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2025

Faculty of Health

Faculty Publications

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Original citation:

Ou, C., Lou, N. M., Maheshka, C., Shi, M., Takemura, K., Cheung, B., & Heine, S. J. Healthy sleep durations appear to vary across cultures. *Proceedings of the National Academy of Sciences*, 122(19). <https://doi.org/10.1073/pnas.2419269122>

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Healthy sleep durations appear to vary across cultures

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Edited by Susan Fiske, Princeton University, Jamaica, VT; received September 19, 2024; accepted March 21, 2025

Past research finds that sleep duration is reliably linked with health yet sleep durations differ substantially between countries. We investigated whether countries with shorter sleep durations have worse health. Study 1 analyzed national sleep durations from 14 past investigations ($k = 353$) and found that they were not associated with national health. Study 2 collected sleep duration and health data from people from 20 different countries ($N = 4,933$). Average sleep durations varied substantially between countries (range = 1.57 h). A quadratic relation between sleep duration and health was found in all countries, although the turning points varied between countries. Individuals whose sleep duration was closer to their country's perceived ideal reported better health. The results suggest that the amount of sleep associated with optimal health varies across countries.

sleep duration | health outcomes | cultural fit | cross-cultural

Like other organisms, humans need a sufficient amount of sleep in order to stay healthy (1). Yet, cross-national comparisons consistently reveal that the average sleep duration varies across countries and sometimes to a large extent (2, 3). These differences emerge using a wide variety of measures, including self-report (4), activity monitors (5), sleep apps (6), and time between phone usage (7), and the difference between the average sleep durations of countries are often greater than 1.5 h (2, 3, 8). Moreover, these cultural differences have been found to exist across all age groups examined, even among infants and children (9, 10). In particular, countries in East Asia have shorter sleep durations, with Japan most often anchoring the shortest end, whereas countries in Oceania and Western Europe typically have the longest sleep durations (2, 5). However, thus far, there has been little explanation for why sleep durations vary across countries. Some researchers have speculated whether the differences are due to biological variability in sleep needs across ethnic groups (9, 11). Research contrasting the sleep durations of Asian-Canadians and Japanese suggests that the differences may be cultural (12). Moreover, latitude has been found to correlate with sleep durations, with longer sleep durations observed further from the equator (2, 13).

The large national differences in sleep duration are curious because much research finds that sufficient sleep duration is critical for people's health. For example, shorter sleep durations have been found to be associated with chronic health problems and psychopathology (14, 15), although for many of these conditions, there is a curvilinear relation with sleep, such that both short and long sleep durations are associated with worse health (16–19). The strong relationship between sleep duration and health raise the question of whether countries with shorter sleep durations may be suffering from worse health than those with longer sleep durations (1, 20). One investigation comparing Japanese and Canadian university students found that despite that Japanese slept about an hour less than Canadian students, their self-reported health was better across the duration of the study (12). However, cultures differ in many ways, and there may be other aspects of Japanese culture (e.g., diet), that may be protective of their health. Thus far, the field has largely remained silent on the question of how national average sleep durations are related to health outcomes.

The Present Research

We sought to shed some light on the consequences of national differences in sleep duration by exploring sleep duration and health outcomes in two separate large cross-national investigations. While past research reliably finds that sleep duration relates to health (16, 21–24), there are no published studies comparing how average national sleep durations relate to average national indices of health. If sleep duration is linked with health in a universal manner, then countries with shorter sleep duration would be expected to have worse health outcomes while controlling for other relevant variables. In the first investigation, we examined past research assessing sleep duration across cultures to estimate average national sleep durations which we compared with national-level measures of health.

Significance

Two common findings from past research on sleep duration are that people who sleep too little suffer from various health consequences and that people from some cultures often have sleep durations that are far shorter than others. We explored whether people from countries with shorter sleep durations suffer from worse health across two separate investigations. We found that 1) people from cultures with short sleep durations do not suffer from more negative health outcomes; 2) the optimal amount of sleep duration varies between cultures, and 3) people whose sleep duration is closer to their cultural ideals enjoy better health. This reveals that people's sleep needs are flexible and are shaped by cultural norms.

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Author contributions: C.O., N.M.L., K.T., B.C., and S.J.H. designed research; C.O., C.M., M.S., and S.J.H. performed research; N.M.L., C.M., and M.S. analyzed data; and C.O., K.T., B.C., and S.J.H. wrote the paper.

The authors declare no competing interest.

This article is a PNAS Direct Submission.

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This article contains supporting information online at <https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.2419269122/-/DCSupplemental>.

Published May 6, 2025.

Table 1. Multiple-Regression Results from National Variables in Study 1

	Heart Disease				
	<i>b</i>	<i>SE</i>	<i>CI</i>	<i>t</i>	<i>P</i>
Sleep Duration	0.36	0.68	-1.00, 1.71	0.52	0.605
Nutrition	-114.2	15.19	-144.17, -84.19	-7.52	< 0.001
GDP	-0.44	0.05	-0.54, -0.33	-8.25	< 0.001
Gini	-0.04	0.15	-0.33, 0.25	-0.29	0.773
Latitude	0.60	0.09	0.42, 0.78	6.44	< 0.001
	Obesity				
	<i>b</i>	<i>SE</i>	<i>CI</i>	<i>t</i>	<i>P</i>
Sleep Duration	2.26	0.36	1.55, 2.98	6.20	< 0.001
Nutrition	-97.77	6.99	-111.52, -84.02	-13.99	< 0.001
GDP	0.16	0.02	0.12, 0.2	8.05	< 0.001
Gini	0.08	0.06	-0.03, 1.87	1.38	0.17
Latitude	0.25	0.03	0.19, 0.31	8.04	< 0.001
	Diabetes				
	<i>b</i>	<i>SE</i>	<i>CI</i>	<i>t</i>	<i>p</i>
Sleep Duration	-1.71	0.16	-0.49, 0.13	-1.14	0.256
Nutrition	-19.60	3.02	-25.53, -13.67	-6.50	< 0.001
GDP	0.03	0.01	0.01, 0.04	3.18	0.002
Gini	0.05	0.02	0.003, 0.1	2.08	0.038
Latitude	-0.09	0.01	-0.12, -0.06	-6.89	< 0.001
	Life Expectancy				
	<i>b</i>	<i>SE</i>	<i>CI</i>	<i>t</i>	<i>P</i>
Sleep Duration	0.10	0.15	-0.19, 0.40	0.69	0.493
Nutrition	41.08	2.86	35.45, 46.71	14.35	< 0.001
GDP	0.09	0.08	0.08, 0.11	11.77	< 0.001
Gini	-0.05	0.02	-0.09, -0.001	-2.03	0.044
Latitude	0.00	0.01	-0.03, 0.01	-0.77	0.443

Note. The sleep duration values come from 14 separate cross-cultural investigations from 71 countries totaling 353 national sleep duration means. Bolding of p-values indicates statistically significant values ($P < 0.05$).

We tested whether the evidence is consistent with sleep durations predicting health universally by regressing national means for health conditions (that included ischemic heart disease, obesity, diabetes, life expectancy), on to average national sleep durations (353 national sleep duration means from 71 countries that were obtained from 14 cross-cultural investigations) incorporating several controls (*SI Appendix, Tables S1 and S2*).

In the second investigation, we conducted a preregistered cross-sectional online survey about health and sleep duration from approximately 250 participants in each of 20 countries during the week of the Autumnal Equinox when the length of day is similar across the globe.

Results

SI Appendix, Table S3 summarizes the zero-order correlations among all the variables in Study 1. We then regressed each of the individual criterion variables (*viz.*, mortality rates for heart disease, obesity rates, diabetes rates, and life expectancy) onto the controls (*viz.*, nutrition index, GDP, Gini, and latitude; see Table 1) and standardized sleep duration. We present the results for each criterion in order.

Heart Disease. The overall model was significant, $R^2 = 0.49$, $F(5, 172) = 33.51$, $P < 0.001$. Ischemic heart disease rates were significantly predicted by nutrition (countries with better nutrition had less heart disease), GDP (wealthier countries had lower heart disease), and latitude (countries that are further from the equator had higher rates of heart disease). However, regressing mortality

rates from heart disease on sleep duration was not significant, $\beta = 0.36$, $P = 0.605$, unlike the relation that past research has identified within countries (14, 16, 25).

Obesity. The overall model was significant, $R^2 = 0.55$, $F(5, 331) = 81.86$, $P < 0.001$. Obesity rates were significantly predicted by nutrition (countries with better nutrition were less obese), GDP (wealthier countries were more obese), and by latitude (countries that were further from the equator were more obese). Moreover, sleep duration was significantly positively related to obesity rates, $\beta = 2.26$, $P < 0.001$, indicating that countries in which people slept longer were more likely to be obese. However, this is the opposite pattern as that which has been found within countries (14, 21, 26).

Diabetes. The overall model was significant, $R^2 = 0.46$, $F(5, 331) = 57.44$, $P < 0.001$. Diabetes rates were significantly predicted by nutrition (countries with better nutrition had less diabetes), GDP (wealthier countries had more diabetes), inequality (unequal countries had more diabetes), and latitude (countries closer to the equator had more diabetes). However, regressing diabetes rates on sleep duration was not significant, $\beta = -0.18$, $P = 0.256$, unlike the relation that past research has identified within countries (14, 24, 27).

Life Expectancy. The overall model was significant, $R^2 = 0.72$, $F(5, 331) = 166.2$, $P < 0.001$. Life expectancy was significantly predicted by nutrition (people in countries with better nutrition tended to live longer), GDP (people in wealthier countries tended to live longer), and inequality (people in unequal countries tended to live shorter). However, regressing life expectancy on sleep duration was

not significant, $\beta = 0.10$, $P = 0.493$, unlike the relation that past research has identified within countries (16, 17, 23, 28).

In sum, despite that each of the four health variables have been found to be associated with sleep duration within countries, national means of sleep duration did not significantly predict any of the national criteria in the same direction found from previous research. We do not find any evidence that countries with shorter sleep duration have any worse health than those with longer sleep duration. One key challenge in interpreting these results is that the findings are vulnerable to the ecological fallacy, in which one assumes that relations among individual-level data should parallel those relations among aggregate data. As Study 1 relies on aggregate data, it is possible that sleep duration shows different relations with criteria at the individual level than it does at the national level because of ecological biases, although ecological biases tend to be reduced when appropriate controls are included in the analyses (29). The problems with ecological biases can be circumvented if individual observations of sleep duration were collected, along with measures of various health criteria, within many countries, and then, multilevel modeling could be conducted to examine the relations both within and between countries (30). We attempted to address this in Study 2 where we investigated the relations between sleep duration and health data from approximately 5,000 participants across 20 countries on six continents.

SI Appendix, Table S4 presents a correlation table of the key variables in Study 2 across the entire sample. Replicating past research (2, 13), we found that sleep duration was positively predicted by absolute latitude. In addition, we found that people's estimates of what people in their country viewed the ideal amount of sleep to be correlated with sleep duration, suggesting that average sleep durations tend to conform with local cultural norms. Those individuals who had a longer sleep duration (operationalized either as Last Night's Sleep or as Typical Day's Sleep) had better mental

health, lower depression, better subjective health, and fewer chronic health conditions (with the exception of Typical Day's Sleep). However, unexpectedly, body mass index (BMI) was not significantly related to sleep duration, in contrast to past research (21, 26), which may be due to some participants appearing confused by the question that asked them to specify either metric or imperial measurements as many provided implausibly large and small values. We do not report any further analyses with BMI. The values in *SI Appendix, Table S4* indicate that Last Night's Sleep was more highly correlated than was Typical Day's Sleep with each of our remaining health variables, indicating that Last Night's Sleep appears to be the more accurate measure of sleep duration. We present the correlations of the national-level variables included in the study in *SI Appendix, Table S5*. We only present the remaining analyses for Last Night's Sleep in the manuscript and describe the parallel analyses for Typical Day's Sleep in the SOM (see *SI Appendix, Figs. S1, S2 and Tables S11–S15*).

As preregistered, in our cross-cultural analyses we include health-sleep attitudes, smoking, drinking, income, absolute latitude of the participant's location, age, and gender as individual control variables, and nutrition index, gross domestic product, and economic inequality (Gini coefficient) as country-level control variables in all analyses. First, comparing the countries in sleep duration without controls, we find a significant cultural difference in Last Night's Sleep, $F(19, 4812) = 15.57$, $P < 0.001$, $\eta_p^2 = 0.06$, 90% CI = [0.04, 0.07]. France had the longest average sleep duration at 7 h 52 min, whereas Japan had the shortest average sleep duration at 6 h and 18 min (Fig. 1), for a range of 1.57 h (the means are shown in *SI Appendix, Table S6*, along with the means for the other dependent variables, and the accompanying between-country ANOVAs). The countries' average sleep durations remain significantly different when the analysis is conducted including the controls, $F(19, 4770) = 13.91$, $P < 0.001$, $\eta_p^2 = 0.05$, 90% CI = [0.04, 0.06].

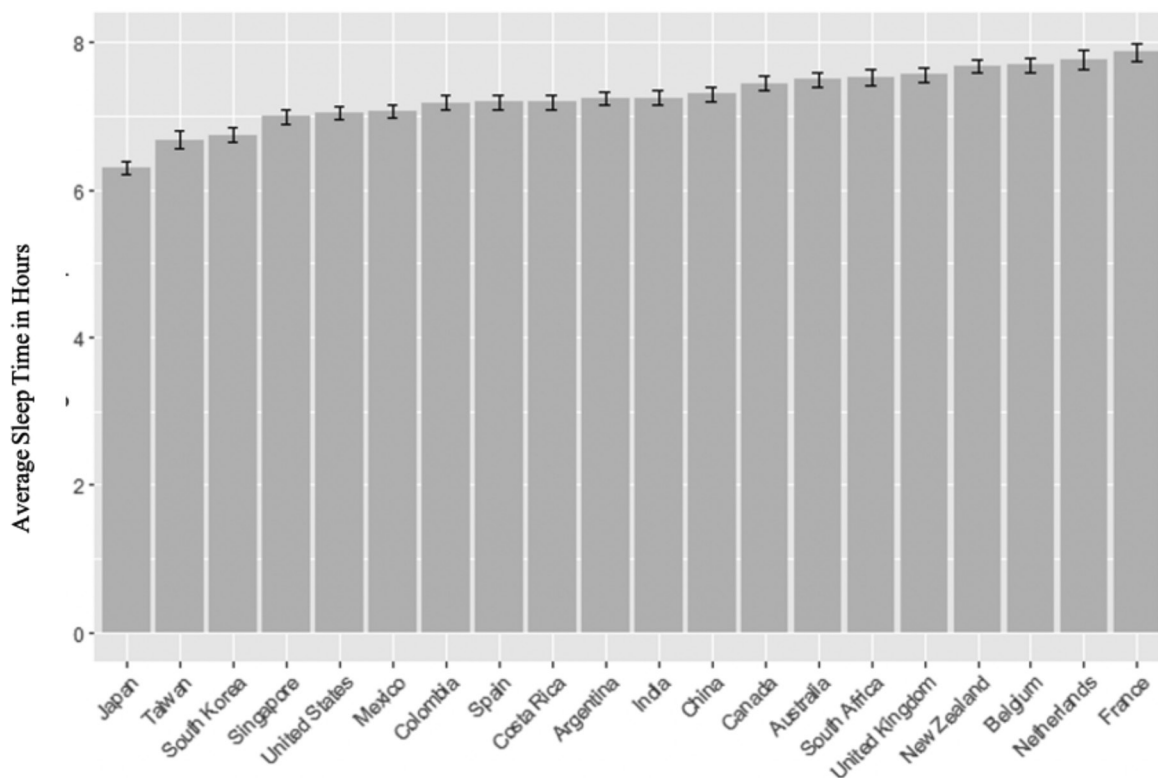


Fig. 1. Last Night's Sleep Durations by Country, Study 2.

Multilevel analyses were used to analyze the nested structure of the data: individuals (level 1) nested within countries (level 2). Following the recommendation, individual-level predictors were centered within their country's mean (31). In the first model, we examine the linear relationship between sleep and health outcomes. In the second model, the polynomial model is specified to examine the quadratic relationship between sleep and health outcomes. In the third model, we included the deviation between actual sleep and cultural ideal as an additional predictor.

We explored how sleep duration, centered within country, related to each of our health variables (viz., depression, mental health, the number of chronic health conditions, and subjective health), which are described in *SI Appendix, Tables S7–S10*. Because the patterns of results were similar (and were significant) for each health variable and that the individual health variables correlated with each other

($r_s = 0.30 \sim 0.80$), we created a composite measure of health by averaging participants' standardized scores for depression (reverse scored), mental health, the number of chronic health conditions (reverse scored), and subjective health.

As shown in Table 2, Model 1 reveals that sleep duration (centered within country) was linearly related to composite health, such that across our global sample, more sleep was associated with better health. In addition, men tended to have better overall health, as did individuals with higher income. People who believed that sleep duration was positively associated with physical health had worse health, as did individuals who smoked, and lived further from the equator. At a national level, we found that a country's average sleep duration was *not* significantly associated with the health composite, ($b = 0.09$, 95%CI = $[-0.10$ to $0.27]$, $P = 0.349$). That is, while we found that sleep duration within

Table 2. Regression Predicting Health Composite from Last Night's Sleep Duration for Study 2

Predictors	Model 1 Health Composite			Model 2 Health Composite			Model 3 Health Composite		
	Estimates	CI	P	Estimates	CI	P	Estimates	CI	P
(Intercept)	-0.59	-2.18 to 0.99	0.464	-0.44	-1.96 to 1.08	0.571	-0.39	-1.88 to 1.10	0.607
Last Night's Sleep cwc	0.09	0.07 to 0.10	<0.001	0.07	0.06 to 0.09	<0.001	0.06	0.04 to 0.08	<0.001
Age cwc	0.00	-0.00 to 0.00	0.088	0.00	-0.00 to 0.00	0.161	0.00	-0.00 to 0.00	0.175
Gender	0.18	0.13 to 0.22	<0.001	0.16	0.12 to 0.21	<0.001	0.16	0.11 to 0.20	<0.001
Income cwc	0.04	0.03 to 0.05	<0.001	0.04	0.03 to 0.04	<0.001	0.04	0.03 to 0.04	<0.001
Health-Sleep Attitudes	-0.04	-0.06 to -0.02	<0.001	-0.04	-0.06 to -0.03	<0.001	-0.04	-0.06 to -0.03	<0.001
Drinking	0.00	-0.01 to 0.01	0.542	0.00	-0.01 to 0.01	0.904	0.00	-0.01 to 0.01	0.822
Smoking	-0.05	-0.07 to -0.04	<0.001	-0.05	-0.06 to -0.03	<0.001	-0.05	-0.06 to -0.03	<0.001
Absolute Latitude	-0.01	-0.01 to -0.00	0.013	-0.01	-0.01 to -0.00	0.015	-0.01	-0.01 to -0.00	0.014
Country-level Last Night's Sleep	0.09	-0.10 to 0.27	0.349	0.08	-0.10 to 0.25	0.406	0.08	-0.10 to 0.25	0.390
Country GDP	-0.04	-0.07 to -0.00	0.038	-0.04	-0.07 to -0.00	0.038	-0.03	-0.07 to -0.00	0.040
Country Nutrition	0.94	-0.49 to 2.37	0.197	0.84	-0.52 to 2.21	0.225	0.84	-0.50 to 2.18	0.218
Country Gini	0.05	-0.06 to 0.16	0.372	0.05	-0.06 to 0.16	0.355	0.05	-0.05 to 0.16	0.330
Last Night's Sleep cwc ²				-0.03	-0.03 to -0.02	<0.001	-0.02	-0.02 to -0.01	<0.001
Individual's Actual Sleep vs Cultural Ideal							-0.06	-0.08 to -0.03	<0.001
Random Effects									
σ^2	0.50	0.49	0.49						
τ_{00}	0.02 _{country}	0.02 _{country}	0.01 _{country}						
τ_{11}	0.00 _{country.avg_last_sleep_cwc}	0.00 _{country.avg_last_sleep_cwc}	0.00 _{country.avg_last_sleep_cwc}						
ρ_{01}	-0.35 _{country}	-0.32 _{country}	-0.30 _{country}						
ICC	0.04	0.03	0.03						
N	20 _{country}	20 _{country}	20 _{country}						
Observations	4,633	4,633	4,618						
Marginal R ² / Conditional R ²	0.114/0.147	0.134/0.164	0.138/0.167						

Note: cwc = centered within country, ² = quadratic term, GDP = gross national product, Gini = index for degree of inequality. Bolding indicates statistically significant values ($P < 0.05$).

countries predicted health, differences in sleep duration between countries were not significantly related to health outcomes, which converges with the findings of Study 1. Countries with higher GDP curiously had worse composite health, which the analyses described in *SI Appendix, Tables S7–S10 and S12–S15* reveal was only the case for people’s reported subjective health. None of the other variables showed a significant relationship with the health composite.

Model 2 reveals that the linear relation between sleep duration and health was also qualified by a significant quadratic relation. That is, health increased alongside sleep duration until it reached a turning point, followed by which increasing sleep duration was associated with worse composite health, replicating past research (17, 19, 22).

Model 3 reveals that the addition of a cultural fit variable (the absolute difference between an individual’s sleep duration and their perceived cultural ideal for sleep) also predicted the health composite, such that people whose sleep duration the previous night was closer to their estimate of their culture’s ideal amount of sleep had better health. This suggests that sleeping in line with local cultural norms predicts better health.

We next explored the turning points for sleep duration and the health composite for each country (Fig. 2). For each of the 20 countries, the turning point was higher than the country’s average sleep duration which indicates that, on average, each country’s sleep duration is shorter than the optimal sleep duration, as indicated by the health composite. An analysis comparing the countries revealed a significant difference between the turning points across countries, $F(19, 4913) = 44.77, P < 0.001$, partial $\eta^2 = 0.15$, 90%CI [0.13, 0.16]. This indicates that the sleep durations that are associated with optimal scores on the health composite are

significantly different between countries, although the precision of the estimates of the turning points is limited because the sample sizes within countries are relatively small. In other words, the amount of sleep that predicts optimal health appears to vary across countries. The correlation between a country’s average sleep duration and the turning point for the health composite was not significant ($r = 0.30, P = 0.20$), although it was nominally in the direction of countries with shorter sleeping durations having earlier turning points.

We present all of the same analyses conducted with Typical Day’s sleep duration in *SI Appendix, Tables S11–S15 and Figs. S1 and S2*, in the SOM. All of our conclusions hold for both operationalizations of sleep duration, with the exception that Typical Day’s sleep duration did not show a significant linear relation to the number of chronic conditions, and the inclusion of cultural fit yielded only marginally significant effects for depression and the number of chronic conditions.

One issue with the above quadratic relation between sleep duration and health is that the shape of the curve is sensitive to the sample density across the values of sleep duration. We explored an alternative approach, by conducting a smoothing spline approach using Generalized Additive Mixed Models (Table 3). This test also found that cultural fit significantly predicted the health composite. This smoothing spline approach also supports a nonlinear curve between Last Night’s Sleep Duration and the health composite which is shown in Fig. 3. We also tested whether the turning points of this smoothing spline approach varied significantly across cultures, and found that they did as well, $F(19, 4913) = 43.27, P < 0.001$, partial $\eta^2 = 0.14$, 90%CI [0.13, 0.15], demonstrating the robustness of the cultural variation in the relation between sleep duration and health.

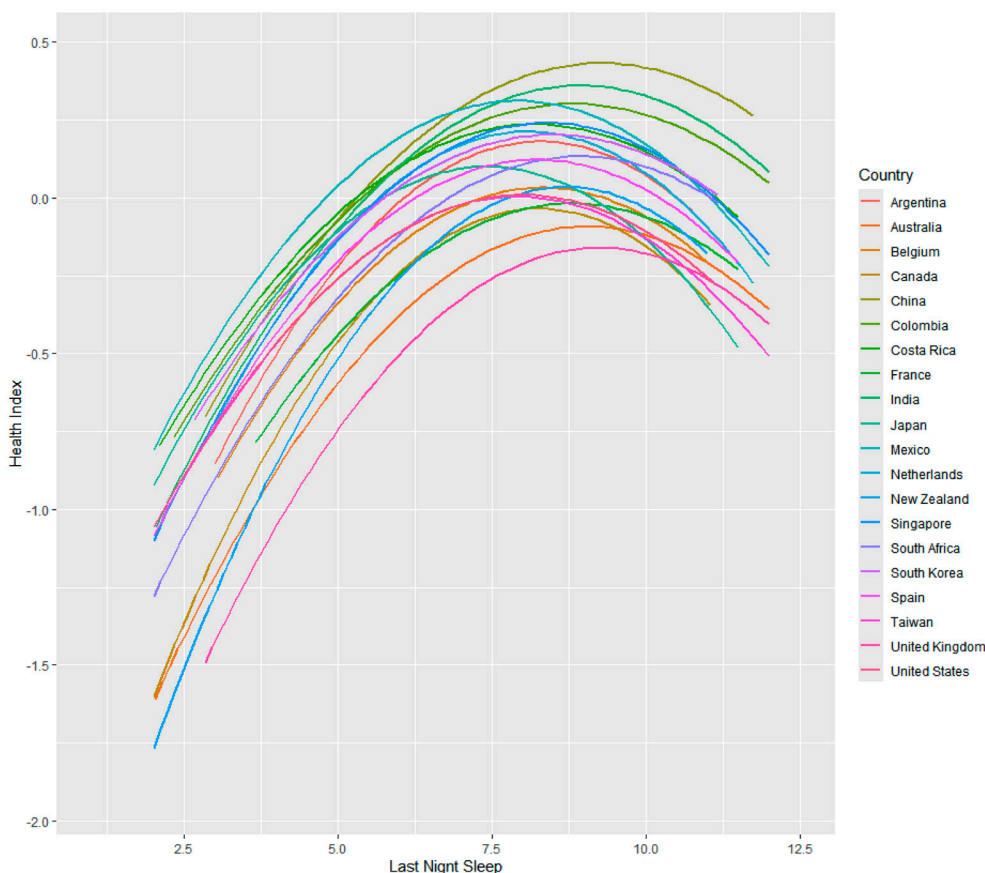


Fig. 2. Relation between Last Night’s Sleep Duration and Health Composite.

Table 3. Exploring the Shape of Curve of the Relation between Last Night's Sleep and Health Composite using Generalized Additive Mixed Models for Study 2

Component	Term	Model 1 Health Composite				Model 2 Health Composite			
		Estimate	Std Error	t-value	P-value	Estimate	Std Error	t-value	P-value
A. parametric coefficients	(Intercept)	-0.266	0.939	-0.284	0.7766	-0.248	0.864	-	0.7738
	Age_cwc	0.002	0.001	1.482	0.1383	0.002	0.001	1.364	0.1726
	Gender	0.164	0.022	7.409	<0.001	0.159	0.022	7.154	<0.001
	Income_cwc	0.036	0.004	9.759	<0.001	0.036	0.004	9.558	<0.001
	Health-Sleep Attitudes	-0.043	0.009	-4.930	<0.001	-0.044	0.009	-5.013	<0.001
	Drinking	0.001	0.006	0.226	0.8211	0.002	0.006	0.346	0.7292
	Smoking	-0.047	0.007	-7.056	<0.001	-0.046	0.007	-6.879	<0.001
	Absolute Latitude	-0.006	0.002	-2.365	0.0181	-0.006	0.002	-2.353	0.0187
	Country-level Last Night's Sleep	0.034	0.113	0.304	0.7614	0.036	0.104	0.343	0.7316
	Country GDP	-0.039	0.025	-1.571	0.1162	-0.035	0.022	-1.581	0.1139
	Country Nutrition	0.711	0.909	0.782	0.4345	0.719	0.829	0.868	0.3855
Country Gini	0.018	0.064	0.280	0.7795	0.029	0.059	0.491	0.6231	
Individual's Actual Sleep vs Cultural Ideal		-0.065	0.012	-5.380	<0.001				
	Term	edf	Ref. df	F-value	P-value	edf	Ref. df	F-value	P-value
B. smooth terms	s>Last Night's Sleep cwc, Country)	19.126	23.743	12.341	<0.001	14.008	18.449	5.125	<0.001
	s(Country)	9.080	14.000	4.369	<0.001	9.634	14.000	4.563	<0.001

Note: The goal of this additional analysis is to examine how Last Night's Sleep in Model 1 and cultural fit in Model 2 predicts composite health, while controlling for various covariates, using different modeling approaches. We applied Generalized Additive Mixed Models (GAMMs), which allow for nonlinear relationships between predictors and outcomes through smooth functions, and account for the multilevel nature of the data (i.e., country) by including random effects. Specifically, we compared different GAM models that utilized various types of basis splines (Thin Plate Spline, Cubic, Random Smooth, Gaussian Process Smooths, and Duchon/Double Splines) for modeling the effect of average sleep duration on the health composite. All models incorporated random effects for the intercept and random smooth terms. We found that the Duchon spline (ds) model, which allows the relationship between the predictor and outcome to vary by country, provided the best fit, as indicated by the lowest AIC. We also found the inclusion of the cultural fit variable in Model 2 improved the model fit. Bolding of p-values indicates statistically significant values ($P < 0.05$).

Summary of Findings:

1. The relationship between Last Night's Sleep and the health composite is nonlinear and varies significantly across countries. Smooth terms account for nonlinear and/or varying effects in the model.
2. There are significant differences in the health composite across countries.
3. Individual-level predictors such as gender, income, smoking, and self-reported sleep and health are all significant predictors of the health composite.
4. There is significant random variation in the health composite across countries, but specific country-level predictors (e.g., GDP, nutrition) do not show strong linear effects.
5. As shown in Model 2, cultural fit negatively and significantly predicted the health composite.

Discussion

Our results demonstrate that national sleep durations do not predict health in a universal manner. First, Study 1 found that national means of sleep duration did not predict any of the national health indicators in the directions found by previous research conducted within countries. That is, countries that have shorter sleep durations did not have shorter life expectancies, nor higher rates of heart disease or diabetes, and they curiously had lower rates of obesity compared with countries with longer sleep durations.

In line with past research (17–19, 22, 32), we found in Study 2 that both too little sleep and too much sleep are associated with worse health.

Countries with longer sleep durations did not have significantly better health outcomes than those with shorter sleep durations, although the power of this analysis is limited by having only

20 countries. This null finding is in accordance with what was observed in Study 1.

In each of the 20 countries the turning points with regard to the relation between sleep duration and the health composite were higher than the average sleep duration within each country, suggesting that in all countries people were sleeping less than the optimal duration. Importantly, the turning points of the sleep durations varied across countries indicating that the amount of sleep that healthier people report is different across countries. It is important to emphasize, however, that these data are all correlational so it is unclear what might be driving these relations.

We found that people who slept closer to their cultural ideals tended to have better health. This suggests that cultural fit [sometimes called cultural consonance; (33) of sleep duration may predict health, which aligns with past research finding that people who live their lives in ways closer to cultural norms tend to have better health and well-being (34–36). However, questions remain as to how cultural fit influences the relation between sleep duration and health. Some possibilities include that people may feel subjectively healthier if they believe that their sleep behaviors are normative, or that people may objectively experience some friction when they are not sleeping when most others are (e.g., experiencing stress about potentially missing trains and being late for work), or that some people may be genetic outliers which causes them to have poorer fit, and might also be associated with health costs. Thus far, the literature has not yet provided evidence for the mechanisms underlying the health benefits from other studies of cultural fit. It is also possible, given the correlational nature of these findings, that a reverse pattern may be true, such that people who are less healthy are less likely to get what their country views as an ideal amount of sleep.

The results of these two studies indicate that cultural norms for sleep duration importantly vary around the world and that people have better health when they sleep in ways consistent with those

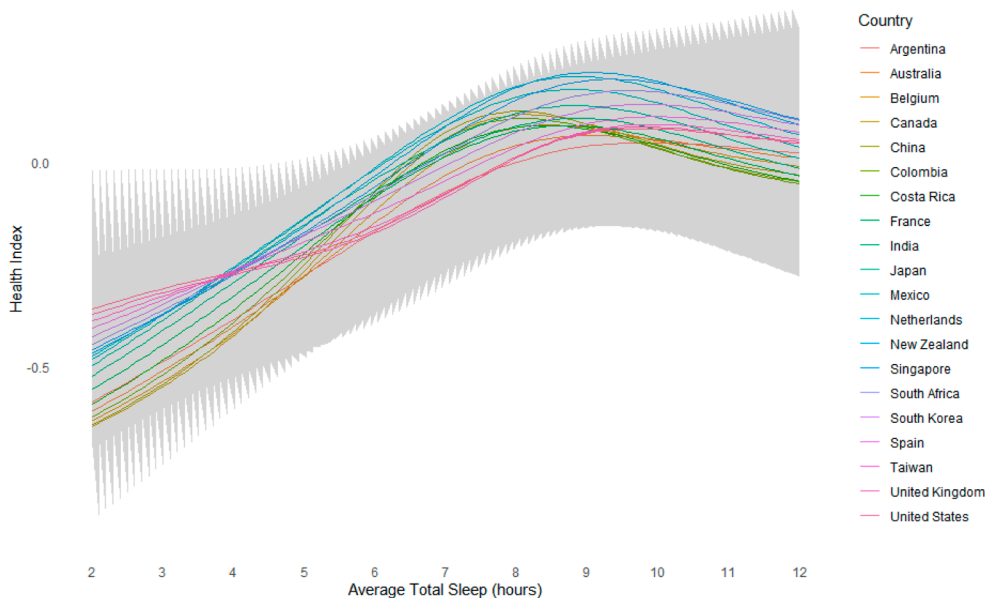


Fig. 3. Exploring the Shape of Curve of the Relation between Last Night's Sleep and Health Composite using Generalized Additive Mixed Models for Study 2.

norms. However, our results do not offer much insight into why these norms differ so much across countries, with the exception that absolute latitude predicts sleep duration. Cultures appear to encourage attitudes with respect to sleep and lifestyle, such as Japanese culture promulgating a norm for relatively little sleep, and French culture cultivating a norm for relatively longer sleep. Future research may prove fruitful in identifying what kinds of cultural practices and beliefs are associated with sleep duration norms. Moreover, our findings add to the literature to suggest that the people have flexible needs for sleep duration (37), and that the duration of sleep that is necessary to satisfy one's basic physiological needs is somehow achieved differently across countries.

Limitations. Our findings are limited by the self-report nature of our sleep duration and health measures. It is possible, for example, in cultures where people have less favorable attitudes towards long sleep durations that people may report shorter sleep durations than they actually experience. We are unable to rule out this possibility, however, we note that our obtained rank ordering of national sleep duration is comparable to what has been found in other investigations that relied upon objective measures of sleep ($ICC [3,k] = 0.92$; see Study 1 *Materials and Methods*). A limitation of the analyses in Study 1 is that the different investigations collected the sleep duration data at different times than the investigations that collected the health data. The causes of these health conditions may transpire over decades, and we have no evidence that a country's sleep duration means are stable across time, so we recommend caution in interpreting these findings. We also note that while we strived to control for other cultural-level variables that might predict health outcomes (we included a nutrition index, GDP, inequality, and absolute latitude), there are countless cultural differences between countries that may also contribute to health outcomes that we did not control for. Moreover, there may be other health conditions that show different patterns than what we observed for the conditions that we investigated. Study 2 shares this limitation in that only a relatively small number of health conditions were examined. In addition, Study 2 considered data from only 20 countries, so it remains to be seen whether people with other health conditions or from other countries show similar patterns. Last, the participants from Study 2 were recruited from Qualtrics Panel, and they did not use representative sampling. Hence, it is possible that participants from different countries had different weightings

along numerous relevant dimensions, such as age, health, gender, and income. We did control for several variables in our analyses to help make the samples more comparable, but the results still do not reflect representative samples from each country, so we are cautious in generalizing from our samples.

Materials and Methods

In Study 1 we explored the published literature and the web to identify any efforts to compare sleep duration of people from multiple countries. We had criteria that the efforts must compare the sleep of individuals from at least five different countries, relying on the same methodology for each country. We identified 14 investigations that met these criteria, which are described below. The means for sleep duration for each country are shown in *SI Appendix, Table S1*.

We first standardized the sleep duration means within each study to make the different studies comparable, because the average estimated amounts of sleep varied so much from study to study. This variation between studies was likely due both to differences in the average age of the samples and the different methods that were used to calculate sleep duration. We calculated an intraclass correlation between the different datasets and revealed an $ICC (3,k)$ of 0.92, indicating that there was much stability across datasets. There was at least one sleep duration mean available for each of 71 different countries, and the maximum number of investigations that a single country appeared in was 13 times. Each instance that a country had an estimated average sleep duration was a datapoint for the analyses reported below. Overall, there were 353 national sleep duration means included in the analyses. These data are available on the OSF at: <https://osf.io/hezb3/> (38).

We used the standardized means for sleep duration from these 14 cross-cultural investigations to predict a number of outcomes between countries that have been found to be correlated within countries in previous research. Specifically, we included 1) national mortality rates from ischemic heart disease (39) as shorter sleep duration has been found to be associated with heightened risk for heart disease (14, 16, 25); 2) national obesity rates (40), as obesity has been found to be negatively associated with sleep duration (14, 21, 26); 3) national diabetes rates (41), as shorter sleep durations are associated with increased diabetes risk (14, 24, 27); and 4) national expected life expectancy (42), as overall longevity has been found to be positively correlated with sleep duration (16, 17, 23, 28). The national values for each of the criterion variables (as well as the controls described below) are presented in *SI Appendix, Table S2*.

We used the following variables as controls in the analyses: 1) a global nutrition index (a single statistic that summarizes a country's nutritional status in terms of deficits, excess, and food security) (43), to assess between-country differences in dietary quality (range from low, 0.720 to high, 0.987); 2) Gross

Domestic Product per capita (purchasing power parity)(44), to indicate the overall wealth of a country (range from low, \$3500, to high \$106,300); 3) Gini index (45), to indicate how unequally wealth is distributed across a country (range from low, 23.7 to high, 62.5); and 4) the latitude (absolute value) of the city with the largest population in each country as past research finds that latitude correlates with sleep duration (range from low, 1.3° to high, 64.1°) (2, 13).

The following is a list of 14 past datasets that were used to compare sleep duration across countries.

Organization for Economic Cooperation and Development (46). Adults from 18 different countries (sample sizes are not reported) completed a time-use survey to investigate how people around the world spent their leisure time, including sleep duration. Across all countries, the average sleep duration was 8 h and 22 min.

Soldatos et al. (4). A cross-sectional survey inquiring about sleep habits was given to 35,327 adults in 10 different countries. Across all countries, the average sleep duration was 7 h and 34 min.

National Sleep Foundation (47). The National Sleep Foundation conducted a public opinion poll to explore sleep habits among 1,500 randomly selected people in 6 countries. The average amount of sleep across the countries was 6 h and 49 min.

The Economist (48). The maker of a digital sleep app, Sleep Cycle, released their data from 55 different countries in the world (sample size is not specified). The average of the countries' means for sleep duration was 7 h and 7 min.

Walch et al. (3). A smartphone app called ENTRAIN, was used to estimate sleep habits among 8,070 adults who opted to submit their data from 20 different countries. The average of the countries' means for sleep duration was 7 h and 51 min.

Ackermann et al. (49). Measures of intradiurnal internet activity were used to estimate sleep duration among 218,609 individuals in 645 different urban centers in 45 countries. The average of the countries' means for sleep duration was 8 h and 52 min.

Steptoe et al. (50). A total of 17,465 university students in 24 countries completed a self-report measure of health, including sleep duration. Participants were asked "On average, how many hours of sleep do you get in a 24 h period?" The average of the countries' means for sleep duration was 7 h and 28 min.

Chaput et al. (51). An accelerometer was used to assess the sleep duration of 5,777 children aged 9 to 11 from 12 different countries. The average of the countries' means for sleep duration was 8 h and 51 min.

Mindell et al. (10). An internet-based version of the Brief Child Sleep Questionnaire was given to 2,590 parents of preschool-aged children in 13 countries. The average of the countries' means for sleep duration was 11 h and 3 min.

Mindell et al. (9). Parents of 29,287 infants and toddlers from 17 countries completed an internet-based version of the Brief Infant Sleep Questionnaire. The average of the countries' mean total sleep time was 12 h and 33 min.

Willoughby et al. (8). An Oura ring was used to assess the sleep duration of over 220,000 users in 35 countries. The average of the countries' means for sleep duration was 6 h and 53 min.

Coutrot et al. (2). Users of a Sea Hero Quest app provided self-report estimates of sleep duration of 630,187 participants from 61 countries. The average of the countries' means for sleep duration was 7 h and 2 min.

Fisher and Robinson (52). Sleep estimates from an unspecified number of participants in 16 countries were collected using an unspecified method. The average of the countries' means for sleep duration was 8 h and 19 min.

Data from Study 2 of the present paper. Self-reported sleep durations (including naps) were collected from 4,933 adult participants in 20 countries. The average of the countries' means for sleep duration was 7 h and 52 min.

In Study 2, we aspired to recruit 250 participants from each of 20 countries, although the number in each country providing complete data ranged from a low of 233 to a high of 261 (total $N = 4,933$). Participants were recruited via Qualtrics panel sampling. Previous research suggests that 15 to 20 countries is sufficient for country-level comparison in multilevel modeling (53). A power analysis further showed that a sample of 250 within each country can achieve 0.80 statistical power to detect a correlation of 0.156 (one-tailed) or 0.175 (two-tailed). To be eligible, participants had to be between 25 to 60 y of age (although the average ages of each sample varied somewhat; see *SI Appendix, Table S16*), reside in one of 20 countries specified and be able to complete the survey in one of the provided survey languages. Those who worked night shifts were excluded from participating. To control for varying lengths of daylight and its effects on sleep patterns, the survey was administered over a 1-wk period straddling the Autumnal Equinox so that day and night were of similar length at all locations. We preregistered our planned analyses at <https://osf.io/9wq2f>. We received ethical approval from the research ethics board of the University of British Columbia (H10-02590). All participants completed informed consent prior to survey administration. The list of countries and a summary of the characteristics of the samples from each country are presented in *SI Appendix, Table S16*.

Asurvey about health and sleep was constructed for Study 2 using measures of self-report sleep, sleep-related behaviors, health, well-being, and perceptions of cultural norms regarding sleep duration. Surveys were translated from English to Korean, Chinese, Japanese, French, and Spanish, and the quality of the translation was assessed using back translation (54).

Sleep duration was operationalized in two ways in this study. First, we asked participants the time that they went to bed and woke up from the previous night (Last Night's Sleep). Second, we asked people their typical bedtimes and waking up times both on workdays and on nonworkdays. In addition, we asked people how many days in a typical week are workdays, and how long they typically nap in a day. Compiling all of these responses enabled us to calculate participants' total typical daily sleep duration, including naps (Typical Day's Sleep). We use both operationalizations of sleep duration throughout this paper.

Individual control variables in Study 2 included age, income, gender, smoking behaviors, drinking behaviors, latitude of each participant, and their health-sleep attitudes. Country-level control variables included GDP, Gini, and a global nutrition index (43–45). The outcome variables were assessed with five separate measures of participants' health. First, they were asked to provide their health and weight, and selected a drop-down menu to report those either in metric or imperial, so we could calculate their BMI. They also completed a measure evaluating their subjective health, a measure asking how many of 18 different chronic health conditions that they had, and validated measures of depression and overall health (PROMIS Depression and Global Health) (55, 56). We also included several other measures not related to health which we do not discuss here. The complete set of measures, R-code, and datafile can be seen at the OSF at <https://osf.io/hez3/> (38).

Data, Materials, and Software Availability. Study 1 and Study 2 data have been deposited in OSF (<https://osf.io/hez3/>) (38).

ACKNOWLEDGMENTS. We thank Hazuki Miyoshi and Hui-Hui Ou for their assistance with translations. Social Sciences and Humanities Research Council Insight Grant #435-2019-0480 (S.J.H.)

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