SSM - Population Health 7 (2019) 100344

Contents lists available at ScienceDirect

SSM - Population Health

journal homepage: www.elsevier.com/locate/ssmph

Article

Adverse life experiences and risk of unintended pregnancy in adolescence and early adulthood: Implications for toxic stress and reproductive health

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A B S T R A C T

Objective: We examined the effects of adverse life experiences (ALEs) on rates of unintended first pregnancy, including differential effects by race/ethnicity and socioeconomic status, among women in a national longitudinal cohort study.

Methods: We drew upon 15-years of data from 8810 adolescent and young adult females in the National Longitudinal Study of Adolescent to Adult Health. Using 40 different ALEs reported across childhood and adolescence, we created an additive ALE index, whereby higher scores indicated greater ALE exposure. We employed Cox proportional hazard models, including models stratified by racial/ethnic and socioeconomic groups, to estimate the effects of ALEs on time to first unintended pregnancy, controlling for time-varying sociodemographic, health and reproductive covariates.

Results: Among all women, a 1-standard deviation increase in ALE scores was associated with an increased rate of unintended first pregnancy (adjusted Hazard Ratio 1.11, 95% Confidence Interval = 1.04–1.17). In stratified models, associations between ALE scores and risk of unintended pregnancy varied across racial/ethnic, socioeconomic, and age groups and according to various elevated ALE thresholds. For example, the 1-standard deviation increase in ALE score indicator increased the unintended pregnancy risk for African-American (aHR = 1.12, CI = 1.01–1.25), Asian (aHR 1.69, CI = 1.26–2.26), and White women (aHR = 1.12, CI = 1.03–1.22), women in the lowest ($0-$19,999; aHR = 1.21, CI = 1.03–1.23) and highest (> $75,000; aHR = 1.36, CI = 1.12–1.66) income categories, and women aged 20–24 (aHR = 1.13, CI = 1.04–1.24) and > 24 years (aHR 1.25, CI = 1.06–1.47), but not among the other sociodemographic groups.

Conclusion: ALEs increased the risk of unintended first pregnancy overall, and different levels of exposure impacting the risk of pregnancy differently for different sub-groups of women. Our ongoing research is further investigating the role of stress-associated adversity in shaping reproductive health outcomes and disparities in the United States.

1. Introduction

The social context of stress and morbidity has received significant attention from public health professionals over the last two decades. Toxic stress process - the prolonged activation of the stress response system in the body and brain - has been found across samples and settings to contribute to long-term inflammatory, immune, and neuroendocrine dysfunction, accelerated cellular aging, mental distress, cognitive impairment, and biological and psychological "weathering" (Boardman & Alexander, 2011; Geronimus, 2001; Geronimus et al., 2010; Gouin, Glaser, Malarkey, Beversdorf, & Kiecolt-Glaser, 2012; Hogue & Bremner, 2005; Hogue et al., 2013; McEwen & Seeman, 1999; Rondo et al., 2003; Williams, 2002; Williams, Yan, Jackson, & Anderson, 1997). Studies have linked toxic stress to increased rates of cardiovascular disease, diabetes, cancer, depression, substance use, and even premature death among U.S. women and men. Socially disadvantaged groups, such as minority and poor women, are particularly vulnerable to long-term stress effects, and as such, stress is a direct contributor to health disparities (Boardman & Alexander, 2011; Geronimus, 2001; Geronimus et al., 2010; Gouin et al., 2012; McEwen & Seeman, 1999; Williams, 2002; Williams et al., 1997).

Toxic stress results from prolonged exposure to adverse life experiences (ALEs), such as discrimination, economic hardship, violence, and other life stressors (Centers for Disease Control and Prevention, 2016; Shonkoff et al., 2012). ALEs during childhood and adolescence are of particular concern given their potential to alter critical bio-psycho-social developmental processes, subsequently having negative long-term physical, mental, and social consequences (Centers for Disease Control and Prevention, 2016; Shonkoff et al., 2012). ALEs are associated with many health risks during adolescence and early adulthood, including tobacco, drug/alcohol abuse, depression/suicide, obesity, disrupted social/family dynamics, reduced education/employment

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https://doi.org/10.1016/j.ssmph.2018.100344
Received 22 June 2018; Received in revised form 17 December 2018; Accepted 19 December 2018

opportunities, homelessness, incarceration, and violence (Centers for Disease Control and Prevention, 2016; Shonkoff et al., 2012).

While much is known about ALEs, toxic stress, and health broadly, the extent to which these phenomena shape reproductive health outcomes has been less studied. A relatively large body of biomedical and clinical research points to the effects of biophysiologic stress, infertility, and adverse perinatal outcomes later in the reproductive lifecourse (Khashan et al., 2009; Nepomnaschy, Sheiner, Mastorakos, & Arck, 2007; Rondo et al., 2003). The majority of stress-focused family planning research has examined the influence of acute psychological stress (e.g. perceived stress in the prior 2 weeks) on the risk of unintended pregnancy and its proximate determinants. From our own clinic- and community-based research on adolescent and young adult women, we have found moderate/severe levels of perceived stress to be associated with increased odds of weekly sexual activity, contraceptive nonuse, misuse, less effective method use, and discontinuation, and unintended pregnancy (Hall, Kusunoki, Gatny, & Barber, 2014; Hall, Kusunoki, Gatny, & Barber, 2015; Hall, Moreau, Trussell, & Barber, 2013; Hall, Richards, & Harris, 2017; Hall, White, Rickert, Reame, & Westhoff, 2012). Studies to date on stress and family planning, though, have seldom investigated the complex social context of stress, nor have they considered chronic stress exposure.

A few retrospective and cross-sectional studies of adult U.S. women have described ALEs occurring specifically at the time of pregnancy, and their relationship to perinatal and health outcomes (D'Angelo et al., 2007; Hall, Dalton, Zochowski, Johnson, & Harris, 2017; Hogue et al., 2013). In a population-based, case-control study, as women reported higher overall numbers of ALEs and as women experienced multiple, varied types of ALEs, the odds of stillbirth versus live birth increased (Hogue et al., 2013). In a national web-based survey of 1078 U.S. women aged 18–55 years, we found that higher numbers of ALEs occurring at the time of unintended pregnancy were positively associated with increased risk of chronic disease, mental health conditions, and higher depression, perceived stress and social discrimination symptoms (Hall, Dalton, et al., 2017). These studies did not investigate the prospective contribution of social stress occurring earlier in the life course or its cumulative toxic effects on adverse reproductive health events, especially during critical developmental periods.

From a chronic stress perspective, exposure to ALEs (predominantly violence) has been linked with sexual risk behaviors among men and women in the U.S. The landmark CDC-Kaiser ACE study, a retrospective cohort study of adults in Southern California enrolled in a large managed care organization conducted in the mid-1990s, found a graded response between cumulative number of adverse childhood experiences (ACEs) and sexually transmitted infection history (Hillis, Anda, Felitti, Nordenberg, & Marchbanks, 2000). Other reports have described an association of ACEs with increased risk of early sexual debut, multiple sexual partners, sexual violence, and multiple abortions (Anda et al., 2002; Dietz et al., 1999; Felitti et al., 1998; Hillis et al., 2010, 2004; Hillis, Anda, Felitti, & Marchbanks, 2001; Hillis et al., 2000).

Overall, research to date has provided a foundation on which to conceptualize and further study the role of toxic stress as it shapes reproductive health outcomes and inequities and the various potential biological, psychological and social mechanisms that may link them. Methodological limitations, including limited prospective measurement of chronic stress processes and social context, lack of developmental frameworks and life course perspectives, small sample sizes, and limited racial/ethnic and socioeconomically representation, however, have precluded a robust investigation of whether and how ALEs may shape rates and disparities in unintended pregnancy during adolescence and young adulthood. Here, we begin to test these hypothesized relationships first by examining the distal effects of ALEs on risk of unintended first pregnancy among a large, population-based sample of adolescent and young adult U.S. women. We further examine potential differential effects of ALEs on unintended pregnancy risk by race/ethnicity, socioeconomic status, and age group. While an exploration of the specific

Table 1
Sociodemographic, Health, and Sexual History Characteristics of the Sample.

N = 8810	Unweighted n	(Weighted %)
Age at Wave 1		
Mean (SE of mean)	15.27	(0.1)
< 13 years	279	(3.7)
13 years	1078	(16.2)
14 years	1293	(17.3)
15 years	1639	(17.7)
16 years	1701	(17.1)
17 years	1601	(15.3)
18 years	1056	(11.1)
> 18 years	163	(1.7)
Race/ethnicity		
Hispanic	1449	(11.7)
Black	1948	(15.8)
Asian	595	(3.7)
Other	234	(2.7)
White	4575	(66.0)
Missing	9	
Highest educational attainment		
Less than high school	845	(11.1)
Completed high school	1866	(21.1)
Some college	3205	(36.9)
Bachelor's degree or higher	2891	(30.9)
Missing	3	
Immigrant status		
Born in U.S.	8042	(93.7)
Not born in U.S.	764	(6.3)
Missing	4	
Parents' highest educational attainment		
Less than high school	1120	(11.7)
High school diploma, vocational/ technical, or GED	2292	(28.8)
Some college or business/trade school after HS	2430	(28.8)
Graduated from college/university or more	2827	(30.6)
Missing	141	
Parental income		
0 to $19,999	1408	(22.0)
$20,000 to $49,999	2719	(40.7)
$50,000 to $74,999	1476	(23.0)
$75,000 or higher	939	(14.2)
Missing	2268	
Received welfare or public assistance		
Yes	1939	(25.7)
No	5606	(74.3)
Missing	1265	
Childhood family structure		
Two biological parents	4545	(54.0)
Other	4261	(46.0)
Missing	4	
Geography of residence		
Rural	2223	(28.5)
Suburban	3159	(37.8)
Urban	3233	(32.7)
Other	99	(1.1)
Missing		
Religious denomination		
Baptist	1969	(23.4)
Mainline Protestant	2238	(26.3)
Catholic	2310	(24.7)
Other Christian Affiliation	810	(9.5)
Religious non-Christian	374	(4.6)
None	961	(11.5)
Missing	148	
Frequency of religious service attendance		
Once a week or more	3546	(39.9)
Once a month or more, but less than once a week	1697	(18.6)
Less than once a month	1588	(17.9)

(*continued on next page*)

Table 1 (*continued*)

N = 8810	Unweighted n	(Weighted %)
Never	1966	(23.6)
Missing	13	
Self-rated health status		
Excellent or very good	5642	(64.7)
Good, fair, or poor	3158	(35.3)
Missing	10	
Relationship status at Wave 1		
Married or previously married	23	(0.3)
In a relationship	3107	(33.7)
Single/no reported relationship	5638	(66.0)
Missing	42	
Relationship status at Wave 2		
Married or previously married	43	(0.6)
In a relationship	2556	(36.3)
Single/no reported relationship	4084	(63.1)
Missing	2127	
Relationship status at Wave 3		
Married or previously married	1391	(19.4)
In a relationship	3342	(47.5)
Single/no reported relationship	2461	(33.1)
Missing	1616	
Age at first sexual intercourse		
< 15 years	2126	(25.2)
15–18 years	4563	(51.5)
> 18 years	1459	(15.5)
Never had sexual intercourse	656	(7.7)
Missing	6	
Total number of sexual partners		
< 2 partners	1204	(13.6)
2–5 partners	2877	(32.6)
6–10 partners	2021	(25.2)
> 10 partners	1677	(20.5)
Never had sexual intercourse	656	(8.0)
Missing	375	
ALE score at Wave I		
Mean (SE of mean)	1.45	(0.05)
Standardized mean (SE of mean)	0.0	(0.03)
ALE index > = 2 SD above mean	499	(5.4)
ALE index 1–2 SD above mean	632	(7.4)
ALE index < 1 SD above mean	7647	(87.2)
Missing	32	
ALE score at Wave II		
Mean (SE of mean)	1.24	(0.04)
Standardized mean (SE of mean)	0.0	(0.02)
ALE index > = 2 SD above mean	298	(4.1)
ALE index 1–2 SD above mean	663	(10.0)
ALE index < 1 SD above mean	5725	(86.0)
Missing	2124	
ALE score at Wave III		
Mean (SE of mean)	1.29	(0.03)
Standardized mean (SE of mean)	0.0	(0.02)
ALE index > = 2 SD above mean	310	(4.4)
ALE index 1–2 SD above mean	763	(10.6)
ALE index < 1 SD above mean	5897	(85.0)
Missing	1840	
Pregnancy history		
Had a pregnancy	5118	(57.1)
Had an unwanted pregnancy	2737	(30.4)
No pregnancy	3692	(42.9)

N = 8810 Results are unweighted Ns and weighted proportions.

pathways linking ALEs to unintended pregnancy is of interest and highly relevant to our overarching hypothesis, it is beyond the scope of this analysis; as such, we are continuing to explore them in our ongoing work.

2. Methods

Data were drawn from the National Longitudinal Study of Adolescent to Adult Health (Add Health) (Harris, 2013; Harris et al., 2013). In brief, this longitudinal cohort study followed a nationally representative sample of adolescents through adulthood between 1994 (wave I, participants from grades 7–12) and 2009 (wave IV, participants aged 24–32 years). Here we utilized data from all four waves to obtain a sub sample of participants who self-identified as female and completed at least wave I and one additional wave (89% of females from wave I). We excluded female participants who experienced a pregnancy before the first wave (n = 344) or who had missing data on pregnancy (n = 31) or pregnancy intendedness (n = 19). The remaining sample included 8810 women (Table 1); of which 7528 (85%) were last followed at wave IV, 838 (10%) at wave III, and 444 (5%) at wave II. We also excluded 656 women from the bivariate and multivariable analyses due to no history of sexual intercourse. Following Add Health guidelines, analyses were weighted to adjust for the complex sampling design (Chen & Chantala, 2014). Our analysis was approved by the Institutional Review Board of Emory University.

2.1. Measures

2.1.1. Adverse life experiences

Add Health measured 40 different ALEs across Add Health survey waves I through IV (see Table 2). To ensure temporal ordering of our ALE exposure to unintended pregnancy outcome, we created an additive index score of the ALEs for each wave, which comprised items measured at each wave I, II, and III, a method using these same 40 ALEs that has been previously used and tested by other researchers on social stress and health outcomes research using Add Health data (Boardman & Alexander, 2011). Exposure to each individual ALE was coded as 1 and ALEs were summed for a total score at each wave, with higher scores indicating exposure to a greater number of ALEs over the study period. We standardized ALE index scores to a normal distribution (mean = 0, standard deviation [SD] = 1). Mean responses were imputed into missing items, but if women were missing more than 5 items for any particular wave, their ALE score was set to the value of the score from the last available wave with non-missing data. We refer to ALEs as time-varying as our models accounted for changes in ALE scores across the three waves. For analyses, we used two methods for defining time-varying ALE exposure: (1) a continuous indicator, estimating changes in the outcome per 1 SD increase in ALE index score, and (2) categorical ALE indicators, where we conducted sensitivity analysis to examine potential threshold effects for ALE scores 1–2 SD above the mean and > = 2 SD above the mean (reference group < 1 SD above the mean).

2.1.2. Pregnancy

Our outcome was time to first pregnancy reported as unintended. We utilized Add Health's wave IV pregnancy table as it contained the most comprehensive pregnancy data for the study period and allowed us to establish temporal ordering of time-varying ALE exposure at each wave to pregnancy event at the subsequent wave. For those women who did not complete wave IV, data were drawn from the latest available wave. Interviewers first asked respondents if they had ever been pregnant, including all current or past pregnancies that ended in live birth, abortion, stillbirth, miscarriage, or ectopic/tubal pregnancy. Respondents who had experienced at least one pregnancy were then asked a series of questions regarding timing (month and year), outcome, and intendedness of the pregnancy(ies). Intendedness was assessed by a dichotomous yes/no answer to "thinking back to the time just before this pregnancy with [Partner], did you want to have children then?" Women who responded no to this question were categorized as having an unintended pregnancy. Five pregnancies in our sample were impacted by a slight wording change in wave II, where an additional

Table 2
Adverse Life Experiences, by Wave.

	Wave 1 (N = 8810) Weighted %	Wave 2 (N = 6697) Weighted %	Wave 3 (N = 7232) (Weighted %)	Wave 4 (N = 7528) Weighted %
Death of a parent	0.7	0.6	0.2	1.3
Suicide attempt resulting in injury	1.2	0.8	0.7	0.4
Friend or relative committed suicide	4.5	4.7	3.5	2.4
Saw violence	8.5	5.3	2.4	5.9
Threatened by knife or gun	6.2	4.9	2.4	4.4
Was shot or stabbed	2.8	1.9	0.5	2.6
Was jumped	5.4	3.9	1.5	2.6
Threatened someone with a knife or gun	2.0	2.0	0.3	1.2
Shot or stabbed someone	0.7	0.6	0.1	0.7
Was injured in a physical fight	5.1	2.6	1.8	Not asked
Hurt someone in a physical fight	10.4	4.3	1.9	0.4
Had a child adopted	0.0	0.0	0.1	0.0
Death of a child	0.0	0.0	0.4	0.4
Romantic relationship ended	26.4	0.8	28.7	13.1
Non-romantic sexual relationship ended	2.7	2.7	Not asked	Not asked
Had sex for money	0.7	1.7	1.8	0.8
Contracted a STD	2.0	3.0	12.0	13.5
Skipped necessary medical care	19.2	19.3	21.5	24.4
Juvenile conviction	0.2	0.2	0.0	Not asked
Adult conviction	0.1	0.1	1.6	1.0
Served time in jail	0.8	0.8	3.2	7.6
Was expelled from school	1.7	0.9	Not asked	Not asked
Suffered a serious injury	11.3	10.6	Not asked	9.8
Parent received welfare	10.1	9.6	Not asked	Not asked
Was raped	6.5	2.2	1.8	0.8
Ran away from home	8.9	7.1	Not asked	Not asked
Suffered verbal abuse in romantic relationship	Not asked	14.2	Not asked	Not asked
Suffered physical abuse in romantic relationship	Not asked	5.3	17.9	12.9
Suffered verbal abuse in non-romantic sexual relationship	Not asked	1.2	Not asked	Not asked
Suffered physical abuse in non-romantic sexual relationship	Not asked	0.5	Not asked	Not asked
Evicted from residence or cut off service	Not asked	Not asked	5.1	5.7
Entered full time active military duty	Not asked	Not asked	0.0	0.0
Discharged from the armed forces	Not asked	Not asked	0.3	0.1
Cohabitation dissolution	Not asked	Not asked	8.1	3.4
Received welfare	Not asked	Not asked	10.4	Not asked
Involuntarily dropped from welfare	Not asked	Not asked	0.7	Not asked
Marriage dissolution	Not asked	Not asked	1.1	2.2
Death of romantic partner	Not asked	Not asked	0.3	Not asked
Death of spouse	Not asked	Not asked	0.0	0.0
Lost job	Not asked	Not asked	Not asked	2.3
ALE index, sum				
Mean (SD)	1.5 (1.8)	1.3 (1.7)	1.3 (1.5)	1.3 (1.6)
Min	0	0.0	0	0
Max	16.25	15.0	14.5	11.8
Missing	32	11.0	262	159
ALE index, standardized				
Mean (SD)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)
Min	−0.8	−0.7	−0.8	−0.8
Max	8.5	8.1	8.5	6.6
Missing	32	11	262	159

N at Wave 1 = 8810. N's for subsequent Waves reflect loss to follow up at each Wave. Proportions are calculated based on N for the respective Wave. Full versions of the specific individual items reflected above are publicly available on the Add Health website interactive codebook page and our full working data dictionary for this analysis and larger project in the form of a large excel file is available to researchers interested in the topic upon request.

option of "neither wanted nor did not want" was categorized as unintended. Women whose first pregnancy was intended or who never had a pregnancy were included in the reference group.

2.1.3. Sociodemographic covariates

We selected specific sociodemographic, health and reproductive history covariates based on our previous work (K. S. Hall, Richards, et al., 2017). Some sociodemographic indicators were measured at a single time point while others were treated as time-varying. Wave I data were used for self-reported race/ethnicity, parental income, birthplace, receipt of public assistance, parental education, residence, religion, religious service attendance, and self-rated health status. Data on age at first sexual encounter and total number of sexual partners were measured from the last wave at which women reported this information. Time varying covariates were age, educational attainment, and relationship status.

2.2. Statistical analysis

For each wave, we calculated the mean ALE index score as well as the proportions of women with scores 1–2 SD and > = 2 SD above the mean. We also calculated the number of pregnancies, any and unintended, over the study period. We used unadjusted bivariate statistics to compare sample characteristics between ALE exposure groups and between those who experienced a first unintended pregnancy and those who did not experience a first unintended pregnancy (i.e., had a first pregnancy that was intended or never had a pregnancy).

Using multivariable Cox proportional hazard models, we estimated

the association between ALE scores at wave X and time to unintended first pregnancy at wave X + 1, censoring women after their first pregnancy (i.e. we did not examine multiple pregnancies) or at the end of the observation period for never-pregnant women. We utilized person-months since entry into the Add Health study as the time scale. Variables in the bivariate analyses with a p-value of 0.25 or less were included as covariates in the regression models. Utilizing a step-wise approach, we first modeled the unadjusted association between ALE index score and unintended first pregnancy, then added socio-demographic and health variables, and finally sexual history variables. We present fully adjusted models controlling given that the estimated effects of ALE exposures on unintended pregnancy appeared stable across all models.

We then stratified models by race/ethnicity, parental income level at wave I, and age at which first pregnancy occurred (< 20 years, 20–24 years, > 24 years). In a series of sensitivity analyses, we ran models testing the different thresholds for ALE exposure. We also repeated our modeling approach including only women who completed all waves of data. Results were similar, so we present the results including all women with at least one additional completed wave of data in order to maximize sample size.

We present exponentiated coefficients from regression models as adjusted hazard ratios (HRs) and corresponding 95% confidence intervals (CIs). Two-tailed alphas of $p < 0.05^{*}$, $p < 0.01^{**}$, and $p < 0.001^{***}$ were considered significant. All data were analyzed using SAS 9.4 (Cary, North Carolina) and SUDAAN 11.0 (Research Triangle Institute, Research Triangle Park, North Carolina).

3. Results

Sociodemographic characteristics of the sample are presented in Table 1. Mean ALE scores were 1.45 (standard error of mean [SE] = 0.05) in wave I, 1.24 (SE = 0.04) in wave II, and 1.29 (SE = 0.03) in wave III. The weighted proportions of women with ALE scores at least 1 SD above the mean were 12.8% in wave I, 14.1% in wave II, and 15.0% in wave III. Weighted proportions of women experiencing specific ALEs by wave are presented in Table 2. During the study period, 5118 (57.1%) women had at least one pregnancy and 2737 (30.4%) had an unintended first pregnancy.

In unadjusted analyses, proportions of women with an elevated ALE index score at wave 1 (> = 2 SD above mean) were higher for those who had experienced an unintended pregnancy than compared to those who had not (8.3% vs. 4.3%, $p < 0.001$). All sociodemographic and reproductive characteristics were associated with wave I ALE scores (p-values < 0.01)(not shown). In general, higher ALE scores were noted among racial/ethnic minority, lower income, less educated, and urban women and those with poorer self-reported health status, compared to their counterparts.

Rates of unintended first pregnancy were higher among women with higher ALE scores (by all indicators and across all waves) compared to those with lower scores. For example, 55.6% of women at wave III with ALE score > 2 SD above the mean reported an unintended pregnancy versus 32.1% of women with lower ALE scores. All sociodemographic and reproductive characteristics, except birthplace, were associated with unintended pregnancy (p-values < 0.001)(not shown), with rates generally higher among racial/ethnic minority, lower income, less educated, and urban women and those with poorer self-reported health status, compared to their counterparts.

In adjusted hazard models (Table 3), women with higher ALE scores were more likely to experience an unintended first pregnancy compared to women with lower ALE scores (by all indicators). For example, each SD increase in ALE score was associated with an 11% increase in the risk of unintended first pregnancy (HR = 1.11, 95% CI: 1.04–1.17, $p < 0.01$). The risk of unintended pregnancy for women with ALE scores > 2 SD above the mean was 1.41 times that of women with ALE scores < 1 SD above the mean (HR = 1.41, 95% CI 1.14–1.76, $p < 0.01$).

In stratified models (Table 4), varying trends in associations between ALE scores and risk of unintended pregnancy were found across demographic groups and according to specific ALE indicator. For example, all indicators were associated with unintended pregnancy for White women, whereas a 1 SD increase in ALE score or having an ALE score 1–2 SD above mean (but not > 2 SD, compared with < 1 SD) were associated with unintended pregnancy for Black women. In income-stratified models, ALE scores were associated with unintended pregnancy for women at the lowest ($0–19,999) and highest ($ > 75,000) income levels (1 SD increase: HR 1.21, 95% CI: 1.03–1.23, $p < 0.01$ and HR 1.36, 95% CI: 1.12–1.66, $p < 0.01$, respectively). However, some differences were noted across indicators. The unintended pregnancy risk associated with an ALE score > 2 SD above the mean compared with < 1 SD was strongest for women in highest income group, but was not significant for women at lowest income level. Interaction terms for ALE-by-race/ethnicity and ALE-by-income level were not significant (p-values > 0.20). Finally, in age-stratified models, elevated ALE scores (all indicators) were associated with unintended pregnancy for women 20–24 years and > 24 years (1 SD increase: HR 1.13, 95% CI: 1.04–1.24, $p < 0.01$; HR 1.25, 95% CI: 1.06–1.47, $p < 0.01$, respectively), but not for < 20 years. The ALE-by-age interaction term was significant ($p < 0.001$); though, its inclusion in models did not alter primary ALE effects.

4. Discussion

Increased exposure to ALEs during childhood and adolescence was associated with an increased risk of unintended first pregnancy among young women in this large U.S. cohort study. There were clear and consistent ALE effects across the different levels of exposure on the overall sample's pregnancy risk. These findings are consistent with prior research to suggest a role of psychosocial stress in shaping family planning outcomes (Chen, Stiffman, Cheng, & Dore, 1997; Hall et al., 2014; Hall, Kusunoki, et al., 2015; Hall, Richards, et al., 2017; Hall et al., 2012; Maness, Buhi, Daley, Baldwin, & Kromrey, 2016; Takahashi et al., 2012). A few older studies have found ALEs, mostly in the form of abuse, to influence risky sexual behaviors and markers of unintended pregnancy (e.g. abortion, early childbearing/parenthood) (Dietz et al., 1999; Hillis et al., 2004; Steinberg & Finer, 2011). An analysis of data from 9159 adult women in the CDC-Kaiser ACE study found that the proportions of those who reported experiencing a teen pregnancy increased in a graded fashion with exposure to increasing numbers of ACEs (Hillis et al., 2004). In other analyses, psychological and physical abuse was associated with increased risk (odds ratios 1.4 and 1.5 respectively) of an unintended first pregnancy among adult women (Dietz et al., 1999); for males, each ACE exposure was associated with an increased risk of impregnating a female partner during adolescence (odds ratios range 1.2–1.8) (Anda et al., 2002).

We build upon that literature to more robustly measure the social context of stress as it relates to unintended pregnancy risk across adolescence and young adulthood. We comprehensively analyzed 40 different ALEs, ranging from physical/emotional/sexual violence, economic hardship, discrimination, injury, death, legal trouble, school trouble, suicide, to disrupted family/social networks. Other strengths included the large demographically diverse national sample; detailed pregnancy history calendar data enabling us to estimate time to *first* pregnancy and establishing a temporal order of ALE exposure and pregnancy outcomes; robust measurement of 15 different known confounders; and the 15-year longitudinal design permitting a life course and chronic stress approach to developmentally-relevant ALEs across childhood, adolescence, and early adulthood. The results from our age-stratified models may suggest that cumulative effects of ALE exposure are more salient for unintended pregnancy risk as age increases with the entry into adulthood. Indeed, ALE exposure may have implications for young women's immediate health and wellbeing, but also for their

Table 3
Hazard Models Estimating the Effect of Adverse Life Experiences on the Risk of Unintended First Pregnancy.

	Model 1			Model 2		
	Standardized ALE Index			Moderate/Severe ALE Exposure		
	HR[a]	(95% CI)	p	HR[b]	(95% CI)	p
1 SD increase in ALE index (continuous)	1.11	(1.04, 1.17)	< .01**			
1–2 SD above mean (vs. < 1 SD)				1.41	(1.14, 1.76)	< .01**
> =2 SD above mean (vs. < 1 SD)				1.43	(1.15, 1.77)	< .01**
Mean age in years	0.98	(0.95, 1.02)	0.33	0.98	(0.95, 1.02)	0.23
Race/ethnicity						
Hispanic	1.21	(0.93, 1.57)	0.15	1.21	(0.93, 1.57)	0.15
Black or African American	1.60	(1.33, 1.92)	< .001***	1.60	(1.33, 1.93)	< .001***
Asian	1.58	(1.10, 2.28)	0.01*	1.59	(1.10, 2.28)	0.01*
Other	1.14	(0.74, 1.75)	0.56	1.10	(0.71, 1.71)	0.68
White	1.00	(Reference)		1.00	(Reference)	
Adolescent's educational attainment						
Less than high school	1.04	(0.61, 1.78)	0.87	1.03	(0.61, 1.75)	0.91
Completed high school	1.11	(0.68, 1.81)	0.68	1.10	(0.68, 1.79)	0.70
Some college	1.53	(0.96, 2.42)	0.07	1.52	(0.96, 2.41)	0.07
Bachelor's degree or higher	1.00	(Reference)		1.00	(Reference)	
Parents' highest educational attainment						
Less than high school	1.44	(1.12, 1.83)	< .01**	1.43	(1.12, 1.83)	< .01**
High school diploma, vocational/technical, or GED	1.33	(1.08, 1.63)	< .01**	1.32	(1.07, 1.62)	< .01**
Some college or business/trade school after HS	1.28	(1.07, 1.52)	< .01**	1.27	(1.07, 1.51)	< .01**
Graduated from college/university or more	1.00	(Reference)		1.00	(Reference)	
Parental income						
0 to $19,999	1.22	(0.93, 1.60)	0.14	1.22	(0.94, 1.60)	0.14
$20,000 to $49,999	1.28	(1.02, 1.61)	0.04*	1.28	(1.02, 1.61)	0.04*
$50,000 to $74,999	1.12	(0.89, 1.41)	0.34	1.12	(0.89, 1.41)	0.35
$75,000 or higher	1.00	(Reference)				
Received welfare or public assistance						
Yes	1.01	(0.86, 1.20)	0.87	1.01	(0.86, 1.19)	0.90
No	1.00	(Reference)		1.00	(Reference)	
Childhood family structure						
Two biological parents	1.00	(Reference)		1.00	(Reference)	
Other	1.22	(1.06, 1.40)	< .01**	1.22	(1.06, 1.40)	< .01**
Geography of residence						
Rural	0.94	(0.79, 1.11)	0.45	0.94	(0.79, 1.12)	0.49
Suburban	0.93	(0.79, 1.09)	0.35	0.93	(0.79, 1.09)	0.38
Urban	1.00	(Reference)		1.00	(Reference)	
Other	0.80	(0.42, 1.55)	0.51	0.81	(0.42, 1.56)	0.53
Religious denomination						
Baptist	0.91	(0.75, 1.09)	0.29	0.91	(0.76, 1.09)	0.30
Mainline Protestant	1.00	(Reference)		1.00	(Reference)	
Catholic	0.90	(0.74, 1.08)	0.26	0.90	(0.74, 1.09)	0.27
Other Christian Affiliation	1.22	(0.98, 1.53)	0.08	1.22	(0.98, 1.53)	0.08
Religious non-Christian	0.79	(0.52, 1.19)	0.26	0.80	(0.53, 1.21)	0.28
None	0.79	(0.64, 0.99)	0.04*	0.80	(0.64, 1.00)	0.05*
Frequency of religious service attendance						
Once a week or more	1.00	(Reference)		1.00	(Reference)	
Once a month or more, but less than once a week	1.19	(1.01, 1.40)	0.04*	1.19	(1.01, 1.40)	0.04*
Less than once a month	1.07	(0.89, 1.28)	0.49	1.06	(0.89, 1.27)	0.49
Never	1.15	(0.92, 1.43)	0.22	1.13	(0.91, 1.41)	0.27
Self-rated health status at Wave 1						
Excellent or very good	1.00	(Reference)		1.00	(Reference)	
Good, fair, or poor	1.12	(0.97, 1.29)	0.13	1.12	(0.98, 1.29)	0.10
Relationship status (time-varying)						
Married or previously married	1.00	(Reference)		1.00	(Reference)	
In a relationship	2.41	(1.59, 3.67)	< .001***	2.42	(1.59, 3.68)	< .001***
Single/no reported relationship	2.09	(1.34, 3.25)	< .01**	2.08	(1.34, 3.24)	< .01**
Age at first sexual intercourse						
< 15 years	1.33	(1.15, 1.54)	< .001***	1.33	(1.15, 1.54)	< .001***
15–18 years	1.00	(Reference)		1.00	(Reference)	
> 18 years	0.49	(0.38, 0.62)	< .001***	0.48	(0.38, 0.62)	< .001***
Total number of sexual partners						
< 2 partners	0.68	(0.50, 0.93)	0.02*	0.68	(0.50, 0.92)	0.01*
2–5 partners	1.00	(Reference)		1.00	(Reference)	
6–10 partners	1.36	(1.15, 1.61)	< .001***	1.36	(1.15, 1.60)	< .001***

(*continued on next page*)

Table 3 (*continued*)

	Model 1			Model 2		
	Standardized ALE Index			Moderate/Severe ALE Exposure		
	HR[a]	(95% CI)	p	HR[b]	(95% CI)	p
> 10 partners	1.44	(1.23, 1.67)	< .001***	1.43	(1.23, 1.67)	< .001***

NOTES: N = 5551 women who were not missing any data on exposure, outcome, and covariates (see Table 1). All models adjusted for sociodemographic covariates (age [time-varying], educational attainment [time-varying], parents' highest educational attainment, parental income, receipt of welfare or public assistance, household structure, geography of residence, religious denomination, frequency of religious service attendance, self-rated health status) and sexual/reproductive health covariates (age at first sexual intercourse, total number of sexual partners, and relationship status [time-varying]). [a]Hazard ratio estimates the association between a 1-standard deviation increase in continuous standardized adverse life experiences index and unintended first pregnancy. [b]Hazard ratio estimates the association between each category of elevated adverse life experiences index (1–2 SD above mean, ≥ 2 SD above mean compared with < 1 SD above mean) and unintended first pregnancy.

longer-term reproductive health outcomes.

We also found that varying levels of ALE scores appeared to relate to unintended pregnancy risk differently for different sociodemographic groups of women, such that for some increasingly high exposure levels placed them at risk for pregnancy (e.g. White and high-income women) whereas small increases in ALE exposures or lower levels that plateaued were riskiest for other groups (e.g. Black and low-income women). Additionally, ALEs were not significantly associated with unintended pregnancy risk for the groups of women who experience the highest rates of unintended pregnancy overall (e.g. women at the lowest income level). Further, effect sizes were at times largest for our Asian subsample – perhaps the most understudied racial/ethnic group in regards to toxic stress and reproductive health. While stress threshold effects have not been tested to explain racial/ethnic differences in reproductive health outcomes, other studies examining adult diabetes and risk of cardiovascular disease in childhood have pointed to potential threshold effects (Dowd, Palermo, & Aiello, 2012; Huffhines, Noser, & Patton, 2016). Reasons for these potential threshold effects and disparities across groups, especially the most under-studied ones, are not clear. We did not account for psychosocial buffers of stress, such as resilience, coping, social support, and other protective factors known to ameliorate the effects of ALEs on specific health outcomes (e.g. depression, chronic disease, health risk behaviors) (Centers for Disease Control and Prevention, 2016; Shonkoff et al., 2012). Few, if any, family planning studies have concurrently considered the harmful and protective factors that may interact to either contribute to or prevent toxic stress, unintended pregnancy, and reproductive health disparities. In the CDC-Kaiser ACE study, Hillis et al. (2010) found that when childhood abuse and household dysfunction were present, the odds of adolescent pregnancy demonstrated an increasingly protective effect as the numbers of childhood family strengths increased (OR declined from 1 to 0.54); sociodemographic differences were not examined.

Alternatively, perhaps ALEs do not contribute additional or unique pregnancy risk beyond the many other risk factors faced by the most socially disadvantaged women. In our related work on depression and pregnancy, we draw upon a common risk factors model and social ecological framework, arguing for consideration of the multitude of concurrent risk factors relevant to social context, health inequities, and reproductive health (Hall, Richards, et al., 2017). While we accounted for 15 different potential confounders here, we could not control for all possible individual, systems, community and macro exposures known to contribute to adverse reproductive health outcomes and inequities during adolescence and young adulthood. Future studies using multilevel, intersectional frameworks, comprehensive bio-psycho-social measures, and diverse samples and settings are needed to disentangle whether, how, and why some groups of women may be more vulnerable to different levels of stress exposure and what that means for their reproductive health.

Our simple additive index approach, as tested and applied by others interested in toxic stress and health outcomes, may not have included an exhaustive list of all potentially relevant Add Health items, nor did it account for different ALEs categories, which would have been beyond the focus of this particular paper (Boardman & Alexander, 2011). Notably, some very specific types of traditionally measured adverse childhood experiences, for instance, parent/caregiver abuse and neglect or household dysfunction or parental substance abuse, were not evaluated or considered here in our scale. This important omission has implications for comparisons of research findings across different studies measuring and operationalizing ALEs in diverse ways. Additionally, we are unable to comment on whether some exposures, for instance financial-, emotional-, trauma- or partner-related ALEs, matter more or less for unintended pregnancy risk. We are, however, continuing to examine types and dimensions of different ALEs as they relate to different conceptualizations and measurement of stress and its social context in our ongoing analyses of these data and perinatal outcomes. Additionally, not all ALEs explored here, for instance marriage dissolution or adoption, are necessarily experienced adversely by all adolescents and young adults. The varying valuations of different life events as potentially stressful or not during adolescence and young adulthood requires further investigation. Moreover, little research has focused on specific types of ALEs beyond abuse in regards to reproductive health, with recent studies mostly investigating intimate partner violence as a contributor to adverse contraceptive and pregnancy experiences (Decker et al., 2017). Additionally, we did not examine acute psychological stress or chronic stress biomarkers, though we are exploring various bio-psycho-social stress indicators in ongoing work.

There is likely bias in the retrospectively self-reported pregnancy estimates in Add Health, perhaps even differentially for women with greater ALE exposures. Unintended pregnancy items do not adequately distinguish between pregnancy intentions, mistiming, unwantedness, or ambivalence. Additionally, although Add Health recommends the Wave IV pregnancy table as the most accurate source of reproductive history information, there remains the potential for misclassification bias across Waves. Finally, missing parental income data reduced our sample sizes for income-stratified models; thus, findings may not be fully representative of adolescents with unknown or lower incomes.

Despite limitations, our findings have implications for research, practice, and policy. In uncovering the prevalence of sexual and other types of violence recently, the World Health Organization and public health institutions have recommended trauma-informed approaches (Amin, MacMillan, & Garcia-Moreno, 2018; Ko et al., 2008; Lucio & Nelson, 2016; Martin et al., 2017). A few studies have examined the integration of trauma-informed care, including ALE screening, evidence-based treatments, education and resources provision, and referral systems, into family planning clinic settings (Decker et al., 2017) and school-based teen pregnancy prevention programs (Martin et al., 2017). Integrated care models hold promise for simultaneously addressing social context, mental health, and family planning but will benefit from further evaluation for their effectiveness and

Table 4
Models Estimating Effect of Adverse Life Experiences on Risk of Unintended First Pregnancy, Stratified by Race/Ethnicity, and Parental Income Level.

RACE/ETHNICITY	Hispanic			Black or African American			Asian			Other			White		
	(N = 843)			(N = 1148)			(N = 275)			(N = 141)			(N = 3144)		
	HR	(95% CI)	p	HR	(95% CI)	p	HR	(95% CI)	p	HR	(95% CI)	p	HR	(95% CI)	p
1 SD increase in ALE index	1.01	(0.87, 1.19)	0.86	1.12	(1.01, 1.25)	0.03*	1.69	(1.26, 2.26)	< .001***	1.21	(0.74, 1.98)	0.45	1.12	(1.03, 1.22)	< .01**
1–2 SD above mean (vs. < 1 SD)	1.47	(0.85, 2.56)	0.17	1.46	(1.03, 2.07)	0.03*	1.99	(0.56, 7.05)	0.28	4.67	(1.41, 15.46)	0.01*	1.36	(1.01, 1.84)	0.05*
> = 2 SD above mean (vs. < 1 SD)	1.27	(0.62, 2.63)	0.51	1.32	(0.92, 1.90)	0.14	3.61	(1.35, 9.65)	0.01*	0.96	(0.23, 3.95)	0.95	1.71	(1.22, 2.39)	< .01**
PARENTAL INCOME	**$0 to $19,999 (N = 1170)**			**$20,000 to $49,999 (N = 2299)**			**$50,000 to $74,999 (N = 1270)**			**$75,000 or higher (N = 812)**					
	HR	(95% CI)	p	HR	(95% CI)	p	HR	(95% CI)	p	HR	(95% CI)	p			
1 SD increase in ALE index	1.21	(1.03, 1.23)	< .01**	1.06	(0.97, 1.16)	0.21	1.11	(0.94, 1.30)	0.22	1.36	(1.12, 1.66)	< .01**			
1–2 SD above mean (vs. < 1 SD)	1.44	(1.04, 2.00)	0.03*	1.25	(0.93, 1.67)	0.13	1.29	(0.81, 2.06)	0.27	1.93	(0.97, 3.80)	0.06			
> = 2 SD above mean (vs. < 1 SD)	1.38	(0.98, 1.94)	0.07	1.42	(0.93, 2.16)	0.1	1.52	(0.81, 2.86)	0.19	3.38	(1.70, 6.74)	< .01**			
AGE AT FIRST UNINTENDED PREGNANCY	**< 20 years (N = 5546)**			**20–24 years (N = 4288)**			**> 24 years (N = 2600)**								
	HR	(95% CI)	p	HR	(95% CI)	p	HR	(95% CI)	p						
1 SD increase in ALE index	1.03	(0.95, 1.12)	0.47	1.13	(1.04, 1.24)	< .01**	1.25	(1.06, 1.47)	< .01**						
1–2 SD above mean (vs. < 1 SD)	1.19	(0.85, 1.66)	0.31	1.43	(1.04, 1.96)	0.03*	2.22	(1.19, 4.12)	0.01*						
> = 2 SD above mean (vs. < 1 SD)	1.15	(0.83, 1.60)	0.39	1.64	(1.11, 2.42)	0.01*	2.36	(1.22, 4.55)	0.01*						

NOTES: N = 5552 women who were not missing any data on exposure, outcome, and covariates (see Table 1). All models adjusted for sociodemographic covariates (age [time-varying], educational attainment [time-varying], parents' highest educational attainment, parental income, receipt of welfare or public assistance, household structure, geography of residence, religious denomination, frequency of religious service attendance, self-rated health status) and sexual/reproductive health covariates (age at first sexual intercourse, total number of sexual partners, and relationship status [time-varying]). [a]Analyses based on 817 women with unwanted pregnancies that occurred < 20 years old compared with 4729 women who either did not have a pregnancy or had a wanted pregnancy and entered the Add Health study before their 20th birthday. [b]Analyses based on 789 women with unwanted pregnancies that occurred at 20–24 years old compared with 3499 women who either did not have a pregnancy or had a wanted pregnancy and remained in the Add Health study beyond their 20th birthday. [c]Analyses based on 218 women with unwanted pregnancies that occurred at > 24 years old compared with 2382 women who either did not have a pregnancy or had a wanted pregnancy and remained in the Add Health study beyond their 25th birthday. ALE = adverse life experiences.

implementation feasibility in reproductive health contexts (Hall, Patton, Crissman, Zochowski, & Dalton, 2015). Unintended pregnancy carries significant health and social consequences itself, especially for younger, poor and minority women (Finer & Henshaw, 2006; Gipson, Koenig, & Hindin, 2008), and whether it can be conceptualized as a unique ALE or social stressor, and how that may compound the cumulative effects of other toxic stressors across the life course is in need of study (Hall, Dalton, et al., 2017). Similarly, other multi-level public health interventions could harness techniques like motivational interviewing, perhaps in school, clinic, community- or even web-based settings, to promote social support, relationship enhancement, resilience, and coping for individuals, families, and communities most at-risk for the reproductive health consequences of stress (Chmitorz et al., 2018; Ortiz & Sibinga, 2017; Sypniewski, 2016). Finally, the upstream effects of macrosocial interventions like policy on the stress process, and subsequently on mental and reproductive health outcomes, also requires study. Legislation designed to assure healthcare access, economic security, educational attainment, environmental safety, and civil rights may surely target the root causes of ALEs, toxic stress, *and* reproductive health disparities to improve overall health and wellbeing for all groups of women in the U.S. (Boyd-Swan, Herbst, Ifcher, & Zarghamee, 2016; Komro, Livingston, Markowitz, & Wagenaar, 2016; Markowitz, Komro, Livingston, Lenhart, & Wagenaar, 2017; Tefft, 2011).

Disclosures

We have no relevant disclosures or conflicts of interest to report.

Funding

This work was supported by National Institute of Child Health and Human Development grants #K01HD080722-01A1 (KSH) and # T32HD052460 (JLR).

Acknowledgements

This research uses data from Add Health, a program project directed by Kathleen Mullan Harris and designed by J. Richard Udry, Peter S. Bearman, and Kathleen Mullan Harris at the University of North Carolina at Chapel Hill, and funded by grant P01-HD31921 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development, with cooperative funding from 23 other federal agencies and foundations. Information on how to obtain the Add Health data files is available on the Add Health website (http://www.cpc.unc.edu/addhealth).

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