The Brutish and Short Arm of Adolescence: Sex Differences in U.S. Adolescent and Young Adult Mortality

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Abstract

U.S. women live longer than men due to a range of social, psychological, behavioral, and health factors. Prior research has largely focused on health behaviors as particularly risky for males and socioeconomic status as a risk factor for females in shaping sex differences in mortality. However, this research has largely focused on mortality during mid- and older-adulthood, with most deaths occurring at older ages. This study focuses on sex differences in mortality among U.S. adolescents and young adults, ages 12-46. We employ Cox proportional hazard models and data from the National Longitudinal Study of Adolescent to Adult Health (Add Health), which was recently linked to mortality records through 2021. The hazard of dying is much greater (HR=1.69; $p<.001$) for males compared to female adolescents and young adults, with larger disparities for external compared to internal causes of death. Results show that sex differences in mortality are reduced but persist when controlling for childhood experiences, health behaviors, risky behaviors, and social ties. The relatively poor mental and physical health of females suppresses the differences; that is, sex differences in mortality would be even larger were it not for the poorer mental and physical health of young females compared with males. The findings point to adolescent factors that, if changed, could reduce mortality for both U.S. males and females, while reducing sex differences in mortality among younger adults. Such changes could contribute to increased life expectancy of the general U.S. population, and to reductions in mortality and sex differences at older ages.

Key Words: mortality, young adults, Add Health, United States, biological sex, gender

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Introduction

Death in early and midlife is much more common in the United States compared to peer countries (Ho 2013; Rogers et al. 2022). Thus, it is important to better understand risk factors that contribute to mortality and to health disparities, including the sex gap in mortality. Compared to males, females have higher life expectancies and lower mortality risk at every age, but the magnitude of the advantage differs across life stages. The relative sex gap in mortality is greatest among young adults and is lower in the age extremes (including at ages less than 15 and among those 65 and older). Indeed, the age-specific sex ratio of death rates is over 2.0 for ages 15 to 34 (Rogers et al. 2022; Xu et al. 2021). Much prior research examining sex differences in mortality focuses on older adulthood, with scant literature detailing patterns earlier in the life course. Additionally, causes of death and their social causes differ across historical periods and birth cohorts (Etherington 2017), yet we know little about the social patterns in mortality among younger cohorts. Investigating the social, economic, psychological, health, and behavioral determinants of sex differences in U.S. early adult mortality when the relative gap is the largest can shed light on how and why mortality risk differs by sex.

Explanations for sex differences in mortality may vary across life stages. For example, socioeconomic status (SES) disadvantages females compared to males in adulthood, but should be relatively evenly distributed by sex during childhood and adolescence. Another reason that sex differences in adolescent and young adult mortality may diverge from older ages is because the causes of death differ across the life course. Compared to older ages, deaths during adolescence and early adulthood are much more likely due to external causes: homicide, suicide, and such unintentional injuries as car crashes and accidental drug overdoses (Rogers et al. 2022).

The preventability of these deaths suggest they may be more sensitive to individual behaviors, mental health, or early life exposures compared to deaths in middle and older adulthood, although this has yet to be established. The life course stage of both the social factors and the deaths may be salient for understanding sex differences in mortality (Zheng, Dirlam, and Echave 2021).

We therefore seek to document and better understand the sex gap in adolescent and young adult mortality in the United States among a cohort who has not yet reached middle age. The National Longitudinal Study of Adolescent to Adult Health, or Add Health, began in 1994-95 and the cohort has been followed ever since (Harris et al. 2019); the data include a wealth of social, economic, psychological, health and behavioral variables that may be important for understanding sex differences in U.S. mortality during the early part of the life course. Such an analysis can shed light on mortality risk among U.S. adolescents and young adults and thus have potential to better understand why most individuals survive until older ages while others (particularly males) are much more likely to die far too early.

Background

Sex differences in mortality can be attributed to social, psychosocial, behavioral, social structural, health, and biological factors (Read and Gorman 2011; Rogers 2010). While biological factors (e.g., estrogen level) affect the sex gap in mortality, they "fail to explain why the gender gap in health differs over time and by social group" (Read and Gorman 2010: 374). The sex gap in U.S. mortality thus largely reflects social factors and norms related to gender. Prior research has highlighted how the prevalence of risk and protective factors differs quite markedly across sex, but exhibit similar effects on mortality (Rogers at al. 2010). Here, we

highlight findings from work on sex differences in mortality that focus on female-male differences in childhood experiences, risky or delinquent behaviors, health behaviors including substance use, social ties, and physical and mental health, and how these potential mechanisms may apply to this study that pertains to adolescence and subsequent mortality through young adulthood.

Across the life course, females report greater morbidity, but experience lower annual risk of death compared to males, which is termed the mortality-morbidity paradox (Austad and Fischer 2016). For example, females of all ages generally demonstrate more chronic physical and mental health conditions such as depression and disability, compared to males (Short and Zacher 2022). Suicide is particularly illustrative, as females are more likely to express suicidal ideation but less likely to die from suicide compared to males (Schrijvers, Bollen, and Sabbe 2012). There are multiple steps between suicidal ideation and suicide deaths, including planning, attempting, and completing suicide. Thus, physical and mental health factors that serve as risks for young adult mortality will likely be disadvantaged for female compared to male adolescents but, at the same time, may not operate as strong mechanisms for understanding sex differences in young adult mortality. That is, depressive symptoms and suicide ideation may be more common among young females than males and may increase the risk of mortality for everyone, including suicides. But the explanatory power of mental health factors for the sex gap in mortality may not be very strong. In terms of physical health, high body-mass index (BMI) may increase the risk of early life mortality as well, but may not play a particularly strong role since cardiovascular disease and other fatal diseases from this risk factor often take time to develop and are relatively uncommon during adolescence and young adulthood.

U.S. females enjoy greater social support and more social ties than males (Umberson and Montez 2010). They generally report more friends and exhibit higher levels of social integration; they are also more likely to engage in social activities, including attending religious services, which are related to greater longevity (Chu, Saucier, and Hafner 2010; Hummer et al. 1999, 2004; Rueger, Malecki, and Demaray 2010). Thus, higher levels of social ties in adolescence may serve as a protective factor for females, in which case it could explain some of the sex differences in adolescent and young adult mortality.

Compared to females, males are less likely to engage in health promoting behavior (Rogers et al. 2010). In particular, males tend to engage in more substance use/abuse than females. But the sex differences in substance use and abuse have been narrowing as females, especially younger females, have been increasing their substance use (McHugh et al. 2018). While males are generally more likely to smoke cigarettes and use drugs, females are catching up and in some instances surpassing male rates, particularly at younger ages. In 2019, for example, 15.5% of adult males and 13.0% of adult females were current smokers; but among those aged 18-24, 7.8% of males and 8.2% of females were current smokers (National Center for Health Statistics [NCHS] 2023). Similarly, in 2019, among those 12 and over, 15.5% of males and 10.7% of females had used illicit drugs in the past month; but among those aged 12-17, 8.9% of males and 8.5% of females had used illicit drugs in the past month (NCHS 2023). Thus, male-female differences in substance use and abuse may not be as important for mortality risk among young adults compared to older ages. Nonetheless, we expect that substance use is greater among male adolescents, which may contribute to their higher mortality risk.

Adverse childhood experiences produce detrimental short- and long-term health effects (Kalmakis and Chandler 2015). Research studies operationalize adverse experiences in different

ways but can include abuse, exposure to violence, and household dysfunction (Boullier and Blair 2018). Males and females are exposed to some forms of adversity in similar ways. But compared to females, larger percentages of males aged 0-17 report physical assault (41.6% versus 33.0%), the witnessing of assault in the community (20.2% versus 16.6%), and exposure to shootings (4.7% versus 3.2%) (Finkelhor et al. 2015). Other factors that reflect early life circumstances and are associated with longevity, such as childhood socioeconomic status or family structure (Hayward and Gorman 2004), may shape risk of early life mortality, but may not contribute much to sex differences.

Compared to females, U.S. males are more likely to engage in reckless, risky, aggressive, violent behaviors, which is a major contributor to sex differences in mortality across the life course (Owens 2002; Rogers et al. 2010; Tilstra et al. 2022). Boys and young males are often socialized to act aggressively, take risks, and stoically endure pain (Rogers et al. 2022). Males also tend to engage in unhealthy or risky behaviors in part as performance of masculinity (Courtenay 2000). Compared to females, males are more likely to drive fast and drive while drunk (Cockerham 2018), and they are less likely to wear seatbelts when driving. Further, many more males than females struggle with school, entry into the labor market, and social relations (Reeves 2022). Indeed, males were over twice as likely as females to receive disciplinary actions, including suspensions and expulsions, in public elementary and secondary schools in 2017-2018 (NCES 2023). Females (at 88%) were more likely than males (at 82%) to graduate high school on time in 2018 (Reeves 2022). There are declines in male college enrollment and graduation rates, with males more likely than females to take time out or to drop out of college (Reeves 2022). Females now receive 57% of the bachelor's degrees in the United States (NCES 2020; Reeves 2022). Thus, problems in school, including suspensions and expulsions, likely

reflect risky behaviors that are more common among males and may influence the sex gap in adolescent and young adult mortality.

In adolescence through young adulthood, some causes of death display strong differences by sex while others are much more muted. We expect smaller sex differences in mortality due to cardiovascular causes, neoplasms, or other similar internal causes of death that are rare in adolescence and young adulthood, and greater sex differences in mortality due to external causes of death. Boys and young males are at greater risk of suicides, alcohol-related deaths, and drug overdoses (Case and Deaton 2017, 2020; Reeves 2022). In 2021, the rate of deaths from drug overdoses was more than twice as high for males compared to females (Spencer, Minino, and Warner 2022). Compared to females, males have three to four times higher suicide mortality rates (Garnet et al. 2022). External injuries and violence, including homicides and suicides, are especially high among young adult males (Tilstra et al. 2022). Motor vehicle traffic deaths were about 2.5 times higher for males compared to females in 2019 (Spencer, Hedegaard, and Garnett 2021). Thus, we anticipate that external causes of death largely drive sex differences in mortality from adolescence through young adulthood.

Current Study

Understanding how key early life factors are associated with adolescent and young adult mortality can help us determine variables and processes that shape sex differences in longevity. Data constraints are a primary reason that studies are unable to explore the range of early life factors associated with adolescent and young adult mortality: few studies offer detailed, prospective information on health and social factors in early life in addition to mortality status. We therefore draw on rich information on the social determinants of health among adolescents

that has recently been linked to mortality status across young adulthood in Add Health. Through documenting the observed difference in adolescent and early adult mortality risk by sex in this cohort, we first establish the sex gap for this life stage among a recent U.S. cohort. We then examine whether this difference closes, widens, or persists when considering a range of early life health, social, psychological, and behavioral risk factors.

Overall, we address three research questions:

1. How wide is the sex gap in adolescent and young adult mortality among a recent U.S. cohort passing through adolescence and young adulthood? What causes of death are largely responsible for the sex gap in mortality from ages 12-46?
2. What adolescent health, social, psychological, and behavioral factors are associated with adolescent and young adult mortality risk?
3. Do sex differences in mortality risk close, widen, or persist when accounting for observed adoelscen factors?

Methods

Data and Sample

We analyze Add Health, a longitudinal, nationally representative dataset that has recently released linked mortality information (see https://addhealth.cpc.unc.edu/). This dataset is well-respected and widely used in social science, public health, and medical research, and offers substantial insight into the lives of adolescents enrolled in the study (Harris et al., 2019). Add Health collected in-home, nationally representative survey data on 20,745 adolescents ages 12-

19 in 1994-1995 (Wave I), and conducted follow-ups in 1996 (Wave II), 2001-02 (Wave III), 2008-2009 (Wave IV), and 2016-2018 (Wave V).

We use the adolescent and parent survey information from Wave I and mortality follow-up information from the Add Health Mortality Outcomes Surveillance data file, which provides data on the vital status of the original 20,745 members of the Add Health cohort (Trani et al. 2023). The data file includes deaths between study enrollment (1994-1995) and December 2021, offering more than 25 years of follow-up, with the deaths ranging from age 14 to 44. Deaths in the Add Health cohort were identified through linkages to the National Death Index as well as through intensive efforts geared toward tracing the cohort across time (Trani et al. 2023). From these follow-up efforts, 647 decedents (3.1% of the original cohort) were identified. Our analyses use data on vital status, year and month of death, and underlying cause of death.

Measures

Our outcome variable is vital status, indicating if the individual has died, and if so, the date and underlying cause of death. Our key independent variable is biological sex, self-reported by the respondent at Wave I. We consider all-cause mortality and mortality from specific underlying causes. The Add Health Mortality Outcomes Surveillance data file provides ICD-10 classification codes for underlying causes of death, with some classifications aggregated and some causes suppressed to preserve confidentiality (Trani et al. 2023). We further collapse categories to describe the predominant causes of death; we subsequently examine models focusing separately on external (ICD-10 codes V01–Y99) and internal (ICD-10 codes A00–R99) causes of death.

The explanatory variables derive from Wave I in-home surveys completed by the adolescent respondents and one of their parents. We use a measure of racial/ethnic identity to control for any differences in mortality risk due to experiences across groups. We include variables across multiple domains: childhood experiences, health behaviors, risky behaviors, social ties, and physical and mental health,. We examined a variety of variables in these domains, such as binge drinking, engaging in physical fights, and physical activity. These variables were often correlated with one another and with those presented here, but did not offer any substantively different results or further insight. We chose the variables presented here because they show an association with mortality risk, differ across sex, and/or have been commonly used in prior literature.

For childhood experiences, we include four variables. We include a measure of exposure to violence, which categorizes those who witnessed or experienced a shooting or stabbing in the previous 12 months. A variable for household poverty represents whether adolescent household income was below the poverty threshold for that year and household size. Family structure captures whether the adolescent family consists of two biological parents or some other structure. Lastly, a dichotomous variable comprises neighrbohood safety, with those reporting yes or no to the question “Do you usually feel safe in your neighborhood?”.

We include three dichotomous variables for risky or reckless behaviors: whether the respondent was ever suspended or expelled from school, if the respondent had reported at least one instance of taking something from a store without paying for it (shoplifting) in the past 12 months, and if the adolescent deliberately damaged someone else’s property in the previous 12 months.

Use of tobacco, non-cannabis drugs, and seatbelts comprise health behaviors. For smoking and drug use, dichotomous variables capture if the respondent reported using tobacco or any drug (other than tobacco, alcohol, or cannabis) during the previous 30 days. Seat belt use is a dichotomous variable indicating whether the adolescent never, rarely, sometimes, or most of the time wear seat belts, compared to "always".

Social ties include religious attendance and feeling socially accepted. Religious attendance compares those who reported attending any frequency of religious services in the last 12 months, compared to those who reported never attending such services. A dichotomus measure captures whether respondents said they agree or strongly agree (rather than neither agree nor disagree, disagree, or strongly disagree) with the statement "You feel socially accepted".

Physical and mental health includes body mass index (BMI), depressive symptoms, suicidal ideation, self-rated health, and the respondent's report of how likely it is they will be killed by the age of 21. BMI consists of categories using conventional thresholds, calculated using self-reported height and weight. Depressive symptoms is a scale averaging responses to 19 questions about the respondents' emotions during the prior week, which is summed and then standardized to have a mean of 0 and standard deviation of 1. Suicidal ideation is a dichotomous variable representing whether the respondent reported seriously thinking about committing suicide in the previous 12 months. Self-rated health consists of a 5 point response to the question, "In general, how is your health?", with respondents reporting excellent (1), very good (2), good (3), fair (4), or poor (5). Lastly, respondents indicated their certainty to the statement "You will be killed by age 21", with response options dichotomized: "almost no chance" or "some chance,

but probably not" coded as 0 and "a 50-50 chance," "a good chance," and "almost certain" coded as 1.

Mortality Analyses

We employ Cox proportional hazard models and perform model building to identify explanatory factors related to sex differences in mortality. These models use age at Wave I interview as the entry; duration is either age at December 2021 for those alive or the age at death for those deceased, with those ages calculated using the birthdate collected in Wave I. This approach implicitly uses age as the time factor; thus, age does not need to be included in the model (Thiébaut and Benito 2004). The models assume proportionality, with hazard ratios (HRs) reflecting increases (above 1.0) or decreases (below 1.0) in risk across the follow-up period. All analyses use Stata 15 (StataCorp 2017).

Per Add Health Morality Outcomes Surveillance instructions (Trani et al., 2023), we adjust for complex sampling design using Wave I design measures, which also account for the clustering of individuals in schools and households. Of the 20,745 Wave I respondents, 1,821 do not have a valid weight, and an additional three respondents are omitted due to missing information on sex or age of death. For all-cause mortality, the sample is 18,921 respondents with 602 deaths. For analyses of internal causes of death, we exclude those who died from external or suppressed causes, leaving a sample of 18,557 respondents with 255 decedents. Similarly, models for external causes of death do not include decedents with internal or suppressed causes of death, resulting in a sample of 18,651 with 332 external causes of death. Multiple imputation using a chained equations approach addresses independent variable missingness in the regression models (see Allison 2001). We use conventional significance

levels and also present significance levels at 0.10 because of the relatively modest number of deaths; that is, while mortality occurs all too often among U.S. adolescents and young adults, it is fortunately a relatively rare event.

Sensitivity Analyses

To assess the suitability of our modeling approach, we examine whether the hazard of dying is proportional for males and females through a test of proportionality using Schoenfeld residuals, a visual examination of the hazards, and interaction terms between age and sex in discrete time models. We find that the base and full Cox models do not violate proportionality. Additionally, interaction effects between sex and age categories were not significant. Together, these additional results suggest that males and females have proportional hazards of death across the age range examined. Similarly, interactions between sex and the significant variables from the full model (each interaction term assessed separately) did not show any significant differences in the associations with mortality across males and females.

Results

Table 1 shows descriptive mortality information among the Add Health cohort by cause of death. Of the 602 deaths in our sample, 238 (or 39%) are due to internal causes and 332 (or 56%) are due to external causes; Add Health suppressed cause of death information for an additional 42 deaths (see column 1). Compared to females, males exhibit a slightly higher proportion of external deaths. Further, comparing external categories such as transport and non-transport unintentional injury, suicide, and homicide, males show two to four times as many deaths as females (for similar results, see Rogers et al. 2022). Within these broad categories, transport

fatalities (usually motor vehicle accidents) account for the largest number of deaths for both males and females.

Table 1 about here

Table 2 presents descriptive statistics for the explanatory variables for males and females combined and separately. Compared to males, females are more likely to report suicidal ideation (which can be detrimental) and to attend religious services (which can be beneficial to survival). Smoking and drug use rates are similar across sex for adolescents (for similar results, see NCHS 2023). Compared to females, males are less likely to engage in preventive health behaviors and more likely to engage in risky and violent behaviors. For instance, they are more likely to report being suspended or expelled from school (37% versus 20%). Males and females also exhibit differential exposure to violence. For example, while 12% of females reported witnessing violence in childhood, 23% of males did so.

Table 2 about here

Table 3 turns to the hazard models of mortality risk. Compared to females, males have higher mortality risk over the follow-up period, controlling for race/ethnicity and adjusting for age (HR=1.69, Model 1). This difference attenuates when controlling for childhood experiences (Model 2), risky behaviors (Model 3), and health behaviors (Model 4), although the magnitude of attenuation varies. The sex difference remains uncaned with the inclusion of social ties (Model 5). In contrast, the HR accentuates with controls for physical and mental health (see Model 6), suggesting that the relatively poorer physical and mental health for females suppresses sex differences in mortality. he smallest HR (1.44) in Model 3, reflects strong relationships between both delinquency and suspension/expulsion with mortality; such risks are more common among males.

Table 3 about here

Compared to Model 1 (HR=1.69), the full model (Model 7) shows a diminution in the HR (1.54), which suggests that part of the sex difference in mortality in adolescence and young adulthood is due to more prevalent risk factors for males compared with females. Thus, netting out the positive and negative factors, male mortality rates converge somewhat toward females, although sex differences in mortality do not close completely.

Table 4 presents HRs for internal and external causes of death, respectively. The sex gap in risk of death is more than two-fold for external causes, but does not reach significance for internal causes. There are more external than internal deaths during this life course stage (as shown in Table 1); there is also a wider sex gap among these preventable deaths. For internal causes of death, the highest BMI category is associated with an increased risk of death, whereas suicidal ideation, smoking, suspension/expulsion, and an expectation to be killed by age 21 exhibit significant relationships with external causes of death. Nonetheless, inclusion of the complete set of explanatory factors exhibits only a modest reduction in the sex mortality gap for these external causes of death.

Table 4 about here

Discussion

Our results provide unique health, social, and mortality information on a national representative cohort of adolescents and young adults. Whereas most previous literature has empirically examined sex differences in mortality among older adults, we contribute to the literature by concentrating on younger adults. Importantly, the death rate sex ratio is higher among young adults than any other age group. Our results demonstrate that, compared to females, males have

much higher risk of death across adolescence and young adulthood primarily from external causes of death that are preventable. We find associations between adolescent health and social factors and subsequent mortality risk, and sex differences attenuate but persist when considering these factors. We draw further conclusions about the adolescent social factors shaping these sex differences, with some similarities and differences to prior literature on older adults.

Our results indicate that adolescent health and social factors are linked to subsequent mortality and to sex differences in mortality, suggesting that adolescence is a key stage for "risks of risks" (Link and Phelan 1995). Sex differences among older adults are due in part to SES, physical activity, social relations, and risky behaviors (Rogers et al. 2010). In contrast, our study examining younger adults finds that sex differences are due in part to health and other behavioral factors, and especially risky or delinquent behaviors (see also Tilstra et al. 2022), including activities that resulted in being suspended or expelled from school. Prevention efforts for this life stage are likely to be beneficial across the life span, and thus may be more economically and socially expedient. Such efforts may consider both reducing the prevalence of such factors as school suspension/expulsion, as well as their deleterious effects on subsequent health and mortality.

Comparing our study to other studies examining mortality within or across other life stages, our findings for race/ethnicity and socioeconomic status diverge. These factors are influential on mortality at both older and younger ages (e.g. Hayward and Gorman 2005; Tilstra et al. 2022), but do not appear salient in our analyses for this cohort. Rather, our results point to social and behavioral norms related to gender. For example, Table 2 shows that males are much more likely than females to be suspended or expelled from school (37% versus 20%,

respectively). We find that compared to females, more males are exposed to and commit violence. An American culture of violence targets men, but spills over to women.

Compared to younger adults, older adults often have larger sex variations in health behaviors, with greater exposures (longer durations engaging in risky behaviors). Sex differences in substance use are small in adolescence (see Table 2) but widen at older adult ages (see also NCHS 2023). Thus, it is reasonable to expect, as our results show, that substance use has a small effect on sex differences in mortality at younger ages (see Table 3, Model 4). Because there are dose-response and duration effects between smoking, drinking, and drug abuse and mortality, and because sex differences in substance use are greater at older ages, we would expect that substance use will exert much greater effects on sex differences in mortality at older ages (see, for example, Rogers et al. 2010). Adolescent substance use may serve as a proxy for conscientiousness, propensity for risk, or social networks that link these factors to mortality. Still, young males and females could reduce their prevalence of smoking and drug use, which could increase their survival.

Suicide is a major cause of death among young adults (see Table 1). Compared to males, females are more likely to express suicide ideation (10% versus 16%; see Table 2), which increases the risk of death (HR=1.59 in Model 6, Table 3) and narrows the sex gap in mortality. Yet, males have higher rates of suicide than females, in part because they are more likely to commit suicide with firearms, which are often more lethal than suicide attempts by other means, such as poisonings or suffocation (including asphyxiation, hanging, or strangulation) (Garnet et al. 2022).

Compared to other high-income countries, the United States has substantially higher firearm-related mortality, which contributes to injuries, suicides, and homicides (Wintemute

2015). Firearm ownership is much higher among males, at about 35%, than females, at 11% (Wintemute 2015). Firearm-related mortality is also much higher among males than females; males comprise 86% of all firearm deaths (CDC 2023). Compared to females, males have higher firearm-related mortality, especially among those 20 to 39 years of age (Rees et al. 2022). Thus, reducing deaths due to firearms would reduce young adult mortality and narrow the sex gap in mortality.

Sex differences often involve preventable or avoidable causes of death (Beltrán-Sánchez 2011). Males have higher mortality from most causes of death analyzed (except cancer, endocrine/nutrition/metabolic, nervous system, and the suppressed causes). Thus, it is possible to close the sex gap in mortality by reducing such preventable causes of death as accidents (including drug overdoses and motor vehicle accidents), homicides, and suicides. The sex gap in mortality has no baseline. Instead, the sex gap in young adult mortality can widen or narrow with sex variations in social, behavioral, lifestyle, and cultural factors. We should ultimately strive to reduce mortality for both sexes. Table 3 demonstrates that it would be possible theoretically to reduce the HR sex gap among young adults from 1.69 to 1.44 by reducing risky behaviors among males. If we eliminated all external causes of death (which is theoretically possible because these are avoidable), the HR sex gap could bottom out at 1.14, although we should also consider the potential of omitted variable bias.

Alternatively, the sex ratio could increase to nearly two-fold if males continue to engage in risky behaviors and females realize improvements in their physical and mental health. Realistically, based on the current socioeconomic and political climate globally and within the United States– with continued COVID-19 infections, economic turmoil, social unrest, a culture of violence, high levels of gun ownership and gun violence, and political divisions and

polarization – we expect that the sex gap in young adult mortality over the next decade will persist or slightly widen.

This study has several limitations. This study was possible because the Add Health was linked to mortality follow-up data. With 602 deaths, we have limited statistical power to examine intersectionality or other detailed categories. We also focus on adolescence as a key life stage for gender norms and risk and protective factors. Future research could examine variables from subsequent waves (e.g., Wave 2), and exploit changes between waves by examining time-varying covariates (for example, changes in substance use).

Extensive controls partly closed the sex gap in mortality. Future research could consider genetic and biological variables, including measures of inflammation (e.g., C-reactive protein [CRP]), cardiovascular risk factors (e.g., measures of hypertension and cholesterol), and risk factors for diabetes (Rogers et al. 2010). Compared to females, males have higher levels of testosterone, which is associated with higher blood pressure, along with greater risk-taking behaviors, violence, and aggression. Compared to males, females have higher levels of estrogen, especially in early adult life, which contributes to lower risk of inflammation and heart disease. And compared to females (with XX chromosomes), males (with XY chromosomes) have a less vigorous response to infections and a greater genetic predisposition to some diseases that is more pronounced in early adult life (Kalben 2000; Rogers et al. 2022). However, genetic and biological factors should be considered in concert with rather than independent of the social, cultural, and life course circumstances (Perry 2016).

Conclusion

Sex differences in adolescent and young adult mortality are larger than in any other age group, are larger in the U.S. than other high-income countries, are often due to preventable causes of

death, and are amenable to reductions.We identified key factors that contribute to sex differences in mortality. Sex differences in mortality reveal specific mechanisms that increase the risk of death, but are also amenable to intervention. Reducing sex differences in mortality among younger adults could contribute to increased life expectancy of the general U.S. population, and to reductions in mortality and sex differences at older ages.

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Table 1. Frequencies of underlying causes of death by sex, deaths through 2021

		All	Males	Females
Underlying Cause	ICD-10 Code	n	n	n
Internal				
Infectious	A00-B24	20	11	9
Cancer	C00-C96	57	20	37
ENM[a]	E00-E90	35	2	11
Nervous system	G00-G99	11	3	8
Circulatory	I00-I69	59	36	23
Respiratory	J00-J99	15	8	7
Digestive	K00-K99	15	12	3
COVID-19	U07.1	14	6	8
Other internal	R00-R99	12	8	4
Internal subtotal		*238*	*106*	*110*
External				
Transportation	V01-V89.2	102	71	31
Unintentional poisoning	X40-X49	85	56	29
Unintentional injury[b]	W00-X39, X50-X59	21	13	8
Suicide	X60-X74	66	53	13
Homicide	X85-Y09	43	29	14
Undetermined intent	Y10-Y98	15	12	3
External subtotal		*332*	*234*	*98*
Suppressed/missing[c]		32	15	17
Total		602[d]	*377*	*225*

Source: Add Health Mortality Outcomes Surveillance

Notes: [a] ENM= Endocrine, Nutrition, Metabolic [b] Non-transportation and nonpoisoning unintentional injuries [c]Suppressed cases reflect infrequent causes of death that are masked to prevent deductive disclosure.

Table 2. Means and percentages for Wave I (1994-1995) adolescent factors, ages 12-19, by mortality status (with follow-up through 2021 and sex, United States

	All (N=18,921)			Men (N=9,288)			Women (N=9,633)		
	All	Alive	Died	All	Alive	Died	All	Alive	Died
Childhood Experiences									
Witnessed violence	17%	17%	23%	22%	22%	26%	12%	12%	17%
Adolescent household below poverty	18%	18%	18%	18%	18%	17%	19%	19%	21%
Feel safe in neighborhood (Y/N)	90%	90%	89%	90%	90%	91%	89%	89%	84%
Two biological parents									
Risky behaviors									
Property damage	18%	18%	25%	24%	24%	31%	12%	12%	12%
Shoplifting	23%	23%	27%	26%	26%	31%	20%	20%	21%
Suspended or expelled	29%	28%	47%	37%	36%	52%	20%	20%	38%
Substance use in last 30 days									
Smoked in last 30 days	28%	28%	40%	28%	27%	41%	28%	28%	39%
Non-cannabis drug use	6%	5%	10%	6%	6%	7%	5%	5%	14%
Does not always wear seatbelt	50%	50%	57%	55%	55%	60%	45%	45%	51%
Social ties									
Any religious attendance	75%	75%	70%	73%	73%	69%	77%	78%	72%
You feel socially accepted (SA/A vs N/D/SD)	85%	85%	81%	87%	87%	86%	83%	83%	73%
Physical and Mental health									
BMI									
<20	32%	32%	25%	29%	30%	24%	35%	35%	26%
20 - <25	47%	47%	48%	48%	48%	47%	45%	45%	49%
25 - <30	15%	15%	16%	16%	16%	18%	13%	13%	11%
30 - <35	5%	5%	7%	5%	5%	7%	5%	4%	8%
35+	2%	2%	4%	2%	2%	4%	2%	2%	6%
Depressive symptoms, standardized (mean 0, SD 1)	-0.05	-0.05	0.01	-0.10	-0.10	-0.04	-0.01	-0.01	0.10
Suicidal ideation	13%	13%	21%	10%	10%	16%	16%	16%	28%
Expect to be killed by 21	1.64	1.64	1.78	1.63	1.62	1.79	1.66	1.65	1.77
Self-rated health	3.87	3.88	3.69	3.95	3.96	3.79	3.80	3.81	3.51

Source: Add Health. Notes: Adjusts for complex sampling using Wave I in-home weights. Percentages provided for dichotomous and categorical variables; means provided for continuous variables.

Table 3. Cox proportional hazard ratios for all-cause mortality, ages 12-46, 1994-2021, United States (N=18,921; 602 deaths)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Sex/gender (male)	1.69***	1.64***	1.44**	1.66***	1.69***	1.78***	1.54**
Race/ethnicity (NH White)							
NH Black	1.26+	1.1	1.09	1.40*	1.29+	1.21	1.14
Hispanic	0.69+	0.64*	0.65*	0.74	0.69+	0.66*	0.67+
All other	0.66	0.65	0.68	0.72	0.65	0.64	0.69
Childhood Experiences							
Witnessed violence		1.30+					1.01
Adolescent household in poverty		1.08					1.00
Feel safe in neighborhood		0.93					1.05
Two biological parents		0.78*					0.89
delinquent behaviors							
Property damage			1.26				1.16
Shoplifting			1.02				0.91
Suspended or expelled			1.94***				1.64***
Health Behaviors							
Smoked in last 30 days				1.59***			1.28*
Non-cannabis drug use				1.43			1.15
Does not always wear seatbelt				1.16			1.07
Social ties							
Any religious attendance					0.80		0.95
You feel socially accepted”					0.75+		0.91
Physical and Mental health							
BMI (20 - <25)							
<20						0.86	0.90
25 - <30						0.95	0.98
30 - <35						1.28	1.33
35+						1.93*	2.11**
Depressive symptoms						1.08	0.89
Suicidal ideation						1.59**	1.47*
Self-rated health						1.18*	1.13+
Killed by 21 expect						1.40**	1.32*

Source: Add Health. Notes: Adjusts for complex sampling using Wave I in-home weights. + .10 * p<.05, **p<.01, ***p<.001

Table 4. Cox proportional hazard ratios for cause-specific mortality, ages 12-46, 1994-2021, United States

	Internal Causes (N=18557; deaths=255)		External Causes (N=18651; deaths=332)	
	Base	Full	Base	Full
Sex/gender (male)	1.14	1.06	2.26***	2.03***
Race/ethnicity (NH White)				
NH Black	2.24***	1.94**	0.81	0.76
Hispanic	0.68	0.64	0.76	0.76
All other	1.78	1.84+	0.15***	0.16***
Childhood Experiences				
Witnessed violence		0.99		0.99
Adolescent household below poverty		0.91		1.13
Feel safe in neighborhood (Y/N)		0.87		1.26
Two biological parents		0.76		0.94
Risky behaviors				
Property damage		0.88		1.45+
Shoplifting		1.10		0.81
Suspended or expelled		1.46+		1.67**
Substance use in last 30 days				
Smoked in last 30 days		0.94		1.62**
Non-cannabis drug use		1.25		1.05
Does not always wear seatbelt		0.97		1.21
Social ties				
Any religious attendance		0.73		1.21
You feel socially accepted (SA/A vs N/D/SD)		0.73		0.95
Physical and Mental health				
BMI (20 - <25)				
<20		0.78		0.91
25 - <30		0.87		0.96
30 - <35		1.66+		0.92
35+		3.56***		0.70
Depressive symptoms (standardized)		0.66		1.03
Suicidal ideation		1.31		1.60*
Self-rated health		1.22+		1.04
Expects to be killed by 21		1.23		1.46*

Source: Add Health.

Notes: Adjusts for complex sampling using Wave I in-home weights. + .10 * p<.05, **p<.01, ***p<.001