($p=0.48$), or PPV23 vaccine rate ($p=0.21$).

Smokers were less likely to seek GME ($p=0.02$) and have lower completion rate of HPV vaccination ($p=0.04$) (Table 1). While the association of GME remained significant after accounting for HOUSES ($p=0.03$), the inverse association of completion of HPV vaccination with smoking rate was attenuated once adjusting for HOUSES (aOR: 0.43, 95% CI: 0.16-1.12, $p=0.08$).

Discussion

A significant proportion of individuals with asthma in late adolescents had a history of smoking during the study period (27%), majority of whom were current smokers (82%). Socioeconomic status, as measured by HOUSES, was inversely associated with smoking rates among those with asthma.

In this study, a total of 178 subjects (69%) had an educational level of some college or greater which is comparable to national data reporting that 68% of high school graduates in US, 2014 were enrolled in college, suggesting our cohort might reasonably represent high school graduates at a national level.(55) However, the prevalence of current smoker among those with asthma was 23% in this community, which appears higher than the one among general population with similar age (18-24 years) in 2012 (17%, regardless of asthma status).(56) Although literature suggests adolescents with asthma have higher or similar smoking prevalence than those without asthma,(16-20) it should be emphasized for public health that a significant proportion of late adolescents smokes tobacco despite their asthma status and guidelines recommending to reduce risk factors for asthma given cigarette smoking prevalence declined among U.S. adults during 2005–2012.(56)

Smoking has been a well-known risk factor for asthma development and asthma outcomes. (6-15) Passive smoking exposure during childhood has been consistently reported to be associated with the risk of asthma.(7-9) Further, active smoking increases risk of asthma in both adolescents and adults and affects asthma outcome such as hospitalization rate, the effect of corticosteroid on asthma treatment, and lung function.(6, 10-15) Literature also suggests the association between asthma and smoking habit in adolescence may not be unidirectional, but bidirectional. Van de ven et al. in a longitudinal study (22 months) demonstrated that in baseline non-smokers, adolescents with asthma were associated with an increased risk of becoming regular smokers, and adolescents smoking predicted a higher incidence of asthma symptoms.(16) They also reported more frequent smoking at follow-up was observed among those with a lower educational level overall, but failed to report the association with regard to developing asthma. Other studies also showed that adolescents with asthma tended to be earlier and heavy smokers more than those without asthma, and this association seems to be more profound among those who have uncontrolled asthma without using medicine, depression, smoking mother, or use substance.(16-20) Our study results suggest that higher smoking rate among late adolescents with asthma compared with general population may be in part explained by differential smoking rate across different SES. Current smoking rates among the lower SES was 32% and 26% (in Q1 (lowest) and Q2, respectively) whereas 16% among the higher SES (in Q3 and Q4, respectively) had a history of smoking in this study.

For adolescence, in which the peer group influence becomes more important compared to parents,(20) some might expect more adolescents with asthma who start smoking may try to quit earlier than those without asthma. However, Tercyak et al. reported that adolescents with asthma were significantly less likely to quit smoking than their peers without asthma, as observed in adults who with asthma do not appear to selectively avoid cigarette smoking, (21, 22, 57) and this may be true among late adolescents with asthma as well. Our study suggested that SES measured by HOUSES played a significant role in differential smoking rate among late adolescents with asthma. Unfortunately, only a few European studies consider SES as a confounder (or mediator) in the association between smoking rate and asthma and put it in the logistic regression model, but not much attention has been given to the specific role of SES in this association. In the US studies, SES was not even considered as a key risk factor in assessing the pattern of asthma and smoking status among adolescents and this could be because, unlike European countries, the US have reported routine public

health statistics by race or ethnicity, but not socioeconomic status (typically, income or educational attainment).(58)

Our data suggested that educational level also has significant association with smoking status ($p<0.001$). However, one-fourth of eligible study subjects did not have available data on educational level in medical records whereas HOUSES was available for almost all eligible subjects (99%). Besides fluency of SES during this transitioning ages (i.e., education level, occupation, income and/or housing status at this age may change over time), lack of socioeconomic data in the health record causes difficulty in characterizing those individuals with an increased likelihood of smoke exposure. Our prior work has suggested that HOUSES is associated with health outcomes in both children and adults such as the risk of low birth weight, obesity, smoking exposure at home, asthma control status, risk of pneumococcal diseases, post-MI mortality, and risk of rheumatoid arthritis (RA) and post-RA mortality.(34-39) Thus, HOUSES is highly likely to enhance asthma research for late adolescents given that SES is an important predictor for 1) the risk and outcome of asthma and 2) factors associated with asthma outcomes such as smoking history. But SES measures are frequently absent in commonly used datasets for asthma research such as medical records or administrative datasets.

The main strength of our study is the population-based study. Another strength is the availability of SES measures (i.e., HOUSES) for almost all eligible study subjects whereas traditional SES measures such as educational level is yet often unavailable in the clinical dataset. We also verified physician diagnosis of asthma defined by ICD-9 code through checking with medical records. The main limitation of our study is that subjects' address information that was extracted from medical records for calculating HOUSES may reflect inconsistent sources (i.e., parental address vs. their own address) which may misclassify their true SES, and also impacted by other factors such as marital status. However, as shown in our study results, regardless of marital status or the source of address information whether it is parents' or their own, HOUSES index based on available address information from clinical datasets predicts behavioral risk factors for asthma such as history of smoking. This is an important advantage of HOUSES as it is formulated from address in the medical record or a clinical dataset. Another limitation of our study was predominant Caucasian population in our study subjects which may limit generalizability of our study findings to other study settings with different ethnic composition. Also, this study was designed as a cross-sectional study, so while it is possible that those with current asthmatic symptoms are less likely to smoke due to "symptoms", it is also possible that current asthma symptoms are due to smoking (i.e., temporality). Finally, smoking status from medical records (either clinicians' documentation or self-reported administration form) in this present study may not be as accurate as self-report in the questionnaire, and recording tobacco use in medical records may vary by patient and/or physician characteristics.(59-62) For example, young, healthier people were less likely to have information about their smoking status in medical records. (63) In this study, 10% (30 subjects) did not have data on smoking status, and thus were not included in the analysis. However, their SES defined by HOUSES ($p=0.25$), employment status ($p=0.70$), education level ($p=0.80$), or ethnicity ($p=0.28$) were not different from those included in this study, suggesting non-differential misclassification bias.

Conclusions

A significant proportion of individuals with asthma in late adolescence were smokers ever, which was in part explained by differential smoking rate across different SES, as measured by HOUSES. HOUSES may be a potential tool for overcoming the lack of conventional socioeconomic status measures in research concerning behavioral risk factors for asthma among late adolescents.

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Abbreviations

SES	Socioeconomic Status
HOUSES	HOU sing-based SocioE conomic S tatus measure
REP	Rochester Epidemiology Project
HPV	Human Papillomavirus
PPV23	Pneumococcal Polysaccharide Vaccine 23-valent
GME	General medical exam
OR	odds ratios
95% CI	95% confidence Interval

Table 1
Characteristics of Non-smokers and smokers

	Non-smokers (n=187)	Smokers (n=70)	OR ^e (95% CI)	P-value
Age (years), median (IQR)	20.0 (19.5, 20.4)	20.1 (19.5, 20.4)	1.21 (0.71-2.05)	0.48
Gender, male n (%)	76 (41%)	37 (53%)	1.64 (0.94-2.85)	0.08
Race, whites n (%)	173 (93%)	66 (94%)	1.34 (0.42-4.20)	0.62
Education, n (%)			[overall p<0.001] ^f	
High School or less	15 (8%)	20 (29%)	(reference)	(reference)
Some college or greater	140 (75%)	38 (54%)	0.20 (0.10-0.44)	<0.001
Unknown	32 (17%)	12 (17%)	0.28 (0.11-0.72)	0.01
HOUSES in quartile (IQR of z-score), n (%) ^a			[overall p=0.02] ^f	
Q1 (-7.4, -3.2)	38 (20%)	24 (35%)	(reference)	(reference)
Q2 (-3.2, -1.5)	39 (21%)	19 (28%)	0.77 (0.37-1.63)	0.50
Q3 (-1.5, 1.9)	57 (31%)	11 (16%)	0.31 (0.13-0.70)	0.01
Q4 (1.9, 15.1)	53 (28%)	14 (21%)	0.42 (0.19-0.91)	0.03
Employment, n (%)			[overall p<0.001] ^f	
Student	128 (68%)	21 (30%)	(reference)	(reference)
Employed	24 (13%)	28 (40%)	7.11 (3.48-14.5)	<0.001
Unknown	35 (19%)	21 (30%)	3.66 (1.80-7.45)	<0.001
Active asthma, n (%)			[overall p=0.48] ^f	
No	71 (38%)	30 (43%)	(reference)	(reference)
Yes	98 (52%)	31 (44%)	0.77 (0.42-1.35)	0.33
Unknown	18 (10%)	9 (13%)	1.18 (0.48-2.93)	0.72
Asthma medication, n (%)			[overall p=0.64] ^f	
No	85 (46%)	36 (52%)	(reference)	(reference)
Short-acting β -agonist only	68 (36%)	24 (34%)	0.83 (0.45-1.53)	0.56
Inhaled corticosteroid	34 (18%)	10 (14%)	0.69 (0.31-1.55)	0.38
Other atopic disease, ^b n (%)			[overall p=0.59] ^f	
No	99 (53%)	42 (60%)	(reference)	(reference)
Yes	52 (28%)	17 (24%)	0.77 (0.40-1.49)	0.44
Unknown	36 (19%)	11 (16%)	0.72 (0.34-1.55)	0.40
Family history of asthma, n (%)			[overall p=0.9] ^f	
No	72 (39%)	23 (33%)	(reference)	(reference)
Yes	94 (50%)	33 (47%)	1.10 (0.59-2.03)	0.76
Unknown	21 (11%)	14 (20%)	2.09(0.92-4.76)	0.08

	Non-smokers (n=187)	Smokers (n=70)	OR ^e (95% CI)	P-value
General Medical Exam, n (%)	42 (23%)	6 (9%)	0.32 (0.13-0.80)	0.02
HPV ^cvaccine, n (%)			[overall p=0.04] ^f	
No	93 (50%)	47 (67%)	(reference)	(reference)
Not completed	19 (10%)	7 (10%)	0.73 (0.29-1.86)	0.51
Completed	73 (39%)	16 (23%)	0.43 (0.23-0.83)	0.01
Unknown	2 (1%)	0 (0%)	-	-
Influenza vaccine, n (%)	62 (33%)	20 (29%)	0.81 (0.44-1.47)	0.48
PPV23^d, n (%)	42 (23%)	21 (30%)	1.48 (0.80-2.74)	0.21

^a HOUSES missing in two smokers;

^b atopic dermatitis or allergic rhinitis;

^c Human papillomavirus

^d Pneumococcal Polysaccharide Vaccine 23-valent (PPV23);

^e OR (95% CI) for univariate analysis;

^f The overall p value is the likelihood ratio test for including all levels of the variable

Table 2
Association of smoking rate with HOUSES and General Medical Exam

	Adjusted OR (95% CI) ^a	P-value
General Medical Exam	0.35 (0.14-0.90)	0.03
HOUSES (in quartile)	[overall p=0.02]	
Q1 (lowest)	(reference)	(reference)
Q2	0.69 (0.32-1.49)	0.34
Q3	0.30 (0.13-0.70)	0.005
Q4 (highest)	0.39 (0.18-0.87)	0.021

^a Adjusted for age, gender, General Medical Exam, and HOUSES