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Trajectories and predictors of sleep quality during and after the pandemic in five European populations

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ABSTRACT

Objectives: This paper investigates the trajectory and potential predictors of sleep quality across 13 waves of data on 5 European populations from April 2020-September 2024.
Methods: Data are based on the ongoing COME-HERE survey, a comprehensive longitudinal study designed to capture the socioeconomic, health, and psychological impacts of the COVID-19 pandemic across multiple European countries, including 8063 participants and over 60,000 observations drawn from representative samples in France, Germany, Italy, Spain, and Sweden.
Results: Our findings reveal an upward trend in average sleep quality over time, with fluctuations that align with major COVID-19 waves, suggesting pandemic-related disruptions to typical seasonal sleep patterns. Through multivariate regression analysis, female gender, income, employment, physical activity, mental health, and social interactions are key predictors of sleep quality, with financial security and mental health showing particularly strong associations. Importantly, our results hold across diverse groups (by country, gender, age, and education) and remain consistent from the height of the pandemic through to the postpandemic period, supporting the enduring influence of mental health, socioeconomic, and lifestyle factors on sleep quality.
Conclusions: Our study highlights the complex interplay between social determinants, mental health, and lifestyles in shaping sleep quality in the general population, regardless of geographic context and the potential impact of major public health emergencies such as the recent COVID-19 pandemic. These findings further emphasize the need for greater attention to sleep health in both clinical and public health settings.

Introduction

Evidence suggests that poor sleep health is rising in our 24/7 modern society and is associated with psychosocial stress, poor diet, lack of physical activity, addictive behaviors, excessive electronic media use, and a range of adverse health outcomes across different age groups.[1-6] While some people may sleep within the recommended range for sleep duration, they may still suffer from poor sleep quality, which is a common problem, affecting large segments of the general population.[7] Furthermore, accumulating evidence suggests that the COVID-19 pandemic may have adversely impacted sleep patterns. For example, web-based surveys in adult populations found that increased electronic device use during lockdown was associated with decreased sleep quality, reduced sleep duration, prolonged sleep onset latency, and delayed bedtime and rising time.[8] These findings have been corroborated by systematic reviews on the potential detrimental impact of the pandemic on several sleep characteristics, including sleep duration, late bedtimes, and poor sleep quality, in children, adolescents, and adults across multiple geographic contexts and population subgroups.[9-12] As well, evidence indicates that excess social media use is linked to poor sleep quality.[2] These trends suggest that poor sleep health will continue to grow as a public health issue in our society.

Sleep patterns are multifaceted and may be influenced by complex interactions among socioeconomic, behavioral, and psychological factors, as well as the presence of co-occurring physical and mental health conditions.[13-15] Importantly, sleep behaviors may vary across different geographic contexts, both within and across countries, depending on a number of factors such as climatic conditions,

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green space, land use, built environment, urban density and traffic congestion, physical and social neighborhood characteristics, noise, and pollution levels, among others.[16-18] Hence, cross-country comparisons may provide insightful information on the potential range of factors shaping various dimensions of sleep patterns, such as sleep quality.[19,20]

Therefore, the present observational longitudinal study examines the trajectories and potential predictors of sleep quality across and after the pandemic time from April 2020-September 2024, using population-based data from 5 European countries (France, Germany, Italy, Spain, and Sweden), which reflect different sociodemographic, cultural, and economic contexts.

Methods

Study population and variables

This study uses data from the COME-HERE survey, a longitudinal dataset designed to capture the socioeconomic, health, and psychological impacts of the COVID-19 pandemic across several European countries. Since its launch, the survey has grown to encompass 13 waves, with over 60,000 observations drawn from representative samples in France, Germany, Italy, Spain, and Sweden. The data for this study were first collected in April 2020 and continuing in June, August, and November 2020, March, June, and October 2021, February, June, and November 2022, June 2023, February, and September 2024. Each wave, conducted online, takes approximately 20-25 minutes, allowing respondents to reflect on their current conditions, while also building a detailed longitudinal record. Originally launched as a pandemic-focused survey, COME-HERE has evolved into a postpandemic resource, enabling us to examine trends in a world transitioning beyond the immediate COVID-19 crisis.[21] Ethics approval was granted by the Ethics Review Panel of the University of Luxembourg.

The original April 2020 sample comprised 8063 adults, evenly distributed across the 5 COME-HERE countries and stratified by age, gender, and region for national representativeness. As attrition increased, a refreshment sample of 2994 respondents was added in wave 7 (October 2021) to restore representativeness. Because attrition was not random—for example, younger respondents and women were more likely to leave—the refreshment sample included proportionally more of these groups to maintain balance by age, gender, and region.

In this paper, sleep quality is the main outcome of interest and is measured using the following single-item question: "*How would you rate your sleep quality during the last week on average?*". Respondents rate their sleep quality on a 7-point scale ranging from "*very poor*" to "*excellent*." There is no gold standard approach for measuring subjective sleep quality using questionnaires, however, the Pittsburgh Sleep Quality Index (PSQI) is often used, although this measure was developed for clinical populations.[22] The PSQI conceptualizes sleep quality across multiple sleep dimensions, including subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. While the present study does not include the PSQI, our single-item closely overlaps with question 9 of this validated index.

Beyond sleep quality, the COME-HERE dataset offers a wide range of demographic, socioeconomic, and health-related variables. Key information includes respondents' age, gender, education level, employment status, and household composition. Mental health indicators and lifestyle changes are also tracked, providing additional context to explore how various factors interact with sleep quality.[21]

Statistical analysis

We use a linear regression model to examine the predictors of sleep quality. Our first model is specified as follows:

$$SleepQuality_{ict} = \beta_1 D_{ict} + \beta_2 E_{ict} + \beta_3 L_{ict} + \beta_4 H_{ict} + \beta_5 S_{ict} + \delta_t + \alpha_c + \epsilon_{ict}. \quad (1)$$

In this equation, $SleepQuality_{ict}$ represents the sleep quality score of individual i living in country c at time t, measured on a standardized 7-point Likert scale (mean = 0, standard deviation = 1). D_{ict} is a vector of demographic controls, which includes gender, age, age squared, education (we use a dummy equal to one for respondents who have at least a postsecondary diploma), and partnership status. E_{ict} represents economic controls (net household income in PPP and equivalized using the square root of the family size and employment status). L_{ict} captures the following lifestyle controls: smoking (a dummy equal to one for smoker), alcohol consumption (weekly number of drinks), physical activity (number of days per week one engages in moderate-to-vigorous physical activities for 15 minutes or more), daily working hours, caring hours, media time, and leisure time. H_{ict} denotes health controls, comprising both mental and physical health conditions. COME-HERE respondents are asked to report whether they recently received one of the following diagnosis related to mental health: "Major depression," "Generalized anxiety disorder," "Specific phobia," "Panic disorder," "Agoraphobia," "Anorexia nervosa," "Bulimia nervosa," "Binge eating disorder," "Adjustment disorder," "Post-traumatic stress disorder," "Somatoform or somatic symptom disorder," "Illness anxiety disorder or hypochondria," "Alcohol or substance abuse," and "Alcohol or substance dependence." Our measure of mental health conditions is the sum of the number of recent diagnoses. We use the same count approach for physical health with the following list of physical health conditions: "Pollen allergy," "High blood pressure," "Diabetes," "Heart disease," "Lung disease (e.g., asthma or COPD)," "Cancer," "Another clinically-diagnosed chronic physical health condition," "A disability that affects my ability to leave the house," and "Any other disability." S_{ict} includes social interaction controls (dummies equal to one for respondents reporting decreases in in-person and remote contact). The variables included in D_{ict}, E_{ict}, H_{ict}, and S_{ict} are selected because they have been shown to shape sleep patterns in the general population.[1,2,5,8-14,21]

The term δ_t represents time fixed effects, which control for variations in sleep quality common across individuals but changing over time, while α_c are the country fixed effects and capture the time-invariant country differences in sleep quality.

Our second model incorporates individual fixed effects, which account for all time-invariant characteristics, observed or unobserved, specific to each respondent. This model is written as

$$SleepQuality_{ict} = \gamma_1 D_{ict} + \gamma_2 E_{ict} + \gamma_3 L_{ict} + \gamma_4 H_{ict} + \gamma_5 S_{ict} + \delta_t + \mu_i + \epsilon_{ict}, \quad (2)$$

where μ_i denotes the individual fixed effect for respondent i, capturing time-invariant traits such as personality traits, and genes. By including individual fixed effects, we lend more plausibility to the causal interpretation of our estimates, as this approach controls for potential confounders that remain constant within individuals over time. Note that time-invariant variables in D_{ict} (e.g., gender) cannot be included in this model. Standard errors are clustered at the individual level in both Equations (1) and (2).

Table 1
Descriptive statistics of the baseline population (N = 7991)

	Baseline			
	Mean	SD	Min	Max
Sleep quality	4.58	1.53	1	7
Women	0.52		0	1
Age	47.38	16.94	18	93
Postsecondary education	0.40		0	1
Equivalent net HH income (log - PPP)	7.28	0.66	5.21	9.36
In a relationship	0.67		0	1
Employed	0.54		0	1
Smoker	0.26		0	1
No. of alcoholic drinks (per week)	3.44	5.27	0	50
No. of days of physical activity (per week)	2.58	2.35	0	7
Daily working time (in hours)	3.48	3.81	0	23.50
Daily childcare (in hours)	1.29	2.82	0	23.50
Daily home care (in hours)	1.99	1.76	0	23.50
Daily leisure time (in hours)	2.54	2.70	0	23.50
Daily media time (in hours)	3.93	3.24	0	23.50
Mental health conditions (total)	0.23	0.67	0	14
Physical health conditions (total)	0.76	0.94	0	9
Decrease in in-person contact	0.68		0	1
Decrease in remote contact	0.31		0	1
France	0.21		0	1
Germany	0.21		0	1
Italy	0.21		0	1
Spain	0.21		0	1
Sweden	0.15		0	1
Observations	7991			

Note: The numbers on the left refer to the study population at baseline with complete data (72 individuals out of the 8063 original respondents are excluded due to having at least one missing value among the variables considered in this table). 'Equivalent net HH income (log - PPP)' stands for equivalent net household income (log - purchasing power parity).

To estimate these equations, we use a sample made of COME-HERE respondents with nonmissing dependent and independent variables. This produces an estimation sample of 60,957 observations (10,400 individuals). A detailed description of all variables used in the analysis, including their measurement and domains, is provided in Table A1. Descriptive statistics of our estimation sample can be found in Table A2. Descriptive statistics per country can be found in Table A3.

Results

Table 1 presents the descriptive characteristics of the study population at baseline (April 2020), consisting of approximately 8000 respondents evenly distributed across 5 countries. The sample is well-balanced by gender, with an average age of 47.38 years. About 40% of respondents have attained postsecondary education, and 54% are employed. In terms of lifestyle, one in 4 respondents is a smoker,

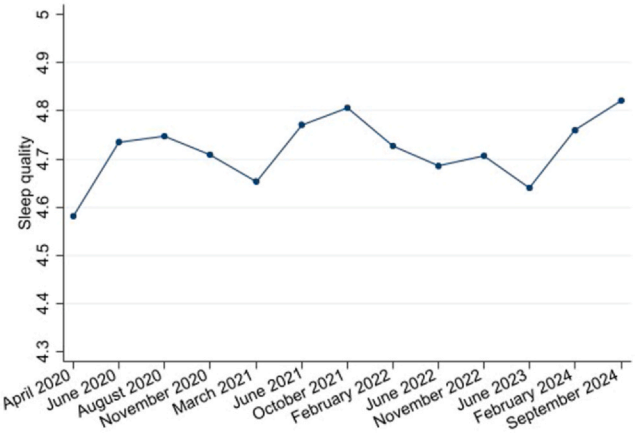

Fig. 1. Average sleep quality over time

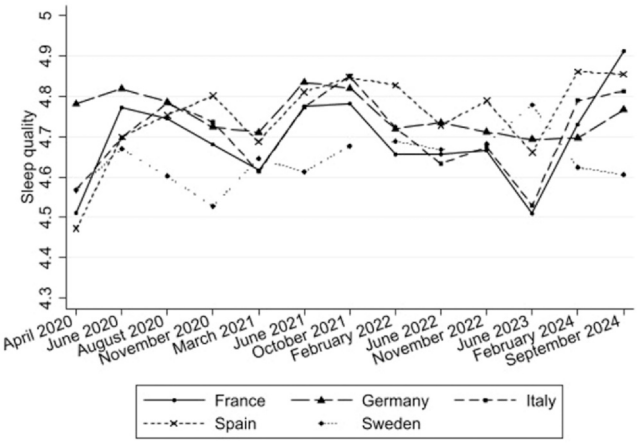

Fig. 2. Average sleep quality over time per country

while the average weekly alcohol consumption is 3.44 drinks. On average, respondents engage in physical activity 2.58 days per week. In April 2020, participants reported spending the most time on media consumption and work, followed by leisure activities, home care, and childcare. The first COVID-19 outbreak and the introduction of social distancing measures in April 2020 significantly impacted social interactions. This is evident from the fact that 68% of respondents reported a recent reduction in in-person contacts. Lastly, the average reported sleep quality in the original sample was 4.58.

The trajectories of average sleep quality across 13 survey waves from April 2020-September 2024 are presented in Figs. 1 and 2. Fig. 1 shows a general upward trend in sleep quality over time, with April 2020 being the lowest point and September 2024 the highest point. However, this pattern includes many fluctuations. Initially, from April 2020-June 2020, sleep quality shows a modest increase, which may reflect a period of adaptation as individuals adjusted to the pandemic's restrictions and lifestyle changes. But it reduces in March 2021 while Europe was facing a new wave of COVID-19. This is in line with our previous findings suggesting that sleep quality is negatively correlated with the evolution of the pandemic.[21] Lastly, we also observe an increase in sleep quality since mid-2023.

Fig. 2 disaggregates the trend in sleep quality by country, allowing for comparisons across France, Germany, Italy, Spain, and Sweden. Although we observe differences in levels, we do not observe notable differences in changes, except for Spain, which was the only country experiencing a relatively steady increase in sleep quality throughout 2020.

Table 2 presents the results from a series of linear regressions estimating the predictive power of a range of relevant factors over sleep quality, measured on a standardized 7-point Likert scale. Each column adds controls, allowing us to observe how the associations between different factors and sleep quality may change as we refine the model. In column (1), the regression includes basic demographic controls and economic variables. Women tend to report lower sleep quality than men, while the association between age and sleep quality follows a U-shaped pattern, with the lowest sleep quality observed around age 33. Higher income shows a positive association with sleep quality, suggesting that financial security may enhance sleep. We find a similar protective effect for employment and partnership.

In column (2), lifestyle variables are added. Smoking and drinking negatively correlate with sleep quality. Longer working and caring hours as well as longer media time are also associated with poorer sleep quality. On the contrary, physical activity and leisure time are positively associated with higher sleep quality, in line with the role of active lifestyles in supporting better sleep health. We also

Table 2
Linear regressions

	Sleep quality (std)					
	(1)	(2)	(3)	(4)	(5)	(6)
Women	−0.129***				−0.111***	
	(0.018)				(0.018)	
Age	−0.024***				−0.021***	
	(0.004)				(0.003)	
Age squared	0.000***				0.000***	
	(0.000)				(0.000)	
Postsecondary education	0.005				−0.009	
	(0.019)				(0.018)	
Equivalent net HH income (log - PPP)	0.084***				0.059***	0.021***
	(0.009)				(0.008)	(0.008)
In a relationship	0.091***				0.083***	0.021
	(0.019)				(0.019)	(0.025)
Employed	0.044**				0.027	0.045**
	(0.022)				(0.022)	(0.021)
Smoker		−0.037**			0.042***	0.001
		(0.017)			(0.016)	(0.014)
No. of alcoholic drinks (per week)		0.024***			−0.007	−0.006
		(0.008)			(0.008)	(0.006)
No. of days of physical activity (per week)		0.105***			0.091***	0.049***
		(0.008)			(0.007)	(0.005)
Daily working time (in hours)		−0.034***			0.007	0.012*
		(0.008)			(0.008)	(0.006)
Daily childcare (in hours)		−0.052***			−0.003	−0.000
		(0.007)			(0.007)	(0.006)
Daily home care (in hours)		−0.024***			−0.011	−0.010**
		(0.008)			(0.007)	(0.005)
Daily leisure time (in hours)		0.089***			0.068***	0.026***
		(0.007)			(0.007)	(0.005)
Daily media time (in hours)		−0.041***			−0.037***	−0.020***
		(0.008)			(0.007)	(0.005)
Mental health conditions (total)			−0.185***		−0.137***	−0.058***
			(0.009)		(0.008)	(0.006)
Physical health conditions (total)			−0.034***		−0.071***	−0.008
			(0.008)		(0.008)	(0.006)
Decrease in in-person contact				−0.054***	−0.038***	−0.017***
				(0.006)	(0.005)	(0.004)
Decrease in remote contact				−0.051***	−0.018***	−0.011**
				(0.006)	(0.005)	(0.004)
Observations	60,597	60,597	60,597	60,597	60,597	60,597
Adjusted R^2	0.056	0.029	0.039	0.009	0.101	0.590
Individual FE	No	No	No	No	No	Yes

Notes: These are linear regressions. The dependent variable is sleep quality on a 7-point Likert scale standardized with a mean of zero and a standard deviation of one. Standard errors in parentheses are clustered at the individual level. All regressions include wave fixed effects and country fixed effects. 'Equivalent net HH income (log - PPP)' stands for equivalent net household income (log - purchasing power parity).

* $p < .1$.
** $p < .05$.
*** $p < .01$.

estimate models controlling for work-from-home status, finding a negative association with sleep quality under individual fixed effects ($p = .098$). Including this variable does not materially change our main results. Results are available upon request.

Column (3) includes health-related variables. Mental health issues are strongly and negatively correlated with sleep quality, while physical health conditions also contribute negatively but to a lesser extent. In column (4), additional social interaction variables are incorporated. Reductions in social interaction, particularly in-person contact, are associated with lower sleep quality, hinting at the role of social isolation in sleep disturbances.

In column (5), models include sociodemographic, lifestyle, health, and social interaction variables. Several key results emerge from this analysis. First, the adjusted R^2 increases substantially, with our set of controls explaining about 10% of the variation in sleep quality. Second, most of the associations between sleep quality and individual characteristics are still found. The most noticeable exceptions are the variables linked to lifestyles, most of which are no longer associated with significant estimates. This is not surprising: lifestyle is not random and is greatly determined by sociodemographic and economic variables such as age, gender, education, and income.

Lastly, we keep constant the influence of all time-invariant confounders (e.g., gender, personality traits) in column (6) where we include individual fixed effects. Adding these fixed effects to this model explains why we cannot estimate point estimates for time-invariant controls (i.e., gender, education) and controls evolving at the same pace across individuals (i.e., age). However, controlling for individual fixed effects makes a causal inference more credible. Interestingly, the adjusted R^2 is now equal to 0.59. This means that time-invariant individual traits explain about half of the variation in sleep quality. Among the most robust and consistent findings, column (6) also confirms that sleep quality is positively associated with income, employment, physical activity, better mental health, and more social interactions. Moving now from statistical significance to the magnitudes of the predictors, we see that the strongest predictors of sleep quality are mental health followed by physical activity and employment. All continuous variables as well as the dependent variable are standardized (mean of zero, standard deviation of one)—which allows us to compare point estimates directly in Table 2. Hence, a reduction of one standard deviation in the total number of mental health conditions predicts a rise of 5.8% of a standard deviation in sleep quality.

Table 3
Linear regressions per country

	Sleep quality (std)				
	France	Germany	Italy	Spain	Sweden
	(1)	(2)	(3)	(4)	(5)
Equivalent net HH income (log - PPP)	0.029	0.001	0.001	0.012	0.059***
	(0.018)	(0.020)	(0.016)	(0.014)	(0.022)
In a relationship	0.104**	0.027	0.031	−0.003	−0.092
	(0.050)	(0.064)	(0.053)	(0.049)	(0.076)
Employed	−0.007	0.089*	0.085**	0.029	−0.014
	(0.046)	(0.049)	(0.043)	(0.046)	(0.056)
Smoker	0.039	−0.009	−0.017	0.001	−0.025
	(0.032)	(0.033)	(0.028)	(0.024)	(0.048)
No. of alcoholic drinks (per week)	−0.028**	−0.029**	0.010	−0.011	0.045*
	(0.014)	(0.012)	(0.013)	(0.011)	(0.023)
No. of days of physical activity (per week)	0.054***	0.021**	0.070***	0.043***	0.062***
	(0.011)	(0.011)	(0.012)	(0.009)	(0.017)
Daily working time (in hours)	0.005	−0.003	0.013	0.034**	0.026
	(0.010)	(0.012)	(0.015)	(0.017)	(0.020)
Daily childcare (in hours)	0.009	−0.000	0.011	−0.012	−0.050
	(0.009)	(0.017)	(0.012)	(0.011)	(0.035)
Daily home care (in hours)	0.004	−0.000	−0.005	−0.047***	−0.025
	(0.009)	(0.008)	(0.013)	(0.012)	(0.022)
Daily leisure time (in hours)	0.021**	0.014*	0.028**	0.044***	0.047***
	(0.008)	(0.008)	(0.011)	(0.012)	(0.017)
Daily media time (in hours)	−0.022***	−0.012	−0.003	−0.010	−0.061**
	(0.007)	(0.008)	(0.016)	(0.017)	(0.024)
Mental health conditions (total)	−0.053***	−0.068***	−0.058***	−0.054***	−0.052***
	(0.015)	(0.013)	(0.013)	(0.014)	(0.015)
Physical health conditions (total)	−0.013	−0.005	−0.011	−0.011	−0.013
	(0.015)	(0.012)	(0.015)	(0.013)	(0.016)
Decrease in in-person contact	−0.010	−0.008	−0.023**	−0.039***	0.010
	(0.009)	(0.009)	(0.009)	(0.009)	(0.013)
Decrease in remote contact	−0.025***	−0.009	−0.009	0.004	−0.020
	(0.009)	(0.011)	(0.009)	(0.008)	(0.013)
Observations	13,590	11,953	13,242	13,776	8036

Notes: These are linear regressions. The dependent variable is sleep quality on a 7-point Likert scale standardized with a mean of zero and a standard deviation of one. Standard errors in parentheses are clustered at the individual level. All regressions include wave fixed effects and individual fixed effects. 'Equivalent net HH income (log - PPP)' stands for equivalent net household income (log - purchasing power parity).

* $p < .1$.
** $p < .05$.
*** $p < .01$.

An important consideration in longitudinal studies is sample attrition. In our panel, only about 24% of the original sample responded at wave 13 (Table A4). Because all respondents are contacted at each wave, attrition is not strictly monotonic—some skip waves and later return. To assess its potential impact, we estimated a linear probability model where the dependent variable indicates missingness in the next wave. The results (Table A5) show attrition is slightly higher among younger, less educated, lower-income, and less physically active individuals, but not associated with sleep quality. We also reweight observations in each wave to match the national population by age, gender, and region, consistent with the initial sample stratification in Table A6, columns (1) and (2). The results are virtually identical.

We also examine whether COVID-19 dynamics explain fluctuations in sleep quality. We added 2 covariates: the Blavatnik School of Government's Stringency Index (0-100), averaged over the 2 weeks before each interview, and the average number of COVID-19 deaths per 100,000 inhabitants in the 4 preceding weeks. The results in Table A6, columns (3) and (4), show that including these variables does not materially alter the associations of other predictors. However, COVID-19 deaths are significantly negatively associated with sleep quality, consistent with our earlier findings from the initial waves.

To assess how much of the temporal trend may reflect pandemic dynamics, we compared wave fixed effects from 3 models: (1) country and wave effects only, (2) our main specification with full controls, and (3) the latter plus COVID-19 variables. In the first 2, wave effects vary markedly over time, mirroring Fig. 1 and indicating pronounced changes in average sleep quality even after controlling for individual characteristics. Adding COVID-19 variables substantially attenuates these effects, suggesting much of the remaining time variation is explained by the pandemic and its policy response (Fig. A1).

Finally, to address potential seasonal confounding, we estimated a model with month-by-year fixed effects to flexibly capture seasonality. The results (Table A6, last 2 columns) are unchanged, indicating our associations are robust to seasonal fluctuations.

Tables 3 and 4 further explore whether the associations between individual characteristics and sleep quality vary by country and sociodemographic characteristics. Starting with Table 3, which presents separate regressions for each country in the sample (France, Germany, Italy, Spain, and Sweden), we see that while the overall direction of associations remains broadly consistent, there are noteworthy variations in magnitude and significance across countries. For example, the positive association between income and sleep quality, which is one of the most robust findings in our pooled analysis, remains significant only in Sweden, suggesting that financial security may play a stronger role in enhancing sleep quality in certain national contexts. Similarly, being in a relationship is associated with greater sleep quality in France but this correlation is negative in Sweden (although not significant). These variations hint at cultural and structural factors that may shape the impact of socioeconomic determinants on sleep. Notably, physical activity and leisure time are associated with positive estimates across all

Table 4
Linear regressions per sociodemographic characteristics

	Sleep quality (std)					
	Men	Women	Age < 50	Age > =50	No postsecondary educ.	Postsecondary educ.
	(1)	(2)	(3)	(4)	(5)	(6)
Equivalent net HH income (log - PPP)	0.017	0.024**	0.010	0.037***	0.030***	0.006
	(0.013)	(0.010)	(0.011)	(0.012)	(0.010)	(0.012)
In a relationship	0.049	0.002	0.013	0.038	0.035	0.006
	(0.036)	(0.034)	(0.033)	(0.038)	(0.034)	(0.038)
Employed	0.033	0.054*	0.076**	0.010	0.049*	0.040
	(0.032)	(0.029)	(0.030)	(0.030)	(0.029)	(0.032)
Smoker	0.002	0.001	−0.013	0.015	−0.002	0.006
	(0.019)	(0.021)	(0.020)	(0.019)	(0.019)	(0.021)
No. of alcoholic drinks (per week)	−0.008	−0.002	−0.005	−0.008	−0.007	−0.006
	(0.007)	(0.012)	(0.010)	(0.008)	(0.008)	(0.010)
No. of days of physical activity (per week)	0.055***	0.043***	0.060***	0.040***	0.045***	0.053***
	(0.007)	(0.008)	(0.009)	(0.006)	(0.007)	(0.008)
Daily working time (in hours)	0.015*	0.009	0.021**	0.001	0.013*	0.010
	(0.009)	(0.008)	(0.008)	(0.009)	(0.008)	(0.010)
Daily childcare (in hours)	−0.006	0.002	0.002	−0.006	−0.002	0.002
	(0.010)	(0.007)	(0.007)	(0.012)	(0.008)	(0.009)
Daily home care (in hours)	−0.010	−0.011	−0.014*	−0.007	−0.010*	−0.010
	(0.008)	(0.007)	(0.008)	(0.006)	(0.006)	(0.009)
Daily leisure time (in hours)	0.021***	0.032***	0.026***	0.025***	0.021***	0.036***
	(0.006)	(0.007)	(0.009)	(0.005)	(0.006)	(0.008)
Daily media time (in hours)	−0.020***	−0.019***	−0.018**	−0.020***	−0.014**	−0.030***
	(0.006)	(0.007)	(0.009)	(0.005)	(0.006)	(0.008)
Mental health conditions (total)	−0.059***	−0.056***	−0.050***	−0.074***	−0.063***	−0.049***
	(0.009)	(0.009)	(0.008)	(0.011)	(0.008)	(0.011)
Physical health conditions (total)	−0.012	−0.003	−0.001	−0.013*	−0.011	−0.002
	(0.008)	(0.009)	(0.011)	(0.007)	(0.008)	(0.010)
Decrease in in-person contact	−0.010*	−0.023***	−0.019***	−0.015***	−0.015**	−0.020***
	(0.005)	(0.006)	(0.007)	(0.005)	(0.006)	(0.006)
Decrease in remote contact	−0.010*	−0.012*	−0.006	−0.016***	−0.014**	−0.006
	(0.006)	(0.006)	(0.007)	(0.005)	(0.006)	(0.006)
Observations	29,910	30,687	29,661	30,936	35,004	25,593

Notes: These are linear regressions. The dependent variable is sleep quality on a 7-point Likert scale standardized with a mean of zero and a standard deviation of one. Standard errors in parentheses are clustered at the individual level. All regressions include wave fixed effects and individual fixed effects. 'Equivalent net HH income (log - PPP)' stands for equivalent net household income (log - purchasing power parity).

* $p < .1$.
** $p < .05$.
*** $p < .01$.

countries, underscoring the universal role of an active lifestyle in promoting better sleep, regardless of the national context.

Table 4 delves into the heterogeneity of results based on sociodemographic characteristics, breaking down the analysis by gender, age group (< 50 and ≥50), and education level. Here, we see several nuanced patterns. For instance, income positively correlates with sleep quality in the 50+ age group only. While employment status positively correlates with sleep quality among the youngest, this association is weaker for the over-50, possibly highlighting how employment may buffer against stress differently across the life cycle. Additionally, physical activity and mental health remain strong predictors across all groups, with changes in magnitudes being marginal in most cases.

Table 5 examines whether the associations between individual characteristics and sleep quality remain consistent between pandemic and postpandemic times. We use the 2020-2022 waves of COME-HERE to study the potential impact of the pandemic period, while we use the 2023 and 2024 waves for the postpandemic period. Looking across the periods, we see that the overall direction of associations remains largely stable, suggesting that key factors—such as income, mental health, and physical activity—retain their predictive power regardless of the pandemic stage. For instance, income consistently shows a positive association with sleep quality each year, reinforcing the idea that financial security remains beneficial to sleep, both during the pandemic and in its aftermath. Similarly, mental health continues to be a strong predictor, with poor mental health consistently linked to lower sleep quality across all periods, highlighting the pervasive impact of mental health conditions on sleep regardless of external conditions. Separate regressions for each year from 2020-2024 are reported in Appendix Table A7 and results are similar.

In sum, sleep quality improved from April 2020-September 2024 but dipped during major COVID-19 waves, reflecting the pandemic's evolution and policy responses. Poor mental health, low income, unemployment, reduced physical activity, and social isolation consistently predict lower sleep quality, with mental health the strongest factor. These associations are robust to attrition, pandemic dynamics, and seasonality, and remain stable between pandemic and postpandemic periods. Cross-country and demographic differences suggest cultural, institutional, and life-course factors may moderate these links.

Discussion

This longitudinal cross-country study provides current, novel evidence on trajectories and potential predictors of sleep quality across the pandemic time and postpandemic transition from April 2020-September 2024. We used 13 waves of population-based data from representative samples of 5 European countries, including France, Germany, Italy, Spain, and Sweden, hence spanning different geographic regions, socioeconomic, and environmental contexts across the continent.

Overall, our findings suggest an upward trend in average sleep quality over time, with fluctuations that align with major COVID-19 waves, suggesting potential pandemic-related disruptions to typical seasonal sleep patterns. In addition, socioeconomic determinants of

Table 5
Linear regressions during the pandemic and post pandemic

	Sleep quality (std)	
	Pandemic years (2020-2022)	Postpandemic years (2023-2024)
	(1)	(2)
Equivalent net HH income (log - PPP)	0.053***	0.052***
	(0.009)	(0.015)
In a relationship	0.089***	0.084***
	(0.019)	(0.030)
Employed	0.029	0.002
	(0.023)	(0.044)
Smoker	0.046***	0.074***
	(0.017)	(0.027)
No. of alcoholic drinks (per week)	−0.004	−0.021
	(0.008)	(0.014)
No. of days of physical activity (per week)	0.089***	0.085***
	(0.007)	(0.013)
Daily working time (in hours)	0.007	0.007
	(0.008)	(0.020)
Daily childcare (in hours)	−0.004	0.007
	(0.007)	(0.012)
Daily home care (in hours)	−0.008	−0.031**
	(0.007)	(0.015)
Daily leisure time (in hours)	0.069***	0.097***
	(0.007)	(0.015)
Daily media time (in hours)	−0.042***	−0.042***
	(0.007)	(0.015)
Mental health conditions (total)	−0.138***	−0.130***
	(0.009)	(0.015)
Physical health conditions (total)	−0.065***	−0.100***
	(0.009)	(0.013)
Decrease in in-person contact	−0.029***	−0.065***
	(0.006)	(0.017)
Decrease in remote contact	−0.016***	−0.034**
	(0.006)	(0.016)
Observations	52,207	8390

Notes: These are linear regressions. The dependent variable is sleep quality on a 7-point Likert scale standardized with a mean of zero and a standard deviation of one. Standard errors in parentheses are clustered at the individual level. All regressions include wave fixed effects and individual fixed effects. 'Equivalent net HH income (log - PPP)' stands for equivalent net household income (log - purchasing power parity).
* $p < .1$.
** $p < .05$.
*** $p < .01$.

health such as income and employment, lifestyle behaviors such as regular physical activity, mental and physical health, and social interactions are key predictors of sleep quality, with financial security and mental health showing particularly strong associations. Importantly, our results hold across diverse groups (by country, gender, age, and education) and remain consistent from the height of the pandemic through to the postpandemic period, underscoring the enduring influence of socioeconomic and lifestyle factors as well as the prominent role of mental health in shaping sleep patterns, regardless of the specific geographic context. Hence, our study underscores the complex interplay between socioeconomic determinants, lifestyles, and mental and physical health conditions associated with sleep quality in the general population, above and beyond the potential impact of the COVID-19 pandemic.[23-25]

As suggested by our trajectory analysis, it is plausible to hypothesize that the COVID-19 pandemic disrupted typical seasonal sleep patterns, especially during the most impactful waves over the first 2 years. The usual seasonal fluctuations in sleep quality, which would typically show clearer improvements in spring and declines in winter,[26-28] appear somewhat absent or inconsistent in our analysis. For instance, while there is some improvement in sleep quality during certain spring and autumn periods, there is also considerable fluctuation without a strong seasonal rhythm in our data. This irregularity could indeed reflect the lasting impact of pandemic-related stressors, lifestyle changes, and disruptions to routines, which are known to influence sleep patterns.[8-12]

Several population-based studies and systematic reviews of observational evidence corroborate the potential detrimental impact of the pandemic on the prevalence of sleep problems in the general population, across different age groups and geographic contexts in both high-income and low-resource settings.[8-12] For example, increased electronic device use during lockdown has been associated with decreased sleep quality, reduced sleep duration, prolonged sleep onset latency, and delayed bedtime and rising time.[8] Likewise, a systematic review indicates that excess social media use is linked to poor sleep quality, particularly among the youth.[2] This evidence suggests that poor sleep patterns exacerbated by the pandemic will continue to be a persistent problem in our society.

Importantly, the present study underscores the critical role of socioeconomic factors in sleep health, in line with a large body of observational data. In fact, differences in sleep behaviors across socioeconomic gradients have been consistently reported, with disadvantaged groups tending to have poorer sleep health. For example, studies from the United States, Canada, Europe, and East Asia investigating factors such as education, income, and employment have generally observed that lower socioeconomic groups have higher rates of subjective and objective sleep problems, as well as more likely to experience abnormal sleep duration and poor sleep quality.[13,14,29,30-34]

Our findings suggest as well that women tend to report lower sleep quality than men, which is also consistent with observational evidence. Generally, women are more likely to self-report insufficient sleep, nonrestorative sleep with daytime sleepiness, and longer sleep duration.[1,14,35-37] In middle-aged and older women, sleep quality is impacted by hormonal changes and poor sleep quality may occur throughout the menopausal transition.[37-39] Epidemiological data raise concern that poor sleep might be associated with detrimental effects on cardiovascular risk among women, which is worrisome given the observed gender differences in sleep quality in our study.[40]

Regarding the potential impact of age on sleep quality, our findings suggest that age has a slightly negative impact on sleep, which seems to flatten as age increases. Previous work supports the notion that the effect of sleep patterns on health outcomes may vary by age.[1,14,41-44] Furthermore, a higher prevalence of sleep disturbances and use of sedative hypnotics is common among older adults.[43] Physiological studies of sleep corroborate the occurrence of changes in sleep structure associated with aging.[42] Age-related changes in sleep may also be a consequence of chronic mental disorders, which are common among older adults.[15,41–44] Generally, problems with sleep behaviors are particularly relevant among older adults, as aging is associated with a reduced ability to initiate and maintain sleep.[42–45] It is estimated that disruptions in sleep quality or sleep duration affect over half of the older adult population.[1,14] Older adults are also vulnerable to additional adverse health effects of poor sleep, such as cognitive decline[46] and an increased risk of falls.[47] Also, the presence of multimorbidity among older adults may further increase the risk for adverse health effects associated with sleep difficulties.[5,6]

Our study provides supportive evidence on the beneficial role of healthy lifestyles, such as regular physical activity, in enhancing sleep health. Indeed, several observational studies have found consistent associations of major behavioral risk factors, such as cigarette

smoking, heavy alcohol consumption, unhealthy dietary patterns, excess body weight, sedentarism, and physical inactivity with poor sleep patterns.[3,4,19] Altogether, sleep problems are closely linked to lifestyle behaviors, which might mediate or confound the associations of sleep patterns with health outcomes.

Furthermore, several studies suggest bidirectional associations between poor mental health and sleep problems.[1,15,48,49] Namely depression, psychological distress, and anxiety are consistent correlates of poor sleep health and sleep disturbances across different age groups. Not surprisingly, mental health was one of the strongest predictors of sleep quality in our study, as in multivariate analysis, poor mental health was consistently linked to lower sleep quality across all waves of data collection, supporting the prominent role of mental health in shaping sleep patterns, regardless of external factors such as the COVID-19 pandemic or the specific geographic context of interest.

There are strengths and limitations of the present study, which should be considered to better interpret our findings. First, sleep quality was based on self-report and assessed with a single-item question. We recognize that there are validated questionnaires, such as the Pittsburgh Sleep Quality Index (PSQI), which are often used in population-based studies.[22] This study does not include the full PSQI but instead uses a single-item self-report closely matching PSQI item 9. While used in prior population studies, it does not capture dimensions such as latency, duration, efficiency, or disturbances, which we acknowledge as a limitation. In addition, our results may be partly confounded by unmeasured time-varying variables, which are potentially linked to both COVID-19 pandemic-related factors and the main study outcome. Lastly, we acknowledge the relatively high attrition rate, which is not surprising given the multiple challenges and disruptions experienced by people during and after the pandemic. Nevertheless, the ample sample size, the sampling frame with the inclusion of representative samples from 5 different European countries, the longitudinal design, and frequency of data collection with the inclusion of several relevant covariates across 13 waves, as well as our analytical approach and robustness checks are major strengths of this study.

In closing, our findings illustrate how a range of socioeconomic, lifestyle, and mental and physical health factors come together to shape sleep patterns in the general population, reflecting the multifaceted influences on sleep health beyond geographic and pandemic-related contexts. The evidence from this study further emphasizes the need for greater attention to sleep health in both clinical and public health settings, hence policy initiatives are urgently needed to tackle this neglected societal issue.[50–52] Moreover, the cross-country heterogeneity observed in the predictors of sleep quality points to a promising avenue for future research aimed at understanding how cultural and institutional contexts shape sleep health and its determinants.

Author contributions

Anthony Lepinteur: Conceptualization, Methodology, Data curation, Formal analysis, Visualization, Writing – original draft. **Claus Vögele**: Conceptualization, Methodology, Funding acquisition, Writing – review and editing. **Conchita D'Ambrosio**: Conceptualization, Methodology, Funding acquisition, Writing – review and editing. **Saverio Stranges**: Conceptualization, Methodology, Writing – review and editing.

Data Sharing

The data used in this study are not publicly available due to confidentiality agreements, but the analysis code is available from the authors upon reasonable request.

Disclosures

None to report.

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Data availability

The data used in this study are not publicly available due to confidentiality agreements, but the analysis code is available from the authors upon reasonable request.

Use of generative AI

During the preparation of this work, the authors used ChatGPT in order to perform the final proofreading. After using this tool, the authors reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.sleh.2025.09.001.

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