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Addictive Behaviors Reports

Why can't smokers quit? Longitudinal study of smokers in the US using the Population Assessment of Tobacco and Health (PATH) waves 1 to 5

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A B S T R A C T

Introduction: Most adult cigarette smokers have tried unsuccessfully to quit. We followed participants in the Population Assessment of Tobacco and Health (PATH) study through five waves (2013–2019), comparing smoking, quit behaviors and other characteristics between persistent smokers and those who became and stayed former smokers.
Methods: The main analysis employed treatment effects to estimate mean differences in smoking and quitting behaviors among smoker groups. Logistic models were used to estimate predicted means based on continuing smokers' demographic characteristics to ensure that any differences in outcomes did not come from differences in demographic characteristics.
Results: Among smokers enrolled in PATH Wave 1, 68 % persisted in all subsequent waves. Compared with smokers who quit after Wave 1, persistent smokers had remarkably stable smoking behaviors, including significantly higher proportions of everyday smokers, consuming 10+ cigarettes per day, and smoking within 30 min of waking up. Persistent smokers were also less likely to try to quit completely, and experienced more negative symptoms from nicotine withdrawal. They also showed less interest in quitting and were less confident of being successful than smokers who quit by the next wave. Neither electronic nicotine delivery systems nor menthol played a role in continued smoking or quitting.
Conclusions: The characteristics and behaviors of persistent smokers in this study were stable over five waves of data collection during a six-year period, suggesting that these smokers need new cessation options.

1. Introduction

The adverse health effects and premature deaths attributable to cigarette smoking have been widely known for decades (USDHHS, 2014). Although adult smoking prevalence in the U.S. has been slowly declining, 13 % (31 million) were current smokers in 2020 (Cornelius, Loretan, Wang, Jamal, & Homa, 2022). Sixty-eight percent of smokers want to quit and 55 % tried at least once in the past year (Babb, Malarcher, Schauer, Asman, & Jamal, 2017), but only 7.5 % are even temporarily successful (Creamer et al., 2019).

A recent study suggested that smokers who quit by age 45 had 87 % lower excess cancer mortality than continuing smokers, and those who quit by age 35 had no excess mortality (Thomson et al., 2021). Policy-makers' have spent billions of dollars on cessation campaigns broadcasting health risks related to smoking, promoting the benefits of cessation, and providing aids such as quitlines and cessation medicines.

Yet this question is unanswered: why do many smokers find it difficult to stop even though they say they want to quit?

There are many studies on the Heaviness of Smoking Index (HSI) and smoking cessation, and most have found that smokers who are highly addicted to nicotine are less likely to quit than those who are less dependent (Breslau, Johnson, Hiripi, & Kessler, 2001; Fagerström et al., 1996; Hughes, 2001; Warner & Burns, 2003). However, not as much is known about persistent smokers and HSI. Chaiton and colleagues (2007) used three waves (1996–2001) of the longitudinal Canadian National Population Health Survey (NPHS) and found that smokers with lower HSI were more likely to report smoking cessation in the prior month at the follow up. Unexpectedly, they also found that smokers with high HSI scores were also more likely to report quitting than those with moderate scores. The current study identifies and compares HSI scores between persistent smokers and quitters.

In addition, there has been a debate about menthol flavored

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cigarettes and quitting. Some studies found that smoking menthol cigarettes was associated with less cessation, while others reported no association. (US FDA, 2022; Foulds, Hooper, Pletcher, & Okuyemi, 2010; Levy et al., 2011; Smith, Bansal-Travers, & Huang, 2016).

While most studies have compared the characteristics of current and former smokers using cross sectional datasets (Kramarow, 2020; Mayer, Reyes-Guzman, & Grana, 2020; Parascandola, Augustson, & Rose, 2009), the current study assesses these factors by using the FDA-sponsored Population Assessment of Tobacco and Health (PATH) (USDHHS, 2022), which is a nationally representative population-based longitudinal study in the US starting in 2013.

The PATH study allows us to follow current smokers for six years (2013 to 2019), comparing demographic characteristics, smoking and quitting behaviors, use of quit aids and adverse effects of quitting between persistent smokers in all waves and those who had become and stayed former smokers after Wave 1.

2. Methods

We used the PATH study, which is a collaboration between the National Institutes of Health, the National Institute on Drug Abuse and the U.S. Food and Drug Administration Center for Tobacco Products (USDHHS, 2022). The first wave recruited 32,320 respondents aged 18 and older in 2013–14. About 82 % (n = 26,444) of those respondents participated in Wave 2, 73 % (n = 23,668) in Wave 3, 66 % (n = 21,284) in Wave 4; about 59 % (n = 18,925) were in all 5 waves. We restricted our sample to those participants who have all Wave 1 demographic variables and have smoking and electronic nicotine delivery system (ENDs) status in all waves (n = 17,155, Supplemental Fig. 1).

2.1. Smoking

We used definitions for cigarette smokers established by the CDC (Cornelius et al., 2022) and derived PATH variables (USDHHS, 2022): Never smokers had not smoked 100 cigarettes in their lifetime; current smokers (C) had smoked at least 100 lifetime cigarettes and smoked every day or some days at the time of the survey; former smokers (F) had smoked at least 100 cigarettes and did not smoke at the time of the survey.

The longitudinal nature of the PATH study allowed us to distinguish distinct patterns of smokers as characterized in Supplemental Fig. 1. At Wave 1 there were 8,517 never, 5,856 Cs and 2,782 Fs. Among Wave 1 Cs, (1) 3,980 (68 %) persisted in all waves (CCCCC). Others (2) became F in Wave 2 and remained (CFFFF, n = 289), in Wave 3 (CCFFF, n = 226), in Wave 4 (CCCFF, n = 211), and in Wave 5 (CCCCF, n = 458). We focused on comparisons between CCCCC and the other groups and excluded Wave 1 Cs who transitioned irregularly between C and F in mixed patterns (n = 692). Our final sample contained 5,164 subjects.

2.2. Ends and other tobacco use

Notably, in Wave 1 the PATH questionnaire included only e-cigarettes; later waves added vape pens, personal vaporizers and mods, e-cigars, e-pipes, e-hookahs, and hookah pens. Never ENDs users in our study had never used the products, even one or two times, or had never used them fairly regularly and did not use at the survey; current users used ENDs every day or some days at the survey; former users had ever used ENDs fairly regularly and did not use them at the survey.

Current smokeless tobacco (ST) users were respondents who reported they had ever used smokeless tobacco products (dip, spit, moist snuff, pouches, chewing tobacco, or snus) fairly regularly and used them every day or some days at the survey. Current other combustible tobacco product users (CBT) had ever used cigars, pipe tobacco, or hookahs fairly regularly and used them every day or some days at the survey.

2.3. Smoking behaviors

Smoking behaviors included the proportion of everyday smokers, cigarettes smoked per day (CPD), time to first cigarette after waking up (TTFC), initiation with and current use of menthol cigarettes (yes or no), and exclusive or dual use of cigarettes and ENDs.

The heaviness of smoking index (HSI) is commonly used to measure nicotine dependence (Borland, Yong, O'Connor, Hyland, & Thompson, 2010; Chaiton, Cohen, McDonald, & Bondy, 2007; Etter, Duc, & Perneger, 1999; IARC, 2008). It combines CPD and TTFC. HSI values range between 0 and 6, where 0–2 is minimally addicted; 3–4 is moderately addicted; and 5–6 is highly addicted (IARC, 2008). In addition, we also included a self-report question, in which smokers were asked "Do you consider yourself addicted to cigarettes? (No, not at all; Yes, somewhat addicted; Yes, very addicted)".

2.3.1. Quit behaviors

Next, Cs were asked a series of questions about quitting behaviors in the past 12 months in all waves (Supplemental Table 1). The format of the key question, "In the past 12 months, have you tried to quit cigarettes?" was altered in Wave 3. In Waves 1 and 2, this was one question with four options: "(1) Yes, I have tried to quit completely; (2) Yes, I have tried to quit by reducing or cutting back; (3) No, I have reduced or cut back instead of trying to quit; and (4) No, I have not tried to quit at all." Smokers who chose options (1) and/or (2) could not select options (3) and (4) and vice versa. However, in Waves 3–5, smokers were asked two separate questions, "In the past 12 months have you tried to quit smoking? (Yes/No)" and "In the past 12 months, have you tried to quit by gradually cutting back on smoking? (Yes/No)". Those questions were not mutually exclusive.

The question format change starting in Wave 3 substantially and systematically increased the prevalence of smokers who had tried to quit completely and reduced the prevalence of smokers who had tried to quit by reducing or cutting back. In addition, PATH administrators noted that this question was incorrectly skipped by some Cs. For these reasons, we provide a cautionary statement in the Results- Quitting behaviors section regarding this change.

Using these questions, we created three types of past-12-month quit attempters: (1) quit completely – Cs who had tried to quit completely but may also have tried to reduce or cut back; (2) reduce/cutback – Cs who had only tried to quit by reducing or cutting back; (3) Cs who had not tried either (1) or (2).

Cs were asked about the number of times they had tried to quit completely in the past 12 months. We grouped the number of quit attempts as follows: (1) once, (2) twice, and (3) 3 or more times. Cs who had tried to quit completely at least 1 time in the past 12 months were asked whether they had tried to stop smoking for one day or longer (yes/no). Those answering affirmative were asked about the length of time they stopped (1 day or less, a week, 1–4 weeks and one month or more).

PATH also asked Cs for information on quit aids used the last time they tried to quit in the past 12 months (Supplemental Table 1). We grouped these aids as follows: (1) None – no aid was used; (2) ENDs – used ENDs and may have used others; (3) Medicines – nicotine replacement therapy (NRT) and prescription medicines (Rx) such as Chantix, varenicline, Wellbutrin, Zyban, or bupropion and may have used others; (4) Only ENDs and medicines; and (5) others such as family and friends, counseling or self-help material, excluding ENDs and medicines.

2.3.2. Symptoms when trying to quit/cutback in the past 12 months

Supplemental Table 1 also presents a series of questions about the symptoms experienced by smokers when quitting or reducing/cutting back: feel depressed; have difficulty falling or staying asleep; have difficulty concentrating; eat more than usual or gained weight; become easily irritated, angry or frustrated; feel anxious or nervous; and feel more restless than usual. We combined these as follows: (1) no

symptoms; (2) 1–3 symptoms; and (3) 4 or more symptoms.

2.4. Interest in quitting

Cs were asked about their interest in quitting in all waves, based on scales 1 to 10 where 1 is not at all interested and 10 is extremely interested. We created a categorical variable with the following options (1) 1–3 low; (2) 4–6 moderate; and (3) 7–10 high. Cs were asked whether they planned to ever quit for good. Those who responded "Yes" were asked about the time frame. If they planned to quit within the next 6 months they were asked about how likely they thought they would be able to quit. Detailed questions are in Supplemental Table 1.

2.5. Analysis

First, we examined the difference in individual characteristics at Wave 1 between CCCCC and other groups (CCCCF, CCCFF, CCFFF, and CFFFF) by using standard t-tests.

Our results report differences in the following outcomes between CCCCCs and smokers who quit (i.e., CCCCF, CCCFF, CCFFF, and CFFFF): smoking and other tobacco use behaviors, quitting behaviors and interest in quitting. We implemented the treatment-effect strategy with inverse-probability weighting, in which CCCCC was the "treatment" group and the other groups were untreated. The treatment-effect model allowed us to estimate means of outcomes in the non-treatment groups by conditional on CCCCCs' individual characteristics. Specifically, we used the logistic model to obtain estimated means for each individual outcome in each wave, conditional on CCCCCs' characteristics i.e., age groups (18–24, 25–44, 45–64, and 65 + years), sex, race/ethnicity (White, Black, Hispanic, and other race), levels of education (less than high school, high school, some college, and more than college), marital status (married, divorced, separated, and widowed, and never married) and geographic regions (north, east, south, and west). These characteristics were selected based on extensive literature on smoking and CDC reports (USDHHS, 2014; Garrett, Martell, Caraballo, & King, 2019;

Cornelius et al., 2022; Gentzke et al., 2022).

The results from the logistic models indicated whether other smoker groups had different estimated means of outcomes compared with CCCCC given that they had the same demo characteristics as CCCCC.

3. Results

3.1. Demographic characteristics

Table 1 presents baseline demographic characteristics. CCCCC differed from those who quit in later waves: a smaller proportion were under 25 years old, they were slightly more likely to be women, and there were higher proportions of Blacks, those with less than high school education and divorcees.

3.2. Smoking and other tobacco use behaviors

We compared smoking behaviors between CCCCC and quitters in later waves. Fig. 1 shows that over 85 % of CCCCC were everyday smokers in all waves; the largest differences were with those who became F in the following wave. For example, in Wave 1 87 % of CCCCC were everyday smokers, compared with 52 % of CFFFF.

In addition to smoking every day, CCCCC were heavier smokers, as illustrated in Supplemental Table 2. They were significantly more likely to consume more cigarettes and consume them within 30 min of waking up, especially when compared with quitters in the next wave. For example, in Wave 1 eleven percent of CCCCC consumed 21 + CPD, 66 % had TTFC ≤ 30 min, and only 48 % had a low HSI, compared with 3.6 %, 43 % and 72 % of CFFFF respectively.

In Wave 1 39–45 % of all smoker groups reported that they had initiated with menthol or mint flavored cigarettes, and 36–48 % currently used menthol or mint flavor in all waves (Supplemental Table 2). Additionally, among Cs who initiated with menthol, 53–66 % smoked menthol in all waves. We found no statistically significant differences between CCCCC and those quitting in later waves with respect
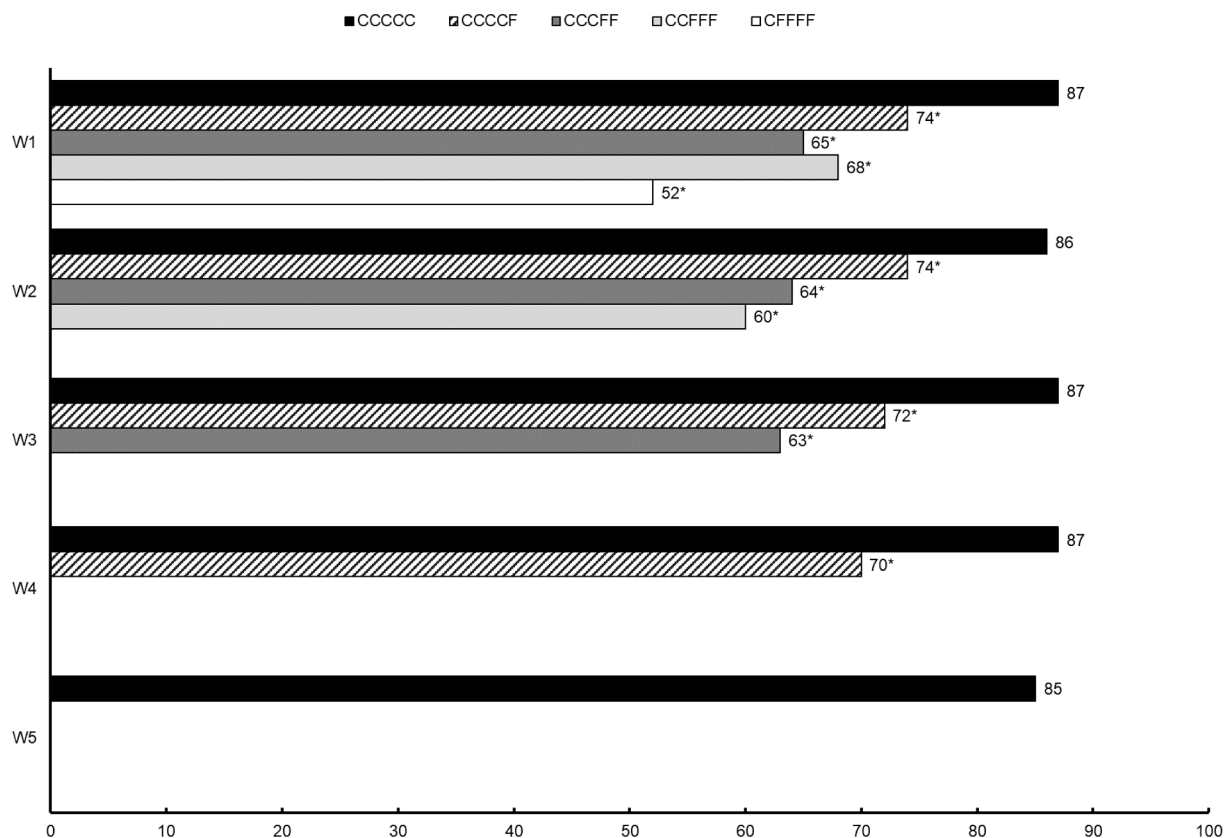
Table 1
Unweighted demographic characteristics at Wave 1.

	(1) CCCCC		(2) CCCCF		(3) CCCFF		(4) CCFFF		(5) CFFFF	
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
N	3980		458		211		226		289	
Age groups										
Age 18–24	676	16.9	122	26.6*	48	22.7*	52	23.0*	65	22.3*
Age 25–44	1672	41.9	171	37.3	98	46.4	94	41.6	123	42.1
Age 45–64	1462	36.6	125	27.3*	54	25.6*	69	30.5*	85	29.1*
Age 65+	185	4.6	40	8.7*	11	5.2	11	4.9	19	6.5
Male	1850	46.3	237	51.7*	105	49.8	132	58.4*	153	52.4*
Race/ethnicity										
NH White	2624	65.7	317	69.2	144	68.2	160	70.8	191	65.4
NH Black	660	16.5	46	10.0*	23	10.9*	23	10.2*	28	9.6*
Hispanic	451	11.3	59	12.9	24	11.4	28	12.4	54	18.5
NH Other race	260	6.5	36	7.9	20	9.5	15	6.6	19	6.5
Levels of education										
Less than high school	735	18.4	67	14.6*	20	9.5*	26	11.5*	35	12.0*
High school	1525	38.2	155	33.8	52	24.6*	63	27.9*	73	25.0*
Some college	1410	35.3	173	37.8	103	48.8*	99	43.8*	128	43.8*
College and more	325	8.1	63	13.8*	36	17.1*	38	16.8*	56	19.2*
Marital status at Wave 2										
Married	1362	34.2	155	33.8	80	37.9	93	41.2*	132	45.7*
Widowed, divorced, separated	1167	29.3	111	24.2*	46	21.8*	42	18.6*	59	20.4*
Never married	1451	36.5	192	41.9*	85	40.3	91	40.3	98	33.9
Region										
Northeast	598	15.0	67	14.6	31	14.7	35	15.5	35	12.0
South	1144	28.6	132	28.8	55	26.1	63	27.9	93	31.8
Midwest	1574	39.4	162	35.4	85	40.3	78	34.5	102	34.9
West	679	17.0	97	21.2*	40	19.0	50	22.1	62	21.2

C denotes current smokers and F stands for former smokers.
Excluded those with missing demographic variables, smoking and ENDs status.
* Indicates statistically significant mean differences from CCCCC (p-value < 0.05).

Fig. 1. Proportions of everyday smokers according to smoker group and wave (W)[1], [1]Adjusted based on CCCCC's demographic characteristics., * Indicates statistically significant difference from CCCCC (p-value < 0.05).

to initiation with or current menthol smoking.

In general, we did not find statistically significant differences in ENDs status between CCCCC and other groups. However, we did identify longitudinal trends in current/former ENDs use within smoker groups, as illustrated in Fig. 2. It shows that current ENDs use among CCCCC was relatively stable in all waves (8–12 %), but former ENDs use increased from 3 % in Wave 1 to 19 % in Wave 5. In three quitter groups (CCCCF, CCFFF and CFFFF), there was a marked increase in current ENDs use in the first wave they became F. All quitter groups also had increases in former ENDs use in subsequent waves. For instance, only about 11 % of CCCCF were current users of ENDs in Wave 4, compared with 23 % after they stopped smoking in Wave 5.

The everyday and some-day status of current ENDs use in all smoker groups are shown in Supplemental Table 2. CCCCC had statistically significantly lower proportions of everyday ENDs use compared with other smoker groups in all waves except CCFFF in Wave 1. Among all quitter groups, there was a significant increase in everyday ENDs use between the last wave of C and the first as F. For example, among CFFFF, the proportion of every-day users increased from 32 % in Wave 1 to 77 % in Wave 2.

Current use of ST and other CBTs (cigars, pipe tobacco, and hookah) among CCCCC and quitter groups are shown in Supplemental Table 2. ST use was low and unchanging throughout all waves, while use of CBTs declined in all groups after Wave 1.

Finally, Supplemental Fig. 2 shows that CCCCC had consistent higher percentages of "Very Addicted" and lower proportions of "Not at All" than other groups in all waves.

3.3. Quitting behaviors

Fig. 3 shows quitting behaviors among Cs in the 12 months before each wave. Although starting in Wave 3 there appears to be significant

increases among all smoker groups of those trying to quit completely, concurrent with significant declines in those trying to reduce consumption, we believe that this finding represents an artifact because PATH changed the format of the quitting behavior questions in Wave 3 as described in the methods section. However, the artifact is not relevant to the following finding: in general, compared with CCCCC, smokers who quit in the following wave reported significantly higher proportions of trying to quit completely in the previous 12 months. For example, in Wave 1 19 % of CCCCC reported trying to quit completely, compared with 30 % of CFFFF.

Among those who tried to quit completely, the length of time they stopped smoking is presented in Supplemental Table 3. Compared with CCCCC, smokers who quit in the next wave had higher percentages of stopping one month or longer and lower proportions of stopping one day or less in all waves. For example, at Wave 2, 22 % of CCCCC stopped for a month or longer compared with 42 % of CFFFF, while 13 % of CCCCC stopped one day or less compared with 2 % of CCFFF. Nevertheless, about 16–22 % of CCCCC reported that they stopped smoking at least a month last time they tried to quit throughout 5 waves.

Although there were almost no significant differences in quit aids used in the previous 12 months between CCCCC and other smoker groups, the comparisons within smoking groups among the five waves are more meaningful, as illustrated in Supplemental Table 3. It shows decreased use of ENDs after Wave 2, corresponding with sharp increases in not using quit aids. For example, use of ENDs among CCCCC fell from 19 % in Wave 2 to 5 % in subsequent waves, while not using quit aids increased from 36 % in Wave 2 to 41–44 %. Similarly, use of ENDs from Wave 2 to Wave 3 fell among CCCCF from 27 % to 6 % and fell among CCCFF from 18 % to 3 %.

We also examined the symptoms reported by smokers within days after they had tried to stop. Generally, a higher percentage of CCCCC reported more adverse symptoms than other smoker groups, especially
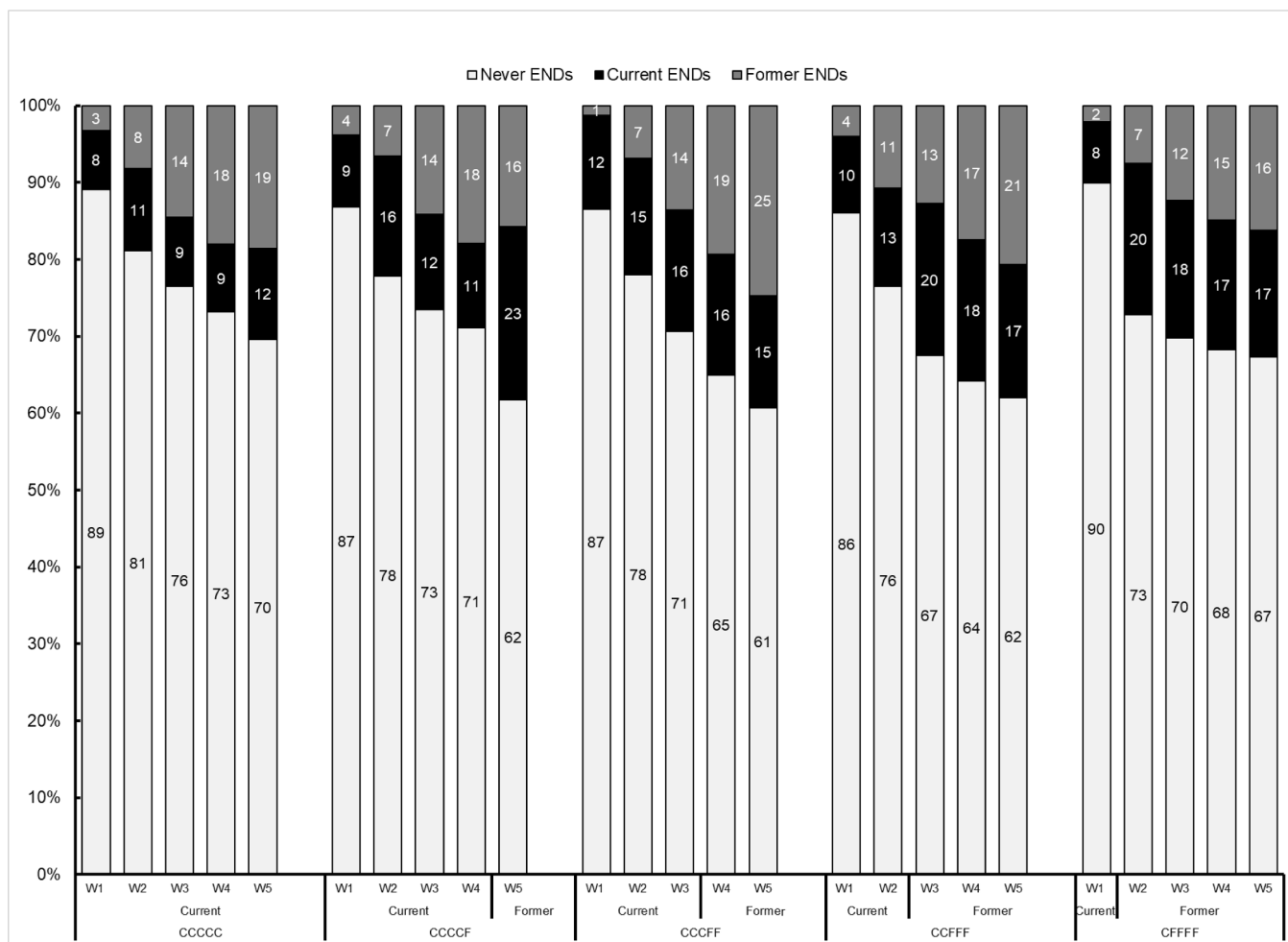
Fig. 2. Proportions using ENDs, according to smoker group and wave (W)[1], [1]Adjusted based on CCCCC's demographic characteristics.

in Waves 1 to 3 (Supplemental Table 3).

3.4. Interest in quitting

About half of CCCCC had high interest in quitting in all waves (Supplemental Table 4), which was lower than those who quit in the next wave (57–67 %). When asked whether they planned to quit for good, high percentages of all groups responded "yes". However, CCCCC who planned to quit always had significantly lower proportions specifying "within 6 months" (38 % of CCCCC versus 56 % of CFFFF in Wave 1). And among the 6-month subgroups, CCCCCs always had far lower proportions than next-wave quitters who thought they were likely to succeed (e.g. 31 % vs. 60 % in Wave 1).

4. Discussion

The PATH longitudinal study allowed us to follow 5,856 current smokers in PATH Wave 1, 68 % of whom (n = 3,980) continued through Wave 5. The proportions of every-day smoking were relatively stable (85–87 %) in all waves, but higher than the proportion of every-day smoking (≈ 77 %) reported by CDC during the same period (Jamal et al., 2014; Jamal et al., 2015; Jamal et al., 2016; Jamal et al., 2018). On the other hand, smokers who quit reported significantly lower proportions of every-day smoking in the wave prior to quitting, for example, only 52 % of CFFFF in Wave 1 identified themselves as every-day smokers.

The longitudinal design of PATH enabled us to evaluate many

characteristics of smoking and quitting that cross-sectional surveys do not capture. For example, CCCCC reported higher average CPD than other groups in all waves (e.g., CCCCC −16.3 vs. CFFFF − 8.9 in Wave 1). Furthermore, CCCCC had somewhat higher CPD than smokers reported by the CDC (CDC-14.2 in 2013 vs. CCCCC-16.3 in Wave 1) (Jamal et al., 2014; Jamal et al., 2015; Jamal et al., 2016; Jamal et al., 2018).

Compared with other smokers, CCCCC had statistically significantly higher proportions of TTFC within 30 min in all waves (>60 %). A systematic review of TTFC literature by Branstetter, Muscat, and Mercincavage (2020) concluded smokers who had early TTFC were less likely to quit, which is consistent with our results.

Regulators in the U.S. have expressed concern that menthol-flavored cigarettes can make it hard to quit (FDA, 2022). However, we did not find statistically significant differences in the proportions of current menthol smokers between CCCCC and smokers who quit after Wave 1. FDA concerns may be based on previous studies from clinical trials with small numbers of participants (FDA, 2022).

In general, current use of ENDs was similar across groups in all waves, producing mixed results. On the minus side, the proportions of everyday ENDs among persistent smokers were relatively stable throughout five waves, and this group reported growing proportions of former ENDs. However, quitters had higher current ENDs use in the wave they became former smokers, and smokers who quit in the next wave tended to increase the percentage of everyday ENDs use at that wave. These findings are consistent with other PATH studies revealing that ENDs have helped some smokers to quit (Kasza et al., 2021; Kasza et al., 2022; Klemperer et al., 2023). In addition, we found that CFFFF
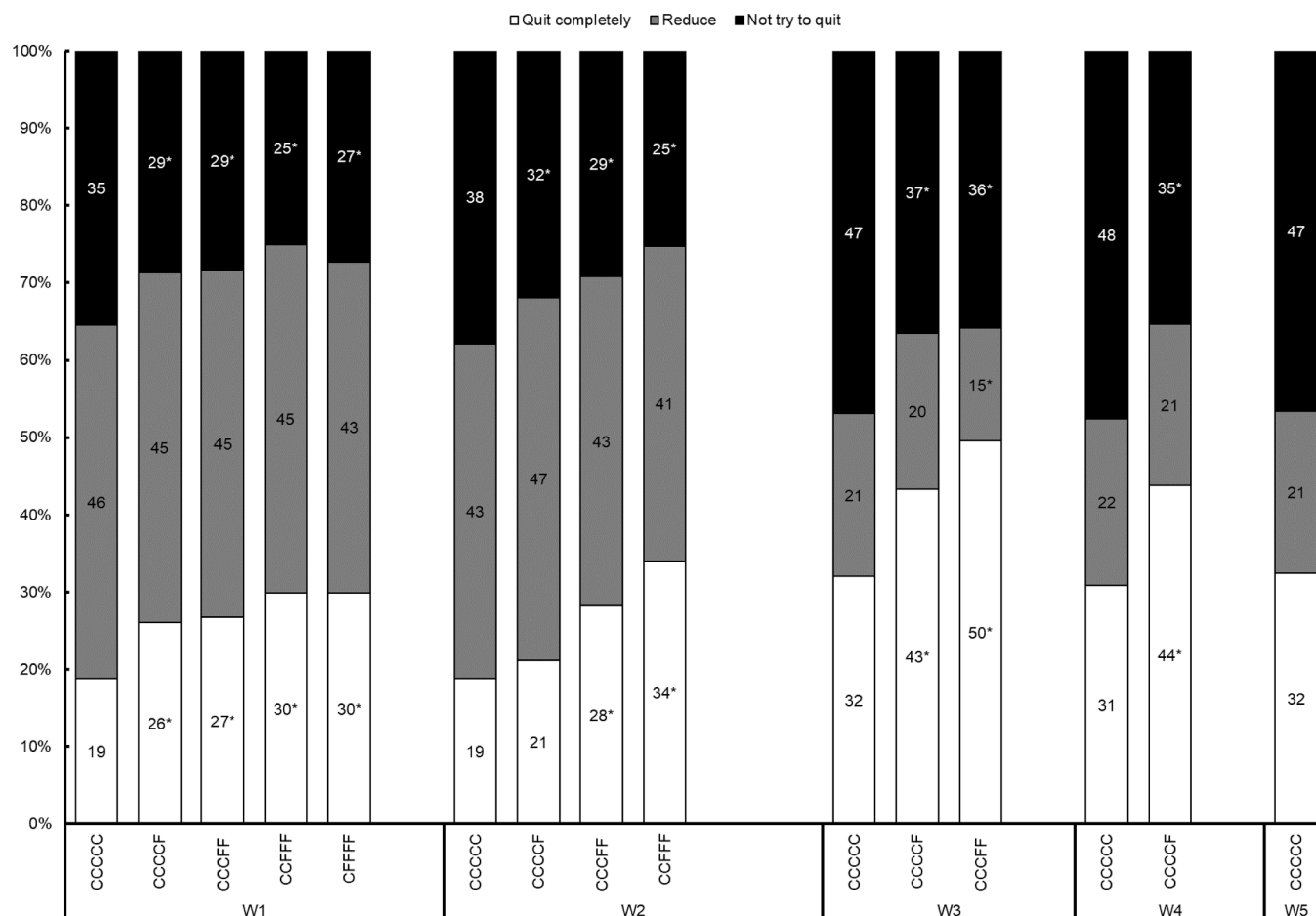
Fig. 3. Proportions trying to stop smoking in the past 12 months according to smoker group and wave (W)[1,2,] [1]Adjusted based on CCCCCs' demographic characteristics., [2] The question changed in Wave 3. As a result, there was a large increase in trying to quit completely corresponding with a decline in trying to reduce/cut back in Waves 3–5. * Indicates statistically significant difference from CCCCC (p-value < 0.05).

who quit after Wave 1 and continued using ENDs did not relapse to smoking during the follow-up period.

While we were not able to establish trends in quitting behaviors due to changes in quit questions between Waves 2 and 3, we observed that CCCCC had the lowest proportions of trying to quit completely and reduce/cut back and the highest percentages of not trying to quit in all waves. Notably, the proportion of reduce/cut back in Waves 1 and 2 in our study were compatible with another national study from the 2010–2011 Tobacco Use Supplement to the Current Population Survey, where more than 40 % of smokers had tried to quit by gradually cutting down their cigarette consumption (Schauer, Malarcher, & Babb, 2015).

Large majorities of all smokers reported that they did not use any aid (often called "quitting cold turkey") in their last effort, which is similar to a CDC study (Caraballo, Shafer, Patel, Davis, & McAfee, 2017). We did not find any differences in quit aids used among smoker groups. While quitting cold turkey worked for some smokers, a selection bias may play an important role.

Consistent with previous studies (Breslau et al., 2001; Fagerström et al., 1996; Chaiton et al., 2007; Hughes, 2001; Warner & Burns, 2003), smokers who quit after Wave 1 reported much higher proportions of low HSI score than CCCCC. In addition, about half of CCCCC considered themselves to be very addicted to cigarettes in all waves while, for example, about 30 % of CFFFF did so.

More than 30 % of CCCCCs used over-the-counter NRTs and/or prescription medications to help them quit, and these percentages were significantly higher than other smoker groups. This suggests that these medicines were not effective, which is in line with clinical trials and

other studies using nationally representative data (Alpert, Connolly, & Biener, 2013; Kotz, Brown, & West, 2014; Leas, Pierce, & Benmarhnia, 2018; Walker, Howe, & Bullen, 2011). It is possible that medicines fail because they are not used in correct doses or for an adequate period of time, but another disadvantage is the end goal of nicotine/tobacco abstinence by cessation professionals.

CCCCCs in our study were highly nicotine dependent and demonstrated many negative effects of abstinence, which is consistent with previous results (Hollands, Sutton, & Aveyard, 2022) and they were the least likely to report no symptoms, characteristics that may explain their inability to quit.

Even though 40 % of CCCCCs did not use any quitting aid, they definitely need extra help to cope with their symptoms. Public policies that encourage smokers to seek medical professional help, promote long-term use of NRT and minimize the stigma of using harm reduction products may directly benefit them. Most smokers in this study believed that nicotine is a chemical in cigarettes that causes cancer (Supplemental Table 5), a finding that is widely reported (Villanti, Byron, Mercincavage, & Pacek, 2019; Weiger, Moran, Kennedy, Limaye, & Cohen, 2022; Yong, Gravely, & Borland, 2022). This misperception may lead to low usage of any aids containing nicotine.

Our study has several limitations. First, despite an initial large sample size at Wave 1, survey dropout was unavoidable, resulting in fewer smokers with complete baseline and follow-up information. Second, our study only included current smokers at Wave 1. Selective non-response may be associated with heavy smokers (Criqui, Barrett-Connor, & Austin, 1978; Cheung, ten Klooster, & Smit, 2017; Van Loon, Tijhuis,

& Picavet, 2013), so our estimates may not have included some highly addicted smokers. Next, responses to questions were self-reported and some retrospective behaviors, especially recall quit attempts and symptoms in the past year, may not be accurate.

Another limitation is desired social norm bias: anti-smoking sentiment may lead smokers to provide answers that conform with social norms, favoring cessation (Soulakova, Hartman, Liu, Willis, & Augustine, 2012) As a result, CCCCC might overreport their quit attempts. It is almost impossible to address this issue due to lack of tangible measurements. Furthermore, some smokers may relapse, especially among recent quitters i.e., in Wave 5. We will need to follow them in Wave 6, which is not yet available. On the same note, we limited our sample to either current smokers in all waves or current smokers at Wave 1 who quit in later waves. We left out participants who reported current and former smoking in different waves. They may be more highly addicted to cigarettes than CCCCC. We also chose basic measures of nicotine dependence, but the PATH study contains many other relevant variables that could be further investigated (Strong, Pearson, & Ehlke, 2017; Strong, Leas, & Noble, 2020). Finally, the survey format for quit attempt questions changed in Wave 3, making comparison between Waves 1–2 and 3–5 impossible.

Despite these limitations, our analysis contributes extensive information about persistent smokers. Previous studies largely used cross-sectional analyses, which in any given year implicitly assume that all existing smokers have similar characteristics that cannot be differentiated based on future quitting. Any policy implications derived from these studies are likely to be broad and unfocused. Using PATH longitudinal survey data, we were able to compare persistent smokers with those who became and stayed smoke-free from survey enrollment through four year-long follow-ups.

Our results do not directly address whether American smokers are becoming harder to "treat," which has been a contentious topic since its examination in a National Cancer Institute monograph twenty years ago (USNCI, 2003, Van Loon et al. (2013)). However, our results do support the existence of persistent, hardened smokers who do not respond to conventional quitting approaches, including cold-turkey or use of NRT, e-cigarettes or other aids. As such, our results may have policy implications, because not all smokers respond positively to measures intending to help them to quit. Some characteristics may make smokers more likely to be future quitters, but persistent smokers may need other options in order to avoid the risk of premature morbidity and mortality.

5. Conclusion

The present longitudinal study provides consistent information about a variety of factors associated with smokers who persisted over a six-year period. Compared with smokers who became and stayed quit, CCCCCs were more likely to smoke every day, have higher measures of nicotine dependence and have more adverse effects of nicotine withdrawal. They were less interested in cessation, less likely to make a quit attempt and less confident that the attempt would be successful. While ENDs and menthol are topics of current debate, neither played a prominent role in continued smoking or quitting. Persistent smokers need new cessation options. Comparing persistent smokers for several years with those who quit provides insights to convert the former to the latter.

CRediT authorship contribution statement

Nantaporn Plurphanswat: Conceptualization, Methodology, Validation, Formal analysis, Data curation, Visualization. **Brad Rodu:** Conceptualization, Validation, Writing – review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

Data availability

Data will be made available on request.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.abrep.2023.100517.

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