BRIEF REPORT

Historical Loss: Implications for Health of American Indians in the Blackfeet Community

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Abstract

Background Historical loss in American Indians (AIs) is believed to contribute to high incidence of mental health disorders, yet less is known about the associations between historical loss and physical health.

Purpose To investigate whether frequency of thought about historical loss predicts risk factors for chronic physical health conditions in an AI community.

Methods Using Community Based Participatory research (CBPR) and Ecological Momentary Assessment (EMA), we measured frequency of thoughts about historical loss in 100 AI adults residing on the Blackfeet reservation. Participants completed a 1-week monitoring period, during which ambulatory blood pressure and daily levels of psychological stress were measured. At the end of the week, we collected a dried blood spot sample for measurement of C-reactive protein (CRP).

Results In hierarchical linear regression models controlling for demographics and relevant covariates, greater frequency of thoughts about historical loss predicted higher average daily psychological stress ($B = .55$, $t = 6.47$, $p < .001$, $\Delta R^2 = .30$) and higher levels of CRP ($B = .33$, $t = 3.93$, $p < .001$, $\Delta R^2 = .10$). Using linear mixed modeling with relevant covariates, we found that greater thoughts about historical loss were associated with higher systolic ambulatory blood pressure ($B = .32$, 95% CI = .22–.42, $t = 6.48$, $p < .001$, $\Delta R^2 = .25$; Fig. 1c) and greater diastolic ambulatory blood pressure ($B = .19$, 95% CI = .11–.27, $t = 4.73$, $p < .001$, $\Delta R^2 = .19$).

Conclusions The data suggest that frequency of thought about historical loss may contribute to increased subclinical risk for cardiovascular disease in the Blackfeet community.

Keywords: Historical loss · American Indians · Ambulatory blood pressure · Inflammation · Psychological stress · Ecological Momentary Assessment

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Introduction

In racial and ethnic minority groups, comprehensive reviews report consistent evidence of adverse health effects of discrimination and stress related to cultural identity across both mental and physical health outcomes [1–3]. As a stressor, discrimination is both unpredictable and uncontrollable, characteristics which are thought to amplify the negative consequences of psychological stress for health [4]. The experience of discrimination as a social stress triggers a pattern of physiological responses. For example, prior work in racial and ethnic minority groups indicates a relationship between perceived racism and ambulatory blood pressure patterns [5–8]. These investigations find that perceived racism or discrimination is associated with higher average ambulatory blood pressure, a pattern which is associated with increased risk for cardiovascular disease (CVD) [9, 10]. To date, the relationship between cultural stressors and health-relevant outcomes have not been investigated

in American Indians, a population which is disproportionately affected by CVD compared to Non-Hispanic Whites [11–13].

For over 500 years, American Indians (AIs) have been subjected to various forms of colonization, genocide, and violence imposed by European and American policy [14]. Beginning in 1860, AIs were forcibly estranged from their families and placed in Indian Residential schools, which were designed to impose assimilation and to eradicate the AI way of life [15]. It was not until the passing of the Indian Child Welfare Act in 1978, that AI parents had the legal right to keep their children out of these schools [16]. These traumatic group experiences contribute to historical trauma, which includes cumulative psychological and emotional wounding carried over the lifespan and across generations [14, 17–22]. The Historical Trauma Response (HTR) is described as a collection of responses to these traumas. The HTR can include depression, substance use, suicidal ideation, anger, and difficulties with emotion regulation [21]. As noted previously, historical trauma can be passed across generations [14, 15], and risk factors for poor health may be exacerbated by the HTR [16–18].

Prior research indicates that historical trauma and associated loss of AI culture, language, and land contribute to high incidence of mental health conditions in AI populations [23–26], and while it is posited that historical trauma and these losses may contribute to persistent disparities in AI physical health, the mechanisms which may contribute to this relationship are unknown.

In a previous investigation, narratives from members of a Pacific Northwest tribe indicated that the effects of historical trauma inhibit engagement in protective cardiovascular health behaviors [27]. In line with this, it is possible that the frequency with which AIs think about these losses shapes daily psychological stress, immune system inflammation, and blood pressure, thereby contributing to chronic health disparities.

As noted previously, AIs have disproportionately high incidence of CVD compared to Non-Hispanic Whites [11, 12], and psychological stress, high blood pressure, and chronic immune system inflammation are implicated in risk for CVD [28–30]. As such, these outcomes are important risk factors for AI communities. Based on literature documenting relationships between psychological stress, high blood pressure and immune system inflammation, and heightened risk for CVD [28–30], and building upon documented associations between historical trauma and loss to poor mental health in AIs [14–26], we investigated the relationships between the degree to which AIs think about historical loss and key variables related to CVS risk, including psychological stress, blood pressure and a marker of immune system inflammation.

We investigated these relationships in a sample of AI adults residing on the Blackfeet reservation, located 40 miles south of the Canadian border in Browning, Montana. The Blackfeet tribe is one of the only tribal communities in Montana that remain on their original territory. In 2017, the Blackfeet completed a Community Health Assessment, including incidence of chronic diseases, availability of health services, and measures of substance use. The findings from this assessment indicated that CVD is one of the top health concerns for community members [31], highlighting the importance for an improved understanding of psychosocial factors which may contribute to the observed high incidence of this chronic disease on the reservation. In the present study, we hypothesized that greater frequency of thoughts about historical loss would be associated with risk factors for these chronic diseases including higher perceived psychological stress, greater immune system inflammation, and elevated blood pressure. In order to understand the nature of these relationships in the real-life environments of Blackfeet adults, we utilized Ecological Momentary Assessment (EMA) to capture reports of psychological stress at the end of each day during a week-long-period and measuring blood pressure as Blackfeet adults moved through their daily routines and real-life environments (i.e., ambulatory blood pressure). EMA assesses individual's experiences as they unfold in real-time in their natural environments [32]. While EMA has not been used in an exclusively AI population previously, it has been used in other racial and ethnic groups to capture daily life measures of CVD risk factors including psychological stress and ambulatory blood pressure [33,34].

Methods

This study was approved by the Blackfeet Nation Institutional Review Board and the Montana State University Institutional Review Board. The research utilized community based participatory research (CBPR) methods which emphasizes the importance of equitable involvement of community members and researchers in all stages of the research process [35, 36]. As such, the scope of the research, questionnaires, and measures, were reviewed and approved by a Community Advisory Board (CAB) consisting of four members of the Blackfeet Community. The CAB was also utilized in the interpretation of these findings and decisions about dissemination of these findings to the community. We did not conduct formal a-prior power analysis for this study. Minimum sample size was based on past research using similar methods and linear-mixed models, with general recommendations of 100 participants when collecting three or more time points [37]. Post hoc sensitivity

analyses indicate that our sample size was able to detect a minimum effect size of small to medium size ($f^2 = .08$) assuming $\alpha = .05$ and $1 - \beta = .80$. This effect size is generally smaller than similar studies examining stress, immune functioning, and blood pressure [38, 39].

Using advertisements on various Blackfeet social media sites, we recruited a sample of 100 AI adults ranging from 20 to 78 years of age ($M = 42.30$, SD = 15.08). To be eligible for participation in this research, individuals had to be 18 years or older, self-identify as American Indian, and currently reside on the Blackfeet reservation. Exclusionary criteria for this research included a clinically diagnosed sleep disorder or chronic health condition. In addition, individuals taking any regular prescription medication were not eligible to participate. Participants visited an office located in a building on the Blackfeet Community College campus. They met with the project coordinator and provided written informed consent. After the informed consent process, participants completed a series of questionnaires including demographics, a measure of symptoms of depression and anxiety, and a measure of the frequency of thoughts about historical loss.

Next, the project coordinator recorded participants' weight and height and obtained a dried blood spot sample. The project coordinator then set each participant up for a week-long monitoring period. First, the project coordinator installed the Illumivu EMA application on participants' mobile devices. The project coordinator used the Illumivu EMA software on the office computer to schedule alerts to be delivered to participants at set times to prompt them to complete surveys on their phone and initialize devices. All of the data provided through the app on their mobile device were stored on the app until the participants returned to the office for their final visit. During this final visit, the project coordinator downloaded the data from the participants' Illumivu app onto a password-protected computer. Subsequently, the data were downloaded into an excel file before being converted to an SPSS file for statistical analyses. The project coordinator also initialized a home blood pressure monitor which participants wore during waking hours for 3 days of the monitoring period. For these 3 days, the Illumivu app was programmed to prompt participants to activate the ambulatory blood pressure cuff four times per day to record a measure of ambulatory systolic and diastolic blood pressure.

Measures

Historical Loss

We used the Historical Loss Scale (HLS), [14] a standardized measure that assesses the frequency with which Indigenous individuals think about the losses to their culture, land and people as a result of European colonization. The HLS includes 12 items. Participants are asked to indicate the frequency with which they think about the described losses. Participants provide their response using a 6-point scale, anchored by (1) several times a day and (6) never. Each response is reverse-scored and a composite score is calculated as the sum of each of these responses. Previous work indicates that the 12 items can be adequately explained by a single latent factor (1). Cronbach's alpha for the HLS was 0.75.

Psychological Stress

We used the psychological stress subscale from the Depression, Anxiety, and Stress Scale-21 items (DASS-21) [40]. The stress subscale contains seven items and participants were asked to indicate the degree to which the statements applied to them over the course of each day. Example items from the scale are "I found it hard to wind down," and "I tended to over-react to situations." At the end of each day of the seven-day monitoring period, participants responded on a scale from 0 to 3 (0: Did not apply to me at all; 1: Applied to me to some degree or some of the time; 2: Applied to me to a considerable degree or a good part of the time; 3: Applied to me very much or most of the time). Responses to each of the seven items were summed and the total score was multiplied by 2 according to the scale instructions. Cronbach's alpha for the stress subscale of the DASS-21 was 0.78.

Immune System Inflammation

C-reactive protein (CRP) was assessed via dried blood spots (DBS). DBS are collected using a relatively noninvasive procedure that has been well validated against standard methods for whole blood collected via venipuncture [41, 42]. Blood spots were collected at the end of the week-long monitoring period. Briefly, participants' fingers were cleaned with alcohol and subsequently punctured with a sterile, disposable microlancet commonly used by diabetic patients. Five drops of capillary blood were collected onto standardized filter paper, and blood spot samples were covered and dried overnight. After 24 hr, the DBS were transferred to a −20 °C freezer until later analyses. DBS samples were assayed for CRP using a high-sensitivity enzyme-linked immunosorbent assay [33]. All samples were run in duplicate, and intra- and inter-assay coefficients of variation were 6.7% and 8.9% respectively.

Ambulatory Blood Pressure

Ambulatory blood pressure, which is measured across the day as individuals move through their regular routines, has been shown to be a better predictor of cardiovascular morbidity and mortality risk compared to clinic measures of resting blood pressure [43–45]. Ambulatory blood pressure was recorded using the Qardio Arm Blood pressure device, a home blood pressure monitor. The accuracy of self-measured blood pressure with the Qardio arm device was evaluated using the European Society of Hypertension (ESH) protocol [46] and compared to a criterion device the Omron M3 Intellisense in a sample of 100 participants across two measurement sessions [47]. This work found that the Qardio arm device displayed consistent readings both within and across sessions, and that the measurements corresponded closely to those from the previously validated criterion device, the Omron M3. The Qardio Arm passed all validation standards set by the ESH protocol. We used the Illumivu EMA application to deliver messages to participants to activate the cuff at four evenly spaced intervals across each day of monitoring. Specifically, participants were prompted by the Illumivu app on their phone to initialize the Qardio device to take a reading at 10 AM, 1 PM, 4 PM, and 7 PM Participants were instructed to sit down with their legs uncrossed before obtaining each recording during their initial meeting with the project coordinator, and were given these instructions each time the Illumivu application prompted them to obtain a blood pressure recording. If participants successfully recorded all four of the blood pressure readings, this provided a total of 12 measurements of ambulatory blood pressure across the 3-day period. During the initial in-lab visit, the project coordinator provided an extensive training focused on using the Qardio arm device to record blood pressure measurements. Upon returning to the office to meet with the project coordinator 1 week after initial appointment, the project coordinator downloaded all of the recorded blood pressures to a computer. Each recording included a measurement of systolic and diastolic blood pressure.

Covariates

Biological sex, age, and annual income, and symptoms of depression and anxiety were utilized as covariates in all analyses given known relationships between these variables and each of our outcomes [48–51]. In addition to these covariates, body mass index (BMI) and alcohol use were included as covariates in our models predicting a marker of immune system inflammation and ambulatory blood pressure given their documented relationships with our outcomes as well as with CVD risk [52–55].

Demographic Variables

Participants self-reported their biological sex and age and their annual income. Annual income was measured on a scale from 1 (below US$20,000), 2 (US$20,000–$40,000), 3(US$40,001–$60,000), 4(US$60,001–$80,000), 5(US$80,001–$100,000) and 6 (US$100,001 and above) [56].

Body Mass Index

The project coordinator measured participant weight using a scale and participant height using a stadiometer.

Symptoms of Depression and Anxiety

We used the Hospital Anxiety and Depression Scale (HADS) as a measure of current symptoms of depression and anxiety during the initial office visit [57]. HADS has 14 items, 7 items comprise a depression subscale, and 7 items comprise an anxiety subscale. Individuals respond to each item using a four-point response category (0–3), with possible scores ranging from 0–21 for depression and 0–21 for anxiety. Cronbach's alpha was 0.85 for the anxiety subscale and 0.88 for the depression subscale.

Alcohol Use

We used the Alcohol Use Disorders Identification Test (AUDIT) [58] to measure alcohol consumption, drinking behaviors and alcohol-related problems. The scale consists of 10 questions. Example questions from this scale include, "How often do you have a drink containing alcohol?" with the response options of *never* (0), *monthly or less* (1), *two to four times a month* (2)*, two to three times a week* (3), and *four or more times a week* (4) and, "How often during the last year have you found you were not able to stop drinking once you started?" with the response options of *never* (0), *less than monthly* (1), *monthly* (2), *weekly* (3), and *daily or almost daily* (4). Cronbach's alpha for the scale was .63.

Data Analyses

Statistical analyses were conducted using SPSS (version 24; IBM, Armonk, NY) and R (version 4.0.3) [59]. Our analytic sample includes 100 Blackfeet adults. Continuous covariates were centered with z-scores before being used in analyses. Participant sex was coded as male = 1 and female = 2. Initial Pearson product–moment correlation analyses were performed to determine bivariate relationships between historical loss, psychological stress, levels of CRP, and average ambulatory

blood pressure. We then examined the distribution of historical loss, and found that it was not highly skewed. Natural log transformations were applied to CRP levels to correct their positively skewed distributions.

We also calculated a measure of ambulatory blood pressure load (i.e., the proportion of blood pressure readings that were above normal ranges). For this measure, we used cutoffs provided by the American Heart Association [60], with systolic blood pressure readings below 120 considered normal, and diastolic blood pressure readings below 80 considered normal.

Next, we used two hierarchical linear regressions to examine i) the relationship between historical loss and psychological stress, and ii) the relationship between historical loss and levels of CRP. Ambulatory blood pressure was measured four times a day for 3 days, resulting in twelve total measurement points. Linear mixed-models using the lme4 package [61] were therefore used to examine the relationship between historical loss and ambulatory blood pressure while accounting for the dependency introduced by repeated measures by specifying participant as a random-effect. Two models were estimated with systolic and diastolic blood pressure specified as dependent variables and historical loss specified as the primary independent variable. All models accounted for age, sex, annual income, alcohol use, BMI, anxiety symptoms, depressive symptoms as covariates based on past research [48–51]. Confidence intervals were calculated using bootstrapping and indicate that the population coefficients will be found in 95% of the 10,000 sampled confidence intervals.

Missing Data

Several efforts were taken to minimize missing data. Participants were provided with extensive training regarding ambulatory blood pressure readings and were sent a message through the Illumivu App at the exact time they were supposed to take the blood pressure reading in order to ensure protocol compliance. Upon completion of the study, three participants were missing one or more ambulatory blood pressure readings. There was no other missing data in this study.

Results

The sample was 53% female. The mean historical loss score was 40.26. (SD = 16.12). Descriptive statistics are listed in Table 1 and bivariate correlations for the main variables of interest and covariates are listed in Table 2. Historical Loss was not significantly related to any of our demographic variables (age, gender, annual income) or alcohol use ($r < .09$, $p > .35$).

Blood Pressure Load

A total of 17 participants had systolic blood pressure under 120 and 30 participants had diastolic blood pressure under 80. There were a total of 1,200 blood pressure measures across people and time. Of these measurements, $n = 1018$ (84.83%) were higher than 120 for systolic blood pressure and $n = 981$ (81.75%) were higher than 80 for diastolic blood pressure.

Historical Loss and Psychological Stress

In a hierarchical linear regression controlling for age, sex, income, and depressive symptoms, and symptoms of anxiety, reported frequency of thoughts about historical loss was a significant predictor of average psychological stress over the week-long monitoring period ($B = .55$, $t = 6.47$, $p < .001$, $\Delta R^2 = .30$, 95% CI [0.19,0.35]; Fig. 1a), with individuals who reported thinking more about historical loss reporting more psychological stress (see Table 3a for full regression model).

Historical Loss and CRP

In a hierarchical linear regression controlling for age, sex, annual income, depressive symptoms, symptoms of anxiety, alcohol use, and body mass index, reported frequency of thoughts about historical loss was a significant predictor of levels of log-transformed CRP ($B = .33$, $t = 3.93$, $p < .001$, $\Delta R^2 = .10$, 95 % CI [0.01,0.02]; Fig. 1b), with individuals who reported thinking more about historical loss having higher levels of CRP (see Table 3b for full regression model).

Historical Loss and Ambulatory Blood Pressure

Two linear-mixed models controlling for age, sex, income, depressive symptoms, anxiety symptoms, alcohol use, and body mass index, were estimated to examine associations between frequency of thoughts about historical loss and systolic and diastolic blood pressure. After accounting for covariates, greater thoughts about historical loss were associated with higher systolic ambulatory blood pressure ($B = .32$, 95% CI = .22–.42, $t = 6.48$, $p < .001$, $\Delta R^2 = .25$; Fig. 1c) and greater diastolic ambulatory blood pressure ($B = .19$, 95% CI = .11–.27, $t = 4.73$, $p < .001$, $\Delta R^2 = .19$; Fig. 1d) (See Table 3c for full regression models).
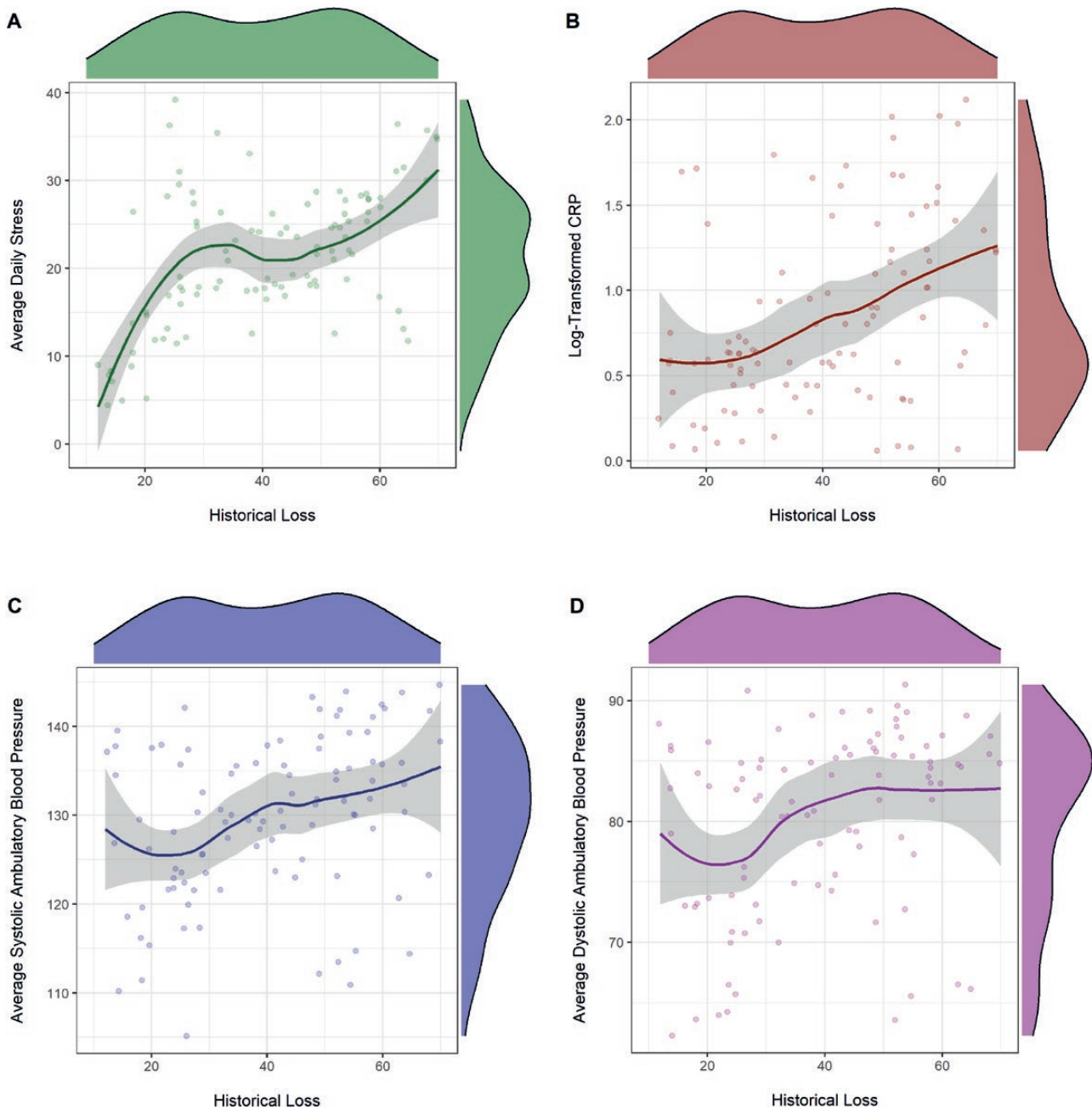
Figure 1. Associations between historical loss and indicators of stress. (a) Association between historical loss and average daily stress. (b) Association between historical loss and CRP. (c) Association between historical loss and systolic ambulatory blood pressure. (d) Association between historical loss and diastolic ambulatory blood pressure.

Discussion

To the best of our knowledge, this is the first investigation to examine the association between historical loss and key psychological and biological risk factors for CVD in an AI community with high incidence of CVD. Our preliminary findings provide initial evidence that frequency of thoughts about historical loss may act as an important predictor of psychological stress, levels of a marker of immune system inflammation, and levels of ambulatory blood pressure, all outcomes which are

implicated in CVD. Blackfeet adults who thought more frequently about historical loss (e.g., loss of language, land and traditions), reported higher levels of psychological stress in their daily lives, had higher levels of CRP, and had higher average ambulatory systolic and diastolic blood pressure over a week long period. This psychological and physiological profile is associated with greater risk for CVD [28–30].

It is important to note that this sample was comprised of individuals who were free from clinically diagnosed chronic disease. As a result, the purpose of this

Table 1. Means, Standard Deviations, and Correlations

Variable	M	SD	1	2	3	4	5	6	7	8	9	10	11
1. Age	42.30	15.08											
2. Gender	n/a	n/a	.13										
3. Income	1.10	1.16	.02	−.13									
4. Dep. Symp.	9.67	4.49	.01	.13	.10								
5. Anxiety Symp.													
6. Body Mass Index	31.37	5.94	.10	.02	.04	.04							
7. Alcohol use													
6. Historical Loss	40.26	16.12	.07	.10	.05	.11		.09					
7. Av. Psych. Stress	21.21	7.89	−.07	−.04	−.01	.18		.04		.52**			
8. C-Reactive Protein	2.56	1.47	−.05	.10	.15	.24**		.20*		.40**	.10		
9. Av. Amb. Sys. BP	129.65	8.95	.09	.01	−.11	−.01		.12		.33**	.26**	.02	
10. Av. Amb. Dia. BP	80.17	7.54	.06	−.01	−.13	−.15		.12		.31**	.23**	.05	.64**

Note. M and SD are used to represent mean and standard deviation, respectively. * *p* < .05. ** *p* < .01. *Symp.* Symptoms; *Av.* average; *Amb.* ambulatory; *Sys* systolic; *Dia.* diastolic; BP Blood pressure.

Table 2. Correlations Between Main Variables of Interest and Covariates

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Age												
2. Gender	.12											
3. Income	.01	−.15										
4. Dep. Symp.	−.001	.14	.13									
5. Anxiety Symp.	.12	.04	.07	.59**								
6. Body Mass Index	−.15	−.03	−.03	−.02	−.10							
7. Alcohol use	.18	.05	−.04	.24**	.13*	.18*						
8. Historical Loss	.10	.10	.01	.11	.05	.15	.10*					
9. Av. Psych. Stress	−.07	−.04	−.04	−.19	.15	.11	.16*	.52**				
10. C-Reactive Protein	−.05	.11	.14	.24**	.10	.47**	.02	.40**	.10			
11. Av. Amb. Sys. BP	.04	.12	.10	.12	.10	.04	−.05	.57**	.23*	.44**		
12. Av. Amb. Dia. BP	.05	.08	.05	.12	.11	.15	−.06	.50**	.14	.39**	.74**	

Note. M and SD are used to represent mean and standard deviation, respectively. * *p* < .05. ** *p* < .01. *Symp.* Symptoms; *Av.* average; *Amb.* ambulatory; *Sys* systolic; *Dia.* diastolic; BP Blood pressure.

Table 3. a) Estimates from hierarchical linear regression model with historical loss predicting average daily psychological stress. b) Estimates from hierarchical linear regression model with historical Loss predicting C-reactive protein levels. c) Estimates from linear mixed modeling predicting Ambulatory Systolic and Diastolic Blood Pressure

	Average Daily Psychological Stress		
	B	*95% CI*	*p*
Step 1			
Age	−0.09	−0.14 to0.04	0.293
Gender	−0.05	−3.58 to1.93	0.281
Income	−.02	−1.38 to−1.13	0.844
Depressive Symptoms	−.22	−0.73 to −0.01	0.046
Anxiety Symptoms	−.04	−0.56 to 0.40	0.39
Step 2			
Historical Loss	0.55	0.19–0.35	<0.001

	Ambulatory SBP			Ambulatory DBP		
	B	*95% CI*	*p*	*B*	*95% CI*	*p*
Step 1						
Age	0.00	−0.10 to 0.11	0.944	0.03	−0.06 to 0.12	0.467
Gender	2.24	−0.92 to 5.41	0.165	0.65	−1.97 to 3.27	0.626
Income	0.77	−0.67 to 2.21	0.296	0.25	−0.95 to 1.44	0.686
Anxiety Symptoms	−0.11	−0.65 to 0.44	0.699	0.04	−0.41 to 0.49	0.858
Depressive Symptoms	0.15	−0.28 to 0.58	0.481	0.04	−0.31 to 0.40	0.818
Body Mass Index	−0.06	−0.36 to 0.24	0.707	0.14	−0.11 to 0.39	0.268
Alcohol use	−0.15	−0.49 to 0.20	0.409	−0.16	−0.45 to 0.12	0.259
Step 2						
Historical Loss	0.32	0.22–0.42	**<0.001**	0.19	0.11–0.27	**<0.001**

Note. *SBP* systolic blood pressure; *DBP* diastolic blood pressure.

	C-Reactive Protein		
	B	*95% CI*	*p*
Step 1			
Age	−0.01	−0.01 to 0.01	.930
Gender	0.08	−0.09 to 0.24	.370
Income	0.10	−0.03 to 0.12	.243
Depressive Symptoms	0.18	−0.002 to 0.04	.076
Anxiety Symptoms	−0.02	−0.03 to 0.03	.831
Body Mass Index	0.46	0.03–0.06	.001
Alcohol use	−0.08	−0.03 to 0.01	.321
Step 2			
Historical Loss	0.33	0.01–0.02	.001

preliminary work was to investigate whether frequency of thought about historical trauma associated with subclinical physiological risk for CVD. Prior research indicates that ambulatory blood pressure is a marker of future CVD risk [44, 45]. As such, although the average ambulatory blood pressure observed in this study was in the prehypertensive range, in the current sample individuals who thought more frequently about historical loss had higher ambulatory blood pressure, and thus may be at greater risk for CVD in the future. In a similar manner, high CRP is associated with increased risk of CVD [29]. The average levels of CRP observed in the current

research was 2.56 mg/mL. In a previous investigation circulating levels of CRP predicted risk for CVD up to 10 years later. Specifically, adults who had CRP levels over 3 mg/mL had 1.82 times greater risk for developing CVD 10 years later compared to adults who had CRP levels less than 1 mg/mL [62]. In the current sample, 18% of the participants had CRP levels over 3 mg/mL, and the mean CRP levels were only slightly under the cutoff for high levels of CRP used in prior work. As such, the CRP values observed here are relevant given that the observed mean CRP levels were just under what has previously associated with increased risk for subsequent CVD.

In samples comprised of adults from other racial and ethnic groups, psychological stress, levels of immune system inflammation, and blood pressure have predicted risk for future chronic diseases [28, 29]. It is possible that in a similar manner, greater frequency of thoughts about historical loss for Blackfeet adults would predict future risk for CVD. These findings are in line with previous work highlighting the negative impact of historical trauma and associated loss on mental health, well-being, and health-behaviors [14–22], and draw attention to the need for interventions and therapies to focus on resolution of historical loss [18, 20]. While outside of the scope of the data reported here, AI scholars indicate that to be effective, these interventions and therapies should be focused upon a return to the traditional ways of life [23–26], including the incorporation of tribally specific cultural practices such as talking circles and sweat lodges.

The findings reported here build upon a significant literature indicating that historical trauma and associated loss of AI culture, traditions, language, and land have contributed to enduring disparities in health. As noted previously, this body of work largely focuses on mental health (i.e., chronic mental health disorders including depression and anxiety disorders) and health behaviors [14–22]. To the best of our knowledge, this is the first research to indicate that historical loss may also contribute to psychological (i.e., psychological stress) and biological risk factors (i.e., immune system inflammation and ambulatory blood pressure) for CVD. After discussion with the CAB, we plan to share the findings of this research with the community at the North American Indian Day Event held on the Blackfeet reservation in the coming year. Future work should extend upon these findings to elucidate additional health behaviors and processes (e.g., dietary intake, sleep-wake cycles), and social factors (e.g., social relationships and environments) which may be responsible for the observed relationship between thoughts about historical loss and risk factors for CVD in the Blackfeet community. In order to better understand mechanistic pathways which may account for the observed relationship between frequency of thought

about historical trauma and risk factors for CVD, future work should include simultaneous measurement of psychological and physiological responses to experiences as they unfold in the real-life environment. For example, a measurement of the physical and social environment the person is at during the time of the ambulatory blood pressure reading, along with the measurement of the psychological stress the person is experiencing in that moment, will allow us to have a better understanding of whether psychological stress accounts for the observed relationship between historical trauma and ambulatory blood pressure.

It will also be important to identify resilience factors. As a community, the Blackfeet people have demonstrated tremendous resilience in spite of the high levels of adversity and trauma they have faced. In our previous work, we found that sense of belonging to the community offset the physiological risk typically associated with childhood trauma [63]. It is possible that similar psychosocial factors may reduce the degree to which historical loss affects risk for chronic diseases. As with the current research, future work in this area should utilize CBPR in order to ensure that the aims, methods, and measures are in line with the community needs and values and that the developed interventions are culturally congruent [64–66].

This work comes with significant limitations which must be acknowledged. First, the relationships observed here are specific to the Blackfeet community and cannot be generalized to other AI populations. Furthermore, the sample of community members who participated in this project do not necessarily reflect the larger Blackfeet community. Second, we were unable to obtain multiple dried blood spot samples, which would have allowed us to track changes in levels of CRP to better understand dynamic correspondence between psychological stress related to historical loss and subsequent changes in levels of immune system inflammation. Relatedly, we were only able to measure one marker of immune system inflammation. Future work should aim to obtain a more comprehensive measurement of immune system profiles including multiple pro-inflammatory cytokines (e.g., interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α)) as well as anti-inflammatory cytokines (e.g., interleukin-4 (IL-4) and interleukin-10 (IL-10)). While there is limited work on the relationship between proinflammatory cytokines and CVD risk in AIs, there is some evidence from an AI sample that levels of proinflammatory cytokines associate with increased risk of heart failure [67].

In addition, while our collection of ambulatory blood pressure across three full days provides a strong reflection of average levels of blood pressure as community members moved through their daily lives, we were unable to investigate full 24-hr blood pressure profiles. This may

be warranted in future work given that the absence of nocturnal dipping of blood pressure has been shown to be a predictor of future risk for CVD [68, 69]. Finally, in future investigations, it will be important to better disentangle one's tendency to think about historical trauma with general rumination tendencies. While including depressive symptoms as a covariate in our analyses may address this issue to some degree, future research should include a more precise measure of rumination tendencies.

Finally, more research is needed to better understand how thoughts about historical trauma may change physiological outcomes linked to risk for CVD. For example, it is possible that thinking about historical trauma may contribute to a sedentary lifestyle or poor diet, both of which might contribute to higher ambulatory blood pressure and high levels of immune system inflammation. Separately, previous work indicates that AIs have worse sleep compared to other racial and ethnic groups [70, 71]. It is possible that thoughts about historical trauma may contribute to poor sleep in this community, and poor sleep is known to affect levels of immune system inflammation and blood pressure [72]. Future work should investigate whether in AI communities, patterns of sleep contribute to observed relationships between historical trauma and physiological outcomes linked to CVD risk.

In conclusion, our preliminary findings demonstrate a significant association between frequency of thoughts about historical loss and several key psychological and physiological variables that contribute to cardiovascular risk, including perceived psychological stress, immune system inflammation and blood pressure. Based on our findings, it is possible that community-driven interventions which are designed to help community members cope with historical loss, or which work to restore the traditional practices and values of the Blackfeet people, could reduce psychological stress, immune system inflammation, and blood pressure levels, and in doing so positively impact the health and well-being of the community.

Compliance with Ethical Standards

Authors' Statement of Conflict of Interest and Adherence to Ethical Standards Authors Neha A. John-Henderson, Benjamin Oosterhoff, Taylor D. Kampf, Brad Hall, Lester R. Johnson III, Mary Ellen Laframboise, Melveena Malatare, Emily Salois, Jason R. Carter, Alexandra K. Adams declare that they have no conflict of interest. All procedures, including the informed consent process, were conducted in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

Authors' Contributions N.A.J.-H. designed the study, analysed and interpreted the data, and wrote the manuscript. B.O. conducted statistical analyses, created figures and tables, and participated in writing and reviewing manuscript. T.D.K. conducted literature review and helped with data cleaning. B.H., L.R.J., M.E.L., M.M., and E.S., are members of the community advisory board which developed the project. They also helped with data interpretation and manuscript preparation. J.R. and A.K.A. helped with data interpretation and writing and reviewing of manuscript.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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