Published in final edited form as:

Curr Addict Rep. 2018 September ; 5(3): 386–395. doi:10.1007/s40429-018-0220-0.

The crossover effect: A review of racial/ethnic variations in risk for substance use and substance use disorder across development

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Abstract

Purpose of Review—The "crossover" effect, a phenomenon by which some minority groups switch from low to high risk for substance use as a function of age, was first documented 25 years ago. However, rigorous methodological research examining the crossover effect has only recently emerged. The current paper reviews the past 25 years of research on the crossover effect, which has primarily examined the shift from low to high substance use risk among Blacks relative to Whites.

Recent Findings—Although findings regarding the crossover effect vary based on gender, socioeconomic status, and substance, Blacks and Hispanics appear to be at lower risk for some substance use— particularly binge drinking and cigarette smoking—than Whites during adolescence and early adulthood, but at higher risk for use in later life. Research regarding the crossover effect of substance use disorder and related problems is limited but more consistent with a similar pattern of effects observed.

Summary—Due to significant limitations of the extant literature examining the crossover effect, it requires additional research clarifying sociodemographic differences in the, identifying its mechanisms, and determining its clinical implications. Such research may have important implications for preventing racial/ethnic disparities in the consequences associated with disordered substance use.

Keywords

Ethnic minorities; racial minorities; substance use; substance use disorder

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Compliance with Ethics Guidelines

Conflict of Interest: Devin Banks and Tamika Zapolski declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent: This article does not contain any studies with human or animal subjects performed by any of the authors.

Introduction

National data has long demonstrated that racial and ethnic minorities in the U.S. demonstrate lower rates of substance use than their White counterparts, an effect largely driven by the higher prevalence of alcohol use among White youth and adults [1]. Despite demonstrating lower rates of alcohol use and similar rates of tobacco and illicit drug use relative to Whites [1], racial and ethnic minorities appear to suffer greater consequences of substance use, including higher rates of transition from substance use to substance use disorder (SUD) [2, 3]. In efforts to explain this paradoxical finding, researchers have examined racial/ethnic variations in substance use across development and identified a "crossover" effect, by which some minority groups switch from low to high risk for substance use as a function of age. The current paper reviews the literature on the racial/ethnic crossover effect of substance use and SUDs, identifies gaps in this literature, and proposes directions for future research to clarify racial/ethnic health disparities in substance use outcomes across development.

The Discovery of the Crossover Effect

The crossover effect was first described by Geronimus et al. [4] in a study comparing rates of current cigarette smoking among Black and White women of childbearing age (i.e., 18–44) in the U.S. The authors found that although White women began smoking cigarettes at an earlier age than Black women, they were more likely to quit at a younger age and quit at all relative to Black women. Due to the quit rates of White women, Geronimus et al. [4] documented not only that rates of current smoking among the two groups converged by age 25, but that rates of Black women crossed over to be higher than those of White women by age 30. Subsequent work replicated this effect, finding that Black women and men were less likely than their White counterparts to smoke cigarettes during adolescence, but more likely than Whites to smoke at ages 25–44 for women and ages 18–24 for men [5]. Despite this initial evidence of the crossover effect for smoking, Geronimus et al.'s [4] finding was not documented again until over a decade later. Since that time, researchers have demonstrated evidence of a crossover effect for various substances, including alcohol [6] marijuana [7, 8], and cocaine [9] (see Table 1).

Theories of the Smoking Crossover Effect

As noted above, the first substance in which the crossover effect was discovered was with cigarette use [4]. Although the crossover effect for cigarette smoking did not receive much attention for over a decade, several studies documented delays in the onset of cigarette smoking among Blacks relative to Whites [10–12]. Thus, researchers began to posit theories that may explain racial disparities in initiation and quitting. Pampel [13] first suggested that racial differences in smoking initiation and cessation among Blacks may be related to increased protective factors during adolescence (i.e., religiosity and parental disapproval) and decreased access to resources that help facilitate cessation (i.e., financial, educational, and social) once individuals start smoking. Pampel [13] was able to provide some support for the latter explanation by examining the crossover effect between and within cohorts. He found that although Blacks exhibited lower rates of smoking relative to Whites during adolescence, they converged among the groups by age 34, an effect that was explained by greater cessation among Whites than Blacks during young adulthood. Thus, he concluded

that a lack of resources for cessation among Black young adults most likely explained the crossover effect.

Subsequent research on the crossover effect of smoking among Blacks highlighted other social factors that may prevent cessation such as less conventional social roles among Blacks relative to Whites. For example, in a test of socialization theory, Kandel et al. [14] found that the crossover for cigarette smoking at age 29 was partially explained by decreased education and marriage rates among Blacks relative to Whites in multiple birth cohorts. Thus, the authors concluded that because Blacks have less conventional occupational and interpersonal social roles during early adulthood, continued cigarette use is more compatible for them relative to Whites [8, 14]. However, the authors also found another factor that helped explain the crossover effect: later smoking initiation was related to more persistence of smoking in Blacks, whereas the opposite effect was found among Whites [8, 14]. Thus, the delay in smoking initiation among Blacks may account for lower prevalence and risk noted during adolescence and young adulthood; however, this delay appears to increase risk for persistence in use during adulthood, accounting for higher risk relative to Whites during this developmental period. This finding suggests process differences in the influence of risk and protective factors between Blacks and Whites that could not be attributed to resource or socialization explanations.

The Crossover Effect for Illicit Drug and Alcohol Use

Evidence for a crossover effect of substances other than nicotine was first documented by Ma and Shive [7], who found that the national prevalence of past-year marijuana and cocaine use was higher among Whites than Blacks at ages 12–25, but higher among Blacks than Whites after age 25. A subsequent report by the Substance Abuse and Mental Health Services Administration (SAMHSA) documented similar findings with rates of lifetime cocaine use; among Black adolescents, rates were lower than those of Whites, but they converged with those of Whites by early adulthood and crossed over by age 35 [9]. Findings from national datasets have also confirmed an age crossover for other substances, although results have varied based on the type of substance examined, whether a composite variable was used, and developmental period. For example, Kandel et al. [8] found no crossover of lifetime substance use for Blacks; however, when examining the effect only among lifetime users, they found a crossover for current marijuana and cigarette use from ages 26–49. When examining past-year use, Ensminger et al. [15] found a similar crossover for Black in early adulthood (i.e., ages 30–34) of heroin and cocaine use, but not alcohol use. Conversely, when examining a larger developmental range, Vogt Yuan [6] found a crossover of past-year alcohol use at age 50, but no crossover for past-year composite illicit drug use. Others have found variations in the crossover not only as a function of age and substance, but also gender. For example, Watt [16] found a crossover for past-month illicit drug use among Black men and binge drinking among Black women age 35 and over; however, for rates of illicit drug use among women and binge drinking among men, the author merely found a convergence of Blacks with Whites.

The crossover effect has also been extended beyond rates of substance use to SUD and related problems. Although Vogt Yuan [6] found no crossover for rates of illicit drug use,

they found a crossover for rates of both drug abuse and alcohol abuse at ages 38 and 48, respectively. This finding was recently corroborated in a study using national data from 2011–2012, which demonstrated a crossover in alcohol use disorder for Blacks at ages 59–68, tobacco use disorder after age 64, and opioid use disorder at ages 56–78 [17]. Theories of decreased aging out among Blacks may not explain this crossover in rates of SUD. For example, among lifetime drinkers, Muthen and Muthen [18] found no crossover for heavy drinking frequency, but did find one for alcohol-related problems. Taken with Vogt Yuan's [6] differential findings between drug *use* and drug *abuse*, these data suggested that Blacks are more likely to experience problems from substance use in later adulthood despite consuming alcohol at similar frequencies to those of their White counterparts. However, recent research also suggests that the crossover in alcohol-and drug-related problems may be related to a crossover of heavy substance use during later adulthood by Blacks [19] (see "Emerging Focus on Heavy Drinking" section). Thus, research is needed that examines differences in potential crossover effects based on frequency and quantity of use, as well as problems from use across development.

Theories of the Crossover Effect for Illicit Drug and Alcohol Use

Like the crossover effect for cigarette smoking, theories have emerged to explain the crossover effect for illicit drug use and alcohol among Blacks. Watt [16] suggested that racialized social systems in the U.S. have created adverse conditions for Blacks that contribute to *compositional* and *process* differences in their risk for substance use across the lifespan relative to Whites. Compositional differences are those racial differences in risk and protective factors for substance use during adolescence and young adulthood that may contribute to the crossover effect. For example, Blacks have higher parental monitoring and sanctioning of alcohol use during adolescence relative to their White peers, which contributes to decreased use during this period [20]; however, Whites have higher rates of marriage during adulthood relative to Blacks, which contributes to their decreased use during this period [14]. Another important compositional difference related to substance use is the stress posed by racial discrimination, which is associated with increased substance use over time among Blacks [21]. Researchers have proposed that compositional differences that are protective for Blacks (e.g., more parental monitoring and less permissive cultural norms toward substance use) may dissipate in the transition to adulthood whereas those that negatively affect Blacks (e.g., decreased involvement in social roles; perceived racial discrimination) may increase during this developmental period.

Support for compositional theories in explaining the crossover effect of alcohol and drug use among Blacks primarily supports the roles of racial disparities in SES and social support. For example, Watt [16] found that low SES, high religiosity, and poor social support explained the crossover effect of binge drinking and drug use among Black women and men, respectively. Social role involvement and quality may be particularly important factors contributing to the crossover effect. For example, Vogt Yuan [6] found that although racial disparities in SES (i.e., income and work status) that negatively affected Blacks helped explain the crossover effect of alcohol and drug abuse among this group, fewer family roles and poor relationship quality were more important predictors, eliminating the crossover effect after adjusting for SES. Similarly, Ensminger et al. [15] demonstrated that decreased

participation in social roles such as education, employment, marriage, and parental status may explain the crossover effect of cocaine use for Blacks. The authors also suggested that participation in social roles may also explain within-group differences in the crossover effect among Blacks.

Rather than racial differences in the presence of a risk or protective factor, process differences refer to differential effects of risk and protective factors as a function of race. For example, researchers have found that adult alcohol use is predicted by coping motives for alcohol use among Blacks during adolescence, but enhancement motives among Whites during adolescence [22]. Regarding the crossover effect for Blacks, research has shown that there may be process differences where there are also compositional differences. For example, although SES has been found to explain the crossover effect among Blacks, there are also process differences in its effect on Blacks and Whites. For example, poverty has been found to be a greater deterrent for substance use for Black adolescents than White adolescents, with the opposite trend in adulthood [16]. Similarly, there are compositional differences and process differences in substance availability and exposure that may help explain the crossover effect. Compositionally, Watt [16] found no racial differences in drug exposure during adolescence, but greater exposure among Blacks during adulthood. Regarding process, the author also found that relative to Whites, drug exposure was a less influential risk factor for Blacks during adolescence, but a more salient risk factor for Blacks during adulthood. Thus, the crossover effect is explained not only by greater protective factors during adolescence and greater risk factors during adulthood among Blacks relative to Whites, but also by a process in which protective factors during adolescence become risk factors during adulthood for some Blacks. Researchers have begun to examine how certain protective factors against substance use can also serve as risk factors for negative consequences of use among Blacks (e.g., conservative norms toward substance use, genetic vulnerability towards the effects of substances) [20]. However, more research is needed to confirm the mechanisms of this protection-to-risk process and whether it explains the crossover effect of alcohol and drug use among this group.

The Crossover Effect in Longitudinal Data

By the early 2010s, previous studies had primarily used several years of data from nationally-representative surveys to mitigate cohort effects, but few studies had yet examined the crossover effect using longitudinal data. This became possible with the emergence of the National Longitudinal Study of Adolescent Health (Add Health), which followed a nationally-representative sample of U.S. adolescents from 1994–2008. Chen and Jacobsen [23] were the first to document the crossover effect of alcohol and drug use among a nationally-representative sample, finding that Whites demonstrated steeper increases in frequency of substance use (alcohol use, binge drinking, smoking, and marijuana use) during adolescence and maintained higher levels of use than Blacks, Hispanics and Asians throughout the 3rd decade of life. However, in the early 30s, rates of substance use between Whites and racial/ethnic minorities converged due to gradual increases in substance use among racial/ethnic minorities and aging out among Whites [23], consistent with previous research [6]. However, there was an exception to this convergence effect: rather than converging with Whites in the early 30s, Blacks crossed-over Whites for marijuana use and

smoking during this time [23], demonstrating the first longitudinal evidence of the crossover effect.

Subsequent studies of Add Health data provided more mixed evidence for the crossover effect. For example, one study found a convergence effect, rather than a crossover effect in the early 30s for Blacks and Hispanics [24] whereas another found evidence for the crossover effect, but only as a function of gender and substance. Specifically, Keyes et al. [25] found no crossover for alcohol or cigarette use among Blacks, but found a crossover for marijuana use among Black women only [25]. Thus, these studies of Add Health data demonstrated consistent convergence effects but inconsistent crossover effects using longitudinal methods. Taken with previous evidence that the crossover effect may occur in later in life, this and similar data may be limited for examining this effect as it captures individuals only until their early-to-mid 30s.

Emerging Focus on Heavy Drinking

In response to data suggesting disparities in alcohol use disorder and related morbidity among Blacks in the U.S. [20, 26, 27] the most recent studies examining the crossover effect have focused on the crossover of binge or heavy drinking frequency (typically defined in national surveys as frequency of consuming either 5 or 6 or more drinks on one occasion in the past 30 days). Similar to previous research on the crossover effect, the findings of these studies vary based on developmental period and sociodemographic characteristics. For example, when stratifying by gender, the crossover for frequency of heavy drinking has been found for Hispanic men and Black women in the fourth decade [28, 29]. Conversely, a study stratifying by income found a crossover for likelihood of heavy drinking among only those Blacks earning less than $20,000 per year [19]. Finally, a study stratifying by generation (those born in 1962 versus those born in 1980) found a crossover for Blacks for heavy drinking among the older cohort by the early 30s, but only a convergence among the younger generation by that age [28].

Further complicating these mixed findings are that little research has attempted to explain these race, gender, income, and generational differences in the crossover effect of heavy drinking, and those that have tried have had difficulty doing so. For example, Mulia et al. [30] found that socioeconomic disadvantage across the lifespan explained the crossover trajectory of heavy drinking for Black women, but not Hispanic men, suggesting that differential influences contribute to the persistence of heavy drinking in these groups relative to their White counterparts. Thus, more research is needed to help clarify sociodemographic differences in the crossover effect for heavy drinking and culturally specific mechanisms that might explain this effect.

Is There a Hispanic Crossover Effect?

Most studies reviewed here have examined the crossover effect among Blacks relative to Whites and have excluded Hispanics. Among those that have included Hispanics, few have examined the crossover effect beyond young adulthood. The SAMHSA report discussed previously was also the first to examine the crossover effect among Hispanics, but unexpectedly, they found an opposite effect. That is, Hispanics demonstrated the highest

rates of illicit drug use of any racial/ethnic group during adolescence, but the lowest rates by age 35 [9]. Subsequent research replicated this opposite crossover effect of illicit drug use and heavy drinking for Hispanics [23, 24], leading researchers to conclude that disparities associated with the crossover do not apply to Hispanics [16]. For alcohol use, research suggests that this may be due in part to process differences in the relationship between SES and alcohol outcomes that favor Hispanic Americans. That is, although low SES is a risk factor for alcohol problems among other racial/ethnic groups, it has been found unrelated to problems among Hispanics [31, 32]. However, for cigarette smoking, researchers have observed a different pattern: Hispanics tend to demonstrate lower rates relative to Whites during adolescence and converge with them in young adulthood [23, 24]. To date, no study extending past the early 30s has examined whether a crossover effect exists for cigarette smoking among Hispanics.

There is also recent evidence for a crossover effect of heavy drinking and some SUD among Hispanics. Hispanics have been found to crossover the heavy drinking of Whites throughout the fourth decade of life [28, 29]. However, this research is nascent and has already been contradicted by others who have recently found no crossover for heavy drinking among Hispanics [19]. Mixed results may reflect a lack of data on nationality in national household surveys, as the prevalence of substance use [33] and SUD vary widely between subgroups of Hispanics [34]. Regarding SUDs, a study using nationally representative survey data from 20122013 found a Hispanic crossover for opioid use disorder from ages 53–66 [17]. Given disparities in substance-related problems that disproportionately affect Hispanics relative to Whites [27], more research examining the potential crossover effect in Hispanics throughout the lifespan is needed, particularly for alcohol and opiate use.

Potential Methodological Limitations

As the crossover effect of race/ethnicity describes a population-based trend unique to the U.S., studies examining the crossover effect have exclusively used nationally-representative or state-representative surveys of the general population. Although this is the only technique that can confirm whether the crossover effect is generalizable to the population at large, there are several limitations of this approach. Firstly, researchers are limited to examining the variables provided in the dataset, which can limit the detail with which they can probe the effect. National household surveys vary in their measurements and definitions of substance use, related problems, and abuse. For example, the National Survey on Drug Use and Health (NSDUH) has defined heavy drinking as consumption of five or more drinks on one occasion for five or more occasions within a month [16] whereas the National Longitudinal Survey of Youth (NLSY) has defined it as six or more drinks on just *one* occasion in the 30 days prior to their interview [18, 29]. Similarly, some studies reviewed here used data that included questions based on DSM-IV diagnostic criteria for substance abuse and dependence (e.g., NSDUH and NLSY) whereas others used DSM-5 criteria for SUD (e.g. National Epidemiological Survey of Alcohol and Related Conditions-III) [17]. National surveys also vary in their measurements of age, with some providing only categorical measurements (e.g., NSDUH) rather than assessments at each age (e.g., Add Health). These varying survey characteristics may limit understanding of substance use patterns throughout the life course and preclude researchers from determining the specific

age at which the crossover effect occurs. They also may preclude researchers from examining mechanisms of the crossover effect (e.g., religiosity is not included in several national surveys).

Second, national surveys are limited in their utility in studying the crossover effect as these surveys sample from households, thus excluding people who are institutionalized (e.g., imprisoned or hospitalized) or homeless. This is an important limitation for examining the crossover effect for two reasons. First, incarcerated and homeless individuals have disproportionately high rates of substance use and SUD relative to the household population [35, 36]. Second, incarcerated and homeless individuals are disproportionately members of racial/ethnic minority groups, particularly Blacks [37]. It is estimated that 90% of incarcerated people will return to low income and poor communities [38]. Thus, the impact of incarceration on substance use in adulthood may be exacerbated among Blacks and help contribute to the crossover effect. However, the data from national household studies prevents proper examination this potential effect.

Third, the use of data from similar or equivalent nationally-representative surveys by various researchers may also bias the crossover effect toward replication. For example, two studies of heavy drinking reported previously found identical results for the crossover effect as they both used data from the 1979 NLSY [28, 29]. Although some studies examining the crossover effect have found similar results across national surveys [9], others have found inconsistent evidence for the crossover effect when comparing various national data sources [39]. Thus, there may be a publication bias favoring the crossover effect from those data sources that confirm it.

Fourth, there are limitations in the method of data collection. Despite the utility of examining the crossover effect based on longitudinal surveys, the replication bias may be particularly salient among these surveys as they report on one cohort of individuals at a specific developmental period in a specific time. Conversely, the cohorts of annual surveys may change over time as various individuals are sampled from the population and may reflect how the social climate influences individuals in various stages of development. However, the cross-sectional, annual surveys are not without limitations. As these surveys are cross-sectional, the contribution of cohort effects to the crossover cannot be ruled out. Although the crossover has been found to persist even when accounting for cohort differences [13], recent longitudinal data suggests that the crossover effect has varied over time by cohort [28].

Directions for Future Research

The current review revealed several opportunities for clarification in the crossover effect. Firstly, there is evidence that the crossover effect varies by gender, particularly for heavy drinking, but replicated results often rely on the same data. More research is needed to clarify gender differences in the crossover effect. Such research should take care to stratify by specific substance use indicators, as they have likely contributed to mixed results in the current literature. If possible, studies attempting to clarify differences in the crossover effect by sociodemographic factors should also extend into later life as those studies that have found an effect in one gender but not another have often only extended through young

adulthood or mid-life (30s-40s), finding a racial convergence by that time regardless of gender [16, 28, 29].

Secondly, the crossover effect has primarily been examined among Blacks. Although there is emerging evidence regarding a crossover among Hispanics, research has been mixed and requires clarification. Future research should examine whether the crossover effect varies by nationality and acculturation among Hispanic adolescents as substance use has been shown to vary within Hispanics based on these factors [26, 33, 40]. Research on the crossover effect has also largely excluded American Indians and Asian Americans. The former group is excluded due to the use of national surveys: given the low population rates of American Indians, it is difficult to compare them to Whites. The latter group is excluded as they exhibit low rates of substance use throughout the lifespan relative to Whites, Hispanics, and Blacks. However, there is some evidence of a convergence of Asians with the other groups in early adulthood [11, 23]. Thus, future research should consider examining the crossover effect in state- or regionally-representative studies with larger populations of American Indians and Asians.

Thirdly, although the crossover effect has been documented extensively, mechanisms that may explain the effect have been studied infrequently. The current literature demonstrates that racial differences in indicators of SES, including work and education, and social roles contribute to the crossover effect, but do not explain it. In fact, controlling for factors related to disadvantage only delays the crossover, but does not eliminate it [14]. This indicates that more research is needed to identify mechanisms that help explain the crossover effect. Extensive research has examined process and compositional racial/ethnic differences in risk and protective factors for substance use [20, 41]. Thus, future research should examine known mechanisms explaining racial/ethnic disparities in substance use outcomes at specific developmental periods to better understand which of these contribute to disparities over time. In particular, such research should focus on explaining the crossover effect for SUD and related problems. As the crossover for SUDs occur later in life than the crossovers in current and lifetime substance use, researchers should note that this effect may reflect racial differences in risk factors for progression to SUD, rather than those for heavy substance use.

Finally, the current research on the crossover effect provides primarily epidemiological data on racial/ethnic differences in the rates of substance use, but the relevance of the crossover of these indicators to problematic outcomes in Blacks and Hispanics has not been examined. Future research should explore clinical implications of the crossover effect among these groups, including related health, psychological and social consequences. Such research should also examine how such consequences are related to specific crossover effects (e.g., the crossover of SUD versus the crossover of past-month illicit drug use).

Conclusions

Although the crossover effect was first identified 25 years ago, rigorous methodological research examining the effect is recent. This research confirms the existence of the effect among Black and Hispanic populations, but research is mixed regarding whether differences in the crossover effect exist within these groups based on gender, SES, substance, and

substance indicator (i.e., lifetime, past-year, heavy, current, etc.). There is also little consensus in the literature as to at what age the crossover effect occurs. Regardless of these sociodemographic differences, Blacks and Hispanics appear to be at lower risk relative to Whites for some substances, particularly heavy drinking and cigarette smoking, at younger developmental periods, but cross over to higher risk at older developmental periods. Moreover, although research regarding the crossover of substance problems and SUD is limited, results are more consistent across indicators: Blacks and Hispanics are at lower risk for SUD and related problems during adolescence and early adulthood relative to Whites, but higher risk in later life. Future research is needed that examines the crossover effect in other racial/ethnic groups, provides clarification on potential sociodemographic differences, illuminates mechanisms of the effect, and identifies its clinical implications for racial and ethnic minorities. This research may have important implications for preventing racial/ethnic disparities in the consequences associated with disordered substance use.

Acknowledgments

Funding

Tamika Zapolski has received funding from National Institutes of Health/National Institute on Drug Abuse awards R25DA035163, P30DA027827, and K01DA043654. The funding agencies had no role in the study design, analysis of data, writing of the report, or decision to submit the article for publication.

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Table 1

Summary of studies examining the racial/ethnic crossover effect of substance use and substance use disorder

Study	Data	Age Range	Design	Substances	Findings
Geronimus et al. [4]	NHIS (Cancer Supplement; 1987)	18–44	Cross-sectional	Cigarettes	White women began smoking cigarettes at an earlier age than Black women but were more likely to quit at a younger age and quit at all relative to Black women. Rates of current smoking among the two groups converged by age 25 and those of Black women crossed over to be higher than those of White women by age 30.
Vogt Yuan [6]	NCS (1990-1992)	15–54	Cross-sectional	Alcohol Illicit drugs Alcohol abuse Drug abuse (DSM-III-R)	Blacks' rates of substance use and abuse were found to crossover those of Whites at age 50 for alcohol use, 48 for alcohol abuse, and 38 for drug abuse. No Black/White crossover was found for drug use.
Ma & Shive [7]	NHSDA (1996-1997)	12-35+	Cross-sectional	Alcohol Cigarettes Smokeless tobacco Marijuana Cocaine Heroin	At ages 12–25, rates of marijuana use were similar among Whites and Blacks and rates of cocaine use were higher among Whites than Blacks. After age 25, rates of both marijuana and cocaine use were higher among Blacks than Whites. Black's rates of past-month cigarette use also crossed over those of Whites after age 35. No crossover effects were observed for Hispanics.
Kandel et al. [8]	NSDUH (2006)	12–49	Cross-sectional	Alcohol Cigarettes Marijuana Cocaine	No crossover was observed for lifetime substance use: Whites were more likely to be lifetime users of every substance compared to Blacks. For current substance use, a crossover effect was observed among Blacks for cigarette and marijuana use at ages 26–34 and 18–25 respectively.
French et al. [9]	YRBS (1991-1997) MTF (19911997) NHSDA (1998)	12-35+	Cross-sectional, descriptive	Alcohol Heavy Drinking Marijuana Cocaine	Lifetime cocaine use was lower among Blacks than Whites and Hispanics during adolescence and young adulthood, but converged with those of the other two groups and crossed over those of Whites by age 35.
Pampel [13]	NYS (1977) NHIS (1976)	12–34	Longitudinal & cross-sectional	Cigarettes	Blacks were less likely to smoke cigarettes than Whites during the teens, but their rates converged with those of Whites by the early 30s. This effect was attributable to later initiation and lower cessation during the twenties among Blacks relative to Whites.
Kandel et al. [14]	NSDUH (2006-2008) NHSDA/NSDUH (1985–2008)	12–49	Cross-sectional & prospective cohort	Cigarettes	Among lifetime smokers, Blacks were less likely than Whites to be current smokers during adolescence and young adulthood, but their rates of current smoking crossed over those of Whites at approximately age 29.
Ensminger et al. [15]	MTF (1978) NHSDA (1992) NSDUH (2003)	18–49	Cross-sectional, descriptive	Alcohol Cigarettes Marijuana Cocaine Heroin Alcohol abuse/dependence (DSM-IV)	Rates of all substance use were lower among Blacks than Whites during adolescence, but at age 30–34, Blacks had higher rates of marijuana, cocaine, and heroin use. Data did not support a crossover for cigarette or alcohol use, but did support a crossover for alcohol abuse/dependence by ages 35–49.

Study	Data	Age Range	Design	Substances	Findings
Watt [16]	NHSDA (1999-2002)	12-35+	Cross-sectional	Heavy drinking Illicit drugs	Black women were less likely than White women to engage in heavy drinking during adolescence and young adulthood, but more likely to engage in heavy drinking after age 35. A similar pattern of results was found for illicit drug use among men. Black women's and men's rates of illicit drug use and heavy drinking, respectively, converged with those of Whites but did not crossover. No crossover was observed for Hispanics; Hispanic men and women generally had lower rates of substance use than Whites at all age groups.
Vasilenko et al. [17]	NESARC-III (2012–2013)	18–90	Cross-sectional	Alcohol use disorder Tobacco use disorder Cannabis use disorder Opioid use disorder (DSM-5)	The prevalence of most substance use disorders (SUDs) were higher for Whites at younger ages but higher for Blacks and Hispanics at older ages. Specifically, among Blacks, a crossover was observed for alcohol use disorder at ages 59–68, tobacco use disorder after age 64, and opioid use disorder at ages 56–78. Among Hispanics, a crossover for opioid use disorder was observed from ages 53–66.
Muthen & Muthen [18]	NLSY (1979)	18–37	Longitudinal	Heavy drinking Alcohol problems (DSM-IV)	Among lifetime alcohol users, Blacks and Hispanics had lower rates of heavy drinking than Whites but the differences among the three groups converge by age 32. Blacks also had fewer alcohol problems than Hispanics and Whites until age 37, after which Blacks have the highest level of alcohol problems than the other groups.
Zapolski et al. [19]	NSDUH (2010-2013)	12-65+	Cross-sectional	Heavy drinking	A crossover effect for heavy drinking was found for Blacks in the lowest income bracket only. Heavy drinking was lower among Black men at ages 18–24 and Black women at ages 18–34 but higher among Black men and women at ages 50–64 relative to Whites. No crossover was observed for Hispanic men or women.
Chen & Jacobson [23]	Add Health (1994)	12–34	Longitudinal	Alcohol Heavy drinking Cigarettes Marijuana	Whites demonstrated steeper increases in frequency of all substance use during adolescence and maintained higher levels of use than Blacks, Hispanics, and Asians until the late twenties, when rates among all four groups converged. Blacks demonstrated a crossover in rates of cigarette smoking and marijuana use in the early thirties and late twenties, respectively.
Evans-Polce et al. [24]	Add Health (1994)	14–32	Longitudinal	Heavy drinking Cigarettes Marijuana	Whites showed higher rates of substance use than Blacks and Hispanics, but the three groups converged in rates of marijuana use by the mid-twenties, and the other substances by the early-thirties.
Keyes et al. [25]	Add Health (1994)	16–29	Longitudinal	Alcohol Heavy drinking Cigarettes Marijuana	Whites were more likely than Blacks to use alcohol and engage in heavy drinking at all ages. Whites were initially more likely than Blacks to smoke cigarettes and smoke more often, but their smoking rates converged with those of Blacks by age 29. There were no differences in marijuana use among Black and White men at any ages, Black

Study	Data	Age Range	Design	Substances	Findings
					women demonstrated a crossover in marijuana frequency by age 29.
Williams et al. [28]	NLSY (1979 & 1997)	17–31	Longitudinal	Heavy drinking	In the older cohort (age 17 in 1979), Black women's and Hispanic men's frequency of heavy drinking crossed over those of their White counterparts by age 31. No crossover was observed for Black men and Hispanic women in the older cohort. No crossover was observed in the younger cohort for any group (age 17 in 1997).
Mulia et al. [29]	NLSY (1979)	21–51	Longitudinal	Heavy drinking	Results demonstrated a crossover in heavy drinking frequency during the thirties for Black women and Hispanic men only relative to their White counterparts. By age 51, rates of heavy drinking among all groups had converged again.
Caraballo et al. [39]	NYTS (2004-2013) NSDUH (2002-2013) NHIS (2001-2013) NHANES (2001-2012)	12-26+	Cross-sectional	Cigarettes	Each survey found that White women have higher rates of current cigarette smoking than Black women at ages 12-25. Depending on the survey, Black women were found to either have similar or higher rates of smoking than White women at age 26 and older. Surveys either showed that Black men have lower or similar rates of smoking than White men from age 12–25, but all surveys showed that Black men have higher rates at age 26 and older