



Double Jeopardy: Young adult mental and physical health outcomes following conception via genocidal rape during the 1994 genocide against the Tutsi in Rwanda

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ABSTRACT

Rwandans conceived by rape during the 1994 genocide against the Tutsi have endured a violent beginning and a troubled childhood. Given compelling evidence of the influence of prenatal environments and adverse childhood experiences (ACEs) on future health, these individuals are at high risk of poor mental and physical health outcomes. The purpose of the study was to characterize mental and physical health outcomes in young adults who were exposed prenatally to maternal stress due to the genocide in general and those conceived by genocidal rape, and to determine whether ACEs compound these effects.

Ninety-one 24-year-old Rwandans – 30 conceived by genocidal rape, 31 born of genocide survivors not raped, and a control group of 30 born of women with neither exposure – completed the Adverse Childhood Experiences International Questionnaire and measures of multiple physical and mental health characteristics. Data were collected from March 7 to April 6, 2019.

Findings demonstrated that 1) individuals conceived during the genocide had poorer mental function ($p = 0.002$) and higher scores in post-traumatic stress disorder (PTSD), anxiety, depression, physical function, pain intensity, and sleep disturbance compared to young adults who were not exposed to genocide (all $p < 0.033$); 2) individuals conceived by genocidal rape reported more depression, PTSD, and pain interference compared to those prenatally exposed to maternal genocide stress only (all $p < 0.008$); and 3) among the group conceived via genocidal rape, the effects of prenatal exposures on depression, physical function, pain intensity and pain interference were exacerbated by ACEs (all $p < 0.041$).

Being conceived during genocide, especially through genocidal rape, is associated with poor adult physical and mental health. The role of ACEs in exacerbating prenatal genocide exposure highlights opportunities for interventions to reduce these effects.

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1. Introduction

In 1994, Rwandans endured one of the most cataclysmic genocides in human history with more than 1,000,000 lives lost in 100 days (Munyandamutsa et al., 2012; Rudahindwa et al., 2020). The genocide against the Tutsi was a result of decades of ethnic tensions and conflict between the Tutsi minority and the Hutu majority, ethnic groups constructed by European colonialists (National Unity and Reconciliation Commission, 2016; Nowrojee, 1996). Rape was used systematically as a weapon of war (Sharlach, 2000); approximately 350,000 women were raped by extremist Hutu (Bijleveld et al., 2009; Nowrojee, 1996). The genocide against the Tutsi has had profound effects on humanity that go beyond its primary victims to include the children that were born as a result. While the exact number is unknown, it is estimated that between 2,000 and 10,000 individuals, now aged 25–26 years old, were conceived via genocidal rape (Bijleveld et al., 2009; Nowrojee, 1996).

Throughout their lives, these young adults are burdened by their origin story. The process of discovering their birth origins is complex and painful for both young adults and their mothers; the mother and the child in some cases require a third party to facilitate the process. Abuse, discrimination, and stigma from their families and communities are not an uncommon experience for affected individuals (Uwizeye et al., n.d.). Given the compelling evidence of the influence of early life adverse experiences on subsequent health outcomes (Gluckman and Hanson, 2006; Mulligan et al., 2012) these young adults may be at elevated risk for mental and physical stress-related chronic diseases. However, the extent to which the experience of being conceived during genocide, and the added burden of being conceived through genocidal rape, influences adult mental and physical health has not been previously explored.

Adverse early life events for these young adults began before, during, and after conception (periconception), when their mothers were undergoing the exceptionally stressful experience of genocide and, for some, rape (Mukamana and Brysiewicz, 2008; Nowrojee, 1996). Exposure to extreme stress, lack of adequate prenatal care, and poor nutrition throughout gestation can affect fetal development, including reducing fetal growth rate and shortening gestation length (Kuzawa and Sweet, 2009). Postnatal exposure to stress from lack of adequate mother-child attachment, abandonment, various forms of abuse, parental poverty, and lack of access to essential health care and food further increase hardship in infancy and early childhood (Godard and Ukeye, 2012; Muhayisa et al., 2016; Mukamana and Brysiewicz, 2008). Research shows that exposure to stress during these critical and sensitive periods can have long lasting adverse effects on health outcomes (Berens et al., 2017; Rääkkönen and Pesonen, 2009; Wadhwa, 2005).

Stressful experiences continue throughout childhood and even into adulthood for the young adults born of genocidal rape. Stressful experiences include abuse, stigma, discrimination, fear, shame, guilt, poverty, lack of parental care, and lack of access to available opportunities, such as education, which may be exacerbated by low socioeconomic status (Godard and Ukeye, 2012; Nowrojee, 1996). There is compelling evidence showing that adverse childhood experiences (ACEs) are associated with multiple negative health conditions in adulthood including cardiovascular and autoimmune diseases, obesity, depression, and anxiety (Kalmakis and Chandler, 2015; Thayer et al., 2017). Prenatal stress- and ACEs-induced changes to stress regulation systems could represent a potential mechanism linking these early life exposures with adverse mental and physical health outcomes in adulthood (Wadhwa, 2005).

Studies among genocide survivors, their children, and other individuals with experiences of violent and life-threatening events reveal that the vast majority remain healthy and functioning (Bonanno, 2004; Munyandamutsa et al., 2012). This indicates that despite experiencing adversity, many individuals are able to preserve wellbeing and move forward; a characteristic or process known as resilience (Panter-Brick, 2014; Southwick et al., 2014). Resilience is dynamic, modifiable, and can improve with tailored interventions (Malhi et al., 2019; Southwick

et al., 2014). Resilience has not been investigated in the children conceived by genocidal rape so it is unknown to what extent resilience mitigates the impact of both prenatal stress exposures and subsequent ACEs in this population.

The purpose of this study was to evaluate the relationship between a range of adult mental and physical health outcomes, and extreme maternal stress related to genocide and rape, and to determine how exposures to cumulative stressors throughout the young adults' childhood may have exacerbated vulnerability to poor mental and physical health outcomes. We evaluated multiple measures of both mental and physical health because our goal was to demonstrate the wide-ranging impacts of these exposures. Our hypotheses were that: (1) Rwandan adults who were conceived during the genocide have an elevated risk for adverse mental and physical health outcomes associated with exposure to extreme stress at conception and throughout their life; (2) adults conceived by genocidal rape have more adverse childhoods as a result of their identities, as measured by ACEs scores; (3) ACEs are associated with poorer health outcomes; and (4) ACEs moderate the effect of prenatal genocide exposures such that within exposure groups, the more adverse the childhood the worse the adult health outcomes.

2. Methods

2.1. Design and sample

A comparative cross-sectional design was used. We enrolled Rwandan women and men, aged 24 years, categorized in three groups: (1) conceived by genocidal rape (double-exposed: prenatal exposure to maternal stress related to genocide and genocidal rape), (2) born of genocide survivors not raped (single-exposed: prenatal exposure to maternal stress related to genocide only), and (3) conceived at the time of the genocide but whose Rwandan mothers were living outside of the country (unexposed to either maternal stress related to genocidal rape or genocide alone). Participants were deemed to have been conceived during the genocide by backdating from their birth date to the period of the genocide: April 7 to July 4, 1994.

Participants were recruited from Rwandan organizations that provide services related to the aftermath of the genocide. A convenience sampling method was used to recruit initial participants, through the Solidarity for the Development of Widows and Orphans to Promote Self-Sufficiency and Livelihoods, known as SEVOTA, an organization that offers support to widows and orphans including individuals born to genocidal rape survivors. For the age- and sex-matched individuals born of genocide survivors who were not raped, the initial recruitment was done through the Association of Genocide Widows Agahozo, known as AVEGA Agahozo, an association that supports genocide survivors and their children. Snowball sampling was used to recruit other individuals born of genocide survivors who might not be supported by either of the two organizations. The unexposed group was recruited in the same geographic locations using snowball methods and came from Rwandan families who left Rwanda and returned after the genocide. Many Tutsi families left Rwanda before the 1994 genocide against the Tutsi for various reasons, including prior political unrest (e.g., in 1959, 1963 and 1973), and socio-economic opportunities (National Unity and Reconciliation Commission, 2016; Nikuze, 2014). None of the participants in the unexposed group came from a family that left the country because of the 1994 genocide against the Tutsi. An extensive screening interview was conducted before being assigned to a study group to confirm participants' birth origins in relation to genocide and rape. Validation of the participants' prenatal exposure to stress related to genocide or genocidal rape also occurred through their response to the study questionnaires. Participants were excluded if they were conceived before or after the genocide, or had physical or cognitive limitations that would have prevented study completion. Data were collected from March 7 to April 6, 2019.

2.2. Data collection procedure

Study approvals were obtained from the Institutional Review Boards of the University of Illinois at Chicago (UIC: 2018–1497), and the University of Rwanda (UR No 063/CMHS IRB/2019). The first participants in both exposure groups were recruited from SEVOTA and AVEGA. Participants were provided with information on the purpose of the study and the nature of participation and were assessed for eligibility by the first author (GU), a female Rwandan nurse with expertise in mental health. Individuals who agreed to participate provided written informed consent prior to completing the study instruments and having anthropometrics measured. Each participant was invited to recommend age- and sex-matched Rwandans who fell in any of the three groups. Data were collected by the principal investigator in a private room and were entered into the Research Electronic Data Capture (REDCap) program. Data collection was conducted in Kinyarwanda and lasted 60–75 min.

2.3. Measures

2.3.1. Demographic and socioeconomic information

Data collected included: date of birth, sex, geographic location, marital status, the person(s) who raised the participant, family structure during the time of interview, level of education, current employment, and income using both individual monthly earnings and the national household socioeconomic status categories.

2.3.2. Exposure to genocide or genocidal rape

A categorical variable for levels of exposure to prenatal maternal genocide and/or rape related stress was created based on participant birth circumstance: Group 1, conceived by genocidal rape (double-exposed: prenatal exposure to maternal stress related to genocide and genocidal rape); Group 2, born of genocide survivors not raped (single-exposed: prenatal exposure to maternal stress related to genocide only; and Group 3, conceived at the time of the genocide but to a Rwandan mother living out of the country (unexposed to either maternal stress related to genocidal rape or genocide alone). This was the main independent variable of the study.

2.3.3. Adverse Childhood Experiences International Questionnaire (ACEs IQ)

The instrument was developed by the World Health Organization (WHO) (World Health Organization, 2018) to measure adverse childhood experiences up to the age of 18 years. The 43-item scale was developed based on the USA Adverse Childhood Experience survey (ACEs) that has been validated and used in numerous studies including a study conducted in Nigeria (Kazeem, 2015). The questionnaire consists of 13 constructs: emotional abuse; physical abuse; sexual abuse; violence against household members; living with household members who were substance abusers; living with household members who were mentally ill or suicidal; living with household members who were imprisoned; one or no parents, parental separation or divorce; emotional neglect; physical neglect; bullying; community violence; and collective violence. Each item is assigned a score of 1 if the event was experienced and 0 if it was not, thus the total score ranges from 0 to 13. The scale was selected because the items were closely related to the lived experience reported in qualitative studies among children born following the 1994 genocide against Tutsi in Rwanda, including emotional and physical neglect and abuse, family environment, peer and community violence (Uwizeye et al., n.d.). The Adverse Childhood Experiences International Questionnaire was translated into Kinyarwanda by Rwandan professional translators fluent in Kinyarwanda and English. G.U., who is fluent in Kinyarwanda and English, verified the translation and piloted the scale among Rwandan young adults who had similar characteristics as those included in the study. The Kinyarwanda version of the scale was reviewed and approved by the University of Rwanda Institutional Review Board. This measure had acceptable internal consistency within

our sample (Cronbach's alpha (α) = 0.70).

2.3.4. Medical outcomes study questionnaire short form 36 (SF-36)

The instrument contains 36 items that measure self-reported physical and mental health dimensions. There are eight subscales, four of which measure mental health function (mental component summary [MCS]) including vitality (VT), social functioning (SF), role-emotional (RE), and mental health (MH) and four of which measure physical health function (physical component summary [PCS]) including physical functioning (PF), bodily pain (BP), general health perceptions (GHP), and physical role functioning (PRF). The raw item numeric values are recoded to a 0–100 point scale. Each subscale score can range from 0 (worst state) to 100 (best state). The validity and reliability have been established (McHorney et al., 1993) and the instrument has been used previously in Rwanda (Munyandamutsa et al., 2012). This measure had good internal consistency within our sample (α = 0.81).

2.3.5. Checklist-civilian Version-5 (The PCL-5)

The PCL-5 was used to measure post-traumatic stress disorder (PTSD). The instrument is a 20-item checklist of PTSD symptoms based on DSM-V criteria. Each item is rated on a 5-point Likert type scale reflecting severity of symptoms ranging from “not at all” (0) to “extremely” (4). The PCL-5 symptom questions refer to stressful experiences in the past 4-weeks and is not specific to any event. The total scores range from 0 to 80. A score above 33 points on the PTSD scale indicates clinical PTSD and the need for psychiatric treatment (Bovin et al., 2016). The scale has been widely used, including in studies conducted in Rwanda, and has sound psychometric properties (Perroud et al., 2014; Ruggiero et al., 2003). This measure had high internal consistency within our sample (α = 0.95).

2.3.6. PROMIS-29 V 2.0

The instrument measures anxiety, depression, fatigue, sleep disturbance, satisfaction with social role, pain interference (i.e., the degree to which pain interferes with daily functions), and pain intensity. Each item is scored on a 5-point Likert type scale (e.g. 1 = not at all, 2 = a little bit, 3 = somewhat, 4 = quite a bit, 5 = very much) except pain intensity which is measured on a scale of 0–10. Higher scores indicate poorer health function. The scale has been used widely and has strong psychometric properties (Liu et al., 2010; Rothrock et al., 2010). The scale has been translated and used in another study conducted by co-authors (Buursm et al., n.d.). The Kinyarwanda scale was reviewed and approved by the University of Rwanda Institutional Review Board in both studies. This measure had good internal consistency within our sample (α = 0.83).

2.3.7. Connor-Davidson resilience scale 25 (CD-risc-25)

The CD-RISC-25 is a 25-item scale that measures resilience. Each item is rated on a 5-point Likert type scale ranging from (0) “not true at all” to (4) “true nearly all the time”. The total scores can range from 0 to 100, with higher scores reflecting greater resilience. The scale has adequate psychometric properties, has been used in many populations, and has been translated into Kinyarwanda (Davidson, 2015). This measure had high internal consistency within our sample (α = 0.90).

2.3.8. Anthropometry

Height, weight, waist, hip circumferences, and skinfold thicknesses were measured. Data were collected using a stadiometer for height in meters (m), digital scale for body weight in kilograms (kg), measuring tapes for waist and hip circumferences in centimeters (cm); and digital calipers to measure skinfold thicknesses in millimeters (mm). Height, waist, and hip circumferences were measured to the nearest half cm, weight measured to the nearest 1/10 kg, and skinfold thicknesses to the nearest half mm.

2.4. Data analyses

Data were exported from REDcap to STATA/IC14.2 for statistical analysis. Descriptive statistics were calculated to summarize the participant characteristics and health outcome values. Chi-squared tests were used to determine the differences in the demographic data among the three groups. We conducted normality tests (skewness/kurtosis and histograms) for continuous variables.

To determine health outcomes in relation to different categories of prenatal exposure to maternal stress related to genocidal rape and genocide only exposure we compared: 1) the unexposed and single-exposed groups to estimate the effect of prenatal exposure to maternal stress related to genocide only; 2) the single- and double-exposed groups to estimate the added burden of prenatal exposure to maternal stress related to rape on genocide; and 3) the unexposed and double-exposed groups to estimate the combined effect. We conducted bivariate regression analysis to evaluate group differences in each health outcome. Linear regression was applied to ACEs, sleep, resilience, weight, height, and waist/hip ratio variables with normal distributions. Skewed outcome distributions (truncated normal distribution) were detected in physical and mental component summaries of the SF-36 scale, PTSD, anxiety, fatigue, BMI, triceps and subscapular skinfold thicknesses measures; Tobit regression was applied to address this distribution (Tobin, 1958). Non-normal heteroscedasticity with outliers was detected for depression, pain intensity, and pain interference. A quantile regression model (non-parametric and robust regression model) was adopted for these analyses (Koenker and Bassett, 1978). Non-parametric Spearman's rank correlation was applied for association of non-normal variables.

Where there were group differences, a Spearman's rank correlation test was performed to assess the association between the health outcome and the ACEs score. ACEs have been found to be strong and independent predictors of stress-related health conditions (Petruccioli et al., 2019), hence we tested their interaction with exposure to genocide in predicting health outcomes. Multiple linear regression analysis was performed with interaction terms of ACEs and exposure groups controlling for sex, marital status, level of education, type of work, and resilience. Past and present family structure were also included in analyses. Past structure was assessed by asking the identity of the person(s) who raised the participant. Present structure ("living or known to be alive family member") was assessed as a binary (yes/no) by presenting a list of relatives (e.g., "mother," "father," "grandmother," etc.). These characteristics have been reported in previous studies as factors influencing the quality of health outcomes in populations affected by genocide (Munyandamutsa et al., 2012). Our sample size was sufficient to achieve 80% power to detect mean differences between groups with a minimum effect size of $r = 0.4$, and a $p < 0.05$.

3. Results

A total of 91 Rwandans, 46 women (50.5%) and 45 men (49.5%), participated. Participants were 24 years old, born between December 13, 1994 and March 30, 1995. Participants were categorized into three groups: (1) 30 participants conceived by genocidal rape (double-exposed); (2) 31 age- and sex-matched participants born of genocide survivors not raped (single-exposed); and (3) 30 age- and sex-matched participants conceived at the time of the genocide but whose Rwandan mothers were living outside of the country (unexposed). All 91 participants completed the study and were included in the analyses.

3.1. Participant characteristics

Sociodemographic characteristics of the sample are presented in Table 1. The groups differed in family structures. Both single- and double-exposed participants were more likely to have been raised solely by a mother compared to unexposed participants. None of the

participants was married during the time of interview. Double-exposed individuals attained the lowest levels of education compared to single and unexposed individuals, and both double- and single-exposed individuals had lower levels of employment than those who were unexposed. Double- and single-exposed participants were more likely to be in lower socioeconomic categories than unexposed. Double-exposed participants were in slightly lower socioeconomic categories compared to single-exposed. Only double-exposed and unexposed individuals had significant differences in resilience with significantly lower resilience scores among double-exposed compared to unexposed individuals ($\beta = -0.324$, $p = 0.007$, Table 2).

3.2. Exposure to prenatal genocide or genocidal rape stress and health outcomes

The three groups differed significantly in several mental health outcomes (Table 2). Single-exposed participants fared significantly worse than unexposed in mental function ($B = -15.14$; $p = 0.002$), post-traumatic stress disorder (PTSD) ($B = 12.68$, $p = 0.008$), anxiety ($B = 11.56$, $p = 0.002$), and depression ($B = 8.00$, $p = 0.001$). Double-exposed participants scored even worse than single-exposed in depression ($B = 8.00$, $p = 0.001$) and PTSD ($B = 12.68$, $p = 0.008$). Double-exposed participants more than double the level of clinical PTSD than did single-exposed participants, but the difference did not reach statistical significance (36.67% vs. 16.13%, $X^2(1) = 3.32$, $p = 0.07$).

There were also differences in physical health outcomes. Single-exposed participants fared significantly worse than unexposed in physical function ($B = -11.84$, $p = 0.010$), pain intensity ($B = 3.00$, $p = 0.033$), and sleep ($\beta = 0.39$, $p = 0.001$). Double-exposed participants had lower scores than single-exposed ($B = 14.00$, $p < 0.001$) and unexposed ($B = 14.00$, $p < 0.001$) participants in pain interference. Double-exposed participants also scored significantly lower than unexposed on fatigue ($B = 6.17$, $p = 0.011$). There was only one anthropometric measure that differed significantly: double-exposed participants were significantly shorter than unexposed ($\beta = 0.25$, $p = 0.045$) but did not differ in height from single-exposed.

3.3. Adverse childhood experiences

There were significant differences in ACEs scores according to prenatal exposure category (Fig. 1). Double-exposed individuals had the highest ACEs score (mean: 7.20, SD: 2.12) when compared to single-exposed (mean: 5.74, SD 2.45) and unexposed (mean: 3.87, SD 2.29). ACEs were associated with health outcomes that differed by group with moderate (fatigue $r = 0.34$ and resilience $r = -0.35$) to strong correlations among all variables (PTSD $r = 0.55$, depression $r = 0.56$; mental $r = -0.52$ and physical $r = -0.42$ function, anxiety $r = 0.46$ and sleep $r = 0.49$), with the exception of height.

3.4. Exposure to prenatal rape and/or genocide stress, adverse childhood experience and health outcomes

The results of the moderation models, adjusted for demographic characteristics, demonstrate that the interaction between prenatal exposure to rape and/or genocide related stress and ACEs differed depending on exposure group (Table 3). The difference between unexposed and single-exposed groups in any measured health outcomes was not moderated by ACEs. In contrast, higher ACEs scores moderated the effect of prenatal exposure to genocidal rape related stress on depression, physical function, pain intensity and pain interference, such that the double-exposed group fared worse when compared to the single-exposed group individuals ($B = 2.99$, $p = 0.004$; $B = -4.09$, $p = 0.041$; $B = 1.74$, $p < 0.001$; $B = 3.46$, $p = 0.008$; respectively) (Fig. 2). Double-exposed individuals fared worse than unexposed (but not single-exposed) individuals in PTSD with increasing ACEs ($B = 4.28$, $p = 0.035$).

Table 1
Demographic characteristics.

Characteristics	Total				Group difference (Chi-squared)		
		Unexposed ^a N (%)	Single-exposed ^b N (%)	Double-exposed ^c N (%)	Unexposed/Single-exposed	Single/Double-exposed	Unexposed/Double-exposed
Sex					0.900	0.900	1.000
Female	46 (50.55)	15(50)	16(51.61)	15(50)			
Male	45 (49.45)	15 (50)	15 (48.39)	15 (50)			
Marital status					0.157	0.590	0.206
Single	86(94.51)	30 (100)	29 (93.55)	27 (90)			
Married	0	0	0	0			
Committed Relationship	1(1.10)	0	0	1 (3.33)			
Single parent	4 (4.40)	0	2 (6.45)	2 (6.67)			
Province (residence)					0.743	0.768	0.673
Kigali City	60 (65.93)	21 (70.00)	21 (67.74)	18 (60.00)			
East	12 (13.19)	4 (13.33)	3 (9.68)	5 (16.67)			
West	4 (4.40)	1 (3.33)	2 (6.45)	1 (3.33)			
North	1 (3.33)	1 (3.33)	0 (0.00)	0 (0.00)			
South	14 (15.38)	3 (10.00)	5 (16.13)	6 (20.00)			
Family member ^d							
Mother	82 (90.11)	30 (100.00)	23 (74.19)	29 (96.67)	0.003	0.013	0.313
Father	40 (43.96)	27 (90.00)	13 (41.94)	0 (0.00)	<0.001	<0.001	<0.001
Stepfather	12 (12.09)	0 (0.00)	1 (3.23)	10 (33.33)	0.002	0.002	0.001
Sibling(s)	80 (87.91)	30 (100)	26 (83.87)	24 (80.00)	0.032	0.694	0.010
Paternal grandparents	26 (28.57)	20 (66.67)	5 (16.13)	1 (3.33)	<0.001	0.093	<0.001
Maternal grandparents	34 (37.36)	20 (66.67)	6 (19.35)	8 (26.67)	<0.001	0.497	0.002
Raised by							
Both parents	34 (37.36)	22 (76.67)	11 (35.48)	0 (0.00)	0.001	<0.001	<0.001
Mother only	33 (36.26)	4 (13.33)	13 (41.94)	16 (53.33)	0.003	0.900	<0.001
Mother and stepfather	8 (8.79)	0 (0.00)	5 (16.13)	7 (23.33)	0.321	0.020	0.005
Mother and other relative	16 (17.58)	4 (13.33)	0 (0.00)	6 (23.33)	0.758	0.479	0.317
Mother and Other	1 (3.33)	0 (0.00)		1 (3.33)	0.321	0.321	n/A
Level of education completed					0.063	0.017	0.012
Primary education	3 (9.68)	0 (0.00)	3 (9.68)	0 (0.00)			
Some high school	6 (6.59)	0 (0.00)	1 (3.23)	5 (0.00)			
High school	68 (74.73)	25 (83.33)	19 (61.29)	24 (80.00)			
Some post high- school	5 (5.49)	0 (0.00)	4 (12.90)	1 (3.33)			
College	9 (9.89)	5 (16.67)	4 (12.90)	0 (0.00)			
Type of work					0.014	0.960	0.020
Farmer/Trader	5 (8.20)	0 (0.00)	3 (6.45)	2 (6.67)			
Casual worker	17 (18.68)	2 (6.67)	7 (22.58)	8 (26.67)			
Professional/civil servant	8 (8.79)	3 (10.00)	2 (6.45)	3 (10.00)			
Student	54 (59.34)	25 (83.33)	15 (45.16)	14 (46.67)			
Unemployed	7 (7.69)	0 (0.00)	4 (12.90)	3 (10.00)			
Socio-economic categories ^e					0.005	0.075	<0.001
1. Category	8 (8.79)	0 (0.00)	2 (6.45)	6 (20.00)			
2. Category	35 (38.46)	4 (13.33)	14 (48.39)	17 (56.67)			
3. Category	48 (86.67)	26 (86.67)	15 (48.39)	7 (23.33)			
4. Category	0	0	0	0			

Boldface indicates statistical significance with a P value <0.05.

^a Unexposed: not exposed to maternal stress related either to genocidal rape or genocide alone.

^b Single-exposed: prenatal exposure to maternal stress related to genocide only.

^c Double-exposed: prenatal exposure to maternal stress related to genocide and genocidal rape.

^d Family member: family member living with or known to be alive to the participant at the time of interview.

^e Rwandans are classified into four socio-economic categories (Ibyiciro by'Ubudehe) by the Rwandan government based on income/consumption and household assets: Category 1: poorest, Category 2: poor, Category 3: middle class and Category 4: wealthy.

Table 2
Group differences in outcomes according to exposure to genocide or genocidal rape.

Outcomes	Group comparisons					
	Unexposed/ Single-exposed ^a		Single/Double- exposed ^b		Unexposed/ Double- exposed ^d	
	B ^c /β ^d	P	B ^c /β ^d	P	B ^c /β ^d	P
Mental Component ^c	-15.14	0.002	-5.16	0.278	-20.31	< 0.001
PTSD total ^c	12.68	0.008	9.82	0.035	22.50	< 0.001
Anxiety ^c	11.56	0.002	3.53	0.302	15.09	< 0.001
Depression ^c	8.00	0.001	4.90	0.034	12.90	< 0.001
Social Role and activity ^d	-0.19	0.125	-0.05	0.658	-0.24	0.051
Physical Function ^c	-11.84	0.01	-1.64	0.715	-13.48	0.004
Pain intensity ^c	3.00	0.033	1.00	0.472	4.00	0.005
Pain interference ^c	0.00	1	14.00	<	14.00	< 0.001
Fatigue ^c	4.25	0.075	1.93	0.415	6.17	0.011
Resilience ^d	-.203	0.090	-.1229	0.298	-0.324	0.007
Sleep ^d	0.39	0.001	0.06	0.623	0.44	< 0.001
Height ^d	-0.13	0.272	-0.11	0.345	-0.25	0.045
Weight ^d	-0.09	0.489	0.07	0.595	-0.02	0.873
BMI ^c	-0.11	0.909	1.28	0.199	1.17	0.244
Waist/Hip ratio ^d	-0.13	0.282	0.19	0.112	0.06	0.639
Triceps ^c	0.49	0.761	1.43	0.38	0.93	0.569
Subscapular ^c	-0.20	0.869	1.53	0.196	1.34	0.264

Boldface indicates statistical significance with a P value <0.05. Linear regression was applied to sleep, and height variables with normal distributions. Tobit regression was applied to address the skewed outcome distributions (truncated normal distribution) detected in physical function components of the SF-36, PTSD, anxiety and fatigue. A quantile regression model (non-parametric model) was adopted for depression, pain intensity, and pain interference with non-normal heteroscedasticity with outliers.

Unexposed: not exposed to maternal stress related either to genocidal rape or genocide alone; Single-exposed: prenatal exposure to maternal stress related to genocide only; Double-exposed: prenatal exposure to maternal stress related to genocide and genocidal rape..

- ^a Reference group: unexposed.
- ^b Reference group: single-exposed.
- ^c B: Unstandardized coefficient for Tobit or quantile regressions.
- ^d β: standardized coefficient regression.

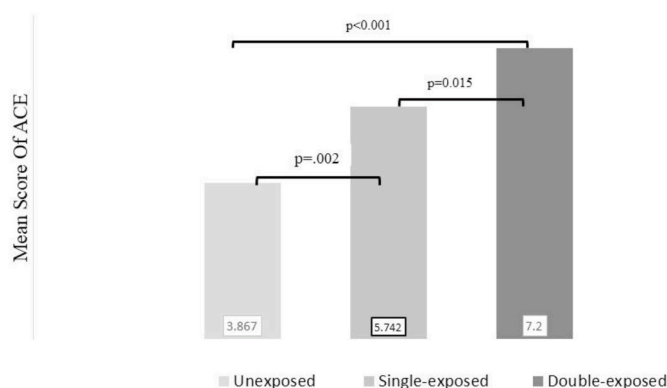


Fig. 1. Group Differences in Adverse Childhood Experiences. Unexposed: not exposed to maternal stress related either to genocidal rape or genocide alone; Single-exposed: prenatal exposure to maternal stress related to genocide only; Double-exposed: prenatal exposure to maternal stress related to genocide and genocidal rape.

Table 3
Interaction between exposure to genocide or genocidal rape and adverse childhood experiences.

Outcomes	Unexposed/ Single-Exposed ^a		Single/Double- Exposed ^b		Unexposed/ Single-Exposed ^a	
	B ^c /β ^d	P Value	B/β	P Value	B/β	P Value
Mental function ^c	-0.52	0.800	-3.43	0.076	-2.91	0.144
PTSD ^c	2.06	0.326	2.22	0.256	4.28	0.035
Anxiety ^c	-3.39	0.040	-0.11	0.936	-3.50	0.027
Depression ^c	0.43	0.682	2.99	0.004	3.42	0.001
Physical Function ^c	-2.98	0.159	-4.09	0.041	-7.07	0.001
Pain Intensity ^c	0.51	0.307	1.74	< 0.001	1.24	0.012
Pain Interference ^c	-.32	0.015	3.46	0.008	3.15	0.018
Fatigue ^c	-1.86	0.104	2.32	0.33	0.45	0.682
Sleep ^d	0.05	0.902	-0.09	0.836	-0.03	0.941
Height ^d	0.11	0.659	0.27	0.389	0.40	0.230

Boldface indicates statistical significance with a P value <0.05. Unexposed: not exposed to maternal stress related either to genocidal rape or genocide alone; Single-exposed: prenatal exposure to maternal stress related to genocide only; Double-exposed: prenatal exposure to maternal stress related to genocide and genocidal rape.

Simultaneous multiple variate linear regression for each outcome with interaction terms of exposure groups and ACEs controlling for sex, marital status, current family structure, the person who raised the participant, level of education, type of work, and resilience.

- ^a Reference group: unexposed.
- ^b Reference group: single-exposed.
- ^c B: Unstandardized coefficient for Tobit or quantile regressions.
- ^d β: standardized coefficient regression.

Simultaneous multiple variate linear regression for each outcome with interaction terms of exposure groups and ACEs controlling for sex, marital status, current family structure, the person who raised the participant, level of education, type of work, and resilience.

4. Discussion

Our findings demonstrated that: 1) Rwandan young adults conceived during the genocide have poorer mental and physical health outcomes compared to sex- and age-matched Rwandan young adults who were not exposed to genocide; 2) Rwandan young adults conceived by genocidal rape had even poorer mental and physical health outcomes when compared to those exposed to maternal stress related to genocide only; 3) exposure to ACEs, which was higher among the single- and double-exposed groups, was associated with poor mental and physical outcomes; and 4) among those conceived by genocidal rape, more adverse childhood experiences were associated with worse adult health.

To our knowledge this is the first study in any population to systematically evaluate adult mental and physical health outcomes of both prenatal exposure to maternal stress related to genocidal rape and the postnatal aftermath. This is the first study, of which we are aware, that looks at physical health outcomes among this population. Given that this is a relatively young, lean, healthy population, it is meaningful that physical health is compromised. We demonstrate compelling evidence that double-exposed young adults consistently exhibited the poorest health outcomes, even when compared to other individuals conceived during the genocide. In our analyses there was a consistent and significant additional risk for those conceived through genocidal rape of greater PTSD, depression, and pain that interferes with daily life. Our findings are consistent with previous studies on the health differences between the children of genocide survivors and those of unexposed women (Mutuyimana et al., 2019; Perroud et al., 2014; Yehuda et al., 1998), including a Rwandan study that reported higher PTSD and depression severity among young adults exposed to genocide during the mother's second or third trimester, compared to an age-matched group of Rwandans who were not exposed (Perroud et al., 2014). In contrast to our study, that study did not take into account the impact of prenatal exposure to maternal stress related to genocidal rape, nor did they include measures of physical health. Women who were raped as part of genocidal strategies to exterminate the Tutsi have reported experiencing

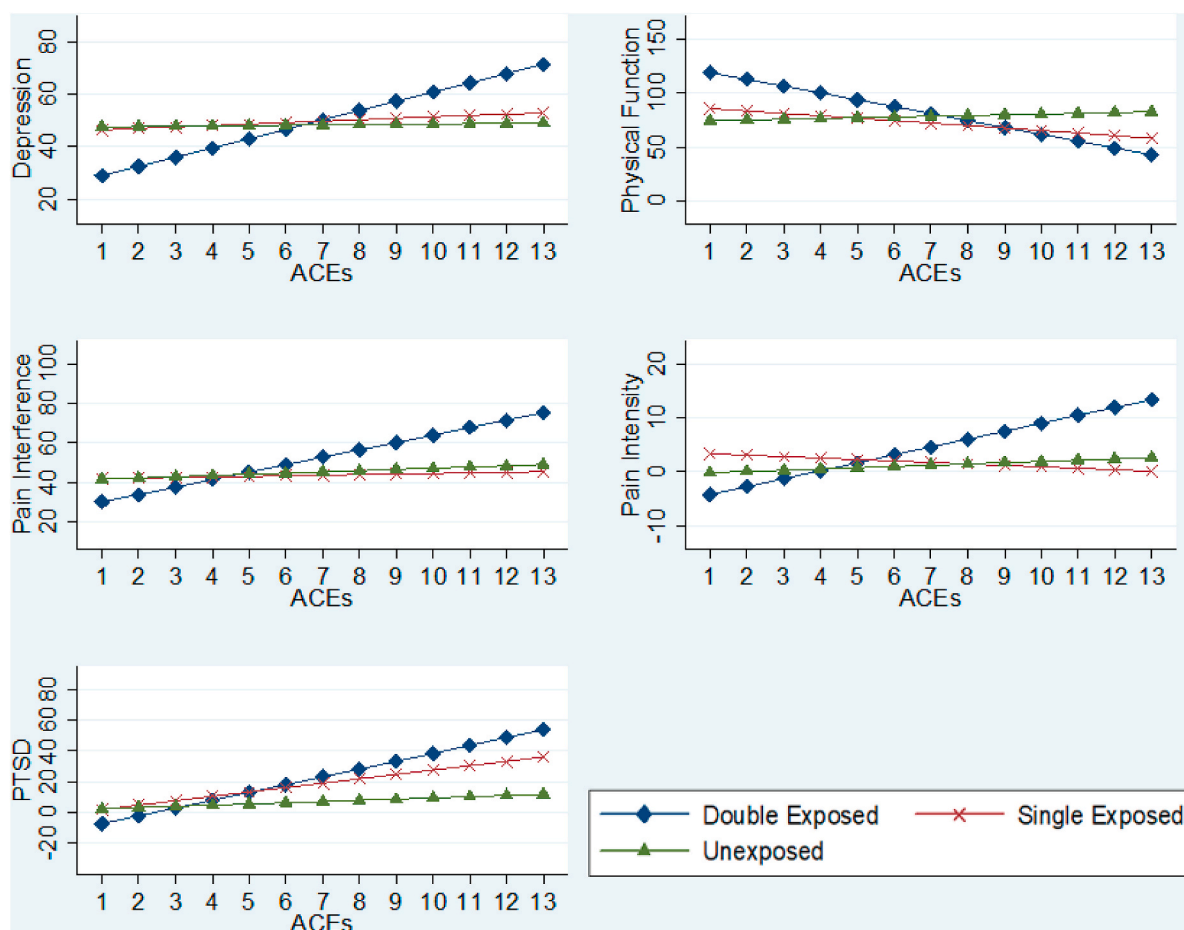


Fig. 2. Interaction effects of exposure to genocide or genocidal rape and adverse childhood experiences on health outcomes.

intense shame and guilt as a result of their rape and subsequent conception (Mukamana and Brysiewicz, 2008; Nowrojee, 1996). It is now well supported that adverse maternal experience is linked to offspring biology and disease outcomes (Kuzawa and Quinn, 2009). Mechanisms through which maternal stress affects the fetus are thought to involve the stress regulatory systems (Mulligan et al., 2012; Ruth-erford, 2012; Sosnowski et al., 2018; Thayer et al., 2018; Wadhwa, 2005).

The finding that the double-exposed group had the highest ACEs scores and that ACEs exacerbates the effect of genocidal rape exposure on health outcomes also suggests the importance of postnatal and childhood events. Our previous work has shown that the children born of genocidal rape report extreme lifelong emotional and mental health challenges due to the stigma of their birth origins, experiencing shame, violence, and discrimination in their families and communities (Uwizeye et al., n.d.). In this study, the vulnerabilities induced by prenatal exposure to genocide or genocidal rape were magnified by adverse childhood experiences, providing a less favorable environment for growth and development and thus elevated risk for a large range of negative mental and physical health outcomes in adulthood. However, it is worth noting from the moderation models that for some in the double-exposed group, health outcomes were comparable or better than those in the other groups when ACEs were low. This makes clear the important role ACEs play in moderating the effect of prenatal exposure on health outcome. Low ACEs suggests a supportive family, peer and community environment where the process of building sufficient levels of resilience can take place. In this study, double-exposed individuals had the lowest levels of resilience, lowest socioeconomic status, and the least family support structure compared to the other groups. It is

possible that those double-exposed individuals with low ACEs were able to achieve a level of resilience that improved their wellbeing, consistent with other theoretical and empirical work (Seery, 2011). These findings add to the debate that suggests that early adversity is not overly determinant of long-term health outcomes but points toward the potential of mitigating the effects of these exposures on health if early and evidence-based interventions are implemented. ACEs may be preventable or modifiable, and resilience can be improved through strength-based interventions that enable individuals to harness resources needed to mitigate the effects of adverse experiences (Betancourt et al., 2011; Malhi et al., 2019; Zraly et al., 2013). This study highlighted the importance of addressing adverse experiences from a life course perspective – accounting for both pre- and postnatal life experience to reduce disparities in non-communicable diseases, particularly in countries affected by genocide, war, and forced displacement.

Our findings are in line with a growing literature suggesting that variations in health outcomes, even within groups with similar exposures, cannot be solely attributable to pre-existing vulnerability related to family genetics; rather, multiple pathways should be explored. Since ACEs and other lived trauma lead to intense, repeated and/or prolonged stress exposures, this can affect health via the prolonged and or repeated activation of the stress response (Thayer et al., 2017). Similarly, prenatal stress exposures may operate along similar physiological pathways, exacerbating the impact of ACEs. In the future, evaluating stress response biomarkers will further elucidate the physiological pathways leading to the adverse health outcomes documented here, and provide insight into those that may emerge as this population ages. We have demonstrated a significantly decreased baseline of physical health in these double-exposed young adults, suggesting that their life trajectory

may be quite different from their unexposed or single-exposed counterparts. Regardless of the pathways, our findings suggest that both prenatal exposures and subsequent life experience interact to affect the physical and mental health of these adult children of women raped during genocide.

The study does have some limitations. We used a retrospective cross-sectional design with potential for recall bias. Our sample is not representative of all the individuals conceived during the genocide since we were able to include only the individuals who survived into adulthood; it is possible early life mortality and morbidity differed across our exposure groups. We conducted an intensive screening interview to ensure only individuals born of genocidal rape were included. However, it is possible that someone could have been conceived via rape, other than genocidal rape, and been unaware or chose to not reveal the circumstances of their birth. While the unexposed group had better socioeconomic status at the time of this study, it was beyond the study scope to establish whether the parents of unexposed participants had better socioeconomic status at the time they left Rwanda (prior to the 1994 genocide) or at the time of conception, both of which could have influenced the current health outcomes and socioeconomic status of their children. Given that most of these “unexposed” individuals were refugees in Rwanda’s neighboring countries, it is possible that their socio-economic and life experience as refugees in those countries were comparable in many respects to those who remained in the country. We found no group differences in anthropometric measures; however, our participants were 24 years old, and very lean.

There are limitations to the generalizability of ACEs constructs in the context of genocide and genocidal rape (Finkelhor, 2018; Kelly-Irving and Delpierre, 2019). Participants reported only the ACEs that they could recall which could have led to underreporting of very early life adversity, especially among those conceived by genocidal rape. In addition, the ACEs-IQ focuses on ACEs in a nuclear family structure, while our previous qualitative study (Uwizeye et al., n.d.) shows that individuals conceived through genocidal rape frequently endured ACEs from extended family and community. Hence, it is possible that the ACEs measures failed to capture the breadth of adverse experiences related to additional familial and community settings, particularly by the double-exposed group. In addition, we measured self-reported resilience at the individual level, which did not capture aspects of resilience at the family and community level. Finally, we collected data in the month before the genocide memorial period “Icyunamo”. While mental health symptoms may be more likely to worsen with the actual memorial events, we cannot rule out effects of the stress of the pre-memorial period on our results.

Despite these limitations, our findings of a significant negative impact of early life exposure to the genocide and being conceived via genocidal rape, and the amplification of those effects by adverse childhood experiences, are remarkable and useful for those working with populations with similar experiences and could inform further studies.

5. Conclusion and implications

Our findings confirm that being conceived during the 1994 genocide against the Tutsi predicts poorer adult physical and mental health. Those who were conceived due to genocidal rape carry additional burdens. The impact of ACEs highlights opportunities for more effective interventions since the effect of childhood trauma from being born of genocidal rape could be mitigated by implementation of timely and well-tailored interventions at the individual, familial, and community levels. Our study adds to the evidence pointing to the importance of life course perspectives in global health efforts aimed at addressing health disparities in non-communicable diseases, particularly in countries affected by genocide, war, and forced displacement. Though the primary prevention of genocide and genocidal rape should be the ultimate goal, our work helps point the way toward supporting the legacy victims of genocide.

Credit author statement

Glorieuse Uwizeye: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review & editing, Visualization, Project administration, Funding acquisition. **Zaneta M. Thayer:** Conceptualization, Methodology, Interpretation of Data, Writing – review & editing Supervisor. **Holli A. DeVon:** Conceptualization, Methodology, Writing – review & editing. **Linda L. McCreary:** Conceptualization, Methodology, Writing – review & editing. **Thomas W McDade:** Conceptualization, Methodology, Interpretation of Data, Writing – review & editing. **Donatilla Mukamana:** Conceptualization, Methodology, Investigation, Writing – review & editing. **Chang Park:** Conceptualization, Methodology, Formal analysis, Interpretation of Data, Visualization Writing – review & editing. **Crystal L. Patil:** Conceptualization, Methodology, Writing – review & editing. **Julienne N. Rutherford:** Conceptualization, Methodology, Interpretation of data, Visualization, Writing – review & editing, Supervision.

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