sources. Therefore, Appendix 3.1 provides a comprehensive, detailed review of the data and the measures provided from the four primary surveys as well as comparable findings gleaned from the National Longitudinal Study of Adolescent Health and the National Health Interview Survey (NHIS) of adults.

Appendix 3.1 also provides supplemental analyses on subtopics related to the major topics presented here, including intensity of cigarette smoking, transitions and trajectories in smoking, implications for smoking during adolescence for young adults, nicotine addiction in adolescence and young adulthood, attempts to quit smoking, trends in knowledge and attitudes about smoking, cigarette smoking and depression, patterns of cigar use, and patterns of use of emerging tobacco products.

Data Analysis

Using these data sources and relevant measures, population-weighted estimates with 95% confidence intervals were calculated using statistical software to account for the multistage probability sampling designs of the surveys. For some analyses, but not all, statistical tests were conducted to investigate differences in prevalence estimates by demographic factors of interest (e.g., age/grade, gender, race/ethnicity) and, when possible, in trends over time. Significance ($p < 0.05$) was determined by the use of two-sided *t*-tests, throughout.

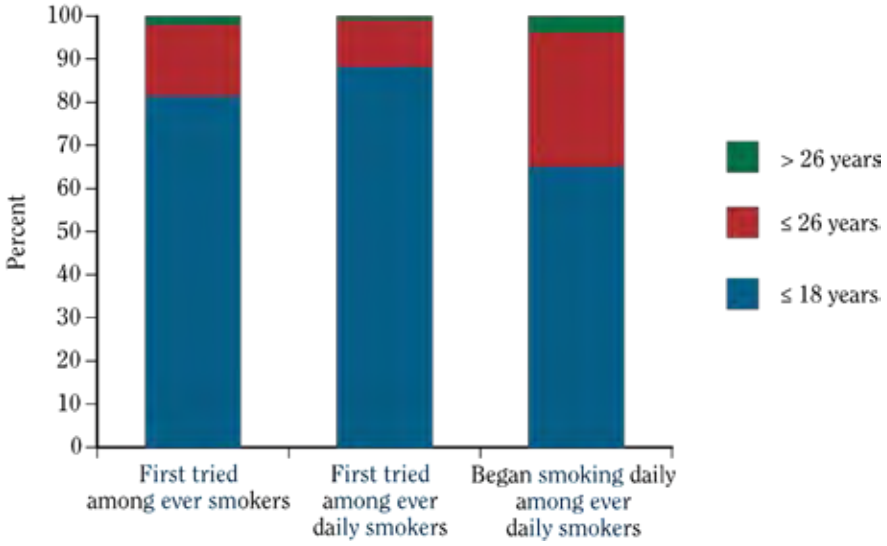
Key Epidemiologic Findings

In this section, epidemiologic analyses that support the major conclusions of this chapter are considered. These analyses are selected from a more comprehensive set that is presented in Appendix 3.1. These findings reinforce and extend, as appropriate, conclusions that were first presented in the 1994 Surgeon General's report on preventing tobacco use among young people.

Age When Cigarette Smoking Begins

One of the most important—and widely cited—findings from the 1994 Surgeon General's report on smoking and health was that virtually all cigarette smoking begins before adulthood. Figure 3.1 and Table 3.2 illustrates and updates this finding, using the most recent data from NSDUH (2010) in an analysis parallel to that conducted for the 1994 Surgeon General's report. In this survey, adult smokers 30–39 years of age were asked about their first experience with cigarette smoking. Among adults who had ever tried a cigarette, 81.5% reported trying their first cigarette by the time they were 18 years of age, while an additional 16.5% did so by 26 years of age. Among adults who had ever smoked cigarettes daily, 88.2% reported trying their first cigarette by the time they were 18 years of age, while an additional 10.8% did so by 26 years of age. About two-thirds (65.1%) of adults who had ever smoked daily began smoking daily by 18 years of age, and almost one-third of these adults (31.1%) began smoking daily between 18 and 26 years of age. Therefore, virtually *no* initiation of cigarette smoking (<1–2%) and few transitions to daily smoking (<4%) actually occur in adulthood after 26 years of age. Moreover, it is important to note that the initiation of cigarette smoking can often occur quite early in adolescence, before 18 years of age. In this analysis of the 2010 NSDUH data, for example, more than one-third (36.7%) of adults who had ever smoked cigarettes reported trying their first cigarette by 14 years of age, which is the age when one typically enters high school in the U.S. (Table 3.2). This is one of the most critical epidemiologic findings of this report, underscoring again that adolescence and young adulthood represent a time of heightened vulnerability to tobacco use and the initiation of cigarette smoking. Additional analyses that investigate distinct developmental trajectories and transitions in cigarette smoking across adolescence through young adulthood are presented in Appendix 3.1 (e.g., see Figure 3.1.4 and Tables 3.1.16–3.1.20). It is important to note that these NSDUH estimates from adults represent smoking initiation that occurred during the late 1990s, at about the time of the Master Settlement Agreement, when the prevalence of youth tobacco use was beginning to decline (see "Trends in Cigarette Smoking Over Time" later in this chapter). To investigate more contemporary trends in tobacco use initiation, we turned to adolescent and young adult data from NSDUH in recent years (2006–2010). Initiation rates for cigarette smoking have been stable over the last 5 years. Comparing 2006 to 2010, the rate of initiation of cigarette smoking (number of persons who smoked cigarettes for the first time in the last 12

Figure 3.1 Percentage of recalled age at which adult smokers first tried a cigarette and began smoking daily, among 30- to 39-year-old adult smokers, by smoking status; National Survey on Drug Use and Health (NSDUH) 2010; United States



Source: 2010 NSDUH: Substance Abuse and Mental Health Services Administration (unpublished data).
Note: Based on responses to the following questions: "Have you ever smoked part or all of a cigarette?" "How old were you the first time you smoked part or all of a cigarette?" "Has there ever been a period in your life when you smoked cigarettes every day for at least 30 days?" "How old were you when you first started smoking cigarettes every day?" For further information, refer to Appendix 3.1, Table 3.1.12.

months divided by the number of persons who had never smoked in the last year) among adolescents (12–17 year of age) and young adults (18–25 years of age) did not change overall and for all subgroups (i.e., by gender and race/ethnicity) ($p > 0.05$) (Appendix 3.1, Table 3.1.30).

Current Prevalence of Cigarette Smoking

According to the 2009 NYTS, about 1 in 4 (23.2%) high school seniors is a current cigarette smoker (i.e., had smoked a cigarette in the last 30 days; see Appendix 3.3 for more detail on this definition). This figure is comparable to the prevalence of current cigarette smoking among adults (≥26 years of age), according to the 2010 NSDUH survey (22.8%) (SAMHSA 2011b). Young adults (18–25 years old) have the highest prevalence of current cigarette smoking of all age groups, at 34.2% (SAMHSA 2011b) (see Figure 3.1). By multiplying the current smoking prevalence in middle school (from the NYTS 2009) and the current smoking prevalence in high school (from the NYTS 2009) with the number of students enrolled in middle and high school, respectively (US Census Bureau 2009), this report finds that about 3.0 million (95% confidence interval [CI], 2,782,555–3,295,540) high school students and about 624,000 (95% CI, 515,957–731,939) middle school students are current cigarette smokers. Note, then, that the total number of current smokers is somewhat higher given out-of-school youth. By way of comparison, among young adults aged 18–25 years, about 11.7 million (95% CI, 11,352,000–11,980,000) are current cigarette smokers and about 14.7 million (95% CI, 14,343,000–15,005,000) have smoked a cigarette within the past year (SAMHSA 2011a). To achieve the national Healthy People objectives outlined for 2020, further reductions in cigarette smoking are necessary and will likely require renewed intervention efforts (see "Trends in Cigarette Smoking Over Time" later in this chapter). According to the 2009 YRBS, 19.5% of students in grades 9–12 currently smoke cigarettes. The target prevalence estimate referenced in *Healthy People 2020* for current smoking among adolescents (in grades 9–12) is 16% and among adults (≥18 years old) is 12% (USDHHS 2011). *Healthy People 2020* also references 2% reductions in smoking initiation (USDHHS 2011).

Table 3.2 Cumulative percentages of recalled age at which a respondent first used a cigarette and began smoking daily, by smoking status among 30- to 39-year-olds; National Survey on Drug Use and Health (NSDUH) 2010;[a] United States

	All persons		Persons who had ever tried a cigarette	Persons who had ever smoked daily	
Recalled age (years)	(a) First tried a cigarette % (95% CI)	(b) Began smoking daily % (95% CI)	(c) First tried a cigarette % (95% CI)	(d) First tried a cigarette % (95% CI)	(e) Began smoking daily % (95% CI)
≤10	4.1 (3.54–4.77)	0.4 (0.24–0.61)	5.9 (5.12–6.90)	6.7 (5.60–8.09)	1.0 (0.65–1.64)
≤11	5.8 (5.16–6.58)	0.7 (0.48–1.01)	8.4 (7.47–9.51)	9.6 (8.25–11.14)	1.9 (1.29–2.70)
≤12	12.1 (11.13–13.19)	1.8 (1.40–2.23)	17.5 (16.14–19.02)	20.9 (18.85–23.14)	4.7 (3.75–5.93)
≤13	18.5 (17.36–19.78)	3.5 (2.95–4.07)	26.8 (25.18–28.53)	32.4 (30.15–34.71)	9.3 (7.93–10.82)
≤14	25.4 (24.02–26.78)	6.0 (5.30–6.72)	36.7 (34.89–38.56)	43.6 (41.17–46.09)	16.0 (14.31–17.81)
≤15	34.4 (32.94–35.93)	10.5 (9.57–11.52)	49.8 (47.87–51.72)	58.5 (56.03–61.00)	28.1 (25.89–30.46)
≤16	43.9 (42.31–45.42)	15.3 (14.22–16.39)	63.5 (61.59–65.27)	72.9 (70.55–75.07)	40.9 (38.53–43.26)
≤17	49.4 (47.76–50.95)	19.2 (18.08–20.40)	71.4 (69.64–73.10)	80.3 (78.21–82.27)	51.4 (49.09–53.74)
≤18	56.3 (54.75–57.90)	24.3 (23.03–25.66)	81.5 (79.91–82.98)	88.2 (86.45–89.81)	65.1 (62.67–67.41)
≤19	59.3 (57.72–60.86)	27.4 (26.06–28.88)	85.8 (84.37–87.10)	91.8 (90.30–93.11)	73.5 (71.14–75.65)
≤20	61.9 (60.38–63.41)	30.0 (28.55–31.44)	89.6 (88.33–90.68)	93.2 (91.75–94.38)	80.2 (78.11–82.16)
≤21	64.2 (62.67–65.72)	32.0 (30.53–33.50)	92.9 (91.81–93.86)	95.9 (94.78–96.77)	85.6 (83.82–87.27)
≤22	65.2 (63.72–66.75)	33.1 (31.63–34.61)	94.4 (93.40–95.25)	96.6 (95.61–97.43)	88.6 (86.92–90.08)
≤23	65.9 (64.39–67.39)	33.9 (32.40–35.40)	95.3 (94.45–96.11)	97.3 (96.34–98.00)	90.7 (89.13–92.02)
≤24	66.5 (65.03–68.02)	34.6 (33.09–36.12)	96.3 (95.42–96.97)	97.9 (97.02–98.50)	92.6 (91.14–93.78)
≤25	67.6 (66.11–69.04)	35.7 (34.22–37.27)	97.8 (97.14–98.30)	98.8 (98.23–99.23)	95.6 (94.56–96.49)
≤26	67.8 (66.28–69.20)	35.9 (34.43–37.47)	98.0 (97.39–98.53)	99.0 (98.39–99.36)	96.2 (95.18–96.96)
≤27	67.9 (66.44–69.36)	36.1 (34.62–37.68)	98.3 (97.64–98.73)	99.1 (98.46–99.42)	96.7 (95.74–97.44)
≤28	68.1 (66.61–69.52)	36.5 (34.98–38.04)	98.5 (97.90–98.94)	99.3 (98.75–99.60)	97.7 (96.90–98.27)
≤29	68.2 (66.69–69.59)	36.7 (35.14–38.20)	98.6 (98.01–99.03)	99.3 (98.81–99.64)	98.1 (97.39–98.63)
≤30	68.7 (67.28–70.14)	37.0 (35.50–38.56)	99.4 (98.98–99.69)	99.8 (99.44–99.93)	99.1 (98.50–99.43)
31–39	69.1 (67.68–70.53)	37.4 (35.85–38.91)	100.0	100.0	100.0
Never smoked	100.0	100.0	NA	NA	NA
Mean age (years)	15.9	17.9	15.9	15.1	17.9

Source: 2010 NSDUH: Substance Abuse and Mental Health Services Administration (unpublished data).
Note: **CI** = confidence interval; **NA** = not applicable.
[a]Based on responses to the following questions: "Have you ever smoked part or all of a cigarette?" "How old were you the first time you smoked part or all of a cigarette?" "Has there ever been a period in your life when you smoked cigarettes every day for at least 30 days?" "How old were you when you first started smoking cigarettes every day?"

Current Prevalence Among Adolescents

The prevalence of current cigarette smoking among high school and middle school students is provided in Table 3.3a and Appendix 3.1, Table 3.1.2. In the NYTS–high school survey, the prevalence of current cigarette smoking was higher for males than for females overall (19.6% vs. 14.8%, $p < 0.05$), but no significant differences by gender were observed for YRBS (19.8% vs. 19.1%, $p > 0.05$) or NYTS–middle school (5.6% vs. 4.7%, $p > 0.05$). For NYTS–high school, White and Hispanic students had the highest prevalence of current cigarette smoking (19.2%), followed by Other youth (16.4%) and Blacks

Table 3.3a Percentage of high school students and middle school students who currently smoke cigarettes, by gender and race/ethnicity; National Youth Risk Behavior Survey (YRBS) 2009, and National Youth Tobacco Survey (NYTS) 2009; United States

	YRBS 9th–12th grades[a]		NYTS 9th–12 grades[a]		NYTS 6th–8th grades[a]	
Characteristic	**% (95% CI)**	**SN[b]**	**% (95% CI)**	**SN[b]**	**% (95% CI)**	**SN[b]**
Overall	19.5 (17.9–21.2)		17.2 (15.0–19.4)		5.2 (4.2–6.1)	
Gender						
Male	19.8 (17.8–21.9)	a	19.6 (16.6–22.5)	a	5.6 (4.3–6.9)	a
Female	19.1 (17.2–21.0)	a	14.8 (12.8–16.7)	b	4.7 (3.9–5.5)	a
Race/ethnicity						
White	22.5 (20.0–25.2)	a	19.2 (16.4–21.9)	a	4.3 (3.1–5.5)	a
Male	22.3 (18.9–26.0)		21.2 (18.0–24.5)		4.5 (3.0–5.9)	
Female	22.8 (20.3–25.5)		17.1 (14.5–19.8)		4.1 (2.7–5.6)	
Black or African American	9.5 (8.2–11.1)	b	7.5 (4.6–10.3)	b	5.1 (3.6–6.6)	a,b
Male	10.7 (8.4–13.5)		8.6 (3.6–13.6)		5.8 (3.6–8.0)	
Female	8.4 (6.5–10.9)		6.3 (3.0–9.6)		4.4 (2.7–6.1)	
Hispanic or Latino	18.0 (16.0–20.2)	c	19.2 (16.5–21.9)	a	6.7 (5.2–8.2)	b
Male	19.4 (16.7–22.5)		22.6 (19.9–25.4)		7.0 (5.3–8.7)	
Female	16.7 (14.4–19.2)		15.7 (12.0–19.4)		6.4 (4.5–8.3)	
Other[c]	16.5 (13.1–20.5)	c	16.4 (13.2–19.5)	a	7.2 (2.5–12.0)	a,b
Male	15.9 (12.4–20.2)		21.7 (16.6–26.8)		8.7 (0.2–17.2)	
Female	16.7 (12.5–21.9)		11.2 (6.7–15.8)		5.7 (3.0–8.5)	

Source: 2009 YRBS: Centers for Disease Control and Prevention (CDC 2011d); 2009 NYTS: CDC (unpublished data).
Note: **CI** = confidence interval; **SN** = statistical note.
[a]Estimates are based on responses to the question, "During the past 30 days, on how many days did you smoke cigarettes?" Respondents who reported that they had smoked on at least 1 or 2 days were classified as current smokers.
[b]This column represents the results of statistical tests that were run separately within each surveillance system (e.g., YRBS). These tests were performed to examine differences in estimates within specific demographic subgroups (e.g., gender). Estimates with the same letter (e.g., a and a) are not statistically significantly different from one another ($p > 0.05$). Estimates with different letters (e.g., a and b) are, in contrast, statistically significantly different from one another ($p < 0.05$).
[c]Includes Asians, American Indians or Alaska Natives, Native Hawaiians or Other Pacific Islanders, and persons of two or more races.

(7.5%; $p < 0.05$ for all comparisons with Blacks). Note that students in the Other category include other racial/ethnic subgroups besides White, Black, and Hispanic (such as American Indian/Alaska Native and Asian). For YRBS, White students had the highest prevalence of current smoking (22.5%), compared to Hispanic (18.0%), Other (16.5%), and Black (9.5%) students ($p < 0.05$ for all comparisons with White students). Differences between Hispanic and Other students were not significant for YRBS ($p > 0.05$). For NYTS–middle school, Hispanic students had a higher prevalence of cigarette smoking than did White students (6.7% vs. 4.3%, $p < 0.05$).

Current Prevalence Among Young Adults

The prevalence of current cigarette smoking among young adults (18–25 years old) is provided in Table 3.3b. In the 2010 NSDUH, the prevalence of current cigarette smoking was higher for young adult males than for females (38.1% vs. 30.3%). White youth had the highest prevalence (39.1%), followed by Hispanic (27.4%) and Black (23.3%) youth (SAMHSA 2011b). Of all age groups in the United States, young adults have the highest prevalence of current cigarette smoking (Figure 3.2), and this prevalence is especially high among young adults who are not college educated (Green et al. 2007). It should be noted that the tobacco industry targets young adults (18–

Table 3.3b Percentage of young adults (18–25 years old) who currently smoke cigarettes, by gender and race/ethnicity; National Survey on Drug Use and Health (NSDUH) 2010; United States

	NSDUH 18–25 years of age[a]	
Characteristic	**% (95% CI)**	**SN[b]**
Overall	34.2 (35.3–35.2)	
Gender		
Male	38.1 (36.8–39.4)	a
Female	30.3 (29.2–31.4)	b
Race/ethnicity		
White	39.1 (38.0–40.3)	a
Male	41.9 (40.3–43.5)	
Female	36.3 (34.9–37.8)	
Black or African American	26.3 (24.2–28.5)	b
Male	31.7 (28.5–35.0)	
Female	21.4 (19.0–24.1)	
Hispanic or Latino	27.4 (25.5–29.5)	b
Male	33.1 (30.2–36.1)	
Female	20.7 (18.1–23.6)	
Other[c]	27.2 (23.7–31.0)	b
Male	32.5 (27.8–37.5)	
Female	22.0 (18.0–26.5)	

Source: 2010 NSDUH: Substance Abuse and Mental Health Services Administration (unpublished data).
Note: **CI** = confidence interval; **SN** = statistical note.
[a]Based on responses to the question, "During the past 30 days, have you smoked part or all of a cigarette?" Respondents who chose "Yes" were classified as current smokers.
[b]This column represents the results of statistical tests that were run separately within each surveillance system (e.g., NSDUH). These tests were performed to examine differences in estimates within specific demographic subgroups (e.g., gender). Estimates with the same letter (e.g., a and a) are not statistically significantly different from one another ($p > 0.05$). Estimates with different letters (e.g., a and b) are, in contrast, statistically significantly different from one another ($p < 0.05$).
[c]Includes Asians, American Indians or Alaska Natives, Native Hawaiians or Other Pacific Islanders, and persons of two or more races.

25 years of age) through its advertising and promotional campaigns (Katz and Lavack 2002; Ling and Glantz 2002; Biener and Albers 2004). Therefore, cigarette smoking (and other tobacco use) among young adults should continue to be monitored closely. Data from NSDUH will be helpful in this regard, as this national surveillance system has a wide repertoire of tobacco use measures that can be compared across age groups, for adolescents (12–17 years old), young adults (18–25 years old), and adults (≥26 years old). Young adulthood may be a critical time in life for deciding whether cigarette smoking will become an established, lifelong behavior or will be rejected for a healthier lifestyle. Studies suggest that the number of individuals aged 18 and 19 years in the early stages of smoking initiation may be more than double that of established smokers aged 18 years (Ling and Glantz 2002; Biener and Albers 2004; Green et al. 2007). As illustrated in Figure 3.1 and Table 3.2, transitioning to daily smoking will not occur until young adulthood for about one-third of young smokers. Thus, about 2/3 of young smokers transitioned to daily smoking **before** age 18.

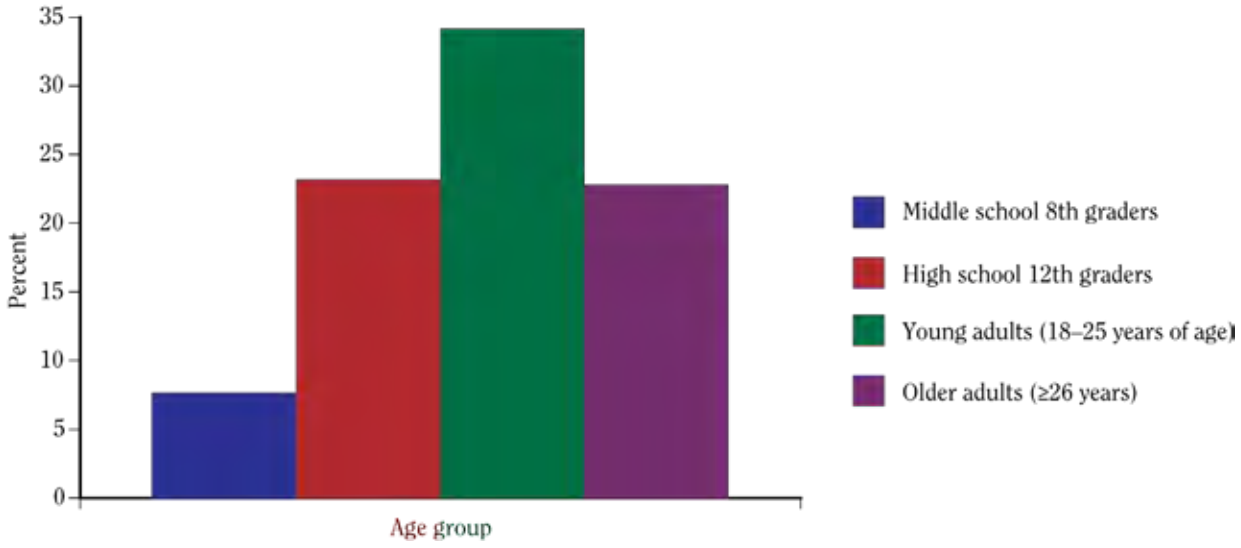
Trends in Cigarette Smoking Over Time

Trend data for cigarette smoking and other tobacco use among young people are available from four primary surveillance systems: YRBSS, NYTS, MTF, and NSDUH. Trends in the prevalence of current cigarette smoking and other tobacco use based on YRBS data are illustrated upfront in this chapter, (e.g., Figures 3.3a, 3.3b, 3.6a, 3.8a and 3.8b) and in Appendix 3.1 (e.g., Figures 3.1.6 onward). Trend data from MTF are also provided in Figure 3.6b and in Appendix 3.1 (e.g., Figures 3.1.5 onward). MTF data include prevalence estimates for ever and current cigarette smoking, as well as trends in knowledge and attitudes about cigarette smoking over time. Finally, trend data from NSDUH are also available here (Figures 3.5a and 3.5b) as well as in Appendix 3.1 (e.g., Figure 3.1.13 onward). This includes trends in the prevalence of current cigarette smoking among adolescents and young adults, as well as information on the initiation of tobacco use over time, among adolescents and young adults alike. To supplement these analyses, recent published manuscripts on trends in cigarette smoking over time are cited where appropriate (e.g. Nelson et al. 2008; CDC 2010a,d).

Trends in Cigarette Smoking Among Adolescents

Figures 3.3a and 3.3b illustrate trends in the prevalence of current cigarette smoking for students in 9th–12th grades since 1991, using YRBS. After a dramatic increase in the prevalence of current smoking in this population through the mid-1990s, the prevalence of current smoking dropped sharply. This inflection point (i.e., the point in time when the prevalence of cigarette smoking stopped increasing and began to decrease) coincided with

Figure 3.2 Percentage of middle school 8th graders, high school seniors, young adults (18–25 years of age), and adults (≥26 years of age) who currently smoke cigarettes; National Youth Tobacco Survey (NYTS)[a] 2009 and National Survey on Drug Use and Health (NSDUH)[b] 2010; United States



Source: Middle school and high school data, 2009 NYTS: Centers for Disease Control and Prevention (unpublished data). Young adult and older adult data, 2010 NSDUH: Substance Abuse and Mental Health Services Administration (published data). (For young adults, see SAMHSA 2011a, Table 2.24B.) (For adults ≥26 years, see SAMHSA 2011a, Table 2.25B.)

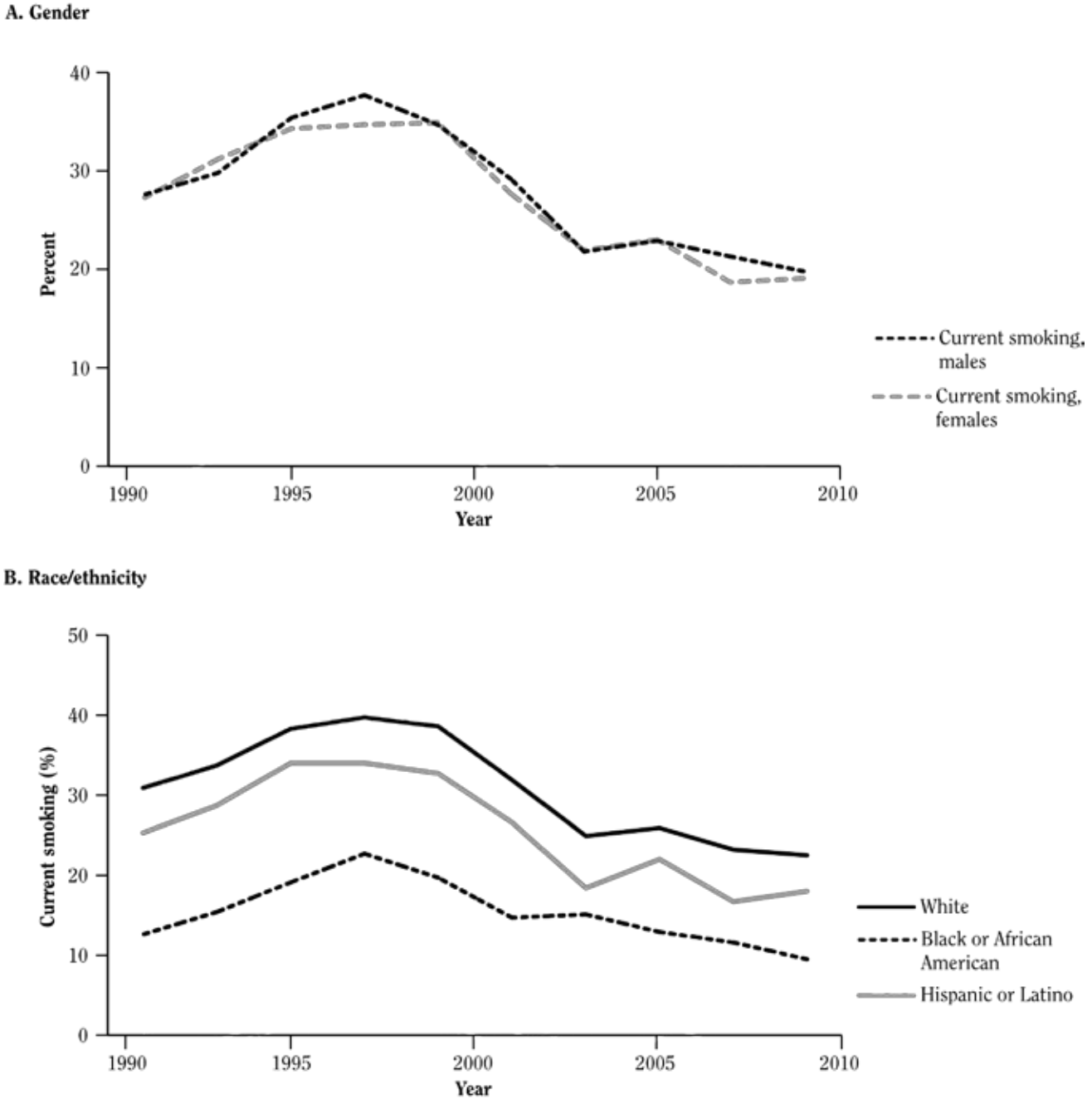
[a]Based on responses to the question, "During the past 30 days, on how many days did you smoke cigarettes?" Respondents who reported that they had smoked on at least 1 or 2 days were classified as current smokers.

[b]Based on responses to the question, "During the past 30 days, have you smoked part or all of a cigarette?" Respondents who chose "Yes" were classified as current smokers. For further information, refer to Appendix 3.1, Table 3.1.2.

the Master Settlement Agreement in 1998 when new initiatives to reduce youth tobacco use became widespread. Over time, however, this decline has decelerated, and for some subgroups, may have stopped altogether. YRBS data suggest the rates of decline in the prevalence of current smoking, ever smoking, and frequent smoking began to slow in 2003 (CDC 2010a). CDC estimates that if the decline in the prevalence of current smoking had continued from 2003 to 2009 at the same rate as had been seen from 1999 to 2003, 3 million fewer youth and young adults would have been current cigarette smokers by 2009 (Figure 3.4) (CDC unpublished data). Unfortunately, subgroup analyses suggest that the 1999–2003 rate of decline in the prevalence of current cigarette smoking only continued past 2003 for Black female students (CDC 2010a). For some subgroups of youth—White female students, Black male students, and younger students (9th–10th-grade students)—the decline in prevalence of current cigarette smoking began to slow in 2003 (CDC 2010a). The decline in current cigarette smoking stalled completely in 2003 for White males, Hispanic males, Hispanic females, and older students (11th–12th-grade students) (CDC 2010a). Data from MTF are consistent with the trends found using YRBS. According to MTF, the deceleration in ever smoking among students seems to have started in 2003, as well (Appendix 3.1, Figure 3.1.5), while the deceleration in current smoking among students may have started a year earlier or later, depending on the subgroup(s) involved (e.g., in 2002 for 12th-grade males and in 2004 for 8th-grade males and females; see Figure 3.1.8 in Appendix 3.1).

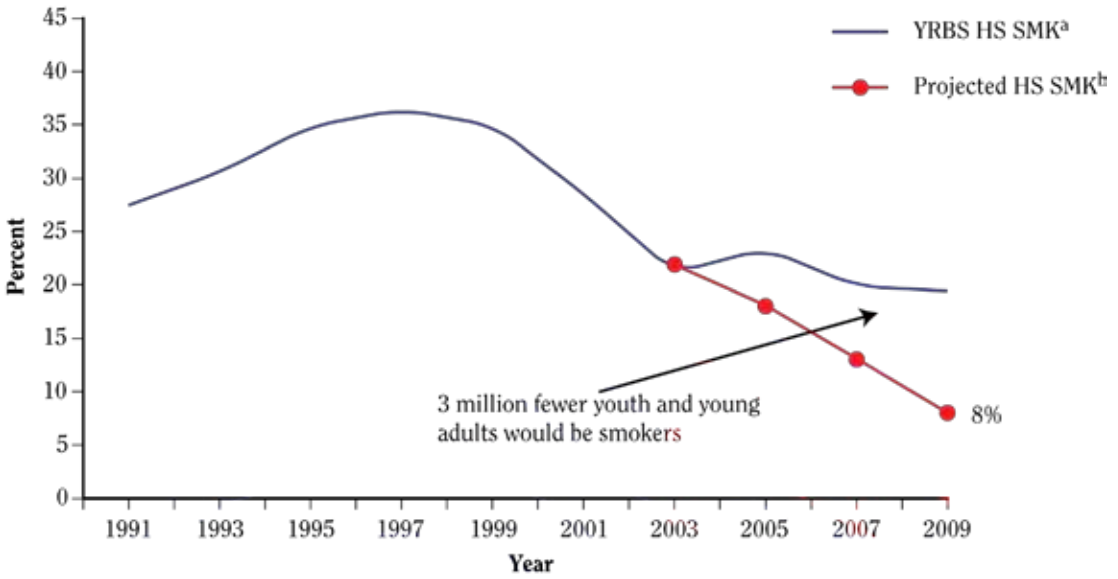
Detailed NSDUH data on trends in smoking prevalence among adolescents are not provided in this report, but are found elsewhere (SAMHSA 2009a,b; 2011b), with comparable surveillance data over time available from 2002. In contrast to YRBS and MTF, NSDUH, which includes both in-school and out-of-school youth, shows a consistent decline in the prevalence of cigarette smoking among adolescents overall (12–17 years old) from 2002 to 2008 (SAMHSA 2009b) and through 2010 (SAMHSA 2011b). However, when subgroup analyses were conducted, the decline in the prevalence of current cigarette

Figure 3.3 Trends in the prevalence of current cigarette smoking over time among high school students, by gender and race/ethnicity; National Youth Risk Behavior Survey (YRBS) 1991–2009; United States



Source: 1991–2009 YRBS: Centers for Disease Control and Prevention (2011d).
Note: Based on responses to the question, "During the past 30 days, on how many days did you smoke cigarettes?" Respondents who reported that they had smoked on at least 1 or 2 days were classified as current smokers. Also see Appendix 3.1, Figures 3.1.7 and 3.1.9D.

Figure 3.4 Current high school cigarette smoking and projected rates if decline had continued; National Youth Risk Behavior Survey (YRBS); United States, 1991–2009



Source: 1991–2009 YRBS: Centers for Disease Control and Prevention, Division of Adolescent and School Health, Office on Smoking and Health (unpublished data).
Note: **HS SMK** = high school smokers. Based on responses to the question, "During the past 30 days, on how many days did you smoke cigarettes?" Respondents who reported that they had smoked on at least 1 or 2 days were classified as current smokers.
[a]High school students who smoked on 1 or more of the 30 days preceding the survey.
[b]Projected high school students who smoked on 1 or more days of the past 30 days if 1997–2003 decline had been maintained.

smoking between 2007 and 2008 appears to have been limited to White males and females only (SAMHSA 2009b), and between 2009 and 2010, the decline in the prevalence of current cigarette smoking was limited to White males only (SAMHSA 2001b). For all other subgroups, no significant differences in the prevalence of current cigarette smoking were observed between 2007 and 2008 (SAMHSA 2009b) or 2009 and 2010 (SAMSHA 2011b). This suggests the decline might have finally stalled for these subgroups at these time points, from NSDUH's perspective. However, the rate of initiation of cigarette smoking among adolescents (12–17 years old) declined overall from 2006–2010 (Appendix 3.1, Table 3.1.30) ($p < .05$), decreasing for females and Whites ($p < .05$) and unchanged for other groups.

These recent trends in the prevalence of current cigarette smoking among adolescents are difficult to fully reconcile, especially given subgroup differences both within and between surveillance systems. Nevertheless, it seems clear that progress in decreasing youth cigarette smoking has greatly slowed for some subgroups and halted altogether for others. Analyses of NYTS data through 2009 show that susceptibility to cigarette smoking (defined as the absence of a firm commitment not to smoke cigarettes or, conversely, a willingness to experiment with cigarette smoking) has remained unchanged since it was first measured in the 1999–2000 school year (Mowery et al. 2004; CDC 2010c).

Trends in Cigarette Smoking Among Young Adults

Trends in cigarette smoking among young adults from 1973 through 2005 have been reviewed elsewhere (Nelson et al. 2008) through an analysis of NHIS data. In this review, changes in the prevalence of current cigarette smoking among young adults (18–24 years old in this analysis) lagged a few years behind the changes for adolescents, providing evidence for a cohort effect (Lantz 2003; Nelson et al. 2008). After the increase in the prevalence of current smoking among adolescents in the mid-1990s, young adult smoking peaked at about the year 2000, a few years after the inflection point for adolescents, (i.e., the point when the prevalence of current cigarette smoking

stopped increasing and began to decrease). Throughout this period, from the 1990s into the first part of the new millennium, the rise and fall of young adult smoking was never as steep as it was among adolescents (Nelson et al. 2008). In recent years, NSDUH data suggest that the decline in young adult prevalence may have stalled, too for certain subgroups. The initiation rate for cigarette smoking among young adults overall (18–25 years old) remained stable between 2006 and 2010, according to NSDUH ($p > 0.05$). Still, for Whites, there was a significant decrease from 2006–2010 ($p < 0.05$). This is illustrated in Figures 3.5a and 3.5b (see also Appendix 3.1, Table 3.1.31). Trends in the prevalence of current smoking for young adults (18–25 years old) from 2002 through 2010 are presented in Appendix 3.1, in Figures 3.1.13 to 3.1.15. As can be seen from these figures, cigarette smoking appears to have stalled from 2007 forward in young adult males and females (Figure 3.1.13) and in White, Black, and Hispanic subgroups of young adults (Figure 3.1.14) overall. When examined by SES status, however (Figure 3.1.15), this flat line may be masking an important difference: for young adults at or below the poverty line, the prevalence of current cigarette smoking actually began to increase in 2007, as it continued to decrease for those above the poverty line, albeit at a slower rate. No changes in current smoking for any of these subgroups occurred between 2009 and 2010, as reflected by either education level or employment status (trends by poverty level have not been publicly reported) (SAMHSA 2011b). The take-home message for young adults, then, is equally as worrisome as that for adolescents. As noted before (Figure 3.2), it must be emphasized that young adults have the highest prevalence of cigarette smoking of all age groups and may be uniquely situated, as they transition into older adulthood, to benefit from interventions, especially help with cessation, although research to date suggests few young adults avail themselves of these resources (see Chapter 6, "Efforts to Prevent and Reduce Tobacco Use Among Young People"). Continued surveillance of smoking and interventions to reduce smoking should be cognizant of critical differences in the prevalence of cigarette smoking among young adults by education level and SES status (Lantz 2003; Green et al. 2007).

Current Prevalence of Smokeless Tobacco Use and Cigar Smoking

According to the 2009 NYTS, about 1 in 10 high school males (11.6%) are current smokeless tobacco users (i.e., had used smokeless tobacco in the last 30 days [Table 3.4a; see Appendix 3.3 for more detail on this definition]), compared to about 1 in 100 high school females (1.8%), overall. The prevalence of smokeless tobacco use is highest among White high school students, compared to any other racial/ethnic group ($p < 0.05$), according to NYTS–high school. The prevalence of cigar smoking is somewhat higher than that of smokeless tobacco use, overall. Again, according to the 2009 NYTS–high school, 15.0% of high school males and 6.7% of high school females ($p < 0.05$, comparing males to females) currently smoke cigars (i.e., had smoked a cigar in the last 30 days; [Table 3.5a; see Appendix 3.3 for more detail on this definition]). The prevalence of current cigar smoking is highest among White (12.0%) and Hispanic (11.8%) high school students ($p > 0.05$, comparing Whites to Hispanics), followed by students of Other race/ethnicities (8.0%) and Blacks (7.3%) ($p > 0.05$, comparing Others to Blacks), according to NYTS–high school (see Table 3.5a). By multiplying the current tobacco use prevalence (which includes cigarettes, smokeless tobacco, and cigars) in middle school (from the NYTS 2009) and the current tobacco use prevalence in high school (from the NYTS 2009) with the number of students enrolled in middle and high school, respectively (US Census Bureau 2009), this report finds that approximately 4.3 million (95% CI, 3,699,710–4,399,235) high school students and about 985,000 (95% CI, 863,928–1,103,908) middle school students currently use a tobacco product (includes cigarettes, smokeless tobacco, and cigars). Similarly, NSDUH found that, among young adults aged 18–25 years in 2010, 13.9 million (95% CI, 13,582,000–14,228,000) used a tobacco product within the past month and 17.4 million (95% CI, 17,088,000–17,758,000) used a tobacco product within (includes cigarettes, smokeless tobacco, cigars) the past year.

The prevalence of current smokeless tobacco use among young adults (18–25 years old) is provided in Table 3.4b. In the 2010 NSDUH, the prevalence of current smokeless tobacco use was higher for young adult males than for females (12.0% vs. 0.7%; $p < 0.05$). White (9.5%) youth had the highest prevalence, followed by Hispanic (2.2%) and Black (0.6%) youth ($p < 0.05$ for all comparisons with Whites) (SAMHSA 2011b). The prevalence of current cigar smoking among young adults (18–25 years old) is provided in Table 3.5b. In the 2010 NSDUH, the prevalence of current cigar smoking was higher for young adult males than for females (16.6% vs. 5.6%; $p < 0.05$). White (12.5%) and Black (11.5%) youth had the highest prevalence, followed by Hispanic (8.4%) youth ($p < 0.05$ for all comparisons with Hispanics) (SAMHSA 2011b).

5% each of the total cigarette market (Maxwell 2009). It is important to note that market share is influenced primarily by the preferences of adults, not adolescents (given that market share represents cigarette sales, and many youth obtain their cigarettes through social, not commercial, sources). Therefore, these figures indicate that the combined share of Marlboro, Newport, and Camel is not as concentrated in adults (57.4%) as it is for adolescents (80.4%) and young adults (80.3%). However, the consistencies in these data suggest that brand preferences that develop early in the life course will extend into adulthood. This finding extends to smokeless tobacco and cigar use as well. Brand preferences for these products are discussed in Appendix 3.1 (for smokeless tobacco use, see Tables 3.1.44–3.1.45 and 3.1.47; for cigar use, Tables 3.1.50–3.1.52). Like that observed here, brand preference data for smokeless tobacco and cigars among young people are consistent with industry data for market share. Skoal and Grizzly are the most preferred brands of moist snuff (a type of smokeless tobacco that is preferred over chewing tobacco) among young people, while Black & Mild is the most preferred brand of cigars. It should be noted that with the exception of Black & Mild, the top cigar brands preferred by adolescents and young adults alike include various flavorings, such as peach, grape, apple, and chocolate. At present, characterizing flavors are only banned by the FDA for cigarettes, not cigars. Given this loophole, some flavored cigarettes are reemerging as flavored cigars (Associated Press 2009; CSPnet 2010; U.S. House of Representatives Committee on Energy & Commerce 2011).

Evidence Summary

Similar to the 1994 Surgeon General's report on smoking and health, this report finds that cigarette smoking virtually always begins in adolescence or young adulthood, as does the transition to daily smoking. In 2010, among adults aged 30–39 years, 81.5% of those who had ever tried a cigarette did so by the age of 18 years and 98.0% did so by the age of 26 years, based on NSDUH data (Table 3.2; Appendix 3.1, Table 3.1.9). Among those who had ever smoked cigarettes daily, the mean age of initiation was even younger; 88.2% first smoked by the age of 18 years and 99.0% first smoked by 26 years of age. Smoking initiation was most likely to occur in a young person's 15th or 16th year, which was also true in 1994 (USDHHS 2011). Adolescent and young adult initiation rates for cigarette smoking have been stable over the past 5 years (Appendix 3.1, Table 3.1.31). This finding is consistent with the idea that tobacco companies are successfully targeting young people in advertising and promotion efforts to attract new smokers (see Chapter 5).

Almost one-fifth of high school students are current cigarette smokers, and the prevalence rises with age; one-fourth of high school seniors are current cigarette smokers at present (Figure 3.3; Table 3.3a and Appendix 3.1, Table 3.1.2). Young adults have the highest smoking prevalence among all age groups (Figure 3.3). Males remain more likely than females to be current smokers in every age group except those aged 65 years and older (CDC 2011c). Similar to findings for adults (CDC 2011c), the prevalence of cigarette smoking among young people is highest for American Indians/Alaska Natives and Whites. The lowest prevalence of cigarette smoking among young people are among Asian and Blacks; in contrast, prevalence are lowest for Asians and Hispanics among adults (CDC 2011c). Since the late 1990s, smoking prevalence has decreased for both youth and young adults (CDC 2001, 2009b). Around 2003, however, the rate of decrease began to slow, such that any changes in the prevalence of current smoking from one iteration of a survey to the next were often statistically insignificant. These findings have led to concern that progress in decreasing youth smoking may have "stalled," or halted. Findings as to which youth demographic subgroups show a more or less pronounced stall are inconsistent across surveys. Overall, however, the most recent reports from both YRBS and MTF suggest a stall in particular subgroups. In NYTS, the prevalence of current cigarette smoking did not differ significantly between 2006 and 2009, the two most recent survey iterations (CDC 2010a). Only NSDUH has shown a continuing, statistically significant decline since 2002 in current smoking, although this decline may be limited to White youth since 2007 (SAMHSA 2009b).

Smokeless tobacco is currently used by less than 10% of adolescents overall, but this finding masks significant differences in patterns of use among youth subgroups. The prevalence of current use among females is less than 2% except in a few Western states (See section on current use of smokeless tobacco, Appendix 3.1). Further, White male students are far more likely than males in other racial/ethnic subgroups to use smokeless tobacco, with the prevalence of current use among white male high school students at around 20%, based on YRBS data (Table 3.4a). Recent data from YRBS and MTF

indicate that smokeless tobacco use may have increased among young White males in the latter half of the last decade. The prevalence of current use of cigars (including little cigars and cigarillos) is more than 10% for high school students but is more common among White male youth than among other youth subgroups (Table 3.5a). However, there are a few states in which female cigar use prevalence is around 5% (Appendix 3.1), especially among Black females. The prevalence of cigar use among youth has been largely unchanged over the last few years with some evidence of an increase among Black females since 2007. Smokeless tobacco and cigars are often used by the same youth who smoke cigarettes. Indeed, more than one-half of White and Hispanic male high school students who use any tobacco product use more than one product, and just under one-half of Hispanic female high school students report the same. About 40% use both cigarettes and cigars; one-half of these youth use smokeless tobacco in addition. The prevalence of concurrent use of multiple tobacco products in the last 30 days among high school students has been stable for the past decade.

Globally, the prevalence of tobacco use and the predominant products used among youth vary broadly. Among the 140 countries and 11 territories, commonwealths, provinces, and regions that implemented the GYTS between 2000 and 2007, cigarettes were the predominant form of tobacco used by 13- to 15-year-old students in the Americas, Europe, and Western Pacific regions (Warren et al. 2008). In the Eastern Mediterranean and South-East Asia regions, other forms of tobacco (such as smokeless tobacco, water pipes, or bidis) were more commonly used (Warren et al. 2008). The prevalence of current cigarette smoking among 13- to 15-year-old students varied by region, from 4.0% in Africa to 9.3% in the Americas; however, even within a region, broad variations in prevalence were noted (Appendix 3.1, Table 3.1.64). Although boys were more likely than girls to be tobacco users and current smokers in the majority of countries, the gender gap was narrow or nonexistent in some places; for example, the gap in current use of any tobacco product was statistically indistinguishable in Brazil (Rio de Janeiro), China (Shanghai), and the Russian Federation (Warren et al. 2008). In Spain and some South American (e.g., Argentina, Brazil, Chile, Uruguay), ever cigarette smoking is more prevalent among girls than among boys.

Conclusions

1. Among adults who become daily smokers, nearly all first use of cigarettes occurs by 18 years of age (88%), with 99% of first use by 26 years of age.

2. Almost one in four high school seniors is a current (in the past 30 days) cigarette smoker, compared with one in three young adults and one in five adults. About 1 in 10 high school senior males is a current smokeless tobacco user, and about 1 in 5 high school senior males is a current cigar smoker.

3. Among adolescents and young adults, cigarette smoking declined from the late 1990s, particularly after the Master Settlement Agreement in 1998. This decline has slowed in recent years, however.

4. Significant disparities in tobacco use remain among young people nationwide. The prevalence of cigarette smoking is highest among American Indians and Alaska Natives, followed by Whites and Hispanics, and then Asians and Blacks. The prevalence of cigarette smoking is also highest among lower socioeconomic status youth.

5. Use of smokeless tobacco and cigars declined in the late 1990s, but the declines appear to have stalled in the last 5 years. The latest data show the use of smokeless tobacco is increasing among White high school males, and cigar smoking may be increasing among Black high school females.

6. Concurrent use of multiple tobacco products is prevalent among youth. Among those who use tobacco, nearly one-third of high school females and more than one-half of high school males report using more than one tobacco product in the last 30 days.

7. Rates of tobacco use remain low among girls relative to boys in many developing countries, however, the gender gap between adolescent females and males is narrow in many countries around the globe.

White and Hispanic adolescents and Asian and Black adolescents. Among American Indian/Alaskan Native, White, and Asian adolescents, the prevalence of current smoking is essentially the same for boys as for girls. Among Hispanics and Blacks, it is higher for boys than girls. By the end of 12th grade, more than 10% of current smokers are smoking at least 20 days per month (i.e., they can be classified as frequent smokers), and more than 5% are smoking at least a half-pack of cigarettes or more per day (i.e., they can be categorized as heavy smokers). The prevalence of frequent and heavy smoking is highest among White adolescents in high school (American Indians/Alaska Natives were not considered here), while racial/ethnic differences are less prominent among middle school youth. Marlboro, Camel, and Newport are the most preferred brands of cigarettes for adolescents and young adults alike. Newport, a menthol cigarette brand, is particularly preferred by Blacks (note that Newport Red, a new brand of Newports, is nonmentholated). Continued surveillance of menthol cigarettes is warranted.

Developmental Patterns of Cigarette Smoking

Adolescence and young adulthood represent a time of heightened vulnerability for both the initiation of tobacco use and the development of nicotine dependence (see Chapter 2 "The Health Consequences of Tobacco Use Among Young People"). Identifying factors that distinguish between young people who experiment with smoking and desist after relatively few trials and those who experiment, escalate, and become dependent smokers can inform the design of interventions. This section describes developmental patterns that would be relevant to these etiologic studies, especially during adolescence. Young adulthood should not be overlooked, however, as recent data suggest at least 20% of smokers begin smoking regularly in young adulthood (Green et al. 2007) and the average consumption per smoker increases in the decade following adolescence (Hammond 2005).

Age or Grade When Smoking Begins

The initiation of cigarette smoking at a young age increases the risk of later heavy smoking and of subsequent smoking-attributable mortality (Tailoi and Wynder 1991; Escobedo et al. 1993; Everett et al. 1999, Lando et al. 1999). Initiation is a complex process that can occur over a number of weeks or years. This section of the chapter focuses on two points in the process of uptake and progression: the age a young person first tries a cigarette and the age at which a young person begins to smoke cigarettes daily. In addition, it considers susceptibility to start smoking cigarettes among never smokers. Susceptibility is defined as the absence of a firm decision to not start smoking.

Table 3.1.12 uses data from recent NSDUH surveys (2008–2010) to estimate the percentage of nonsmoking adolescents who were susceptible to starting to smoke in those years. Susceptibility to smoking, which is a strong predictor of the onset of smoking (Evans et al. 1995; Pierce et al. 1996), was measured with two questions: (1) "If one of your best friends offered you a cigarette, would you smoke it?" and (2) "At any time during the next 12 months, do you think that you will smoke a cigarette?" Those answering "definitely not" to both questions were categorized as not susceptible. Overall, 19.9% of nonsmoking adolescents were classified as susceptible, with boys (20.4%) slightly more susceptible than girls (19.3%). Hispanics had the highest prevalence of susceptibility (24.2%), which was significantly higher than among Blacks (19.4%), Whites (19.0%), and Asians (15.1%) (95% confidence intervals do not overlap).

Because initiation can occur after the adolescent years, this section continues with data from adults in the 2010 NSDUH (Table 3.1.9). The analysis was restricted to adults 30–39 years of age because virtually all initiation ultimately occurs before the age of 30 years (USDHHS 1994), and because in the United States, the majority of the increased mortality that results from cigarette smoking occurs after the age of 40 years (Lopez et al. 1994). Because the recalled age of initiation is often 10 or more years less than the age of the adult respondent at the time of the survey, recall bias may affect the reliability of these estimates. Moreover, these estimates represent initiation that occurred up to 30 years earlier (i.e., from the early 1980s onward). According to the 2010 NSDUH, more than one-half (56.3%) of adults 30–39 years of age (including those who had smoked and those who had not) had first tried a cigarette while they were an adolescent or child (≤18 years of age). Of all adults 30–39 years of age who had ever tried a cigarette, 81.5% tried their first cigarette during adolescence or earlier, with 15.9 years the mean age of first trying a cigarette. Among all adults 30–39 years of age, 24.3% became daily smokers while they were under 18 years of age. Of those who had ever smoked daily, 88.2% tried their first cigarette by 18 years of age, and two-thirds (65.1%) started smoking daily by the time they were 18 years old. The mean age of becoming a daily smoker was 17.9 years. Some initiation does occur in young adulthood (19–26 years of age), and the estimate in this survey was that 11.5% of all persons 30–39 years of age (ever smokers or not) tried their first cigarette as a young adult. Of all

adults 30–39 years of age who had ever tried a cigarette, 16.5% tried their first cigarette in young adulthood. In all, 11.6% of adults (30–39 years of age) became daily smokers when in young adulthood. Of those who had ever smoked daily, 10.8% tried their first cigarette as a young adult and 31.1% started smoking daily in young adulthood.

Surveys conducted in 2009 and 2010 among youth (Table 3.1.13), although lacking information on post-adolescent initiation, provide information on more recent patterns of initiation (i.e., from the mid-1990s onward). Among all 12th-grade students (mostly 17–19 years of age), estimates were that 16.0% (MTF), 19.0% (YRBS), and 18.4% (NYTS) first tried a cigarette by 14 years of age or by the end of 8th grade. Per the NSDUH survey, among 17- and 18-year-olds who had completed the 11th grade, 16.2% first tried a cigarette by the age of 14 years. In all, the estimated percentages of young people who had tried smoking were 43.9% for NSDUH (17 or 18 years of age and completed 11th grade), 39.0% for MTF (12th-grade students), 45.1% for YRBS (12th-grade students), and 41.5% for NYTS (12th-grade students). Daily cigarette use (Table 3.1.14) began by the age of 16 years (or the 10th grade) for 7.4% of 12th-grade students, per MTF, and for 9.3% of those 17 years of age, per NSDUH. Among these youth, by 17 years of age or 10th grade, 13.2% (NSDUH) and 11.7% (MTF) were smoking daily.

Transitions and Trajectories in Smoking

Tobacco use among adolescents and young adults, including use specific to cigarette smoking, is increasingly being conceptualized as a developmental pathway(s) characterized by "transitions and trajectories … from no use to dependence" (Clayton et al. 2000, p. S1). Fortunately, the analysis of these more sophisticated models of smoking onset and progression is now possible because of advances in statistical theory and techniques (Collins and Sayer 2001). A more extensive review of these types of studies is provided in Chapters 2 and 4. In the present chapter, a brief overview of these new analytic approaches is provided, followed by the presentation of data from Add Health, a nationally representative longitudinal study of adolescents and young adults. These data are used to describe "transitions and trajectories" of tobacco use in youth.

Trajectories of Cigarette Smoking

Most research to date describes the natural history of cigarette smoking as a process that begins in adolescence, increases as an adolescent ages and grows into a young adult, then peaks and either stabilizes or declines with time (Chen and Kandel 1995). This conceptualization of the onset and progression of cigarette smoking, however, is limited. It describes only a single trajectory of age-related changes in smoking behavior over time, averaged across all adolescents, and thus it obscures any heterogeneity in this process that is likely to exist.

By using sophisticated statistical procedures, such as growth mixture modeling, recent studies have started to empirically identify multiple trajectories of cigarette smoking behavior. Some have focused only on cigarette smoking in adolescence (e.g., Bernat et al. 2008), while others have described cigarette smoking in young adulthood (e.g., Colder et al. 2006), and still others have characterized cigarette smoking from adolescence through young adulthood (e.g., Chassin et al. 2000). In addition, some studies have considered special populations such as Blacks (e.g., Fergus et al. 2005). In each study, multiple subgroups of youth have been identified who shared a common pathway(s) with regard to the onset and progression of smoking over time; subgroups have usually been defined by measures of the frequency and/or quantity of cigarette smoking across time. Chassin and colleagues (2000), for example, identified six subgroups: (1) abstainers, (2) experimenters, (3) early stable smokers, (4) late stable smokers, (5) quitters, and (6) erratics. These subgroups differed by the intensity of smoking and by the age at which the intensity of cigarette smoking increased or decreased as respondents aged across time. In addition, Chassin and coworkers (2000) used key correlates of tobacco use to differentiate these subgroups in adolescence or young adulthood.

In this chapter, one of several ways to characterize trajectories of cigarette smoking is presented. Multiple trajectories of cigarette smoking are identified using data from Add Health (University of North Carolina [UNC], 2009). These trajectories describe different developmental pathways specific to the onset and progression of smoking from early adolescence through young adulthood. In Add Health, data were collected from a nationally representative sample of youth in three waves. Wave I was collected in 1994–1995, when students were in the 7th–12th grades (11–17 years of age); Wave II in 1996, when students were in the 8th–12th grades (12–18 years of age); and Wave III in 2001–2002, when the youth were young adults (18–26 years of age). At the time this chapter was being developed, data from Wave IV (2007–2008; 24–32 years of age) were not yet available for analysis. The present analysis makes use of only those who participated in Wave I and Wave III. The analysis uses a single measure: "During the past 30 days, on how many days did you smoke cigarettes?" These data were combined through the use of a cohort sequential design to map developmental pathways of smoking from 11 to 26 years of age. Age was included as the only covariate in all models.

Overall, four distinct trajectories were identified in these analyses: (1) nonsmokers, (2) early establishers, (3) late establishers, and (4) quitters (Figure 3.1.4). Nonsmokers had no past-month cigarette use at any time point from adolescence through young adulthood; 48.3% fit this description. Early establishers had an early onset of smoking (ages of 12 or 13 years), which escalated quickly to daily use (smoking on all 30 days before the survey) by age 17 years and remained there throughout young adulthood; 14.5% could be characterized as early establishers. Late establishers had a later onset of smoking, at 15 or 16 years of age, escalating to intermittent use (smoking on no more than 20 of the 30 days before the survey) by the age of 21 years, peaking at 23 years of age, and then falling through the age of 26 years; 25.0% fit this description. Quitters had the earliest onset of smoking, before the age of 11 years, which escalated to less than daily use by 16 years of age then fell throughout the rest of adolescence and young adulthood to the lowest levels among those who reported smoking in the last 30 days; 12.0% of the sample could be characterized in this way. Nonsmokers could be identified by a linear model, early and late establishers with a quadratic model, and quitters by a cubic model.

Some of these trajectories varied by gender and race/ethnicity (Table 3.1.15). Boys, for example, were significantly more likely than girls to be late establishers (odds ratio [OR] = 1.87, 95% CI = 1.55–2.25). Boys and girls were equally likely, however, to belong to the early establisher group and to be quitters. Blacks were significantly less likely than Whites to be members of the late establisher, early establisher, or quitter groups (e.g., for late establishers, OR = 0.55, 95% CI = 0.42–0.72). Comparisons of Hispanics versus Whites yielded similar results (e.g., for late establishers, OR = 0.62, 95% CI = 0.45–0.85).

Levels of nicotine dependence in young adulthood (Wave III), as measured by a modified version of the Fagerström Tolerance Questionnaire (Payne et al. 1994), were highest for early establishers (scale score = 4.04), followed by late establishers (2.94), and then quitters (1.18) (Table 3.1.16). The differences in scale scores between all of these smoking trajectory groups were significant, according to the 95% confidence intervals. A scale score above 4.0 is typically used to identify adults who are dependent on nicotine (Breslau and Johnson 2000). The score on the Fagerström scale was significantly and positively correlated with being an early establisher and being a late establisher ($p < 0.05$), and it was significantly and negatively correlated with being a quitter and being a nonsmoker ($p < 0.05$).

These findings suggest that early—and sustained—intervention throughout adolescence is critical. This includes prevention and cessation initiatives. In Add Health, for example, those who became daily smokers in late adolescence (i.e., early establishers), started smoking before the age of 13 years, on average. Once they became daily smokers, at the age of 18 years, on average, they remained daily smokers throughout young adulthood (26 years of age). The escalation in smoking for early establishers occurred during early adolescence (i.e., as they transitioned from middle school to high school, then throughout high school), while the escalation in smoking for late establishers occurred in late adolescence (i.e., during the latter years of high school, to the transition into college, or to other pursuits of young adulthood). Efforts to prevent the onset of tobacco use and progression to regular use/established smoking, therefore, should begin early in adolescence (e.g., middle school) and be sustained over time (e.g., through young adulthood), to maximize their impact.

Transitions in Cigarette Smoking

The 1994 Surgeon General's report on preventing tobacco use among young people described the continuum of smoking behavior as one that has five stages: (1) preparation, (2) trying, (3) experimentation, (4) regular use, and (5) dependence (USDHHS 1994). To date, however, these stages are still based mostly on theory (Flay 1993), with limited empirical evidence to validate them. Not all young people advance through these stages, but those who become smokers as adults appear to experience similar steps in the onset and progression of cigarette smoking (Caraballo et al. 2009).

Several models of the stages of smoking onset and progression have been proposed; the model presented in the 1994 Surgeon General's report is based on the work of Flay and colleagues (1983). Adolescents begin to develop positive attitudes and beliefs about smoking in the preparation stage, although they have yet to try a single puff of a cigarette. That occurs in the second stage, trying, and can progress to experimentation, the third stage, depending on the physiological effects of initial attempts and social reinforcements. In this model, experimentation is defined by repeated, but irregular, use of cigarettes over an extended period of time. Young people advance to the fourth stage, regular use, when they begin to smoke more often—at least weekly across a variety of personal and social situations. The final stage, dependence, is defined by the physiological need for nicotine. Other models of the onset and progression of smoking include the stages of change (the Transtheoretical Model) (Prochaska and DiClemente 1983), which has been adapted for use with adolescents (Pallonen et al. 1998); and a model specific to susceptibility to smoking (Pierce et al. 1996). These two

models have been combined into a single model (Prokhorov et al. 2002) that further subdivides the preparation stage, above, according to one's susceptibility.

In this chapter, the stages of smoking onset and progression were identified using data from Add Health (UNC 2009). As with the presentation on trajectories (above), data for this analysis included data collected in Wave I (1994–1995, when students were 11–17 years of age) and Wave III (2001–2002, when they were 18–26 years of age), but not Wave II. The two groups of youth considered for the present analysis were those 12–14 years of age at Wave I and those 15–18 years of age at Wave I. These analyses, which included a latent class analysis (LCA) and latent transition analysis (LTA), used four measures: (1) "Have you ever tried cigarette smoking, even one or two puffs?" (2) "During the past 30 days, on how many days did you smoke cigarettes?" (3) "During the past 30 days, on the days you smoked, how many cigarettes did you smoke each day?" and (4) "During the past 6 months, have you tried to quit smoking cigarettes?" LCA and LTA, which are advanced statistical techniques useful in furthering the study of stage-sequential behavior, allow one to empirically identify stages of behavioral change (LCA) and examine movement through them sequentially (LTA) (Lanza et al. 2007).

Data for the younger cohort (12–14 years of age in Wave I) are provided in Tables 3.1.17 and 3.1.19. In this cohort, three statuses, or stages, of cigarette smoking/smokers were empirically identified in the analysis: (1) never smokers, (2) current smokers, and (3) former smokers (Table 3.1.17). Never smokers were those who reported never trying to smoke a cigarette, no cigarette smoking in the past 30 days, and no quit attempts in the last 6 months. Current smokers were those who reported having ever tried to smoke a cigarette and some cigarette smoking in the past 30 days. Some current smokers reported a quit attempt in the last 6 months, while others did not. Former smokers were most likely to report having ever tried a cigarette but reported no use in the last 30 days.

At Wave I (12–14 years of age), 84.8% of these adolescents were never smokers, 12.2% were current smokers, and 3.1% were former smokers. At Wave III (when they were 19–21 years of age), 53.4% of these young adults were never smokers, 38.3% were current smokers, and 8.3% were former smokers. Differences by gender were minimal in Wave I, but at Wave III, substantially more women (57.4%) than men (48.5%) were never smokers, and more men (44.1%) than women were current smokers (33.7%). At Wave I, more Blacks (95.2%) were never smokers than were White (86.2%), Hispanic (85.1%), and Other youth (80.3%). At Wave III, Blacks (76.8%) were also more often never smokers than were White (57.1%), Hispanic (51.9%), or Other youth (44.0%).

Table 3.1.18 presents the probabilities of transitioning from one stage to another time from Wave I (12–14 years of age) to Wave III (19–21 years of age). Estimates in the diagonals (noted in bold) represent stability, or the proportion of young people who stayed in the same stage over time. Estimates in the off-diagonals (noted in plain text) represent change, or the proportion of young people in one stage who moved to a different stage over time. Overall, for example, 63% of those who were never smokers at Wave I remained never smokers at Wave III, while 31% of them had become current smokers. Another 6%, in turn, were former smokers at Wave III, having become current smokers at some point between Wave I and Wave III. Of those who were current smokers at Wave I, 79% remained current smokers at Wave III, and 21% had become former smokers. Of those who had been former smokers at Wave I, only 20% remained in this category at Wave III, and the rest (80%) had become current smokers (again) by Wave III. Differences in transitions across time by gender and race/ethnicity are also presented in Table 3.1.18.

Data for the older cohort (15–18 years of age at Wave I) are provided in Tables 3.1.19 and 3.1.20. In this cohort, four classes, or stages, of smoking/smokers were empirically identified (1) never smokers, (2) former smokers, (3) nondaily smokers, and (4) daily smokers (Table 3.1.19). Never smokers were those who reported never trying to smoke a cigarette, no smoking in the past 30 days, and no quit attempts in the last 6 months. Former smokers reported having ever tried a cigarette but no smoking in the past 30 days. Nondaily smokers reported having ever tried to smoke a cigarette and smoking on 1–29 of the past 30 days. Some nondaily smokers reported a quit attempt in the last 6 months, while others did not. Daily smokers reported having ever tried to smoke a cigarette and smoking on all of the past 30 days. Some daily smokers reported a quit attempt in the last 6 months, but others did not.

At Wave I (15–18 years of age), 63.3% of these adolescents were never smokers; 5.5%, former smokers; 20.3%, nondaily smokers; and 11.0%, daily smokers. At Wave III (22–25 years of age), 48.9% of these adolescents were never smokers; 11.1%, former smokers; 16.7%, nondaily smokers; and 23.3%, daily smokers. Differences by gender were small at Wave I, but at Wave III, more women (53.6%) than men (44.0%) were never smokers, as more men than women fell into the nondaily and daily smoker categories at Wave III (e.g., nondaily smokers, 19.0% of men and 14.8% of women). At Wave I, more Blacks (82.4%) were never smokers than were Whites (70.0%), Hispanics (70.4%), or Other youth (50.9%). More Blacks (61.2%) were never smokers at Wave III, as well, than were Whites (53.8%), Hispanics (58.6%), or Other youth (36.4%).

Table 3.1.20 presents the probabilities of transitioning from one stage to another from Wave I (15–18 years

of age) to Wave III (22–25 years of age). As in Table 3.1.18, estimates in the diagonals (in bold) represent stability, or the proportion of young people who stayed in the same stage over time. Estimates in the off-diagonals (plain text) represent change, or the proportion of young people in one stage who moved to a different stage over time. Overall, for example, 77% of those who were never smokers at Wave I remained never smokers at Wave III; 10% of these earlier never smokers had become nondaily smokers by Wave III, and 8% had become daily smokers. Another 4% were former smokers at Wave III, having been current smokers at some point between Wave I and Wave III. Of those who were nondaily smokers at Wave I, 38% remained nondaily smokers at Wave III, while another 38% became daily smokers and 24% became former smokers. Of those who were daily smokers at Wave I, 82% remained daily smokers at Wave III, while 6% became nondaily smokers and 12% became former smokers. Of those who were former smokers at Wave I, only 37% remained in this category at Wave III, while 34% became nondaily smokers and 29% became daily smokers. Differences by gender and race/ethnicity are also shown in Table 3.1.20.

Measures of cigarette smoking related to early stages of use (e.g., preparation and/or susceptibility) were not available for this study as these measures were not used in Add Health. Having such measures would have allowed for empirical identification of these early stages in theoretical models designed to describe the onset and progression of smoking over time during adolescence. In using the measures available, however, the current analysis does depict the variability inherent in this process, reinforcing the concept of other "stages" of smoking reflected elsewhere in this chapter (e.g., current smoking, frequent smoking, and former smoking). The findings presented here again underscore the need for early intervention, prior to onset, if possible. In the younger cohort, for example, 79% of current smokers at Wave I remained current smokers at Wave III. In the older cohort, 38% of nondaily smokers at Wave I were nondaily smokers at Wave III, and 38% of them became daily smokers. Less than 25% of either of these groups (current smokers at Wave I in the younger cohort, nondaily smokers at Wave I in the older cohort) moved backwards to become former smokers by Wave III. Furthermore, in the older cohort, only 12% of the daily smokers had quit and become former smokers by Wave III.

Implications of Smoking During Adolescence for Young Adults

Some notable findings from MTF regarding young people's expectations to smoke, or to abstain from smoking, are presented in Tables 3.1.21–3.1.24, which use data from students originally surveyed in 1996–2001 as high school seniors. In their senior year, respondents were asked, "Do you think you will be smoking cigarettes five years from now?" In all, an estimated 1.4% of the seniors reported that they would definitely be smoking in 5 years, 11.4% probably would, 24.3% probably would not, and 62.9% definitely would not (Table 3.1.21). This distribution varied by the intensity of smoking. Almost all (98.2%) of those who were not smoking at the time reported that they would probably or definitely not be smoking in 5 years. Among those who were smoking one to five cigarettes per day as a high school senior, two-thirds (67.1%) said they would not be smoking ("probably not" or "definitely not") in 5 years. Just over one-half (53.3%) of the half-pack per day smokers said they would probably or definitely not be smoking in 5 years, and somewhat more than one-third (36.8%) of those smoking one or more packs per day said they would probably or definitely not be smoking at that point. As with any forecasts based on personal predictions, the percentages must be viewed cautiously but are still illustrative of intention.

This group of high school seniors was followed and then surveyed 5–6 years later in 2001–2007 (Table 3.1.22). Of students who were not smoking in their senior year, 86.1% were still not smoking 5–6 years later (Table 3.1.22), well below the predicted 98.2% for this group (probably or definitely not smoking in 5 years) (Table 3.1.21). Among those who were smoking one to five cigarettes a day as a senior, only 30.1% were not smoking 5–6 years later, less than one-half of the prediction of 67.1% for this group (again, "probably or definitely not") in 5 years (Table 3.1.21). As young adults, 21.3% of those who had smoked one to five cigarettes per day as seniors were still smoking one to five cigarettes per day, and 31.0% had begun to smoke a half-pack or more per day (Table 3.1.22). Among those who were smoking one-half pack of cigarettes as a senior, just 22.7% were not smoking 5–6 years later. This, again, was well below the prediction for this group (53.3% for probably or definitely not smoking in 5 years) (Table 3.1.21). In young adulthood, 26.5% were smoking at the same intensity level, and 25.1% had begun to smoke one pack or more each day (Table 3.1.22). Among those who were smoking one pack or more as a senior, only 15.2% were not smoking 5–6 years later (Table 3.1.22), far below the prediction of 36.8% for this group (Table 3.1.21). Almost one-half (48.3%) were still smoking one pack or more a day, and over one-third (36.6%) were still smoking cigarettes but less frequently. This change over time is also summarized in Table 3.1.23.

When earlier smoking behavior was controlled statistically in the analysis, seniors' expectations about quitting ("Will not smoke" in the table) had very limited power to predict their subsequent smoking behavior

(Table 3.1.24). For seniors who smoked one pack per day, for example, only 27.2% of those in the "Will not smoke" classification were not smoking 5–6 years later. The same phenomenon was true for those seniors who smoked one-half pack daily (only 13.3% were not smoking) and those smoking one to five cigarettes per day in high school (just 26.2% were not smoking). In fact, only slightly more than one-half (55.8%) of those who smoked less than one cigarette per day as a senior and were in the "Will not smoke" group were not smokers at follow-up.

Thus, the expectation to avoid smoking seemed to have some impact among those who were nonsmokers and very light smokers in high school, but very few seniors in these two groups had an expectation to smoke. However, among light, moderate, and heavy daily smokers, the expectation to abstain from smoking in the future was not realized in young adulthood. One key implication of these results is that young people should be made aware of the strongly addictive nature of nicotine and its ability to cast aside good expectations about the future. Clearly, prevention is a key goal, but encouraging tobacco cessation is also critically important for adolescents and young adults at all stages.

Nicotine Addiction in Adolescence and Young Adulthood

To date, our understanding of the pathways and processes of nicotine addiction among young people is limited, especially when compared to the findings from decades of research on nicotine addiction among adults (USDHHS 2010). Compared with adults, adolescents appear to display evidence of addiction at much lower levels of cigarette consumption (USDHHS 2010), and thus, attempts to quit smoking may be more difficult for young people. More information about nicotine dependence is provided in Chapter 2. This section presents data from NSDUH that is relevant to nicotine dependence among youth.

Understanding the patterns of addiction among current smokers can inform studies of its etiology and guide interventions to help young smokers quit. As discussed more fully in Chapter 2, indicators of dependence can appear early in the uptake process (CDC 1994; DiFranza et al. 2002, 2007; O'Loughlin et al. 2003). Tables 3.1.25–3.1.27 present data for three indicators of dependence for 12- to 17-year-olds (adolescents), 18- to 25-year-olds (young adults), and older smokers (26 years of age or older), respectively, using data from multiple NSDUH surveys (2007–2010). The first indicator, the percentage of smokers who smoke more than 15 cigarettes per day, is used because the number of cigarettes smoked per day predicts quitting, with heavier smoking associated with lower prevalence of cessation (USDHHS 1988; Hymowitz et al. 1997). The second indicator, the percentage of smokers who smoke their first cigarette within 30 minutes of awakening, is used because time to first cigarette also predicts quitting, with earlier smoking associated with fewer successful quit attempts (Hymowitz et al. 1997; West 2004; Baker et al. 2007). The third indicator is SAMHSA's adaptation of the Nicotine Dependence Syndrome Scale (NDSS) (Shiffman et al. 2004), which uses multiple items to assess dependence on nicotine (for further explanation of these items, see SAMHSA 2009b).

As shown in Tables 3.1.25–3.1.27, all three indicators varied significantly with age of first use ("first puffed" in tables) and age of first daily use, with younger age of first puffing and younger age of first daily smoking associated with increased likelihood of dependence (significance based on 95% confidence intervals). Among 12- to 17-year-olds (Table 3.1.25), the duration (in years) of transitioning from first cigarette use to first daily smoking was not significantly associated with smoking more than 15 cigarettes per day, time to first cigarette or NDSS score (significance based on 95% confidence intervals). For 18- to 25-year-old smokers (Table 3.1.26) and older smokers (Table 3.1.27), there was an inverse relationship between the duration of the transition from first use to first daily smoking and all three indicators of dependence, with a rapid transition from initial trial to daily smoking associated with a higher probability of dependence in later years. The relationship between current smoking behavior and nicotine dependence was strong as well. For the 12- to 17-year-old (Table 3.1.25) and 18- to 25-year-old smokers (Table 3.1.26), the average NDSS score and the percentage who had their first cigarette within 30 minutes of waking increased significantly as the frequency and heaviness of smoking increased. Dependence also varied as a function of use of alcohol, marijuana, or other illicit substances. For example, among 12- to 17-year-olds (Table 3.1.25), the three indicators of dependence were significantly more prevalent or higher among persons who had used alcohol or engaged in binge drinking on 11 or more of the previous 30 days compared to those who engaged in these behaviors on 1–10 of the previous 30 days (significance based on 95% confidence intervals). The same was observed for past month marijuana use (≥11 days vs. 1–10 days and ≥11 days vs. never used) and past month illicit drug use other than marijuana (used in past month vs. never used). Among 18- to 25-year-olds (Table 3.1.26), the prevalence or mean of all three indicators of dependence was significantly higher among persons who smoked marijuana on 11 or more days during the previous month compared to persons who had smoked marijuana on 1–10 days during the previous month or who had never used marijuana (significance based on 95% confidence intervals). In this

age group, dependence was also significantly more likely among persons who used any illicit substances other than marijuana during the previous month compared to never users. The situation with alcohol, however, was different. Two of the three indicators (first cigarette within 30 minutes and the NDSS) were especially high among persons who had previously used alcohol but had not done so during the previous month, while these two indicators were relatively low for the most frequent users of alcohol. For the other indicator (smoke >15 cigarettes per day), the prevalence was significantly higher for the most frequent alcohol users and binge drinkers when compared to the less frequent and never alcohol users and binge drinkers.

Summary

Initiation of cigarette smoking usually occurs during adolescence, although initiating cigarette smoking as a young adult is not uncommon. Among U.S. adults (30–39 years old) who have ever smoked daily, 88.2% did so as an adolescent (≤18 years old), while 10.8% tried their first cigarette in young adulthood (19–26 years old). Moreover, 65% began smoking daily in adolescence, while 31% began smoking daily as a young adult. There is heterogeneity in the developmental pathways that characterize the onset and progression of cigarette smoking during adolescence and young adulthood. For example, some young people begin smoking in early adolescence (12–13 years old), progress to daily smoking in late adolescence (17 years old), and stay daily smokers throughout young adulthood (18–26 years old), while others begin smoking later in adolescence (15–16 years old) and escalate to less than daily use in young adulthood (21 years old). Compared with adults, adolescents appear to display evidence of nicotine addiction at much lower levels of consumption, making quit attempts potentially more difficult for them (USDHHS 2010). Many young smokers have strong expectations of discontinuing use in the near future, but relatively few are able to do so.

Trends in Cigarette Smoking

This section describes trends in the prevalence and initiation of cigarette smoking among young people over time. Again, it relies primarily on data from MTF, YRBS, and NSDUH. Long-term trends in the prevalence of cigarette smoking among adolescents and young adults alike have been nonlinear during the last two decades, particularly since the publication in 1994 of the last Surgeon General's report focused on tobacco use among young people (USDHHS 1994; Nelson et al. 2008; CDC 2010a). In the early 1990s, the prevalence of cigarette smoking began increasing until it hit a peak in the late 1990s, at the time of the Master Settlement Agreement (1998), when it began to decline for both adolescents (Nelson et al. 2008; CDC 2010a) and young adults (Nelson et al. 2008). Since 2003, however, the decline in the prevalence of cigarette smoking among young people overall has slowed considerably, and may have stopped altogether for some subgroups. Between 2003 and 2009, for example, the prevalence of current cigarette use declined more slowly than it did between 1997 and 2003 among female and Black high school students, while it remained stable (i.e., did not decline at all) among male, White, and Hispanic high school students, overall (CDC 2010e). Data from NYTS show that there has been no change between 2000 and 2009 in the percentage of middle and high school students who are susceptible to initiate smoking (CDC 2010e). Those who are susceptible to begin smoking are defined as never smokers who report being willing to try smoking cigarettes. Trends in susceptibility are not discussed in detail in this section; however, cross-sectional data are presented earlier in the chapter. Further details on these more recent trends in cigarette smoking over time are provided below. To achieve the national health objectives outlined for 2020, further reductions in cigarette smoking are necessary and will require sustained support. The target referenced in *Healthy People 2020* for current smoking among adolescents (9th–12th grades) is 16% (USDHHS 2000); in 2009, YRBS indicated that 19.5% of these students were current smokers (Table 3.1.2).

Ever Smoking a Cigarette

Trends over time in the prevalence of ever smoking a cigarette are provided in Figures 3.1.5–3.1.7 using data from MTF (Figures 3.1.5 and 3.1.6A–C) and YRBS (Figures 3.1.6D and 3.1.7). These figures present trends by grade level, gender, and race/ethnicity.

Figure 3.1.5A presents data from MTF that are stratified by grade level (8th, 10th, and 12th grades) and gender. Among 12th-grade students, the prevalence of ever smoking decreased from 1977 to 1992 by an average of about 1% per year (0.9% boys; 1.0%, girls). Then, from 1992 to 1997, it increased by an average of 0.7 % per year (0.5%, boys; 0.8%, girls). From 1997 to 2010, it decreased again, but at a much higher average rate of about 2% per year (1.6%, boys; 2.0%, girls). In 1976, approximately three-quarters (75.6%, boys; 74.8%, girls) of 12th-grade students had ever smoked a cigarette, but by 1992, this figure had fallen to about five-eighths (63.5%, boys; 60.2%, girls). After increasing to 65.9% for boys and 64.4% for girls in 1997, the prevalence of ever smoking fell to less

was not influenced by whether the parents were smokers (Dick et al. 2007b).

Shared time with parents, another parental variable, may affect the expression of genetic risk on lifetime quantity smoked but in an unexpected direction. Among 14-year-olds, spending more time with parents was associated with 50% heritability for lifetime quantity smoked, but spending less time with parents was associated with almost no heritable effects (Dick et al. 2007a). The authors surmised that "spending more time with biologically related relatives may engender the expression of genetic predispositions" and that "for some children, spending time with parents may be beneficial, but for other children, it may not, depending on the behavior and predispositions of the parents" (Dick et al. 2007a, p. 323). Current smoking by parents also moderated the effects of genetic predispositions.

The school environment may also moderate genetic risk for smoking behavior in adolescents. Boardman and colleagues (2008) examined the effects of the social and demographic composition of 7th- to 12th-grade students (mother's education, student's race/ethnicity), school smoking norms (smoking status of popular students), institutional control of smoking (teachers not allowed to smoke on campus, penalties for smoking infractions), and the prevalence of student smoking, on the heritability of ever smoking (heritability estimate, 51%) and daily smoking (58%). They found no effects of these school characteristics on the heritability of ever smoking, but the heritability of daily smoking was significantly lower in schools with higher proportions of White (versus non-White) students and was significantly higher in schools in which the popular students were smokers.

A further layer of detail can be achieved by investigating the interaction between measured genetic and measured environmental factors. In a study of 9th- to 12th-grade students by Audrain-McGovern and colleagues (2006c), risk genotype was not related to smoking progression among those who had had at least one puff of a cigarette but was positively related to physical activity that, in turn, was negatively related to the progression of smoking. However, the relationships between risk genotype and physical activity and between physical activity and the progression of smoking were significant only in adolescents who participated in one or more team sports. Audrain-McGovern and associates (2006c) speculated that the type of physical activity or the social aspects of participation in team sports, or both, may be particularly rewarding in adolescents with risk genotypes, which would tend to decrease the rewarding value of cigarette smoking.

Peer influences, parental behaviors, school characteristics, and school-related activities, such as participation in team sports, are likely to be shared between twins and siblings and are, therefore, likely to be included in the overall estimate of shared environmental variance for smoking behavior unless their effects on genetic risk are explicitly tested. Considering the larger importance of shared environmental factors in the early stages of smoking behavior, it is important to understand the dynamics of measured and latent genetic risk and measured shared environmental factors on smoking behavior. Overall, the interactions of genetic and shared environmental factors are quite complex and call for continued research and careful analyses. More specifically, understanding how genes affect smoking behavior will necessitate identifying key specific factors or sets of factors in the adolescent environment that dynamically interact with genetic vulnerability to affect smoking or nonsmoking.

Neurotransmission and Brain Function in Tobacco Use

Overview of the Effects of Nicotine on the Brain

Upon inhalation of cigarette smoke, nicotine quickly crosses the blood-brain barrier and binds to nicotinic acetylcholine receptors (nAChRs) in the brain (Dani and Heinemann 1996). Activation of nAChRs stimulates the mesocorticolimbic dopamine system (a reward pathway) to produce the primary reinforcing effects of nicotine (Di Chiara 2000). Stimulation of dopamine neurons in the ventral tegmental area (VTA) by nicotine via high-affinity $\alpha4\beta2$ nAChRs (and by all drugs of abuse via specific receptor targets) causes increased firing in terminal dopaminergic fields, such as the nucleus accumbens, amygdala, and the prefrontal cortex (specifically the dorsolateral prefrontal cortex and orbitofrontal cortex). Activation of dopaminergic VTA neurons is also mediated by excitatory glutamatergic neurons projecting primarily from the prefrontal cortex (Taber et al. 1995), and presynaptic $\alpha7$ nAChRs located on glutamatergic projections enhance excitatory input (Mansvelder and McGehee 2000). The GABA interneurons in the VTA, which also express nAChRs and GABA-ergic projections from the nucleus accumbens to the VTA (Walaas and Fonnum 1980; Kalivas et al. 1993), mediate inhibitory and control processes of dopamine stimulation. Thus, the overall effect of nicotine in the VTA stems from the interactions of upstream and downstream effects (Mansvelder et al. 2003). Repeated exposure to nicotine in conjunction with environmental cues (Chaudhri et al. 2007) causes lasting changes in dopaminergic function that contribute to maintenance of smoking and the experience of withdrawal symptoms upon its cessation (Miyata and Yanagita 2001; Balfour 2002).

Studies by Fowler and colleagues (2008) and Salas and colleagues (2003) showed that withdrawal in mice after nicotine intake is linked to the medial habenula and α2 and α5 nicotine subunits. Mice lacking these receptors show a decrease in withdrawal symptoms. Also, mice lacking these receptors demonstrate increased intake of nicotine, possibly due to a difference in the inhibitory signals (i.e., diminished input) from the habenula in response to nicotine. Thus, some individuals (either through genetics or predisposition) may be more vulnerable to nicotine addiction.

Research Using Imaging in Children and Adolescents

Reward and cognitive control neural networks are implicated in the maintenance of addictive behaviors, including the use of nicotine (Kalivas and Volkow 2005; Brody 2006). Several studies have found that 9- to 19-year-old children and adolescents are at increased risk for smoking by virtue of a family history of drug use or personal history of psychiatric illness (e.g., attention-deficit hyperactivity disorder, conduct disorder). The same youth show blunted activation of the reward system (ventral striatum and frontal cortex) and relatively less activation in a distributed network of primarily frontal and cingulate cortex. They also show relatively less activation of temporal and parietal cortical regions that subserve decision making, performance monitoring, and cognitive control (Schweinsburg et al. 2004; Tamm et al. 2004; Sterzer et al. 2005; Scheres et al. 2007; McNamee et al. 2008; Rubia et al. 2008). Decreased activation may indicate deficits in impulse control coupled with dysregulation of reward sensitivity, which may help explain the etiology of psychiatric conditions.

Blunted activation of the brain to reward and challenges to cognitive control are observed in children who have not previously taken drugs. These conditions are also observed in adolescents at heightened risk for drug use relative to age-matched controls without psychopathology or a family history of drug use. This suggests that differences in reward and control processing may exist before exposure to drugs. These differences may contribute to comorbidity involving substance use and psychopathology and may explain why, in vulnerable persons, even a low level of exposure can tip the balance toward an addicted state (Gervais et al. 2006; DiFranza et al. 2007; Scragg et al. 2008).

Tobacco Dependence in Adolescence

Research demonstrates considerable variation in the length of time that youth report it takes to become addicted to using tobacco. The Hooked on Nicotine Checklist (HONC) was developed and validated specifically for assessing adolescents' dependence on tobacco; endorsement of any 1 of the 10 "yes/no" items indicates dependence (DiFranza et al. 2000, 2002):

- Have you ever tried to quit but couldn't?
- Do you smoke *now* because it is really hard to quit?
- Have you ever felt like you were addicted to tobacco?
- Do you ever have strong cravings to smoke?
- Have you ever felt like you really needed a cigarette?
- Is it hard to keep from smoking in places where you are not supposed to, like in school?
- When you tried to stop smoking (or when you have not used tobacco for a while):
  - Did you find it hard to concentrate because you couldn't smoke?
  - Did you feel more irritable because you could not smoke?
  - Did you feel a strong need or urge to smoke?
  - Did you feel nervous, restless, or anxious because you could not smoke?

In a study by DiFranza and colleagues (2007), approximately 10% of middle school adolescents endorsed one or more HONC symptoms within 2 days after having inhaled from a cigarette for the first time. In another study by Scragg and colleagues (2008), 25% of 14- and 15-year-olds endorsed at least one HONC symptom after having smoked just one cigarette in their lives.

Using longitudinal data, one study computed the length of time taken by 25% of a sample of 12- to 13-year-olds to transition from first cigarette puff to several milestones for cigarette use (Gervais et al. 2006). Reports of feeling "mentally addicted to smoking cigarettes" and smoking one entire cigarette were made 2 to 3 months after the first puff, cravings for cigarettes about 4 to 5 months later (than the first puff), and feeling "physically addicted to smoking cigarettes" about 5 to 6 months after the initial puff. Notably, these behaviors preceded monthly smoking, which was reported about 10 months after the first puff, and preceded having smoked 100 cigarettes, which was reached 20 months after the first puff.

These studies show that symptoms of tobacco dependence are seen in some adolescents well in advance of regular smoking. Thus, at least for a subgroup of adolescents, the conceptualization of a stagewise progression toward

tobacco dependence may not be appropriate because these youth are immediately or rapidly reinforced for initial smoking. In brief, these adolescents appear to transition rapidly from a tobacco-naive state to a tobacco-dependent state. Early-emerging symptoms of nicotine dependence during adolescence, however, have been found to be a poor prognostic indicator for chronicity of smoking in adulthood (Dierker and Mermelstein 2010).

Still, biological evidence is accumulating to suggest that the adolescent brain may be particularly susceptible to the addictive properties of nicotine (Chambers et al. 2003). Human and animal studies of the adolescent brain have demonstrated heightened neuronal sensitivity to nicotine and other constituents of cigarettes (Belluzzi et al. 2004, 2005; Cao et al. 2007). In addition, exposing the developing brain to nicotine has been shown to alter its structure and function in a way that introduces long-lasting vulnerability for addiction to nicotine and other substances of abuse (Leslie et al. 2004; Debry and Tiffany 2008; Dao et al. 2011).

Developmental Processes: Prenatal Exposure to Nicotine

More than 15% of pregnant women in the United States smoke (SAMHSA 2010) despite the significant perinatal and postnatal risks of this behavior to their offspring (Salihu and Wilson 2007). Of note is that more than 20% of pregnant adolescents 15–17 years of age smoke (SAMHSA 2010). Use of smokeless tobacco is common in Western Alaska Native pregnant women (58%), though less so over the entire state (17.8%), but still alarming rates in light of the prevalence in the general population of U.S. women of one-half of 1% (Renner et al. 2005; Kim et al. 2010). Use of smokeless tobacco is also prevalent (34%) among pregnant women in certain parts of India (Bloch et al. 2008). Nicotine (in tobacco smoke or in smokeless tobacco products) can have direct effects on nAChRs, which are already present in the brain and spinal cord of fetuses at 4 weeks of gestation (Hellström-Lindahl et al. 1998), suggesting that nAChRs play an important role in the development of the nervous system. Researchers performing animal studies (Slotkin 1998; Slikker et al. 2005) have surmised that prenatal exposure to nicotine affects neural development. Maternal smoking during pregnancy has been associated with increased risks for the offspring of ever smoking, regular (or current) smoking, and dependence on tobacco as preadolescents, adolescents, and young adults (Kandel et al. 1994; Kandel and Udry 1999; Cornelius et al. 2000; Buka et al. 2003; Al Mamun et al. 2006). However, some studies have not found such associations (Kandel et al. 1994; Silberg et al. 2003; Cornelius et al. 2005; Knopik et al. 2005; Roberts et al. 2005; O'Callaghan et al. 2006), and so there is need for further investigation.

Prenatal exposure to nicotine affects outcomes among offspring through established deleterious influences on fetal growth or as part of a maternal profile of substance use or comorbid psychopathology (Cornelius et al. 2011). This kind of prenatal exposure may also alter the sensitivity of the offspring to later environmental influences (Abreu-Villaça et al. 2004), which could predispose the offspring to a given behavioral trajectory. Thus, the environmental influences would become the salient proximal risk factors for behavior and might mask, in statistical analysis, the changes in sensitivity initially conferred by prenatal exposure to nicotine.

Summary

Future research should explore the influence of specific neural mechanisms at all stages of tobacco use and the relationships of such mechanisms with the underlying genetic architecture. Future work should also explore how the brain integrates information from large social and physical environments, small social groups, and cognitive factors to influence tobacco use behaviors in a measurable way.

At this time, research on neurobiological mechanisms that contributes to our knowledge of the etiology of tobacco use in humans lags significantly behind research on the other important influences on tobacco use summarized in this chapter. So far, the evidence from the literature on animals and adult humans indicates that nicotine activates brain reward pathways (Stein et al. 1998; Di Chiara 2000; Rose et al. 2003), the literature on adult humans indicates that smoking history is related to changes in the processing of reward and cognitive control (Anokhin et al. 2000; Martin-Sölch et al. 2001; Neuhaus et al. 2006; Musso et al. 2007), and the literature on adolescents indicates that the same changes in system responsiveness seen in adult smokers (vs. nonsmokers) are seen in tobacco-naive adolescents at risk for smoking (because of psychiatric history or familial substance use) relative to controls (Schweinsburg et al. 2004; Tamm et al. 2004; Sterzer et al. 2005; Scheres et al. 2007; McNamee et al. 2008; Rubia et al. 2008). These latter results suggest that differences in brain processing observed between adult smokers and nonsmokers may result from preexisting differences in brain processing between these groups. Some smokers' use of tobacco might be considered as part of a

general profile of psychopathology and high-risk behavior and may not be a direct effect of brain processing on tobacco use. Although evidence from neuroimaging is consistent in that observed group differences occur in the same direction as lower or higher neural activation and in overlapping brain regions, the evidence is inconclusive as to whether neural processing is related to or causes tobacco use specifically. The evidence that genes play an important role in tobacco use behaviors is increasing in the literature and consistent across samples, age groups, and age cohorts. However, the presence of genetic risk alone is not sufficient for the expression of a tobacco use behavior. Environmental factors can modify the expression of genetic risk, making it impossible to conclude that genetic variation causes a specific tobacco use behavior. Rather, genetic predisposition likely interacts in complex ways with a number of environmental factors across the large social and physical environments and among small social groups.

Evidence Summary

This chapter covered four general levels of predictors related to the etiology of tobacco use among youth. Risk factors at each of these levels are particularly potent for adolescents and young adults as they transition from childhood to adulthood. The changes in social expectations for these age groups, the further expansion of brain functioning, and the influence of peers provide a changing and challenging context with added vulnerability to tobacco use from 12 to 25 years of age.

Large Social and Physical Environments

Factors found in large social and physical environments may establish norms that affect tobacco use. For example, youth who participate in religious activity are less likely to smoke. The expression of other cultural values, such as using cigarettes as gifts, may, conversely, stimulate tobacco use. Educational attainment and academic achievement are consistently (and negatively) associated with tobacco use from early adolescence to young adulthood. In addition, persons of lower SES may be more likely to smoke because of differential norms or as a reaction to pressures, such as discrimination, or targeted marketing (see Chapter 5). Particularly in the developing world, women, who traditionally use tobacco products less often than men, have apparently been using tobacco more in recent years, perhaps as a reaction to increased marketing appeals directed at them. Physical environments favorable to tobacco use—as might be demonstrated by the availability of ashtrays or smoking areas or the presence of advertising displays—may also influence tobacco use through implicit norms that favor use.

Small Social Groups

Social influences are among the most robust and consistent predictors of adolescent smoking. Peer influences seem to be especially salient, perhaps because adolescence is a time during which school and peer group affiliations take on particular importance. Adolescents tend to overestimate the prevalence of smoking among their peers, and perceptions that one's peers smoke consistently predict use of tobacco. Another well-established finding is that adolescents are more likely to smoke if they have friends who smoke. Young smokers tend to affiliate with other young smokers, and both selection (of friends) and socialization (influences of friends) likely contribute to homogeneity in tobacco use among groups of friends. These processes that lead to homogeneity are not separate from, and are likely nested within, a similarity in factors in large social and physical environments, such as religion, social stratification, and ethnicity. In short, youth might be guided by those closest to them and by perceived social norms and then select and be influenced by peers to use or not use tobacco products.

Social network analyses have demonstrated that peer group structure uniquely contributes to the prediction of youth smoking behavior. Youth who are able to mix successfully within small social groups are relatively less likely to conform to the tobacco use behavior of others than are isolates, who perhaps have fewer social skills or experience a sense of being lower in social status within a group. The fact that popular youth are relatively more likely to smoke in schools that have relatively greater concentrations of smokers suggests that smoking behavior among peer networks is also contingent on school-level norms and attempts to be liked by others in the group.

Other smoking transitions. In a study that looked at smoking transitions other than initiation or cessation, Tauras (2005) examined the impact of cigarette prices on such transitions among youth and young adults in the United States. This author examined the transition from nondaily to daily smoking and the transitions from light smoking intensity (defined as 1–5 cigarettes per day) and moderate smoking intensity (defined as 10 cigarettes per day on average) to higher intensities. Tauras (2005) employed baseline surveys from the 1976–1993 longitudinal component of MTF data along with follow-up surveys through 1995 in the analyses and controlled for antismoking sentiment with a variety of techniques. These included having separate indicators for whether the individual resided in a tobacco-producing state or resided in Utah, using U.S. Census Bureau division fixed effects to capture differences between these divisions in smoking sentiment, and estimating the smoking progression equations on a subsample of the respondents who did not reside in either a tobacco-producing state or in Utah during the time the survey was conducted. Cigarette prices were found to have a strong negative impact on all of the estimated smoking transitions. In particular, the estimated mean price elasticities of daily uptake, moderate uptake, and heavy uptake were -0.646, -0.576, and -0.412, respectively. These results indicate that a 10% increase in cigarette prices will decrease daily uptake, moderate uptake, and heavy uptake by an estimated 6.46%, 5.76%, and 4.12%, respectively. These findings clearly indicate that increases in cigarette prices will prevent many young adults from progressing into higher intensities of smoking.

Other tobacco products. Numerous studies on the economic determinants of demand for cigarettes among youth have been published during the past decade, but very few recent econometric studies have been published on the impact of taxes on other tobacco products.

In one such study, Tauras and colleagues (2007) used data extracted from the 1995–2001 national YRBSs to examine the impact of taxes on smokeless tobacco on use of this product among male high school students. The estimates developed clearly indicate that higher taxes on smokeless tobacco would significantly reduce the number of male students who use this product and the number of days they would use it. The estimated tax elasticities of the prevalence of smokeless tobacco ranged from -0.197 to -0.121, and the estimated tax elasticities of days using smokeless tobacco ranged from -0.085 to -0.044. The study also found that cigarette prices had a significant negative impact on both the prevalence of smokeless tobacco and the number of days that male high school students used smokeless tobacco. The estimated cross-price elasticity of the prevalence of smokeless tobacco was -0.715, and the cross-price elasticity of the number of days of use of smokeless tobacco was -0.413. These estimates indicate that a 10% increase in the price of cigarettes would decrease the prevalence of smokeless tobacco by an estimated 7% and would lower the number of days using smokeless tobacco by an estimated 4% among male high school students. Thus, the estimates indicate that smokeless tobacco products and cigarettes are economic complements in consumption for young males. These findings are particularly important in light of the fact that the cigarette companies have purchased smokeless tobacco companies and are now actively promoting dual use of cigarettes and smokeless tobacco with the same branding (e.g., Marlboro Snus and Camel Snus) (Mejia et al. 2010). (More data on the use of multiple tobacco products by young males can be found in Chapter 3.)

Finally, Ringel and colleagues (2005) used data from the 1999 and 2000 waves of the National Youth Tobacco Survey to estimate the impact of cigar prices on demand for cigars among adolescents in grades 6–12. After controlling for laws on smoke-free air and on youth access, the researchers found the price of cigars to be inversely related to the prevalence of cigar use among youth. Specifically, the price elasticity of the prevalence of cigar smoking among youth was estimated to be -0.34.

Tax Avoidance

A preponderance of the aforementioned studies on the effects of price on the demand for tobacco products among adolescents used individual-level survey data and state-level price data. Aside from the problem of intrastate variation in prices, using average prices within a state does not account for an individual's opportunities to avoid taxes. For example, some individuals living near American Indian reservations or close to the border of a state with lower taxes on cigarettes will be able to pay less than the average price for cigarettes in their own state. Thus, when using individual-level data, this type of measurement error in the independent variable (i.e., price) will likely result in an underestimate of the true price elasticity of demand. There will be an underestimate of the response to price because some smokers will maintain their consumption after a tax increase by turning to cheaper (tax-avoided) cigarettes, making it look as though the tax increase had little or no impact on their consumption. Future studies on demand that account for a person's opportunities for tax avoidance are warranted.

Summary Regarding Taxation and Pricing

A few general conclusions can be drawn from recent studies on the effects of taxes and prices on tobacco consumption among youth and young adults:

Tobacco customer base depends on getting youth and young adults addicted => low taxes crucial then.

1. Most of the research over the past decade has concluded that increases in cigarette prices lead to reductions in the prevalence of smoking and its intensity among youth and young adults.

2. A majority of the existing research suggests that the effects of price on smoking prevalence involve both a decrease in initiation of smoking among youth and an increase in cessation among young adults.

3. Most of the recent research has concluded that adolescents and young adults are more responsive than adults to changes in cigarette prices.

4. Limited evidence suggests that higher cigarette prices will prevent young adults from progressing into higher intensities of smoking.

5. A few recent studies have found an inverse relationship among adolescents between product-specific tobacco taxes (or prices) and the propensity to use smokeless tobacco, the intensity of its use, and the prevalence of cigar smoking.

6. The magnitude of the impact of taxes (or prices) on the demand for cigarettes seems to depend on how the model controls for antismoking sentiment.

Future research that uses a large number of waves of longitudinal data on adolescents and young adults during a period of significant changes in tobacco taxes and prices should be helpful in obtaining the most precise estimates for the impact of price on the intensity, prevalence, initiation, and cessation of smoking, smokeless tobacco use, and on other tobacco use transitions.

Policies on Clean Indoor Air

Policies on clean indoor air take the form of legislation and/or regulations at the federal, state, local, and institutional levels that prohibit smoking in specified locations, such as workplaces, public places, restaurants, bars and casinos, schools, day care centers, and health care facilities (USDHHS 1989, 2000b). Although there have been laws on clean indoor air for more than 30 years, their coverage has expanded dramatically in recent years. As of July 1, 2011, 23 states, the District of Columbia, and Puerto Rico have laws that prohibit smoking in all workplaces, including bars and restaurants (American Nonsmokers' Rights Foundation 2011b). The movement for laws on clean indoor air largely began at the local level, and many of the states without comprehensive laws have cities or counties with such laws. The American Nonsmokers' Rights Foundation estimated that as of July 1, 2011, comprehensive local and/or state laws on clean indoor air covered 48.0% of the U.S. population (American Nonsmokers' Rights Foundation 2011a). Figure 6.3 provides a map of the implementation of these laws, (American Nonsmokers' Rights Foundation [2011a]).

Many locations are smoke-free, because of their potential effects on youth. According to the CDC School Health Policies and Programs Study from 2006, in that year 70% of states as well as 95% of school districts included in a nationally representative sample prohibited smoking by students in school buildings, grounds, vehicles, and off-campus school-sponsored events (Jones et al. 2007). However, only 47% of the states but 78% of the school districts had smoke-free schools in which the same restrictions applied to staff (Jones et al. 2007). At least 466 U.S. colleges and universities are completely smoke-free, which includes having 100% smoke-free residential housing policies (American Nonsmokers' Rights Foundation 2011d). On the basis of data from the Tobacco Use Supplement of the Current Population Survey (CDC 2008c), CDC reported that in 2007 the median proportion (by state) of households with smoke-free policies for everyone living in or entering the home was 66%. Finally, smoking has been prohibited in vehicles when children are present in nine U.S. cities or counties, four states, Puerto Rico, eight Canadian provinces/territories, and five Australian states (Blumenfeld 2008; Global Advisors Smokefree Policy 2011).

To this point, little evidence is available about sociodemographic disparities in the coverage of smoke-free policies in public and private locations. In one study, Skeer and coworkers (2004) examined differences in community characteristics in relation to the strength of their local policies on clean indoor air in public places; they found that towns with higher education levels and greater per capita income were more likely to have the most restrictive policies. A recent CDC report using 1999–2004 National Health and Nutrition Examination Survey (NHANES) data found that youth were three to four times as likely as adults to be exposed to secondhand smoke in the home (CDC 2008a). In this study, Black non-Hispanic persons were the most likely and Mexican Americans the least likely to be exposed to secondhand smoke at home, and low-income families were three times as likely to be exposed as their counterparts in the highest income group.

The primary purpose of laws and policies on clean indoor air is to protect smokers and nonsmokers alike from exposure to the toxic effects of secondhand smoke. However, a growing body of evidence suggests that these policies may have the additional benefit of producing lower