Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Original Article

Covid-19 and changes in sleep health in the Blackfeet Community☆

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ABSTRACT

We examined changes in psychological outcomes related to the COVID-19 pandemic (ie psychological stress, perceived control, and perceived ability to cope) and changes in sleep health in the American Indian Blackfeet community over 4 months (August 24, 2020–November 30, 2020). American Indian adults residing on the Blackfeet reservation (n = 167) completed measures of perceived control over contracting COVID-19, perceived ability to cope with pandemic stressors, psychological stress linked to the pandemic, and a measure of sleep health each month. Linear-effects mixed models were used to examine changes in our outcomes. Community members who reported more control over contracting the virus had better sleep health relative to those who reported less control ($B = 0.72$, $SE = 0.29$, $p = 0.015$). Further, during months when individuals felt they had more control over contracting the virus compared to their average perceived control levels, they had better sleep health relative to their own average ($B = 1.06$, $SE = 0.13$, $p < 0.001$). Average sleep health was the lowest in October, 2020, the month during which COVID-19 incidence was at its highest on the reservation. Declines in sleep health linked to low levels of control over contracting COVID-19 may exacerbate high incidence of chronic mental and physical health conditions in tribal communities. Interventions which highlight strategies known to reduce risk of contracting the virus, may increase perceived control and sleep health, and thus may improve downstream health outcomes for this at-risk population.

1. Introduction

On March 11, 2020, the World Health Organization (WHO) declared the outbreak of the novel Coronavirus disease (COVID-19) a global pandemic [1]. As of the middle of June, 2021, the novel Coronavirus disease 2019 (COVID-19) had claimed just over 600,000 lives in the United States [2]. The pandemic has had a substantial impact on all areas of life, presenting novel circumstances and challenges, ranging from financial issues (eg, reduced income, loss of employment) [3], to reduced food security [4], to social problems (eg reduced social engagement, social isolation) [5].

The COVID-19 pandemic has disproportionately affected racial and ethnic minority groups, with regard to both incidence of COVID-19 and COVID-19 mortality, exacerbating preexisting and enduring disparities in health [6]. Infectious disease outbreaks, including the current COVID-19 pandemic, are known to elicit psychological stress [7,8]. Individuals from communities which were vulnerable with regards to financial security and health preceding the pandemic, likely experienced relatively high levels of psychological stress related to the COVID-19 pandemic due to concerns about how their situations could further worsen. Based on a large body of work documenting a relationship between stress and health [9], and recent work highlighting the impact of COVID-19 stress on health behaviors [10,11], high levels of psychological stress in these communities related to the pandemic likely impacted health behaviors and consequent health, thereby exacerbating existing health disparities.

As stress related to COVID-19 increases, health behaviors including sleep may be negatively affected. Indeed, the relationship between psychological stress and sleep, has been well-documented. A systematic review of investigations which used polysomnographic measures of sleep found that psychological stressors were related to

☆ The work described here was performed on the Blackfeet reservation. Data was analyzed at Montana State University.

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decreases in slow wave sleep, rapid eye movement (REM) sleep, and sleep efficiency, as well as increase in awakenings [12]. Across cultures, at different points in development, and in multiple contexts, it has been shown that the quality of one's sleep suffers as psychological stress increases [12]. It is also well established that sleep is intimately linked to mental and physical health [13–16]. Life events and stressors are known to impact sleep health across multiple dimensions including sleep quality, alertness, timing, and efficiency [17–19]. A wide body of work indicates that the current COVID-19 pandemic has negatively affected sleep [20–29]. In one large cross-sectional investigation in adults from 59 countries, more than half of the sample of 6882 adults shifted their sleep towards later bed- and wake-times, and more than one third of the sample reported increased sleep disturbances during the pandemic [20]. One recent investigation found that the effects of the COVID-19 pandemic on sleep outcomes are not uniform across individuals, and appears to be dependent on sleep quality preceding the onset of the pandemic [28]. While there is a significant and growing body of work on the impact of the pandemic on sleep [29], to date, very little is known about how the COVID-19 pandemic has impacted sleep health over time, and even less is known about how life stressors impact sleep in American Indians (AIs) a health disparity population, which has been found to have poor sleep compared to non-Hispanic Whites [30].

In our previous work, in a sample comprised of AI adults from across the United States. We found significant declines in overall sleep quality from before the onset of the pandemic in the United States (the final week of February, 2020) to the final week of April, 2020 [22]. To our knowledge, no research has yet examined changes in sleep quality in AI tribal community in the context of the pandemic. The negative effects of the COVID-19 pandemic on sleep may be particularly pronounced for tribal communities for the following reasons. First, many tribal communities are rural, and rural communities face unique challenges and barriers to social connection [31]. For example, compared to residents of urban communities, residents of rural communities have limited access to transportation, live further apart from their neighbors, have more limited economic resources and limited access to internet activity. These characteristics of rural communities make social connection more challenging, and thus may contribute to social isolation [32]. Previous work suggests that both objective social isolation and perceived social isolation (ie loneliness) can negatively affect sleep [33–35]. It is posited that social isolation feels unsafe, which contributes to a vigilant state, thus disturbing sleep [35]. In order to contain the spread of the virus, many of these tribal communities restricted travel to and from the reservations, thereby further increasing social isolation. Second, changes to employment and financial security linked to the pandemic likely exacerbated already high levels of poverty in these communities, and financial insecurity and low income have been previously linked to poor sleep [36–39].

The Blackfeet reservation, located in Northwest Montana, is home to approximately 17,000 community members. The majority of members of the Blackfeet nation in the United States are descendants of the South Piegan or Piikani. The Blackfeet people have lived in the Rocky Mountain region for the last 100,000 years. The 1855 Blackfeet treaty established the original Blackfeet reservation which included the majority of the northern half of the state of Montana. In a 2017 community health assessment, 37% of a sample of Blackfeet adults fell below the poverty level in the preceding 12 months [40]. The Blackfeet community has disproportionately high incidence of chronic mental and physical health conditions, including depression, cardiovascular disease, and Type 2 diabetes [40]. Sleep, as a behavior or process, is implicated in each of these conditions [13–16]. In our previous work done in partnership with the Blackfeet community prior to the onset of the pandemic, we found that in a sample of Blackfeet adults, average sleep duration was only 6 h [41], and short sleep duration is defined as less than 7 h of sleep in a 24-h period [42]. As such, it is possible that sleep is a behavior which may contribute to existing health disparities in the Blackfeet community, and changes in sleep in response to life events may exacerbate already high incidence of chronic mental and physical health conditions.

As noted previously, AIs across the United States have been disproportionately affected by COVID-19 [5]. In October, 2020, the Blackfeet community experienced one of the fastest increases in COVID-19 cases and COVID-19 mortality observed across the United States [43]. However, it is unknown how the surge in cases and COVID-19 mortality affected the sleep health of the community, and/or whether observed changes in sleep quality were related to changes in COVID-19 specific psychological stress, perceived control over contracting COVID-19, and perceived ability to cope with the COVID-19 pandemic.

As an extension of our previous work which indicated poor average sleep duration in a sample of Blackfeet adults [29], in collaboration with a community advisory board comprised of 4 Blackfeet community members, we began a new line of research to examine changes in sleep health and COVID-19 related stress. Based on previous research indicating that control and coping are important predictors of the amount of psychological stress an individual experiences in response to a life-event [44–50], we also considered the amount of control community members felt they had over contracting the virus, and the degree to which they felt able to cope with the pandemic. We expected that as COVID-19 cases and mortality increased in the community, sleep heath, COVID-19 coping, and COVID-19 control would decrease, while COVID-19 specific psychological stress would increase. We also expected greater COVID-19 coping and control to be associated with greater sleep health, and greater COVID-19 related stress to be associated with lower sleep health.

2. Methods

2.1. Participants and procedure

This research utilized a Community Based Participatory Research (CBPR) framework, which emphasizes the importance of equitable partnerships between community stakeholders and researchers, and the need for research to be driven by the needs of the community [51]. The Community Advisory Board (CAB) noted that sleep was likely to suffer in the context of the COVID-19 pandemic and associated uncertainty about the economy and its future. The research described here was approved by the Blackfeet Nation Institutional Review Board. All participants were recruited using advertisements placed at community centers, at the Blackfeet Community college and on community social media sites. Eligibility criteria included current residence on the Blackfeet reservation and self-identification as American Indian (AI). All participants ($N = 167$) were recruited during the first two weeks of August, 2020. There were 4 waves of data collection (Wave 1: The last 2 weeks of August, 2020, Wave 2: The last 2 weeks of September, 2020, Wave 3: The last 2 weeks of October, 2020, and Wave 4: The last 2 weeks of November, 2020). A sample size minimum of 150 participants was selected to provide sufficient power to detect a medium effect size in general linear mixed models based on simulations. Upon confirmation of eligibility, participants were sent questionnaires using the Qualtrics platform. The surveys were available to participants to complete at each wave of data collection during the respective 2 week time period. Upon completion of the survey, participants were emailed an Amazon.com gift card with

increasing incentives in order to promote retention (Wave 1: $20, Wave 2: $25, Wave 3: $30, and Wave 4: $40).

2.2. Measures

Demographics. All participants self-reported their age, biological sex, and income at Wave 1. Annual income was self-reported using the following categories: *Below $20,000* (1), *$20,000-$40,000* (2), *$40,001-$60,000* (3), *$60,001-$80,000* (4), *$80,001-$100,000* (5), *and $100,001 and above* (6). [22].

2.3. Measures

Sleep Health. We used the 6-item RU-SATED questionnaire as a measure of sleep health [50]. The RU-SATED questionnaire has been used previously as a measure of sleep health in adults across 59 countries during the COVID-19 pandemic [20], and has been shown to be psychometrically valid [53]. The measure consists of the following six questions which are used to measure dimensions of sleep health which are consistently associated with health outcomes including regularity, satisfaction, alertness, timing, efficiency and duration respectively. "Do you get in and out of bed at similar times each day?"; "Are you satisfied with your sleep?"; Do you stay awake all day without dozing?"; Are you asleep (or trying to sleep) between 2:00 am and 4:00 am?"; "Do you spend less than 30 min awake at night (This includes the time it takes to fall asleep and awakenings from sleep)?"' and "Do you sleep between 6 and 8 h per day?" Answer choices for all questions were: *Rarely/Never* (0), *Sometimes (1),* and *Usually/Always (2).* For a global measure of sleep health, we summed responses to each of these six items, with higher scores reflecting better global sleep health [52].

Covid-19 specific Psychological stress. As a measure of the stress community members felt specific to the pandemic, we asked the following question: "How stressed do you feel when you think about the COVID-19 pandemic?" Participants responded using a 7-point scale anchored with (1) *Not at all stressed*, and (7) *extremely stressed.*

Sense of control over contracting COVID-19. As a measure of the degree to which community members felt they had control over contracting the virus, we asked the following question: "How much control do you feel you have over contracting the COVID-19 virus?" Participants responded using a 7-point scale anchored with (1): *None,* and (7): *Total.*

Perceived ability to cope with the COVID-19 pandemic. As a measure of perceived ability to cope with the COVID-19 pandemic we asked the following question: "How able are you to cope with the current COVID-19 pandemic?" Community members responded using a 7-point scale anchored with (1) *Not at all able to cope,* and (7) *Extremely able to cope.*

Symptoms of Depression and Anxiety. We used the Hospital Anxiety and Depression Scale (HADS) [54] as a measure of current symptoms of depression and anxiety. The HADS consists of fourteen items, seven of which measure depressive symptoms, and seven of which measure anxiety symptoms. Example items for the anxiety subscale include, "I get sudden feelings of panic," "Worrying thoughts go through my mind." Example items from the depression subscale include, "I feel as if I am slowed down," "I still enjoy things I used to (reverse scored)." Items are scored on a 4-point scale, 0−3; with higher scores reflecting more symptoms. The HADS has good validity [55], and good test-retest reliability [56,57]. In the present sample HADS had good reliability with a Cronbach Alpha coefficient of 0.71 for the depression subscale and 0.81 for the anxiety subscale.

2.4. Analytic technique

Intra-class correlation coefficients (ICCs) were used to characterize within and between person change in COVID-19 psychological stress, sense of control over contracting COVID-19, perceived ability to cope with the COVID-19 pandemic, and sleep health. Generalized linear mixed-effect models were used to estimate growth in these constructs over the course of 4 months during which COVID infections and deaths peaked in the Blackfeet community. Sequential growth models were estimated with linear and quadratic effects of time modeled as Level-1 independent variables. Chi-square tests were used to determine if adding the quadratic term provided a better fit to the data. A linear-effect mixed model was then estimated to examine associations between COVID-19 psychological stress, sense of control over contracting COVID-19, perceived ability to cope with the COVID-19 pandemic, and sleep health. COVID-19 psychological stress, sense of control over contracting COVID-19, and perceived ability to cope with the COVID-19 pandemic were simultaneously entered into the model with between and within-person effects calculated separately. Within-person effects were estimated by calculating the deviation of each person's observed score for a given month from that person's average score across the study period. Between-person effects were estimated by calculating the deviation of each person's average score across the study period from the grand mean. Age, gender, income, depressive symptoms, and anxiety symptoms were entered as covariates. Random effects for time and subject were modeled and allowed to covary. Missing data was minimal (<2%). Linear mixed-effect models accommodate missing data in the dependent variable and those missing data on independent variables were excluded.

3. Results

Table 1 displays the means, standard deviations, and bivariate correlations for all study variables and Fig. 1 shows inter and intra-individual changes in variables over time and Table 2 displays the means and standard deviations for each wave of data collection.

Table 1
Means, standard deviations, and correlations.

Variable	*M*	*SD*	1	2	3	4	5	6	7
1. Age	33.99	7.68							
2. Income	2.89	1.69	-0.12						
3. Depressive Symptoms	11.17	1.39	0.20*	0.08					
4. Anxiety Symptoms	10.62	1.90	0.00	0.00	0.15				
5. COVID Stress	3.54	1.19	-0.01	-0.02	-0.08	0.02			
6. COVID Coping	3.97	1.01	0.08	-0.01	0.10	-0.01	-0.68**		
7. COVID Control	4.08	1.13	0.10	-0.03	0.10	-0.05	-0.74**	0.92**	
8. Sleep Health	5.67	1.70	0.12	-0.00	0.10	-0.31**	-0.24**	0.33**	0.37**

Note. M and *SD* are used to represent mean and standard deviation, respectively. * indicates $p < 0.05$. ** indicates $p < 0.01$.
Scores for depressive symptoms, anxiety symptoms, COVID stress, coping, and control, and sleep health are averaged across the four time points.

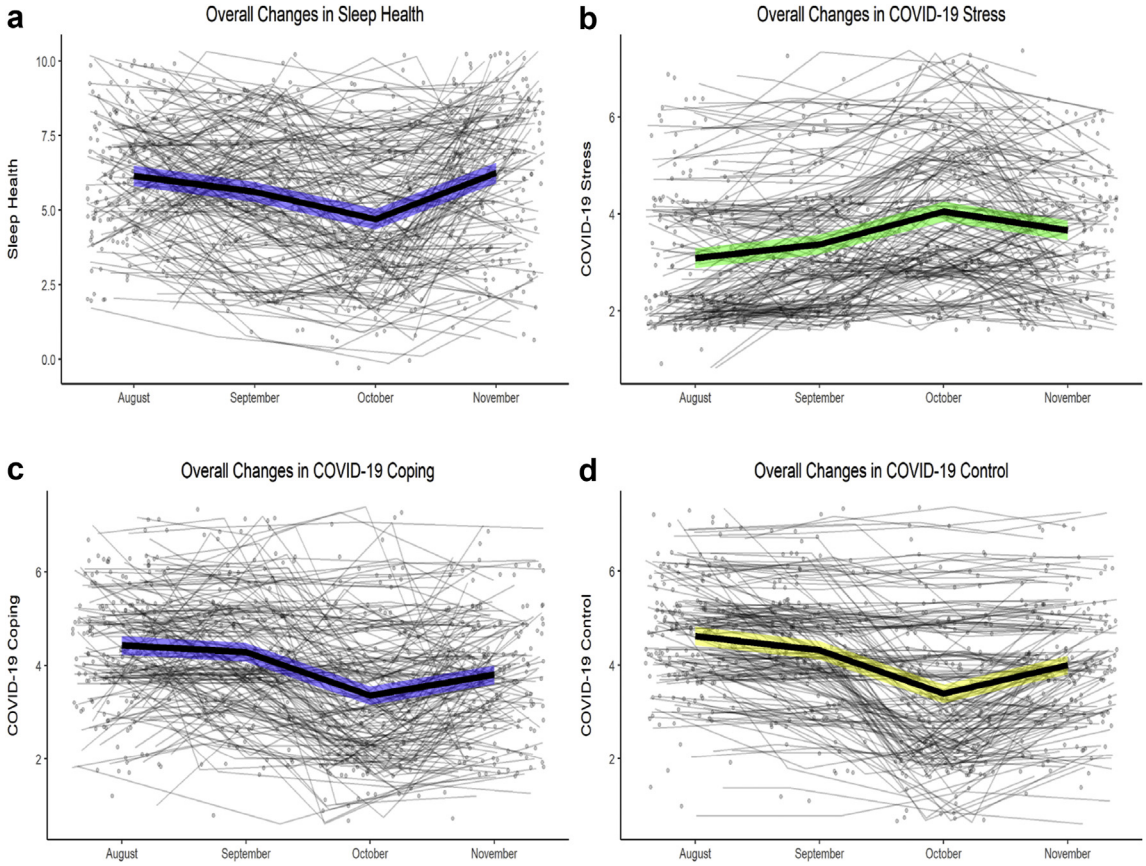

Fig. 1. Changes in sleep health (a), COVID-19 stress (b), COVID-19 coping (c), and COVID-19 control (d) across the study period. Dark lines represent mean scores in the specified construct over time, with color bands representing standard errors. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 2
Means and standard deviations for COVID-19 and sleep health variables across time.

	Wave 1 (August)		Wave 2 (September)		Wave 3 (October)		Wave 4 (November)	
	M	SD	M	SD	M	SD	M	SD
Sleep Health	6.14	1.96	5.60	2.29	4.69	2.35	6.24	2.34
COVID-19 Stress	3.08	1.36	3.37	1.28	4.05	1.45	3.66	1.24
COVID-19 Coping	4.43	1.22	4.28	1.28	3.36	1.46	3.81	1.25
COVID-19 Control	4.62	1.16	4.32	1.20	3.39	1.52	4.00	1.21

Note. *M* and *SD* represent mean and standard deviation, respectively.

COVID-19 psychological stress, sense of control over contracting COVID-19, and perceived ability to cope with the COVID-19 pandemic were moderately correlated with one another and with sleep health. Greater anxiety symptoms were correlated with lower sleep health. ICCs indicated substantial between (36%–65%) and within (35%–64%) person variability in all measures. A series of linear-effect mixed models were used to examine change in sleep health and COVID-19 psychological stress, sense of control over contracting COVID-19, and perceived ability to cope with the COVID-19 pandemic over the four-month study period. For all models, fit improved when estimating both a linear and quadratic term for time (χ^2 = 14.56–57.32), *ps* < 0.001). Sleep health demonstrated a linear decrease from August to October ($B = -2.66$, $SE = 0.35$, $p < 0.001$) followed by an increase from October to November ($B = 0.52$, $SE = 0.07$, $p < 0.001$). COVID-19 coping ($B = -1.02$, $SE = 0.20$, $p < 0.001$) and control ($B = -1.42$, $SE = 0.15$, $p < 0.001$) decreased from August to October followed by increases from October to November (coping: $B = 0.15$, $SE = 0.04$, $p < 0.001$; control: $B = 0.23$, $SE = 0.30$, $p < 0.001$). COVID-19 stress increased from August to October ($B = 1.08$, $SE = 0.15$, $p < 0.001$) and decreased from October to November ($B = -0.17$, $SE = 0.03$, $p < 0.001$).

A linear-effect mixed model tested associations among sleep health and COVID-19 related stress, coping, and control. Subject and time were estimated as a random effects and between and within variance was estimated separately for COVID-19 stress, control, and coping. Age, gender, income, depressive symptoms, and anxiety symptoms were entered as covariates. The full model estimates are displayed in Table 3. Consistent with our analyses examining change in sleep health, there was a significant linear and quadratic effect of time with sleep health decreasing from August to October followed by an increase from October to November. Additionally, women had worse sleep health compared to men and having greater anxiety symptoms was associated with worse sleep health. A significant between-subject effect for COVID-19 control ($B = 0.65$, $SE = 0.29$, $p = 0.024$) indicated those who felt like they had higher control over the likelihood of catching COVID-19 had better sleep health relative to those who felt like they had less control. A significant within-person effect of COVID-19 control ($B = 1.05$, $SE = 0.13$, $p < 0.001$) indicated that during months when a given person experienced greater COVID-19 control compared to their own average they also experienced higher sleep health relative to their own average. Between and within effects for COVID-19 stress and coping were non-significant.

Table 3
Full linear effect mixed-model predicting sleep health.

	Sleep Health		
	B	95% CI	p
(Intercept)	6.94	5.08–8.79	<0.001
Linear Time	−1.32	−2.00–−0.63	<0.001
Quadratic Time	0.30	0.17–0.43	<0.001
Age	0.03	−0.01–0.06	0.109
Sex	−0.50	−0.98–−0.02	0.041
Income	0.02	−0.12–0.16	0.813
Depressive Symptoms	0.05	−0.02–0.12	0.176
Anxiety Symptoms	−0.09	−0.16–−0.03	0.006
COVID Stress (between)	0.06	−0.23–0.36	0.664
COVID Stress (within)	−0.07	−0.28–0.15	0.554
COVID Coping (between)	−0.11	−0.68–0.47	0.715
COVID Coping (within)	−0.14	−0.32–0.04	0.131
COVID Control (between)	0.65	0.09–1.22	0.023
COVID Control (within)	1.05	0.80–1.31	<0.001
Random Effects			
σ^2	2.44		
$\tau_{00\ Subject}$	1.17		
$\tau_{11\ Subject*Time}$	0.04		
$\rho_{01\ Subject}$	0.25		
ICC	0.42		
N $_{Subject}$	164		
Observations	643		
Marginal R^2/Conditional R^2	0.225/0.549		

Notes: B = Unstandardized beta. 95% CI = 95% confidence interval. Between = between-person effect. Within = within-person effect. ICC = Intra-class correlation coefficient.

4. Discussion

The findings reported here indicate a correspondence in the trajectories of COVID-19 incidence on the Blackfeet reservation, sleep health, psychological stress related to the pandemic, the amount of perceived control over contracting the virus, and the degree to which community members felt able to cope with the pandemic. At wave 3 (October of 2020), COVID-19 cases and mortality reached their peak, sleep health was at its worst, community members reported the lowest amounts of control, and felt the least able to cope with the pandemic. Our analyses indicated that Blackfeet adults who felt they had more control over contracting the virus had better sleep health compared to those who felt they had less control over contracting the virus. In addition, within-person analyses indicated that when individuals reported feeling that they had more control over contracting the virus, they had better sleep health compared to their average sleep health over the four-month period. The observed pattern of findings are in line with previous work indicating that perceived control over a life-event dampens event-related psychological stress [49,50]. The current research adds to a large and growing body of work indicating the negative consequences of the COVID-19 pandemic for sleep which was recently summarized in a meta-analytic review [29]. Overall, this review reported that the prevalence of sleep problems during the COVID-19 pandemic is high and affects approximately 40% of people from the general and health care populations [29]. The declines in sleep quality observed in this investigation in this AI tribal community are consistent with much of the prior work summarized in this review indicating declines in sleep quality in various age groups, racial and ethnic groups, and countries [29]. Our findings make an important contribution to this literature, first by investigating the impact of the pandemic on sleep in an understudied health disparity population, and second, by providing evidence that the already poor sleep observed in this community prior to the pandemic was exacerbated by the onset of the pandemic.

In the current data, at a bivariate level, better sleep health was correlated with lower anxiety. While a large body of work documents relationships between sleep and depression, [58] in this investigation, sleep health was not correlated with depressive symptoms at a bivariate level or in the reported linear mixed models. This may be due to numerous additional factors which may have contributed to depressive symptoms during this time-period (eg, COVID-related stress, loneliness, grief). While sleep health likely plays a role in improving or worsening mental health, there are other contextual factors that should be considered. A goal of the current work was to highlight the role of COVID-19 related contextual factors that may affect sleep health during the pandemic.

Future work should expand upon the findings here by using more objective measures of sleep (ie actigraphy and polysomnography) to understand dynamic relationships between daily experiences related to the life event (eg, finding out a loved one was diagnosed with COVID-19) and subsequent sleep. Furthermore, it will be important to understand coping strategies which are utilized in the Blackfeet community in order to develop culturally appropriate interventions to improve coping efforts. Finally, subsequent research should focus on the identification of specific changes in sleep environments and sleep hygiene which may occur on tribal reservation during the context of life stressors such as the COVID-19 pandemic. For example, it is possible that due to changes in employment or financial resources, the number of individuals living together in one household may increase over time, and these changes in household dynamics could affect patterns of sleep.

To our knowledge, this is the first research to examine changes in sleep health in a tribal community during a life event, the COVID-19 pandemic. This is important for several reasons. First, based on AI epidemiological data [24], and data from Blackfeet adults, AIs appear to have shorter sleep duration (relative to other racial and ethnic groups) [22]. Given the implication of sleep in cardiovascular disease, Type 2 Diabetes, and depression, it is possible that sleep may contribute to observed high rates of these conditions in these communities. Second, based on the data reported here, sleep may be further compromised in tribal communities during times of heightened life stress, such as those experienced during the COVID-19 pandemic. Third, it appears that psychosocial factors (ie perceived control and ability to cope) are related to the amount of COVID-19 specific psychological stress community members report. This information is valuable as it suggests that interventions, policies, and public health initiatives which work to increase the degree to which individuals feel that they have the ability to control exposure to and infection from the virus (ie through effective health protective behaviors such as mask wearing, hand washing, and social distancing), or which offer information about coping strategies or resources available to community members could help to reduce psychological stress related to the pandemic. In doing so, such initiatives could help to moderate the degree to which stressful life events such as the pandemic exacerbate poor sleep. It is also possible that interventions which are focused on improving sleep quality in the context of a stressor may improve coping efforts and contribute to use of more effective coping strategies. Given the high incidence of chronic diseases for which sleep is implicated in AI communities, this could be an important step towards reducing persistent AI health disparities.

Credit author statement:

N.A.J. designed the study in collaboration with the community advisory board, oversaw data collection, helped with data analyses and wrote the manuscript.

B.O. led statistical analyses and interpretation and participated in writing and reviewing manuscript.

B.H., L.J., M.E.L., M.M., and E.S. are members of the community advisory board who oversaw the design of the project and helped with data analyses and interpretation of the findings/

J.R.C. assisted with analyses of sleep data and participated in writing and reviewing manuscript.

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Conflict of interest

None declared.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2021.06.041.

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