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RESEARCH REPORT

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# Non-cigarette combustible tobacco use and its associations with subsequent cessation of smoking among daily cigarette smokers: findings from the International Tobacco Control Four Country Smoking and Vaping Surveys (2016–20)

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## Abstract

**Aims:** To examine whether polyuse of cigarettes and other smoked products (polysmoking) is predictive of quit attempts and quit success.

**Design:** A prospective multi-country cohort design.

**Setting:** Australia, Canada, England and the United States.

**Participants:** A total of 3983 adult daily cigarette smokers were surveyed in 2016 (wave 1 of data collection) and were re-contacted in 2018 (wave 2) (i.e. waves 1–2 cohort) in the International Tobacco Control Four Country Smoking and Vaping (ITC 4CV) surveys; and 3736 smokers were surveyed in 2018 and re-contacted in 2020 (wave 3) (i.e. waves 2–3 cohort).

**Measurements:** Participants were asked about their cigarette smoking and use of cigars, cigarillos, pipes and waterpipes. Outcomes were quit attempts between two survey waves and success, defined as having quit smoking all the combustible tobacco at the subsequent survey for 1 month or more.

**Findings:** Levels of polysmoking were 12.7% in the waves 1–2 cohort and 10.5% for the waves 2–3 cohort. Compared with cigarette-only smokers, polysmokers were more likely to attempt to quit between waves 1 and 2 [54.9 versus 42.7%, adjusted odds ratio (aOR) = 1.37, 95% confidence interval (CI) = 1.08–1.74, $P < 0.01$], but not between waves 2 and 3 (43.8 versus 40.1%, aOR = 0.94, 95% CI = 0.72–1.22). Polysmoking predicted reduced likelihood of success in both cohorts among attempters and the overall samples. Between waves 2 and 3 there were significantly more transitions to non-daily smoking among the polysmokers (12.4 versus 5.3%, $\chi^2 = 40.4$, $P < 0.001$).

**Conclusions:** There is a consistent association between polysmoking (use of cigarettes together with other smoked products) and reduced quit success for combustible tobacco, but it is probably due to increased likelihood of transitioning to non-daily use rather than complete cessation.

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KEYWORDS
Combustible tobacco, longitudinal study, nicotine dependence, polysmoking, smoking cessation, survey

## INTRODUCTION

Much of the focus of tobacco control effort is upon cigarette smoking. In a recent study, analyzing data from 2020, we found relatively high but varying levels of use of other combustible tobacco products among current and former cigarette smokers in four high-income countries (from 7.5% in Australia and 11.5% in England, to 13.8% in both Canada and the United States) [1]. This is consistent with other data from the United States [2, 3]. Studies have found that younger people, those living in poverty and some racial/ethnic minority groups are more likely to use two or more smoked tobacco products [4, 5]. Other smoked products include cigars, cigarillos, pipes and water pipes, but do not include heated tobacco products [4, 5]. In this paper, we refer to cigarette smokers who also use at least one other smoked tobacco product as polysmokers or polysmoking. There are unlikely to be any health-related benefits of polysmoking, and potentially increased harm if it leads to increased overall smoking or to use of smoked products which deliver even higher levels of toxins than cigarettes, which can happen if high pH products such as cigars and pipes are inhaled into the lungs rather than just into the oral cavity [6].

Little is known about any possible relationship between polysmoking and subsequent smoking cessation. Cohort data from the United States (2013–16) showed that cigarette smokers who also use cigars were less likely to quit all tobacco than were exclusive cigar users [5]. The same US longitudinal survey showed that among baseline cigarette polytobacco users, the most common pattern of use (transition) was to continue cigarette polytobacco use in subsequent years [7].

To our knowledge, there are no published comparable data on the impact of polysmoking on smoking cessation in other countries. The aim of this study was to analyze multi-country cohort data to examine among daily cigarette smokers whether polysmoking is predictive of future quit attempts and quit success. Where numbers allow, we also explore relationships as a function of type of additional smoked product (e.g. cigars, pipes). No specific predictions were made. If polysmoking is associated with a greater likelihood of quitting smoking, this could suggest that polysmoking is motivated by exploration of alternatives to cigarettes. By contrast, if polysmoking is associated with a lower likelihood of quitting, this might suggest that it is an indication of a greater than average attachment to smoking or of a greater need for nicotine (i.e. greater dependence), which the rapidity of nicotine delivery afforded by smoking would be best suited to fulfill. To more clearly understand possible relationships, we also explored polysmoking in relation to cutting down on smoking.

## METHODS

### Data source and participants

Data came from two cohorts of the International Tobacco Control Four Country Smoking and Vaping (ITC 4CV) Surveys conducted in Australia, Canada, England and the United States in 2016 (wave 1), 2018 (wave 2) and 2020 (wave 3). This paper focuses upon the use of non-cigarette combustible tobacco products among daily cigarette smokers.

At wave 1, a total of 8165 adult daily cigarette smokers were surveyed, of whom 3983 (48.8%) were re-contacted at wave 2 approximately 17 months later (waves 1–2 sample). A total of 8620 daily smokers were surveyed at wave 2, of whom 3736 (43.3%, including 2232 from wave 1) were re-contacted at wave 3 approximately 24 months later (waves 2–3 sample). The study retains ex-smokers and recruits either current smokers, those quit for fewer than 2 years and those who report current vaping. There is some oversampling of younger respondents (aged under 25 years) and vapers. This is detailed in the International Tobacco Control (ITC) methods paper [8] and in reports available at itcproject.org. Briefly, the initial phase of fieldwork included inviting the recontact sample (previous wave respondents). A valid retention estimate is then determined, and once retention has plateaued, a fresh sample (replenishment sample) is invited into the survey to replace those lost to follow up [8]. Supporting information, Table 1 compares the retained samples with those lost to follow-up. Females, older respondents and those with higher levels of nicotine dependence were more likely to be followed-up.

Table 1 presents the baseline characteristics of the waves 1–2 and waves 2–3 cohorts. It reports weighted estimates for key measures.

### Measures

#### Reported use of cigarette and non-cigarette combustible tobacco products

Respondents were asked about current use of cigarettes (at all three waves). The key question was: 'How often, if at all, do you currently smoke cigarettes?' (daily/less than daily, but at least once a week/less than weekly, but at least once a month/less than once a month, but occasionally/not at all/quit/do not know). This was recoded into current use (at least monthly) compared to all other categories for the outcome waves. In some analyses we also differentiated daily from weekly and monthly use.

**TABLE 1** Baseline socio-demographic and smoking-related characteristics of daily cigarette smokers who were followed-up (second wave, *n* = 3983; third wave, *n* = 3736) in Australia, Canada, England and the United States

| | Waves 1–2 | | Waves 2–3 | |
|---|---|---|---|---|
| | *n* | Weighted % | *n* | Weighted % |
| Total | 3983[a] | | 3736 | |
| Country | | | | |
| Australia | 692 | 17.8 | 685 | 18.1 |
| Canada | 1227 | 30.1 | 1032 | 29.2 |
| England | 1268 | 30.0 | 1161 | 28.2 |
| United States | 796 | 22.2 | 858 | 24.5 |
| Gender | | | | |
| Male | 1941 | 56.0 | 1735 | 53.6 |
| Female | 2042 | 44.0 | 2001 | 46.4 |
| Age at recruitment (years) | | | | |
| 18–24 | 284 | 10.5 | 175 | 4.7 |
| 25–39 | 699 | 30.1 | 646 | 34.9 |
| 40–54 | 1297 | 29.2 | 1213 | 30.0 |
| 55+ | 1703 | 30.2 | 1702 | 30.4 |
| Education | | | | |
| Low | 1367 | 35.8 | 1309 | 36.3 |
| Moderate | 1618 | 46.3 | 1465 | 44.2 |
| High | 966 | 16.9 | 939 | 18.7 |
| No information | 32 | 1.1 | 23 | 0.8 |
| Income | | | | |
| Low | 1302 | 24.7 | 1267 | 25.7 |
| Medium | 1335 | 30.3 | 1201 | 30.3 |
| Higher | 1102 | 39.0 | 1085 | 39.2 |
| No information | 244 | 6.0 | 183 | 4.8 |
| Planning to quit | | | | |
| Do not know | 505 | 12.7 | 478 | 12.2 |
| Not planning | 817 | 20.4 | 873 | 22.7 |
| > 6 months | 1332 | 34.7 | 1202 | 34.3 |
| < 6 months | 924 | 22.7 | 852 | 23.0 |
| < 1 month | 403 | 10.3 | 328 | 7.8 |
| % Polysmoking[b] | 502 | 12.7 | 411 | 10.5 |
| % Cigar use | 268 | 6.9 | 213 | 5.1 |
| % Cigarillos | 185 | 4.8 | 159 | 4.0 |
| % Pipe | 81 | 2.2 | 83 | 1.5 |
| % Waterpipe | 132 | 3.4 | 110 | 2.7 |
| Heaviness of smoking index (HSI) | 3815 | (mean = 2.45, SD = 1.5) | 3529 | (mean = 2.41, SD = 1.5) |

[a]In some analyses, the sample size was smaller than the total due to small numbers of missing cases. SD, standard deviation.
[b]Cigarette smokers using at least one other smoked product at the baseline wave.

For non-cigarette combustible tobacco products [i.e. cigars, cigarillos, pipe and waterpipe (note: hookah and shisha were asked together with waterpipe in one question)] the key question was: 'In the last 30 days, have you used any of these other tobacco products?' ('yes' versus 'no/do not know' to each product, at all three waves). In addition, in 2020 (wave 3 only), a new question on frequency of use was also asked of respondents who said they used any of these other smoked products (note: it was not asked for each individual product) by asking: 'In the past 30 days, how often have you smoked any of these other tobacco product?' (daily/less than daily, but at least once a week/less than weekly/not at all/do not know). For these products, 'daily', 'at least once a week' and 'less than weekly' were combined

to compare to 'not at all' and 'do not know'. In some analyses 'daily' and 'at least once a week' were combined to compare to the rest (as 'less than weekly or not use'). Additionally, composite measures (for first two waves) were computed of 'any non-cigarette combustible tobacco product' (i.e. any of cigar, cigarillo, pipe or water pipe tobacco); and 'any other non-cigar and non-cigarette product' (i.e. any of cigarillo, pipe or water pipe tobacco).

### Quitting outcome measures

The main outcomes assessed in this study were: (i) quit attempts, defined as having made at least one quit attempt between two survey waves by asking cigarette smokers: 'How many times have you tried to quit since last survey date?' ('at least one attempt' versus 'no attempt'/'do not know'), or if they were currently quit smoking cigarettes at the time of the subsequent survey; and (ii) quit success, defined as having been quit smoking all combustible tobacco for 1 month or more at the follow-up survey. All who made quit attempts were asked how long the attempt lasted, or if quit how long since they quit. For quit success, we excluded cases quit for less than a month at the survey point, in part because the question on other smoked tobacco referred to use in the last month. Those quit for less than 1 month at the follow-up waves were treated as missing for the outcome analyses. In some sensitivity analyses, we also defined quit success as having been abstinent from cigarettes for at least 1 month at any point between two survey waves among those who tried to quit, a more focused measure of short-term success.

### Covariates

Covariates were measured in the 2016 and 2018 survey waves. In addition to country, socio-demographic measures included gender (male, female), age (18–24, 25–39, 40–54, 55+ years), education and income. Due to the differences in economic development and educational systems across countries, only relative levels of education and income were used. 'Low' level of education referred to those who completed high school or less in Canada, the United States and Australia, or secondary/vocational or less in England; 'moderate' meant community college/trade/technical school/some university (no degree) in Canada and the United States, college/university (no degree) in England, or technical/trade/some university (no degree) in Australia; and 'high' referred to those who completed university or postgraduate studies in all countries. Household income was also categorized into three levels ('low', 'medium' and 'high'), with the tertiles roughly comparable across the four countries; those who did not provide income information were included in the 'no information' group [10].

Nicotine dependence was measured using the continuous version of the Heaviness of Smoking Index (HSI) measure (ranging from 0 to 6), a measure of cigarette consumption. Planning to quit smoking was asked among current smokers via the question: 'Are you planning to quit smoking?'. Response options were 'within the next month', 'within the next 6 months', 'sometime in the future, beyond 6 months', 'not planning to quit' and 'do not know'.

### Data analysis

Descriptive statistics were computed on weighted data, to make the samples representative of smokers in each of the four countries [8, 9]. We also explored the impact of adding use of 'other smoked' to the cessation outcome over and above quitting smoking cigarettes.

Data were initially analyzed separately for the two wave-to-wave transition cohorts. This was to assess the stability of relationships between two similar (indeed overlapping) cohorts. This was complemented by analyses of the smaller cohort who completed all three waves to assess consistency of use of other smoked across the first two waves on the third wave outcome, conditional on being a daily smoker at both previous waves. We also used generalized estimating equation (GEE) analysis to combine the two wave pairs for analysis of quit attempts, but not for quit success, because all who provided two outcomes must have failed on the initial attempt, thus creating an unavoidable bias. We were also able to conduct additional analyses on cutting down to non-daily smoking at the wave 3 outcomes, as we had details regarding frequency of use of other smoked products at wave 3 as well as on cigarette smoking.

The associations between polysmoking and quitting outcomes (both quit attempts and quit success) were assessed using logistic regression with robust standard errors, first unadjusted and then adjusted controlling for country, gender, age group, income level, education level attained, HSI (0–6) and plan to quit smoking. We explored associates of making quit attempts and separately success, both overall and restricted to those who made quit attempts. We first examined the associations between use of 'any' of the four non-cigarette combustible products and subsequent quitting activities. We also explored the associations between use of each of the four individual products entered simultaneously into the same regression models with subsequent quitting activities. We then combined the use of any of the other three products (cigarillos, pipe and waterpipe) but not cigars and added it to the regressions simultaneously along with cigars. *Post hoc*, we tested the effect of cigar use versus the composite three product variable using post-estimation $\chi^2$ analysis. We also tested for country or age interaction effects. In all analyses, a $P$-value < 0.05 was considered statistically significant. All analyses were conducted using Stata SE version 16.0 [11]. The analyses were not pre-registered and therefore the results should be considered exploratory.

## RESULTS

Among the waves 1–2 cohort of daily cigarette smokers ($n$ = 3983) 12.7% were polysmoking at baseline: 6.9% used cigars, 4.8% cigarillos 2.2% pipes and 3.4% waterpipes. Similarly, 10.5% of the waves 2–3 cohort of cigarette smokers ($n$ = 3736) also used at least one other smoked tobacco: 5.1% used cigars, 4.0% cigarillos, 1.5% pipes and

**TABLE 2** The associations between use of non-cigarette combustible tobacco and quitting outcomes among daily cigarette smokers in two wave-to-wave cohorts of the ITC 4CV surveys from 2016 to 2020

| | Making at least one attempt to quit cigarettes | | Succeeding in quitting all combustible tobacco among those who attempted to quit cigarette smoking | | Success in quitting all combustible tobacco among all daily smokers | |
|---|---|---|---|---|---|---|
| | Waves 1–2 ($n$ = 3983[a]) % Attempted[b] | Waves 2–3 ($n$ = 3736[a]) % Attempted[b] | Waves 1–2 ($n$ = 1727) % Succeeded[c] | Waves 2–3 ($n$ = 1473) % Succeeded[c] | Waves 1–2 ($n$ = 3944[a]) % Succeeded[d] | Waves 2–3 ($n$ = 3697[a]) % Succeeded[d] |
| Overall | 44.2 | 40.4 | 20.6 | 25.1 | 9.0 | 10.2 |
| Any polyuse | | | | | | |
| No (ref) | 42.7 | 40.1 | 22.8 | 26.5 | 9.6 | 10.6 |
| Yes | 54.9 | 43.8 | 9.2 | 15.1 | 5.0 | 6.8 |
| Unadjusted[e] OR (95% CI) | 1.64 (1.36–1.98)$P$ < 0.001 | 1.15 (0.94–1.42)$P$ = 0.182 | 0.34 (0.22–0.53)$P$ < 0.001 | 0.49 (0.32–0.75)$P$ = 0.001 | 0.50 (0.33–0.75)$P$ < 0.001 | 0.62 (0.41–0.92)$P$ = 0.018 |
| Adjusted[e] OR (95% CI) | 1.37 (1.08–1.74)$P$ = 0.008 | 0.94 (0.72–1.22)$P$ = 0.631 | 0.36 (0.23–0.58)$P$ < 0.001 | 0.43 (0.27–0.71)$P$ = 0.001 | 0.49 (0.31–0.77)$P$ = 0.002 | 0.53 (0.34–0.83)$P$ = 0.006 |
| Use of each non-cigarette smoked products was included as a separate indicator in logistic regression | | | | | | |
| Cigars | | | | | | |
| No (ref) | 43.3 | 40.3 | 22.0 | 25.3 | 9.4 | 9.8 |
| Yes | 57.5 | 42.7 | 6.5 | 12.2 | 3.8 | 5.7 |
| Adjusted OR (95% CI) | 1.77 (1.28–2.44) $P$ = 0.001 | 0.81 (0.56–1.19)$P$ = 0.284 | 0.30 (0.15–0.58)$P$ < 0.001 | 0.30 (0.13–0.70)$P$ = 0.005 | 0.45 (0.23–0.89)$P$ = 0.021 | 0.31 (0.13–0.73)$P$ = 0.007 |
| Cigarillos | | | | | | |
| No (ref) | 43.7 | 40.1 | 21.3 | 24,8 | 9.2 | 9.6 |
| Yes | 54.6 | 47.8 | 9.1 | 18.0 | 4.9 | 8.5 |
| Adjusted OR (95% CI) | 1.20 (0.83–1.76)$P$ = 0.335 | 1.25 (0.84–1.88)$P$ = 0.270 | 0.53 (0.24–1.16)$P$ = 0.116 | 0.71 (0.34–1.48)$P$ = 0.360 | 0.63 (0.30–1.32)$P$ = 0.219 | 0.88 (0.45–1.74)$P$ = 0.714 |
| Pipe | | | | | | |
| No (ref) | 44.2 | 40.3 | 21.0 | 24,9 | 9.2 | 9.7 |
| Yes | 44.4 | 47.0 | 8.6 | 5.6 | 2.5 | 2.4 |
| Adjusted OR (95% CI) | 0.53 (0.29–0.95)$P$ = 0.032 | 1.03 (0.53–1.79)$P$ = 0.948 | 0.49 (0.10–2.50)$P$ = 0.393 | 0.21 (0.04–0.97)$P$ = 0.046 | 042 (0.09–1.84)$P$ = 0.249 | 0.28 (0.06–1.25)$P$ = 0.094 |
| Waterpipe | | | | | | |
| No (ref) | 43.8 | 40.2 | 21.3 | 24.4 | 9.2 | 9.5 |
| Yes | 58.3 | 47.3 | 6.7 | 27.3 | 3.9 | 11.8 |
| Adjusted OR (95% CI) | 1.17 (0.76–1.81)$P$ = 0.461 | 0.83 (0.50–1.39)$P$ = 0.480 | 0.45 (0.18–1.18)$P$ = 0.104 | 1.19 (0.55–2.58)$P$ = 0.661 | 0.52 (0.20–1.33)$P$ = 0.174 | 1.23 (0.64–2.38)$P$ = 0.539 |
| Analysis using any cigar use and use of any of the other three smoked products | | | | | | |
| Any cigar use | | | | | | |
| Adjusted OR (95% CI) | 1.72 (1.25–2.38)$P$ = 0.001 | 0.82 (0.57–1.18)$P$ = 0.288 | 0.29 (0.15–0.57)$P$ < 0.001 | 0.27 (0.12–0.62)$P$ = 0.002 | 0.44 (0.22–0.86)$P$ = 0.016 | 0.28 (0.12–0.64)$P$ = 0.003 |
| Use of any of the other three products | | | | | | |
| No (ref) | 43.4 | 39.9 | 21.9 | 25.0 | 9.4 | 9.7 |
| Yes[f] | 53.4 | 46.7 | 9.3 | 18.5 | 4.9 | 8.2 |

(Continues)

**TABLE 2** (Continued)

| | Making at least one attempt to quit cigarettes | | Succeeding in quitting all combustible tobacco among those who attempted to quit cigarette smoking | | Success in quitting all combustible tobacco among all daily smokers | |
|---|---|---|---|---|---|---|
| | Waves 1–2 ($n$ = 3983[a]) % Attempted[b] | Waves 2–3 ($n$ = 3736[a]) % Attempted[b] | Waves 1–2 ($n$ = 1727) % Succeeded[c] | Waves 2–3 ($n$ = 1473) % Succeeded[c] | Waves 1–2 ($n$ = 3944[a]) % Succeeded[d] | Waves 2–3 ($n$ = 3697[a]) % Succeeded[d] |
| Adjusted OR (95% CI) | 0.99(0.74–1.32)$P$ = 0.953 | 1.10(0.82–1.50)$P$ = 0.543 | 0.50(0.28–0.91)$P$ = 0.022 | 0.67(0.39–1.14)$P$ = 0.139 | 0.56(0.32–0.99)$P$ = 0.044 | 0.84(0.52–1.36)$P$ = 0.482 |
| Difference Cigars versus rest (*post hoc*) | $\chi^2_{(1)}$ = 5.33, $P$ = 0.021 | $\chi^2_{(1)}$ = 1.13, $P$ = 0.288 | $\chi^2_{(1)}$ = 1.31, $P$ = 0.252 | $\chi^2_{(1)}$ = 2.80, $P$ = 0.094 | $\chi^2_{(1)}$ = 0.28, $P$ = 0.600 | $\chi^2_{(1)}$ = 4.46, $P$ = 0.035 |

Abbreviation: ITC 4CV, International Tobacco Control Four Country Smoking and Vaping.
[a]These were at least daily current cigarette smokers when first surveyed. In some analyses the numbers were less than total due to missing cases.
[b]Percentages reporting having made at least a quit attempt to quit smoking between two survey waves.
[c]Percentages reporting having quit all combustible tobacco at the subsequent survey wave among those who made quit attempts.
[d]Percentages reporting having quit all combustible tobacco at the subsequent survey wave among all daily cigarette smokers. OR = odds ratio; CI = confidence interval.
[e]Adjusted models included country, gender, age group, income, education, heaviness of smoking index (HIS) (0–6) and plan to quit.
[f]Use of any of the other three smoked products.

2.7% waterpipes. There was considerable overlap. For example, among baseline cigarette smokers using cigars ($n$ = 268), 22.4% also used cigarillos, 13.1% pipe and 14.2% waterpipe. Of those polysmoking in 2016 (i.e. wave 1) who were still daily smokers in 2018 (wave 2), only 66.4% were still polysmoking in 2018. The comparable 2018–20 figure was 55.7%. Other details on overlapping of non-cigarette tobacco products are presented in Supporting information, Table 2.

We checked to see if all those quitting cigarettes also quit all smoked tobacco. There were no exceptions in the waves 1–2 cohort ($n$ = 356), but two of 376 who had quit cigarettes reported some other smoking in the waves 2–3 cohort (leaving 374 consistently abstinent).

## The associations between polysmoking and subsequent quitting activities

Table 2 presents the associations between use of non-cigarette combustible tobacco and quitting activities. There were no interactions between either country or age and the outcomes. Polysmoking daily cigarette smokers were more likely to make at least one quit attempt between waves 1–2, compared to those who only smoked cigarettes [54.9 versus 42.7%, adjusted odds ratio (aOR) = 1.37, 95% confidence interval (CI) = 1.09–1.72, $P < 0.01$], but not between waves 2 and 3 (43.8 versus 40.1%, aOR = 0.94, 95% CI = 0.73–1.22, $P > 0.05$).

Among those who made quit attempts, polysmoking was associated with reduced success in quitting all combustible tobacco in both cohorts (see Table 2, columns 4 and 5). When use of each alternative smoked product was included as a separate indicator in the same model, polysmoking including cigars was significantly associated with reduced likelihood of success in both cohorts with both aORs approximately 0.3, suggesting a strong relationship (see Table 2).

When we combined the use of any of the other three products (cigarillos, pipe and waterpipe) with cigars, the composite was not associated with quit attempts, but was significantly associated with reduced likelihood of success in quitting between waves 1 and 2, although significantly less so than for cigars.

In the third pair of columns of Table 2 we report the analysis of success as a function of all who were smoking at the baseline waves, such that even though polysmokers were somewhat more likely to try to quit in the waves 1–2 cohort, overall they were still less likely to succeed in both cohorts.

The patterns of associations also remained essentially the same when we used having quit for at least 1 month between two survey waves as the quit success outcome rather than 1 month abstinence at the follow-up wave.

We also analyzed the subsample of 2056 daily smokers at both waves 1 and 2, and with wave 3 outcomes treating polysmoking at each wave separately. Initially, we included an interaction term to test for an effect of polysmoking at both waves but, as we found no interaction, report only analyses including the two waves of polysmoking as binary variables, controlling for the demographics (at wave 2), as reported above. Here we found no evidence of any effect on quit

attempts, and no clear evidence of effects on success either, particularly for wave 1 polysmoking. The effects for wave 2 polysmoking were very similar to the two entire cohorts, but with reduced power were not significant (0.51, CI = 0.23–1.17, $P = 0.11$) for all 2037 cases with cessation outcomes (and 0.43, CI = 0.18–1.07, $P = 0.07$ for the 749 who made attempts).

In additional sensitivity analyses using the waves 2–3 cohort, where we had details on levels of consumption at the follow-up wave, we also explored whether polysmoking was associated with reduced transitions to non-daily smoking. Here we found, contrary to expected, that there were significantly more transitions to non-daily smoking among the polysmokers (12.4 versus 5.3% for non-polysmokers, $\chi^2 = 40.4$, $P < 0.001$). This effect was numerically larger than the reduced quitting effect, such that overall there was no difference in rates of reduction or quitting, meaning that the polysmokers were at least as likely to transition away from daily smoking, but largely to non-daily smoking and less to quitting all smoking.

## DISCUSSION

We found that polysmoking was not clearly associated with the probability of making quit attempts but predicted a reduced likelihood of success in quitting at both waves, and was associated with increased transitions from daily to non-daily smoking in the waves 2–3 cohort (where we were able to assess it), so overall there were equivalent levels of transition away from daily smoking. The only finding not fully consistent with this is the analyses of the reduced sample for which we also had wave 1 polysmoking data. Here there was no evidence of any impact of wave 1 polysmoking and equivocal evidence on wave 2, and no interaction that might suggest a role for sustained use. As the aORs for successful quitting were essentially the same as for the full cohorts, the difference is most probably a function of reduced power in this smaller cohort. The finding that it was polysmoking in the previous wave associated with the reduced success, and not sustained polysmoking, suggests that the relationship with cessation may be some temporary characteristic associated with polysmoking rather than indexing some fundamentally reduced capacity to successfully quit. In this regard the unexpected finding of greater reductions to non-daily smoking is consistent with polysmoking being used by some as an exploration of alternatives to daily cigarette smoking.

Polysmoking does not appear to be consistently associated with the likelihood of making quit attempts, there being a significant positive effect in one wave pair, but no significant effect in the other, and the composite analyses suggesting no overall effect. We have no explanation for the slightly different findings from the two cohorts regarding making quit attempts. The follow-up wave for the second cohort was collected during the early stages of the COVID-19 pandemic and may have affected more recent quitting activity, but we have no clear sense of how this might have impacted, although we know a small percentage of smokers in this study reported increased quitting related activity due to COVID-19 [12]. Taken as a whole, the evidence points to quitting interest being at least as strong in polysmokers, but there is uncertainty as to whether it is stronger. We can effectively rule out polysmokers being meaningfully less interested in quitting.

Cigars were the most used complement to cigarettes, which may partially explain the stronger negative associations between its use and quitting. However, as the aORs for success were lower for cigars than for the combined measure of the other three products (excluding cigars), albeit non-significantly, except for waves 2–3 (all daily smoker samples where the aORs for success were significantly lower for cigars), it raises the possibility that there may be something about cigar use that related to difficulty quitting that is not shared by the other smoked products. Perhaps they are more valued than cigarettes by some. Where use of other smoked products is sufficiently high, it would be useful to explore whether the nature of the product interacts with quitting in different ways.

The pattern of findings strongly suggests that the reduced quit success in polysmokers is of increased difficulty in succeeding rather than motivation; that is, it probably reflects this group being more dependent or less willing to give up nicotine use. Together with existing literature [1, 5], the findings highlight that polysmoking should be taken into account in studies of cigarette smoking cessation. It will be of interest to determine what happens to the non-dailies, whether it reflects a slower transition to cessation or whether they will revert to some form of daily smoking, and if so what form it will take. That said, the magnitude of the polysmoking relationship is small, so even if causal, polysmoking is only a minor contributor to cessation outcomes, so its importance should not be overstated.

A strength of the study is in our ability to explore both quitting cigarettes and all forms of smoked tobacco and to explore this in relation to both daily smoking and any meaningful level of smoking. Quitting all smoking is a more meaningful outcome from both behavioral and health perspectives, but our study shows that nearly all who quit smoking cigarettes quit other smoked products, so the difference is not of great practical importance. Other strengths include showing that the effects are consistent across four western countries with somewhat different tobacco markets and different levels of use of other smoked tobacco products; the longitudinal design of the study; and a sufficient sample to allow us to explore associations between polysmoking and outcomes of interest. We acknowledge that the study design, being non-experimental, does not allow us to establish definitively whether the observed associations between polysmoking and cessation outcomes are causal.

Other limitations include that the sampling frame for this study was of current cigarette smokers and current vapers, so we can say nothing about the use of other smoking products among anyone who does not use cigarettes. In particular, we cannot compare exclusive users of other smoked products with the polysmokers on the quitting outcomes. Secondly, this study relied upon self-reported behavioral measures without biochemical validation; however, we cannot see any reason why there would be differential misreporting by types of product smoked. The measure of dependence we used (the HSI) does not make allowance for polysmoking and may underestimate dependence in those using other products frequently, but as we do not have

quantitative measures of non-cigarette use, we cannot control for this. Furthermore, as a result of the lack of data on the extent of other-smoking product use at baseline, we are unable to explore whether levels of use of other smoked products are predictive of the outcomes we explored. Finally, there was differential loss to follow-up, meaning lost cases cannot be considered missing at random, so caution is required in generalizing to the overall population. Added to this, the sampling has a non-random component to it (e.g. young people are harder to recruit in surveys such as this, as well as being harder to retain) [8], so sample effects can never be completely excluded. Overall, we can think of no reason why these limitations would have led to spurious associations, but acknowledge that it may have led to missing associations that would have been revealed in a differently constituted sample.

## CONCLUSIONS

In summary, polysmokers are less likely to quit smoking altogether but are considerably more likely to reduce to non-daily smoking, making them overall similarly likely to transition away from daily smoking at least over a 1–2-year period. The data strongly suggest that differential motivation to quit smoking cigarettes is not responsible for the reduced quitting. Polysmoking should, at the very least, be treated as a sign of reduced likelihood of successful quitting, and efforts pursued to find ways to reduce the differential in success rates even if these are not directly related to polyuse, and to determine whether the transition to non-daily smoking is persistent, a slower transition to complete cessation or a sign of probable relapse to daily use.

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### DECLARATION OF INTERESTS

K.M.C. has received payment as a consultant to Pfizer, Inc. for service on an external advisory panel to assess ways to improve smoking cessation delivery in health care settings. K.M.C. has also served as a paid expert witness in litigation filed against cigarette manufacturers. G.T.F. has served as an expert witness or consultant for governments defending their country's policies or regulations in litigation. A.M. is a UK National Institute for Health Research (NIHR) Senior Investigator. The authors believe that the overwhelmingly most important priority for tobacco control is to eliminate regular use of smoked tobacco products, primarily cigarettes. We accept that this belief has shaped our interpretation of the data. Authors have no conflicts of interest to declare. The views expressed in this article are those of the authors and not necessarily those of the NIHR or the other funding agencies. None of the other authors has any conflict of interest to declare.

### AUTHOR CONTRIBUTIONS

**Lin Li:** Conceptualization; formal analysis; methodology; validation; visualization. **Ron Borland:** Conceptualization; funding acquisition; methodology; supervision; validation. **K. Michael Cummings:** Conceptualization; funding acquisition; methodology. **Andrew Hyland:** Conceptualization; methodology. **Michael Le Grande:** Formal analysis. **Geoffrey T Fong:** Conceptualization; funding acquisition; methodology. **Ann McNeill:** Conceptualization; funding acquisition.

### ETHICS APPROVAL

Study questionnaires and materials were reviewed and provided clearance by Research Ethics Committees at the following institutions: University of Waterloo (Canada, ORE#20803/30570, ORE#21609/30878), King's College London, UK (RESCM-17/18–2240), Cancer Council Victoria, Australia (HREC1603), University of Queensland, Australia (2 016 000 330/HREC1603) and Medical University of South Carolina (waived due to minimal risk). All participants gave informed consent. More details about the ITC 4CV Surveys have been reported elsewhere [8,9].

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### REFERENCES

1. Li L, Borland R, Cummings KM, Gravely S, Quah AC, Fong GT, et al. Patterns of non-cigarette tobacco and nicotine use among current cigarette smokers and recent quitters: findings from the 2020 ITC Four Country Smoking and Vaping Survey. Nicotine Tob Res. 2021; 23:1611–6.
2. Richardson A, Xiao H, Vallone DM. Primary and dual users of cigars and cigarettes: profiles, tobacco use patterns and relevance to policy. Nicotine Tob Res. 2012;14:927–32.
3. Sung H-Y, Wang Y, Yao T, Lightwood J, Max W. Polytobacco use of cigarettes, cigars, chewing tobacco, and snuff among US adults. Nicotine Tob Res. 2015;18:817–26.
4. Spears CA, Jones DM, Pechacek TF, Ashley DL. Use of other combustible tobacco products among priority populations of smokers: implications for U.S. tobacco regulatory policy. Addict Behav. 2019; 93:194–7.
5. Edwards KC, Sharma E, Halenar MJ, Taylor KA, Kasza KA, Day H, et al. Longitudinal pathways of exclusive and polytobacco cigar use among youth, young adults and adults in the USA: findings from the

PATH Study Waves 1–3 (2013–2016). Tob Control. 2020;29: s163–9.
6. Benowitz NL, Hukkanen J, Jacob P III. Nicotine chemistry, metabolism, kinetics and biomarkers. Handb Exp Pharmacol. 2009;29–60.
7. Taylor KA, Sharma E, Edwards KC, Halenar MJ, Kissin W, Kasza KA, et al. Longitudinal pathways of exclusive and polytobacco cigarette use among youth, young adults and adults in the USA: findings from the PATH Study Waves 1–3 (2013–2016). 2020;29:s139–46.
8. Thompson ME, Fong GT, Boudreau C, Driezen P, Li G, Gravely S, et al. Methods of the ITC Four Country Smoking and Vaping Survey, wave 1 (2016). Addiction. 2019;114:6–14.
9. ITC Project. ITC Four Country Smoking and Vaping Survey, Wave 3 (4CV3, 2020) Technical Report. University of Waterloo, Waterloo, Ontario, Canada; Medical University of South Carolina, Charleston, South Carolina, United States; Cancer Council Victoria, Melbourne, Australia; the University of Queensland, Australia; King's College London, London, UK; 2021.
10. Li L, Borland R, Cummings KM, Fong GT, Gravely S, Smith DM, et al. How does the use of flavored nicotine vaping products relate to progression towards quitting smoking? Findings from the 2016 and 2018 ITC 4CV Surveys. Nicotine Tob Res. 2021;23:1490–7.
11. StataCorp. Stata Statistical Software: release 16 College Station, TX: StataCorp LLC; 2019.
12. Gravely S, Craig LV, Cummings KM, Ouimet J, Loewen R, Martin N, et al. Smokers' cognitive and behavioural reactions during the early phase of the COVID-19 pandemic: findings from the 2020 ITC Four Country Smoking and Vaping Survey. PLOS ONE. 2021;16: e0252427.

## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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