Original Investigation

Changing age-specific patterns of cigarette consumption in the United States, 1992–2002: Association with smoke-free homes and state-level tobacco control activity

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Abstract

Introduction: During the 1990s, both prevalence and average cigarette consumption declined in the United States, but age-specific changes have not been reported.

Method: All four of the nationally and state representative U.S. Current Population Surveys—Tobacco Use Supplements from 1991–2002 ($n=542,470$) were analyzed for trends in cigarette consumption among smokers in three age groups: 18–29, 30–44, and 45–64 years. A strength of tobacco control index ranking state of residence was added and weighted logistic regression analyses undertaken.

Results: Over the decade, both prevalence and average consumption declined. Moderate-heavy smoking (≥ 15 cigarettes/day [CPD]) prevalence fell strongly over the period in all three age groups. For those aged ≥ 30 years, this reduction was accompanied by a similar drop in total smoking prevalence. For those aged 18–29 years, this reduction was associated with an increase in very light smoking (< 5 CPD; 12% daily and 88% intermittent smokers) to 22.5% of current smokers with a much smaller reduction in prevalence. Smoke-free homes more than doubled in each age group and mediated the increase in very light smoking levels. Smoke-free workplaces and the strength of tobacco control in the state were also important predictors. Very light smoking was particularly prevalent among college students and graduates.

Discussion: The marked reduction in prevalence of moderate-heavy smoking across age groups should translate into a reduced population risk of smoking-related disease in the near term.

That this reduction is offset by an increase in light and intermittent smoking in young adults suggests the effectiveness of tobacco industry marketing and needs further research.

Introduction

In the early 1990s, the key smoking questions in national surveys in the United States were changed to better capture the cross-sectional prevalence of light or intermittent smoking behavior (Giovino et al., 1994). Although cigarette consumption levels below 5 cigarettes/day (CPD) have been labeled as insufficient for nicotine regulation and physiological dependence (Benowitz, Jacob, Kozlowski, & Yu, 1986), some smokers may maintain stable behavior at these low levels because of psychological dependence. Alternatively, for heavier smokers, a period of light or intermittent smoking may be part of a dynamic process of attempting to quit (Zhu, Sun, Hawkins, Pierce, & Cummins, 2003).

Using a longitudinal population survey, Zhu et al. (2003) observed that the majority of light smokers (defined as intermittent or daily and smoking less than 5 CPD) identified in California in the early 1990s did not maintain a stable consumption level over a 20-month period. The changes in consumption observed in these longitudinal data could be represented by a dynamic model of quitting and relapse, in which heavier smokers reduced smoking prior to making a quit attempt (Farkas, 1999) and relapse among former smokers began with a period of light smoking. However, the population trend was an increasing

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proportion of light smokers while overall smoking prevalence declined. This model fits the experimental work of Cinciripini, Hecht, Henningfield, Manley, and Kramer (1997), who have demonstrated that a structured reduction phase prior to a quit attempt can enhance successful quitting.

However, approximately a quarter of Californian light smokers in the early 1990s did maintain a stable pattern of consumption (Zhu et al., 2003). In a series of studies, Shiffman and colleagues have studied “chippers” who have maintained a light or intermittent smoking pattern for at least 2 years. Chippers, who smoked fewer than 5 CPD but more than 4 days/week, did not exhibit the characteristic features of nicotine dependence (Shiffman, Paty, Gnys, Kassel, & Elash, 1995), regardless of whether they had previously been heavier smokers (Shiffman, Paty, Gnys, & Zettler-Segal, 1994). In general, chippers were not social smokers as defined by Moran, Wechsler, and Rigotti (2004) as they smoked more when alone than with others (Shiffman & Paty, 2006) but rather had a smoking pattern similar to smokers who had started smoking only recently (McKinnell & Thomas, 1967; Russell, 1971) with smoking behavior cued by stimuli such as drinking alcohol, eating, relaxing, and socializing (indulgent behaviors) as well as being strongly associated with negative affect (Shiffman & Paty, 2006). This pattern was markedly different from that of heavier smokers, in whom smoking behavior appeared to be cued by a need to maintain blood nicotine levels so as to avoid lapsing into nicotine withdrawal (Shiffman et al., 2002). Shiffman and Paty (2006) hypothesized that these chippers may have somehow been “fossilized” in an early stage of the process of becoming a smoker.

Increased prevalence of such fossilized smoking initiation might be associated with the introduction of restrictions on smoking (Pierce et al., 1991), especially as chippers tend not to smoke when working (Shiffman & Paty, 2006), and in population studies, the prevalence of intermittent smoking is associated with the prevalence of workplace smoking restrictions in the smoker’s resident state (Tauras, 2004). We hypothesized that light and intermittent smoking behavior would have increased among young people along with the known increases of smoke-free workplaces (Gerlach, Shopland, Hartman, Gibson, & Pechacek, 1997) and smoke-free homes (Gilpin, White, Farkas, & Pierce, 1999) across the 1990s. Given that consumption by smokers is strongly influenced by race/ethnicity, with differences by age and acculturation in minorities (Evans et al., 1992; Shiffman et al., 2002; U.S. Department of Health and Human Services [USDHHS], 1998), to avoid confounding, we tested this hypothesis among the national non-Hispanic White population using large population surveys from 1992 through 2002.

Method

Data source

We used the Tobacco Use Supplement to the Current Population Survey (TUS-CPS), national household surveys conducted by the U.S. Census Bureau for the National Cancer Institute. The CPS has been conducted monthly since 1953 to provide labor force statistics for the United States, using a multistage stratified area probability sample, with a household response rate of 92%–97%. Approximately 50,000–60,000 households are interviewed by the CPS each month in a rotating panel de-

sign, with each household interviewed for four consecutive months and independent samples at 4-month intervals. In the first month-in-sample, a Census Bureau representative interviews each household resident aged 15 years or older in person; however, in the subsequent three months, approximately 85% of interviews are by telephone using the Census Bureau’s computer-assisted telephone interviewing software. The TUS-CPS supplements were coordinated by the National Cancer Institute for tobacco use surveillance in 1992–1993, 1995–1996, and 1998–1999, each consisting of a supplement to the September, January, and May CPSs, which are then combined, and in 2001–2002, as a supplement to the June, November, and February CPSs. The most recent survey, from 2006–2007, is not yet publicly available.

As with the CPS, a single household member responded (proxy-response) to the TUS for those not interviewed in person (self-response); however, efforts were made to interview all residents aged 15 years or older who responded to the CPS. Final response rates for self-respondents to the TUS interview were 61%–68%, among the highest in population survey research. Details of methods and complete questionnaires are available elsewhere (U.S. Bureau of Labor Statistics and U.S. Census Bureau, 2002, 2007a, 2007b). Each observation in these population surveys is weighted according to the sampling design and then by a poststratified ratio adjustment so that survey totals agree with 1990 U.S. census totals for each state within gender, age, and race/ethnic classes. These weights adjust for unequal selection probabilities and undercoverage in the sampling design and for observed survey nonresponse. Weighted estimates from the TUS-CPS provide representative population estimates of smoking behavior (U.S. Bureau of Labor Statistics and U.S. Census Bureau, 2007a, 2007b). In the present study, we used data from all self-respondents categorized as non-Hispanic Whites aged 18–64 years. The sample sizes of our study population are 161,158; 130,794; 122,615; and 127,903 for the respective survey years.

Demographic and smoking measures

On the TUS, all respondents are asked if they have smoked at least 100 cigarettes in their lifetime. A positive response classifies a person as an ever-smoker, having established smoking behavior at some timepoints. Ever-smokers are asked whether they now smoke every day, some days, or not at all. Some-day smokers are asked (a) on how many of the past 30 days they smoked and (b) how many cigarettes they usually smoked on those days. Together, these questions determine total monthly (30-day) cigarette consumption, and average cigarettes per day is computed as total monthly cigarettes divided by 30. Daily smokers are asked how many cigarettes they smoke each day on average. Light smokers are defined as those reporting average daily consumption of less than 5 CPD, including both daily and nondaily smokers. Nondaily smokers also are asked whether they had ever smoked daily for 6 months or longer.

Basic demographic information collected by the CPS includes age, gender, ethnicity, income, and educational attainment. As in previous work (Messer et al., 2007), income was categorized as under or over twice the U.S. Census Bureau poverty threshold for the given year, based on family size (U.S. Census Bureau, Housing and Household Economic Statistics Division, 2007). We grouped respondents into age groups of 18–29, 30–44,

and 45–64 years, as in previous research. We did not include respondents aged 65 years or older to avoid bias from differential mortality rates, which are appreciably higher among heavier smokers (USDHHS, 1989).

Smoking restrictions

All respondents were asked about rules governing smoking in their home. Those who reported that no one was allowed to smoke anywhere in the home were classified as having a smoke-free home. Respondents who reported working indoors and who reported that smoking was not allowed in any public area or work area were classified as having a work smoking ban. Those who reported less stringent restrictions, and those not working indoors, were considered not to have a work smoking ban.

Measures of state-level tobacco control

In the early 1990s, states (including the District of Columbia) were ranked on the strength of their tobacco control programs, and this index was a good predictor of average cigarette sales in the state as well as of adult and adolescent prevalence estimates (Gilpin, Stillman, Hartman, Gibson, & Pierce, 2000). Lung cancer rates have been associated with this index (Jemal, Cokkinides, Shafey, & Thun, 2003). States in the top tertile of this index were Washington, California, Utah, Alaska, Hawaii, Arizona, Oregon, Florida, Connecticut, District of Columbia, Texas, New Jersey, Minnesota, Vermont, Maryland, Idaho, and Maine. States in the middle tertile were Massachusetts, New Mexico, New York, Rhode Island, Colorado, Delaware, New Hampshire, Nevada, Wisconsin, Illinois, North Dakota, Nebraska, Pennsylvania, Georgia, Kansas, Oklahoma, and Louisiana. States in the lowest tertile were Mississippi, Virginia, Iowa, Montana, Alabama, Michigan, South Dakota, Wyoming, South Carolina, Ohio, Arkansas, Tennessee, West Virginia, Indiana, Missouri, North Carolina, and Kentucky. Among the highest tertile states, the proportion of smokers reporting smoke-free workplaces (indoor workers only) increased from 38.9% in 1992–1993 to 56.7% in 2001–2002 (46% increase), whereas the proportion reporting a smoke-free home increased from 15.7% to 36.3% (2.3-fold increase). For the middle tertile, the equivalent changes in these proportions were as follows: smoke-free workplaces, 30.3% to 52.8% (74% increase), and smoke-free homes, 9.6% to 27.0% (2.8-fold increase). For the lowest tertile, the equivalent changes were as follows: smoke-free workplaces,

23.5% to 45.4% (93% increase), and smoke-free homes, 8.1% to 21.8% (2.7-fold increase).

Statistical methods

All estimates were weighted by the TUS-CPS survey weights. *CIs* and *p* values were computed using the TUS published replicate weights, with Fay's balanced repeated replication (U.S. Bureau of Labor Statistics and U.S. Census Bureau, 2002, 2007a, 2007b). We assessed trends in prevalence using weighted logistic regression with survey year as a continuous variable and a categorical variable for age group. Differences in trend by age were tested with an age $\times$ time interaction term. All estimates were computed in SAS®-callable SUDAAN® version 9.01, using PROC CROSSTABS or PROC LOGISTIC.

Results

The prevalence of current smoking decreased over time among all age groups over the 10-year study period: 1992–1993 to 2001–2002 (Figure 1). However, the drop in smoking prevalence was much smaller ($p < .001$) among those aged 18–29 years (1.2 percentage points) compared with those aged 30–44 years (3.6 percentage points) or those aged 45–64 years (3.8 percentage points). Over the same period, average consumption among continuing smokers declined in all age groups by more than 2 CPD: from 15.1 (95% *CI* = 14.9–15.2) to 12.5 (95% *CI* = 12.3–12.8; 2.6 CPD decline) in those aged 18–29 years, from 18.8 (95% *CI* = 18.7–19.0) to 16.2 (95% *CI* = 15.9–16.4; 2.6 CPD decline) among those aged 30–44 years, and from 20.6 (95% *CI* = 20.4–20.8) to 18.5 (95% *CI* = 18.3–18.8; 2.1 CPD decline) among those aged 45–64 years. This decline came, in part, from a consistent large decline (~4 percentage points) in the prevalence of moderate-heavy smoking (at least 15 CPD) in each age group (see Figure 1).

A change in the prevalence of light smoking also contributed to the decline in average consumption among continuing smokers. Over the decade, the prevalence of smoking fewer than 5 CPD increased significantly ($p < .001$) among those aged 18–29 years (from 4.7% to 6.0%) so that 22% of current smokers in 2001–2002 in this age group were light or intermittent smokers (see Figure 1). This increase was significantly greater than for either of the older age groups ($p < .03$). At the end of the decade, 4.1% of the 30- to 44-year-old age group (17% of current smokers) and 2.5% of the 45- to 64-year-old age group (12% of current smokers) were in this lightest consumption category, up from 3.5% and 2.4%, respectively, in the 1992–1993 survey.

Changes in smoke-free homes over the decade across age groups

Over the decade of this study, the prevalence of smoke-free homes increased among smokers of all age groups ($p < .001$; Figure 2), and the rate of increase was similar across the three age groups considered (2.6-fold increase for 18–29 years, 2.7-fold increase for 30–44 years, and 2.4-fold increase for 45–64 years). Across the decade, the proportion of smoke-free homes was consistently highest among 18- to 29-year-old smokers, followed by 30- to 44-year-old smokers, with the lowest proportion among 50- to 64-year-old smokers (for 2001–2002: 36.7% vs. 28.9% vs. 21.7%; $p < .001$).

Figure 1. Smoking prevalence (moderate-heavy, medium, and light) among U.S. non-Hispanic White population, 1992–1993 to 2001–2002.

Predicting which 18- to 29-year-old current smokers have light or intermittent consumption

In a multivariate logistic regression model, the year of the survey was not a statistically significant predictor of light consumption among current smokers aged 18–29 years ($p > .15$; see Table 1), indicating that the increase in light consumption over the period was mediated by a change in some other modeled variables. Notably, when the indicator variable for presence of a smoke-free home was removed from the model, year of the survey was again a strong predictor (adjusted odds ratio [OR_{adj}] for year indicators: 1.13, 1.24, 1.36; $p < .001$, model not shown). Respondents who had attended college, particularly college graduates, were more likely to be light smokers than were those with lesser formal education ($p = .001$). We found no significant gender difference and a small significant difference on the income variable that was due to confounding of income with education (data supporting confounding not shown).

In this multivariate model, having work restrictions on smoking increased the adjusted odds that a smoker was light or intermittent by 28% ($OR_{adj} = 1.28$, 95% $CI = 1.18$ – 1.38), whereas if a smoker had a smoke-free home the adjusted odds of being a light or intermittent smoker increased almost threefold ($OR_{adj} = 2.8$, 95% $CI = 2.60$ – 3.04). The strength of tobacco control in the smoker's state of residence also was predictive of the odds of light smoking. Compared with residing in a state in the lowest tertile of tobacco control in 1992–1993, living in a state in the middle tertile increased the adjusted odds of light smoking by just over a quarter ($OR_{adj} = 1.26$, 95% $CI = 1.15$ – 1.38), whereas living in a state ranked in the top third for tobacco control increased the adjusted odds by around two-thirds ($OR_{adj} = 1.68$, 95% $CI = 1.53$ – 1.85).

Association of smoke-free homes with light consumption, within categories of educational attainment

In the logistic regression model, we found a significant interaction ($OR_{adj} = 1.30$, 95% $CI = 1.11$ – 1.54 , $p < .001$; model not shown) between indicators of less than a college education and presence of a smoke-free home, which increased the adjusted

effect of smoke-free homes among the less educated by 30%. Among 18- to 29-year-old college attendees who smoked, 39.5% of those with a smoke-free home were light or intermittent smokers compared with 22.3% of those without a smoke-free home (a 77% increase; Figure 3). Among 18- to 29-year-old smokers who did not go to college, 30% of those with a smoke-free home were light smokers compared with 11.5% of those without a smoke-free home (a 2.6-fold increase).

Changes in nondaily and never-daily smoking among light smokers

The majority of light smokers reported that they did not currently smoke daily, and this proportion did not vary substantially by age or across the study time period within age groups. In 2001–2002, the proportion of intermittent smokers among the light smokers was 86.8% (95% $CI = 85.3$ – 88.4) for the 18–29 age group, 88.7% (95% $CI = 87.1$ – 90.2) for the 30–44 age group, and 85.9% (95% $CI = 83.8$ – 88.0) for the 45–64 age group. Although we found no change over the period of the study, the proportion of light smokers who reported having never smoked daily was significantly lower with each increasing age group: in 2001–2002, aged 18–29 years, 50.5% (95% $CI = 47.6$ – 52.8); age 30–44 years, 43.6% (95% $CI = 41.2$ – 46.0); and age 45–64 years, 34.1% (95% $CI = 31.2$ – 37).

Discussion

Throughout the 1990s, the average consumption level among smokers decreased markedly in the non-Hispanic White majority population of the United States. A major decline in the population prevalence of smokers with high consumption levels (at least 15 CPD) was observed in all age groups. This decline was associated with an equivalent decline in overall smoking prevalence in populations aged more than 30 years. Among young adults (aged 18–29 years), the decline in overall smoking prevalence was considerably smaller, and it appeared to be offset by an increase in the population prevalence of light smokers (those consuming fewer than 5 CPD, of whom 88% reported smoking on fewer than 7 days/week). Given the known association between cigarette consumption and lung cancer (Burns, 1997; Doll & Peto, 1978; Flanders, Lally, Zhu, Henley, & Thun, 2003), this change in population smoking patterns will translate into a significant reduction in smoking-related illnesses in the future.

Over the decade, the proportion of smokers who had smoke-free homes more than doubled in each age group. This increase was strongly associated with the change in consumption patterns across the nation. As has been noted previously, given the large amount of time a person typically spends at home, having a smoke-free home raises a significant barrier to opportunities to smoke (Biener, Cullen, Di, & Hammond, 1997). Previous research suggests that having a smoke-free home may be a marker of social pressure against smoking in the immediate social network (Gilpin et al., 1999). Living with children or nonsmoking adults increased the probability of a smoke-free home, and this probability was increased significantly in the presence of a family preference that the smoker successfully quit.

These barriers to smoking also may explain the higher prevalence of light and intermittent smoking in young people with

Figure 2. Prevalence of smoke-free homes among non-Hispanic White current smokers, by age and year, 1992–1993 to 2001–2002.

Table 1. Logistic regression predicting light consumption (<5 CPD) among 18- to 29-year-old non-Hispanic White smokers

	Percentage of light smokers	Odds ratio	95% CI	p value
Intercept		0.09	0.08–0.11	<0.001
Year				
1992–1993	16.7	1		
1995–1996	18.9	1.03	0.95–1.12	0.47
1998–1999	20.8	1.05	0.96–1.15	0.24
2001–2002	22.5	1.06	0.97–1.16	0.18
Gender				
Male	19.6	0.98	0.91–1.05	0.47
Female	19.7	1		
Education				
College graduate	41.0	3.36	2.95–3.82	<0.0001
Some college	23.1	1.41	1.28–1.56	<0.0001
High school graduate	15.1	0.94	0.86–1.03	0.17
Less than high school	16.2	1		
Income				
Below 2× poverty threshold	18.2	1.12	1.04–1.21	0.003
Above 2× poverty threshold	21.0	1		
Smoking restrictions				
Home bans	34.7	2.81	2.60–3.04	<0.0001
No home ban	14.5	1		
Work bans	26.5	1.28	1.18–1.38	<0.0001
No work ban	17.8	1		
Tobacco control measures at baseline				
Highest tertile	25.1	1.68	1.53–1.85	<0.0001
Middle tertile	19.0	1.26	1.15–1.38	<0.0001
Lowest tertile	14.3	1		

smoke-free homes. Young people who have grown up with a smoke-free home, school, and workplace environment may stabilize at a much lower dependence level than those without such restrictions. Indeed, among young adult smokers, the increase in the proportion of light smokers over time was mediated by the increase in smoke-free homes to the extent that a secular time trend was not significant in our multivariate models.

In our model, young adult smokers who lived in states with stronger tobacco control activities were more likely to be light

Figure 3. Proportion of light smokers among current non-Hispanic White smokers aged 18–29 years by educational status and presence or absence of smoke-free homes.

smokers. This effect was independent of the presence of a smoke-free home and increased with increasing state level of tobacco control activity, suggesting that the social norms around smoking also have an independent impact on the general consumption pattern. Educational level also was independently associated with light smoking. Indeed, we found an interaction effect between education level and the presence of a smoke-free home. Among smokers without a college education, the relative effect of a home smoking ban was stronger, associated with a one-third greater increase in the proportion of light smokers, although the absolute levels of light smoking remained higher among the more educated. If the observed associations are causal, promotion of smoke-free homes may be an effective tobacco control strategy to reduce educational disparities in tobacco use.

As national cessation rates have been rising (Messer et al., 2007) and as low-rate smoking has been postulated to be an integral part of the quitting process (Zhu et al., 2003), it is not surprising that more than 10% of smokers now fall into this light or intermittent consumption category for each age group. However, the strong age gradient observed in the increase of light or intermittent smoking suggests that a change in the pattern of initiation may be occurring as well, as suggested previously (Shiffman & Paty, 2006). Further supporting a change in initiation, young adult smokers were almost twice as likely to be light or intermittent smokers compared with adults aged 50–64 years, and this level of difference between the two age groups is not seen in quitting behavior (Messer et al., 2007).

Many of these light or intermittent smokers had never smoked daily, and this was particularly the case for young adult smokers. Also, in our multivariate models, the increase in smoke-free homes was associated with the increase in light consumption among young adult smokers. These observations are consistent with the hypothesis that smoke-free homes would interrupt the smoking initiation process among young adults, preventing their progression to heavier smoking levels and thus contributing to the increase in light smoking in this age group. However, among light smokers, the proportion who had never smoked daily did not change over the study period, which was unexpected. Our data also are consistent with the hypothesis that lighter smokers will more readily adopt a smoke-free home and, thus, that the higher prevalence of smoke-free homes among young adult smokers is more a consequence than a cause of their higher rates of light smoking. A future analysis of these cross-sectional data by birth cohort may help to clarify these questions.

It is also possible that tobacco industry marketing contributed to the increase in light smoking among young adults. Had smoking initiation rates been lower, the prevalence of light smoking would have been lower among young adults, regardless of whether they later progressed to heavier smoking. This birth cohort of young adults was previously shown to be strongly receptive to tobacco industry marketing influences in the early 1990s (Evans, Farkas, Gilpin, Berry, & Pierce, 1995). Further, these young adults were exposed to the increased tobacco industry marketing in bars and clubs that targeted this cohort around the turn of the 21st century (Gilpin, White, & Pierce, 2005). It is possible that receptivity to tobacco marketing as a young teenager may predict increased susceptibility to tobacco marketing later in life, such as the young adult years. Thus, the tobacco industry may have at least partly succeeded in maintaining smoking initiation rates among young adults even in the face of increasing smoke-free homes and state-level tobacco control activities. Unfortunately, we are limited in exploring this area further as the TUS-CPS does not include any questions on receptivity to tobacco industry marketing.

A major limitation of the present study is that it focused on the majority non-Hispanic White U.S. population to avoid confounding by the known major ethnic differences in smoking consumption patterns. Future work should investigate these questions among Hispanics and other non-White populations. This study is a national population survey enabling estimates of population behavior, and it is limited by the response rate, as are all such surveys. However, compared with other population surveys conducted over the time period, response rates in the TUS-CPS were among the highest at 61%–68%. Further, the large declines in response rates seen in telephone-based surveys (Biener, Garrett, Gilpin, Roman, & Currivan, 2004) were not a major factor in this survey. Although the smoking measure was self-reported and not biochemically validated, considerable evidence indicates that population surveys provide an unbiased estimate of smoking behavior (Gilpin et al., 1994; Pierce et al., 1987). An additional limitation of the present study is that the last publicly available survey in this surveillance series is 2001–2002. Finally, our projection of future health benefits does not factor in any compensation that may occur among smokers. In experimental settings, smokers are known to increase the intensity of their smoking when their access to cigarettes is limited (USDHHS, 1988).

In summary, population increases in both smoke-free homes and social norms about smoking have shown a strong association with reduced consumption levels among smokers, both over time and across states. This pattern change should translate into a reduction in the population health risk for smoking-related diseases in the near term and represents a major success story for national tobacco control programs. However, the absolute increase in the prevalence of light or intermittent smoking among young adults in recent years is troubling. Whether this increase indicates the effectiveness of tobacco industry marketing efforts, particularly in maintaining smoking initiation, warrants further investigation.

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Declaration of Interests

None declared.

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