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Reduction of smoking in Dutch adolescents over the past decade and its health gains: a repeated cross-sectional study

Cindy M. Gielkens-Sijstermans[1,2], Monique A. Mommers[3], Rudolf T. Hoogenveen[4], Talitha L. Feenstra[4], Jacqueline de Vreede[1], Fons M. Bovens[1], Onno C. van Schayck[2]

Background: Smoking is the main preventable lifestyle-related risk factor threatening human health. In this study, time trends in smoking behaviour between 1996 and 2005 among adolescents enrolled in secondary school were assessed. **Methods:** In 1996, 2001 and 2005, a survey was conducted in the south-eastern region of the Netherlands. All students in second and fourth year of secondary education (1996: $n = 20\,000$; 2001: $n = 27\,500$; 2005: $n = 24\,000$) were asked to complete a questionnaire about their smoking behaviour. A simulation model was used to estimate lifetime health gains related to the observed trends. **Results:** In 1996, 2001 and 2005, the number of questionnaires analysed were 13 554 (68%), 20 767 (76%) and 17 896 (75%), respectively. The results show a decrease in 'ever smoking' as well as 'current smoking' between 1996 and 2005. Among second year high school students, current smoking prevalence decreased from 22.2% in 1996 to 8.0% in 2005 ($P_{trend} < 0.001$). Among fourth year students, current smoking declined from 37.5% in 1996 to 22·0% in 2005 ($P_{trend} < 0.001$). Time trends were not influenced by gender or educational level. Model projections show that if these students not take up smoking later in life, 11 500 new cases of COPD, 3400 new cases of lung cancer and 1800 new cases of myocardial infarction could be prevented for the Dutch 13-year-olds. **Conclusion:** This study found that, in the past decade, smoking prevalence among adolescents has declined by almost 50%, potentially resulting in a considerable reduction in new cases of COPD or lung cancer.

Keywords: adolescents, health, smoking.

Introduction

Smoking is the main preventable lifestyle-related risk factor threatening human health. In fact, failing dramatic changes in current use, an estimated 450 million tobacco-related deaths are predicted to occur in the next 50 years.[1]

Smoking is often initiated during adolescence. Approximately 90% of adult (ex)smokers report smoking their first cigarette before the age of 18. Additionally, the prevalence of smoking has been found to increase substantially between the ages of 12 and 16. While smoking cessation in later life still results in substantial health gains and is a cost-effective form of prevention[2], not engaging in daily smoking at all obviously produces the greatest health gains.[3]

Several international studies have shown that the prevalence of cigarette smoking among adolescents has changed in the past two decades. In the United States, the prevalence of current cigarette use among high school students increased from 27.5% in 1991 to 36.4% in 1997, declined to 21.9% in 2003, and remained stable from 2003 to 2007.[4] In Eastern Europe, a slight increase in the prevalence of smoking among 15–16-year-olds was seen between the mid-1990s and 2001. In western Europe, the smoking rate in this age group is roughly stable (26% in 2001).[5] A general population study in the Netherlands showed a strong decrease in smoking among 13- to 15-year-olds from 20.3% in 1999 to 7.4% in 2003.[6] These countries might be in different stages of the smoking epidemic as described by Lopez *et al.*,[7] explaining the different prevalence rates. In the Netherlands, the risks of smoking are by now a major public health concern and the smoking epidemic in this country has most likely progressed into a phase in which the decline in smoking prevalence continues.

To monitor the progress of the epidemic among adolescents, the time trend in smoking behaviour between 1996 and 2005 among students enrolled in secondary school is studied. This study is the first to show the lifetime health consequences of these trends using model projections that illustrate the future health effects of the observed decreases.

Methods

Participants and data collection

In order to investigate the health risk behaviour of adolescents, the Public Health Services located in the southeastern region of the Netherlands conducted a survey study with 4–5-year intervals (1996, 2001, 2005). The particular south-eastern region of the Netherlands has more than 1 million inhabitants of whom >80 000 are between the ages of 12 and 19. In this region, all students in their second and fourth year of secondary education were asked to complete a questionnaire at school, during a class and under the supervision of a teacher. In 2001, ~27 500 students were eligible for participation and, in 2005, ~24 000 students were eligible. For the survey conducted in 1996, ~20 000 students were invited to participate. One region, namely Southeast Limburg, did not participate in 1996.

1 South Limburg Public Health Service, Geleen, the Netherlands
2 Department of General Practice, CAPHRI, Maastricht University, Maastricht, the Netherlands
3 Department of Epidemiology, CAPHRI & NUTRIM, Maastricht University, Maastricht, the Netherlands
4 Department for Prevention and Health Services Research National Institute for Public Health and the Environment (RIVM) and Department of Epidemiology, University Medical Center Groningen, the Netherlands
Correspondence: Cindy M. Gielkens-Sijstermans, South Limburg Public Health Service, P.O. Box 2022, 6160 HA Geleen, the Netherlands, tel: +31 46 850 54 52, fax: +31 46 850 66 67, e-mail: cindy.gielkens@ggdzl.nl

Two weeks before the survey was distributed, the parents of the target group were informed about the study and were given the opportunity to indicate that they did not want their child to participate. Participation was anonymous and voluntary.

All three surveys were conducted in October and November.

Questionnaire and definitions

In the surveys conducted in 1996 and 2005, smoking behaviour was assessed with two questions. The first question was: 'Have you ever smoked (at least one cigarette, cigar or pipe)?' to which respondents could answer 'yes' or 'no'. The second question was: 'How often do you smoke now?'. The answer possibilities were 'every day', 'at least once a week but not every day', 'less than once a week' and 'I never smoke'. Respondents who answered the first question with 'yes' were defined as 'ever smokers', and respondents who answered one of the first three options on the second question were categorized as 'current smokers'. In 2001, these two questions were combined into one question with the same answer possibilities. The education level of the students was divided into (from low to high): preparatory secondary professional education (VMBO), higher general secondary education (HAVO) and preparatory scientific education (VWO).

Statistical analyses

SPSS version 14.0 was used to calculate the prevalence of ever and current smoking. Mantel-Haenszel's Chi-square test for linear association was used to investigate trends in prevalence rates between 1996, 2001 and 2005. Analyses were stratified for gender, grade and education level.

The mean age at which students started smoking was calculated for each survey. Differences in the mean starting age between the three surveys were tested with one-way ANOVA.

A *P*-value of <0.05 was considered statistically significant.

Model analyses

A simulation model, namely the RIVM Chronic Disease Model, was applied to estimate the public health effects that result from the observed smoking trends. The model contains data on the Dutch population and links disease incidence and mortality to smoking behaviour. Details on the model structure and input data with respect to smoking have been published elsewhere.[3,8,9] The model includes 13 smoking-related diseases. The prevalence of smokers, former smokers and never smokers is modelled by start, quit and relapse rates. These rates were estimated using data acquired between 2001 and 2003 for the model's baseline case.[3,8] The model definition of a smoker was a daily smoker. The model accounts for competing risks and uses data specified by age, gender and time since cessation.

Model projections were made for the following outcomes: (i) The disability adjusted life expectancy (DALE) for the average 13-year-old in 1996 compared to the DALE for the average 13 year old in 2005; (ii) the lifetime expected percentage of smokers for the 13-year-old in 1996 compared with the percentage of smokers in the 2005 cohort; and (iii) the cumulative number of new cases of COPD, lung cancer, and myocardial infarct in the 1996 as compared to the 2005 cohort. The smoking percentages were standardized for the age and gender distribution of the reference cohort.

Estimates of the percentage of daily smokers in 1996 and 2005 were based on observed rates of current smokers in the data and also on proportions of current to daily smokers.[10] Two estimates of the public health effects were computed: (i) a pessimistic scenario, that assumed that only the initial smoking class values of 13-year-olds had changed, while all transition rate values, i.e. start, relapse and quit rates remained unchanged; and (ii) a more optimistic scenario that assumed that the transition rate values also had changed. Changes were based on adjusted start rates for all ages up to 20 years of age and proportional to the decreases seen in prevalence rates.

Results

In 1996, 2001 and 2005, the number of questionnaires analysed were 13 554 (68%), 20 767 (76%) and 17 896 (75%), respectively. The age, gender and education level of the participants in all the three surveys were comparable (table 1). The results of the three surveys demonstrated a clear decrease of ever smoking among students in their second year of secondary education from 49.7% in 1996 to 24.0% in 2005 ($P_{trend} < 0.001$). Among students in their fourth year, ever smoking decreased from 68.8% in 1996 to 47.6% in 2005 ($P_{trend} < 0.001$) (table 2). The proportion of current smokers also declined over time. Among students in their second year, the prevalence of current smoking decreased from 22.2% in 1996 to 8.0% in 2005 ($P_{trend} < 0.001$). For students in the fourth year, current smoking declined from 37.5% in 1996 to 22.0% in 2005 ($P_{trend} < 0.001$).

Table 1 Characteristics of the study sample for the three study years

	Year of study		
	1996	**2001**	**2005**
Sex, *n* (%)			
Male	6599 (49.0)	10 056 (48.6)	8619 (48.2)
Female	6861 (51.0)	10 624 (51.4)	9265 (51.8)
School year, *n* (%)			
Second	6372 (47.0)	10 796 (52.0)	9062 (50.6)
Fourth	7182 (53.0)	9971 (48.0)	8834 (49.4)
Age, mean (SD)			
Second school year	13.5 (0.64)	13.3 (0.57)	13.2 (0.53)
Fourth school year	15.6 (0.74)	15.4 (0.64)	15.4 (0.62)
Education level, *n* (%)			
Preparatory secondary professional education (VMBO)	6996 (51.5)	11 491 (55.3)	8464 (47.3)
Higher general secondary education (HAVO)	3252 (24.0)	4827 (23.2)	4703 (26.3)
Preparatory scientific education (VWO)	3326 (24.5)	4449 (21.4)	4729 (26.4)

Table 2 Smoking behaviour among students in their second and fourth year of secondary school by study year

	Study year			
	1996	**2001**	**2005**	***P*-value**
Second year	*n* = 6372	*n* = 10 796	*n* = 9062	
'Ever' smokers	3116 (49·7)	4406 (40·9)	2170 (24·0)	0·000
'Current' smokers	1409 (22·2)	1747 (16·2)	724 (8·0)	0·000
Fourth year	*n* = 7182	*n* = 9971	*n* = 8834	
'Ever' smokers	4858 (68·8)	5952 (59·8)	4190 (47·6)	0·000
'Current' smokers	2692 (37·5)	3124 (31·4)	1937 (22·0)	0·000

Data are presented as number of positive responses with percentages between parentheses. Missing data are not included in the analyses.

The decrease in smoking prevalence among adolescents between 1996 and 2005 was found in both years among boys as well as girls (figure 1). Among girls in their fourth year, the prevalence of current smoking decreased from 39.8% in 1996 to 23.1% in 2005 ($P_{trend} < 0.001$). Among boys in the same year, current smoking decreased from 35.2% in 1996 to 20.7% in 2005 ($P_{trend} < 0.001$).

Furthermore, decreases in smoking behaviour over time were also found in all three education levels (figure 2). The percentage of VMBO students (lowest education level) that were current smokers decreased from 36.7% in 1996 to 21.3% in 2005 ($P_{trend} < 0.001$). Among HAVO students (moderate education level), 30.3% were current smokers in 1996 while, in 2005, this percentage was 12.2% ($P_{trend} < 0.001$). Lastly, among VWO students (highest education level), current smoking decreased from 16.9% in 1996 to 6.1% in 2005 ($P_{trend} < 0.001$).

Comparable time trends were observed in ever smoking. While comparing the 1996 with the 2005 cohort, the model simulations with the most optimistic simulations projected that 11 500 new cases of COPD, 3400 new cases of lung cancer and 1800 new cases of myocardial infarction could be prevented in the lives of Dutch 13-year-olds. Pessimistic assumptions about smoking behaviour after the age of 13 reduced this potential gain to 90, 30 and 15 cases, respectively. For the total Dutch 13-year-old population, the pessimistic scenario showed an increase in the life expectancy of an average 13-year-old of 0.0075 years. DALE increased by 0.0104 years. In contrast, the optimistic scenario for an average 13 year old showed an increase in life expectancy of 0.91 years and an increase in DALE of 1.25 years.

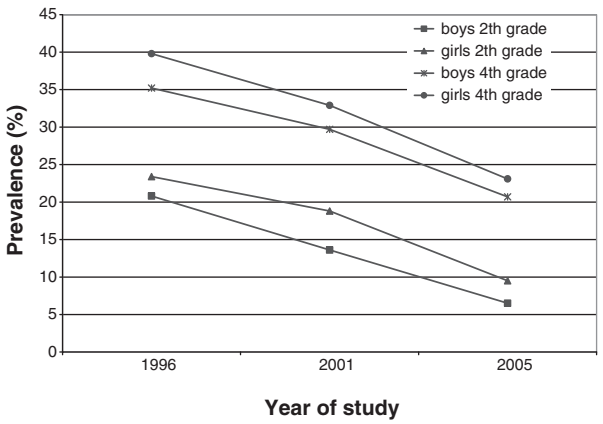

Figure 1 Time trend for current smoking by grade and by sex

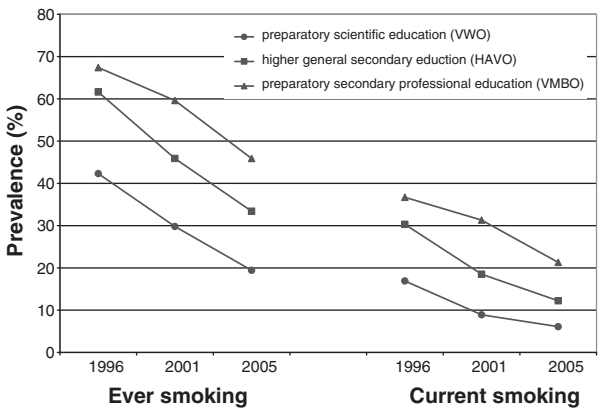

Figure 2 Time trend forever and current smoking by educational level

Discussion

The results of this study have demonstrated a clear decline in ever and current smoking between 1996 and 2005 among adolescents living in the south-eastern region of the Netherlands. This decline was found in both males and females, in all three education levels and in both age groups included in this study. The decrease in prevalence established is likely to generate considerable health gains in the years to come.

In several previous studies in the Netherlands, declining time trends in the prevalence of adolescent smoking have also been observed.[6,11,12] The Health Behaviour in School-Aged Children (HBSC) study found a continuous decrease in the lifetime prevalence of smoking among 12- to 16-year-old Dutch adolescents from 46.1% in 1996 to 33.0% in 2005.[11] Furthermore, the Smoking Youth Monitor showed a declining trend in current smoking among both 13–14-year-old and 15–19-year-old adolescents between 1996 and 2005.[12] In Europe as a whole, the prevalence of smoking among teenagers aged 15–18 is 30% with 'almost no signs of a decrease' according to the World Health Organisation. Several European countries even showed an increase in smoking among teenagers between 1997 and 2001.[6]

In the USA, the prevalence of lifetime as well as current smoking among adolescents aged 13–15 years declined from 70.4% in 1999 to 50.3% in 2007 and from 36.4% in 1997 to 21.9% in 2003, respectively. Current cigarette use remained stable from 2003 to 2007.[4,13]

Interestingly, while smoking prevalence in boys and girls similarly decreased, in all our three surveys, more girls than boys reported smoking. This corresponds with the Dutch HBSC study in which it was established that, although not statistically significant, smoking is indeed more common in girls than in boys[10] although in other countries, boys are more likely to currently smoke cigarettes than girls.[14] Similar decreases for boys and girls in prevalence rates of cigarette smoking have also been observed in American and Filipino studies,[15,16] and might be explained by a similar association between smoking behaviour and perceived addictiveness in both genders, as was reported in a Swedish study.[17]

Despite the fact that students enrolled in the three education levels had different prevalence rates (higher among lower-level students), the decreases over time were not related to education level. The same was found in a study in the USA, where similar gradients in the trends in smoking were seen across subgroups such as gender, age and educational level.[18] Studies among adults, however, have shown smaller decreases in prevalence among people with a lower level of education than among people with a higher level of education, potentially because people with a higher level of education are more actively committed to not-starting or quitting smoking.[19,20]

Strengths of our study are the large numbers of participants and the consistent and robust findings. However, the study has limitations as well. In the 1996 survey, Southeast Limburg did not participate. Thus, the analyses of the data acquired in 1996 were based on fewer students than the 2001 and 2005 surveys. Excluding the Southeast region from the analyses, however, did not change the results and we therefore think selection bias is unlikely. Because the absolute number of adolescents eligible for participation in the study could not be established, we estimated response rates from the total number of second- and fourth-year students enrolled in secondary schools in the Netherlands. Our conservative estimate of the response rates for each survey was 69% in 1996, 76% in 2001 and 75%

in 2005. In order to determine the non-response due to illness, being absent or other reasons, we consulted the absence and presence registration forms completed by the teachers. We concluded that the number of students who did not participate because of the above-mentioned reasons was relatively low (±5%). Most of the non-response resulted from the fact that, in each study year, some schools did not participate, mostly for logical reasons, such as lack of time. These schools did not significantly differ from the participating schools with respect to education level or geographical location. As a result, it seems probable that bias due to non-response was minimal and was not likely to have a significant impact on the results.

Another limitation of our study is that the data were self-reported and smoking behaviour might either be underreported or exaggerated. Moreover, both failures could depend on school type and on time. The extent to which this bias may play a role cannot be established. However, Brener *et al.* did demonstrate that the questions used in their study, which were identical to those used in ours, were reliable over time.[21,22]

Sensitivity and specificity of adolescent self-reported smoking were high when compared to salivary cotinine levels as a biochemical marker of nicotine uptake.[23,24] Nonetheless, despite good reliability and validity of the questionnaire items on smoking behaviour, we cannot fully exclude the possibility that the self-reported smoking behaviour in our study was biased. The social context of smoking has changed in the recent years. Smoking is no longer popular and this may have led to an increased underreporting of smoking behaviour. Although we could not assess this in the present study, the above-mentioned studies were conducted around the same time as our 2005 survey, and they showed no evidence of underreporting. Consequently, we assume that the influence of underreporting is most likely limited.

The above-mentioned differences in the developments of the trends in smoking behaviour among adolescents between the various countries probably illustrate the different stages of the smoking epidemic the countries are dealing with.[7] Not only in western European countries, such as the Netherlands, but also in the USA, the major health consequences of smoking behaviour are already a major public health concern. In these countries, the tobacco control policies are established and have their effects as shown by the continued decline in smoking prevalence rates among adults as well as adolescents.

Conforming to the four-stage model of cigarette consumption, as described by Lopez *et al.*,[7] our findings suggest that the observed reduction in adolescent smoking follows the general trend in the adult population.

Causes of the observed decline among adolescents might include concerns for health and addiction, a positive self-image and perceived confidence.[25] Furthermore, restricting smoking at home, more extensive bans on smoking in public places, and enforced bans on smoking at school may reduce teenage smoking.[26] In the Netherlands, increased school-based efforts to prevent tobacco use in the past ten years may have assisted in achieving these favourable trends. Other factors that might have contributed to the decline are increasing retail prices and increased exposure to mass media smoking-prevention campaigns. Also, smoking legislation in the Netherlands has changed in recent years. Since 2002, advertising tobacco products is forbidden and the negative health risks of smoking are explicated on cigarette packages. Since 2003, the number of selling points has been reduced and cigarettes and other tobacco products can now only be sold to persons aged 16 years and older. Dutch researchers have reported that this last action has led to lower tobacco purchases among adolescents.[6] However, in our study, we saw that the decrease in the prevalence of smoking among adolescents started already before the introduction of the tobacco sales ban in 2003. The model simulations have shown that, for this group of adolescents, the potential health gains of this decrease in smoking are likely substantial. Because of this change, up to 11 500 new cases of COPD, 3400 new cases of lung cancer and 1800 new cases of myocardial infarction may be prevented in the lifetimes of 13 year olds in the Netherlands.

However, the differences between the two scenarios are striking. In order to realize the greatest potential gains in DALE, the adolescents in the 2005 cohort must remain abstinent and not take up smoking later in life. The results of the students in their fourth year of secondary school seem to suggest that this may be the case. Therefore, the pessimistic projections are likely to underestimate the consequences of the lower smoking prevalence in the adolescents.

In conclusion, smoking behaviour among adolescents in the south-eastern region of the Netherlands is changing for the better. In order to realize the health gains that result from decreases in smoking behaviour, we advise that efforts should focus on discouraging young adolescents from starting smoking at an older age.

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Conflicts of interest: None declared.

Key points

- It is important to closely monitor developments in smoking behaviour among adolescents because, first, adolescent smoking behaviour is dynamic and unstable, and second, it has a major impact on health during adulthood.
- This study found that, in the past decade, smoking prevalence among adolescents has declined by almost 50%, potentially resulting in a considerable reduction in new cases of COPD or lung cancer.
- The decrease in smoking prevalence was comparable between boys and girls.
- The decreases in smoking prevalence among adolescents were not related to educational level.

References

1 Slama K. Current challenges in tobacco control. *Int J Tuberc Lung Dis* 2004;8:1160–72.

2 Feenstra TL, Hamberg-van Reenen HH, Hoogenveen RT, Rutten-van Molken MP. Cost-effectiveness of face-to-face smoking cessation interventions: a dynamic modeling study. *Value Health* 2005;8:178–90.

3 van Baal PH, Hoogenveen RT, de Wit GA, Boshuizen HC. Estimating health-adjusted life expectancy conditional on risk factors: results for smoking and obesity. *Popul Health Metr* 2006;4:14.

4 Centers for Disease Control and Prevention. Cigarette use among high school students, United States, 1991–2007. *Morbid Mortal Wkly Rep* 2008;57:686–8.

5 Brown P. Smoking increases among teenagers in eastern Europe. *BMJ* 2002;324:442.

6 Verdonk-Kleinjan WMI, Knibbe RA, Bieleman B, et al. The tobacco sales ban and tobacco purchases by adolescents: a general population study in the Netherlands. *Eur J Public Health* 2008;18:498–503.

7 Lopez AD, Collishaw NE, Piha T. A Descriptive model of the cigarette epidemic in developed countries. *Tobacco Control* 1994;3:242–7.

8 Hoogenveen RT, van Baal PH, Boshuizen HC, Feenstra TL. Dynamic effects of smoking cessation on disease incidence, mortality and quality of life: the role of time since cessation. *Cost Eff Resour Alloc* 2008;6:1.

9 van Baal PH, Polder JJ, de Wit GA, et al. Lifetime medical costs of obesity: prevention no cure for increasing health expenditure. *PLoS Med* 2008;5:e29.

10 Vijgen SM, van Baal PH, Hoogenveen RT, et al. Cost-effectiveness analyses of health promotion programs: a case study of smoking prevention and cessation among Dutch students. *Health Educ Res* 2008;23:310–18.

11 van Dorsselaer S ZE, van den Eeckhout S, ter Bogt T, Vollebergh W. HBSC 2005: Gezondheid en welzijn van jongeren in Nederland, Utrecht, the Netherlands: Trimbos-Institute, 2007.

12 STIVORO Dutch Foundation for Smoking and Health. Roken, de harde feiten: resultaten van de continue Roken Jeugdmonitor.

13 Youth tobacco surveillance—United States, 1998–1999. *MMWR CDC Surveill Summ* 2000;49:1–94.

14 Warren CW, Jones NR, Eriksen MP, Asma S. Patterns of global tobacco use in young people and implications for future chronic disease burden in adults. *Lancet* 2006;367:749–53.

15 Centers for Disease Control and Prevention. Tobacco use among students aged 13–15 years—Philippines, 2000 and 2003. *Morbid Mortal Wkly Rep* 2005;54:94–7.

16 Centers for Disease Control and Prevention. Trends in cigarette smoking among high school students—United States, 1991–2001. *J Sch Health* 2002;72:226–8.

17 Lundborg P, Andersson H. Gender, risk perceptions, and smoking behavior. *J Health Econ* 2008;27:1299–311.

18 Nelson DE, Mowery P, Asman K, et al. Long-term trends in adolescent and young adult smoking in the United States: metapatterns and implications. *Am J Public Health* 2008;98:905–15.

19 Janson C, Kunzli N, de Marco R, et al. Changes in active and passive smoking in the European Community Respiratory Health Survey. *Eur Respir J* 2006;27:517–24.

20 Giskes K, Kunst AE, Benach J, et al. Trends in smoking behaviour between 1985 and 2000 in nine European countries by education. *J Epidemiol Commun Health* 2005;59:395–401.

21 Brener ND, Collins JL, Kann L, et al. Reliability of the Youth Risk Behavior Survey Questionnaire. *Am J Epidemiol* 1995;141:575–80.

22 Brener ND, Kann L, McManus T, et al. Reliability of the 1999 youth risk behavior survey questionnaire. *J Adolesc Health* 2002;31:336–42.

23 Dolcini MM, Adler NE, Lee P, Bauman KE. An assessment of the validity of adolescent self-reported smoking using three biological indicators. *Nicotine Tob Res* 2003;5:473–83.

24 Post A, Gilljam H, Rosendahl I, et al. Validity of self reports in a cohort of Swedish adolescent smokers and smokeless tobacco (snus) users. *Tob Control* 2005;14:114–7.

25 Kulbok PA, Rhee H, Botchwey N, et al. Factors influencing adolescents' decision not to smoke. *Public Health Nurs* 2008;25:505–15.

26 Wakefield MA, Chaloupka FJ, Kaufman NJ, et al. Effect of restrictions on smoking at home, at school, and in public places on teenage smoking: cross sectional study. *BMJ* 2000;321:333–7.

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