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RESEARCH ARTICLE

Perceived risk of COVID-19 exposure and poor COVID-19 prognosis impair sleep: The mediating and moderating roles of COVID-19-related anxiety and knowledge

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Abstract

The ongoing COVID-19 pandemic has been linked to increased levels of stress, depression, and anxiety in many people around the world. Therefore, identifying individuals at risk of psychosocial burden during this unprecedented crisis is essential for developing prevention measures and treatment options for mental health issues. To this aim, we investigated two risk groups: individuals at higher risk of exposure to the virus and individuals at higher risk of poor prognosis if they contract the virus. We conducted a survey ($N = 4167$) with a representative sample of the German population and assessed perceived risk of COVID-19 exposure and poor prognosis if infected, COVID-19-related anxiety, problems with sleep and daytime functioning, as well as self-reported knowledge about the disease. Results showed that perceived risk group membership was linked to increased problems with sleep and daytime functioning via elevated levels of COVID-19-related anxiety. This mediated effect was further moderated by self-reported COVID-19 knowledge, but only for individuals who rated themselves at higher risk of COVID-19 exposure. Thus, knowledge buffered the negative effect of exposure risk on anxiety and ultimately on sleep in this risk group. Reaching individuals at increased risk of exposure with clear information about the disease, how to prevent infection, and treatment options could be an effective strategy to contain anxiety levels and promote good sleep, which is important for general well-being.

KEYWORDS
COVID-19, COVID-19 anxiety, Germany, knowledge, perceived risk group, sleep, sleep problems

1 | INTRODUCTION

The COVID-19 pandemic has been severely impacting lives around the world since its emergence in December, 2019. Over 5 million people have died from the virus (World Health Organization, 2021) and many more have grieved their losses. Efforts to slow the spread of the virus have led to the imposition of lockdowns, subjecting individuals to a variety of changes in their everyday routine, such as sudden school and work closures. From a psychosocial perspective, the pandemic can be seen as a prolonged, intense stressor, as it challenges people on many

different levels (e.g., economic, social, health, political), which in turn, can have negative physical and mental health consequences (Godinic et al., 2020; Pearlin & Bierman, 2013).

Many studies describe the negative effects of the COVID-19 pandemic on the mental health of the general population (see Xiong et al., 2020 for a systematic review) and especially of healthcare workers, who have been constantly and intensively exposed to the virus (see Sahebi et al., 2021 for an umbrella-review). Anxiety, depression, and stress are commonly reported psychological burdens of the general population in the context of the pandemic (Salari et al., 2020). Longitudinal research has further demonstrated a causal impact of the pandemic on the worsening of depression symptoms and acute stress (Holman et al., 2020).

Closely related to physical and mental health, another important aspect of well-being to consider is sleep. Studies exploring the impact of the pandemic on sleep quality have yielded mixed results. As described in a recent systematic review (Lin et al., 2021), some report a deterioration (Cellini et al., 2020; Robillard et al., 2021; Salfi et al., 2021) and others report no change, or sometimes even improvements (Korman et al., 2020; Leone et al., 2020; Salfi et al., 2021). Kocevska et al. (2020) found, for example, that the impact of the pandemic on sleep depended on pre-pandemic sleep quality and mood changes, with pre-pandemic good sleepers reporting a worsening of both sleep and mood during the pandemic. The pandemic seems not only to have heterogenous effects on the population, but also on distinct aspects of sleep quality, as some aspects ameliorated (e.g., sleep duration and daytime functioning) and others worsened (e.g., use of sleep medications and sleep efficiency) (Alfonsi et al., 2021).

The relationship between sleep and anxiety has been well documented over the course of the pandemic with many studies showing that higher levels of anxiety are associated with sleep problems (Al-Ajlouni et al., 2020; Cellini et al., 2020). Although the relationship between anxiety and sleep problems is likely bidirectional (Alvaro et al., 2013), one can hypothesize that in the context of a pandemic, first anxiety levels increase and then, as a consequence, sleep is affected. Thus, the question arises what specific pandemic-related factors might decrease sleep quality by increasing anxiety levels.

One potential cause of increased anxiety during the COVID-19 pandemic might be perceived risk group membership, being at higher risk of exposure to COVID-19 (e.g., because of job-related reasons) or at higher risk of poor COVID-19 prognosis in case of infection (e.g., because of pre-existing medical conditions). Perceived risk of contracting the virus as well as perceived risk of dying from COVID-19 were both found to be predictors of increased levels of anxiety and fear (Harper et al., 2020; Lin et al., 2020). The relationship between increased risk of exposure and poor prognosis and sleep has also been explored in the context of the COVID-19 pandemic. Frontline healthcare workers, who interact directly with COVID-19 patients and, thus, are at higher risk of exposure, have more anxiety and lower sleep quality compared to non-frontline healthcare workers (Lai et al., 2020; Qi et al., 2020; Zerbini et al., 2020). Similarly, individuals with chronic illnesses, who are at increased risk of poor COVID-19 prognosis, report lower sleep quality than individuals without any chronic illnesses (Robillard et al., 2021; Stanton et al., 2020). Thus, associations between being at increased risk of exposure or poor prognosis if infected and both anxiety and sleep problems have been reported previously. Here, we test a mediation model exploring the relationships between these three variables and hypothesize that COVID-19-related anxiety can help to explain the relationship between perceived risk group membership and sleep problems.

Additionally, we wanted to explore whether subjective knowledge about COVID-19 moderates the relationship between perceived risk group membership and COVID-19-related anxiety. Situations that are associated with harm, increased uncertainty, and partially unclear or unknown coping options are often appraised as threatening (cf., Lazarus & Folkman, 1984). Consequently, we expect individuals who feel informed about the symptoms and consequences of contracting COVID-19 to develop less anxiety that arises from their perceived risk-group membership. Exploring a moderating effect of knowledge is also practically relevant as lack of or incorrect knowledge can be addressed through public health campaigns (Anker et al., 2016). Therefore, a knowledge-moderated pathway would provide key insights for policy makers seeking to reduce anxiety and insomnia in populations at risk for COVID-19 as well as similar existing and upcoming diseases or health-threats. Such a moderating role of knowledge has been theorized in the context of the pandemic (Tan et al., 2020), but not yet been tested in our study context, and while many studies have examined the effect of the pandemic on psychological health and sleep, to the best of our knowledge, the effect of risk group membership on sleep difficulties mediated by COVID-19 anxiety has also not yet been examined (see Figure 1 depicting the proposed conceptual model).

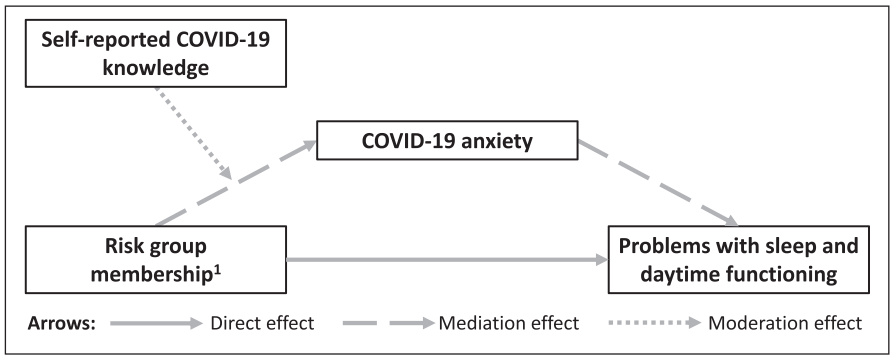

FIGURE 1 Proposed conceptual model. Notes: [1] Perceived risk of COVID-19 exposure or poor COVID-19 prognosis

2 | METHODS

2.1 | Participants and design

To examine the proposed effects, we recruited 4856 adult participants (18 and older) in Germany via the survey provider *respondi Online Panel*, an actively managed panel used for market research with voluntary participation and a double opt-in registration process.[1] To increase representativity, we used a quota sample representative for sex, age (18–74), and province. In accordance with German data protection regulations, personal data and survey data are stored separately. Of the 4856 participating respondents, 4716 participants (91.1%) provided informed consent. Due to missing data on the model variables, 4167 (85.8%) participants (women: 49.3%; average age: 45.8 years ± 15.5) comprise the analytical sample (only participants with complete responses on all scale items used for the analyses were included). Respondents who completed the survey received a small incentive (€0.40) to compensate for their time and to encourage participation (van Veen et al., 2016). Ethics approval was received from the Faculty of Management, Economics and Social Sciences of the University of Cologne (ethics approval number: 200015DM_extension). Data (Zerbini et al., 2022) were collected between December 16 and 29, 2020. At that time Germany was under a lockdown, with schools, hotels, bars, and restaurants closed. Most individuals worked remotely and there were severe restrictions to social gatherings.

2.2 | Measures

2.2.1 | Problems with sleep and daytime functioning

We used the seven-item Athens Insomnia Scale for Non-Clinical Application (AIS-NCA; Sattler et al., 2021). Responses were assessed on a five-point scale. The AIS-NCA provides two subscores, which describe sleep problems (sample item: "I could usually get to sleep (after turning off the lights)..." with response options ranging from "immediately" to "after a very long time") and impaired daytime functioning (sample item: "Throughout the day, my level of (physical and mental) performance was usually..." with response options ranging from "very good" to "very bad"), and a total score. Items were averaged to calculate each score, with possible values ranging from 1 to 5. Higher scores indicate more problems with sleep and daytime functioning. Reliability was good for both of the two subscales and for the total score (range of Cronbach's $\alpha = .77$-$.85$).

2.2.2 | Risk group

Two self-report indicators for belonging to a risk group were used. The first was higher risk of exposure to the virus and the second was higher risk of poor COVID-19 prognosis. Some examples were given to the participants to clarify the meaning of risk of exposure (e.g., because of working in a hospital or school) and of poor COVID-19 prognosis (e.g., because of suffering from diabetes or a lung disease) (cf., Gouin et al., 2021). Responses options were "no" [0] and "yes" [1] in each case.

2.2.3 | COVID-19 anxiety

We used three items of the German version of the Corona Anxiety Scale (CAS; Hölzel & Willenborg, 2020; Lee, 2020) to measure dysfunctional COVID-19 related fear and anxiety. Respondents assessed how frequently they experienced physiologically-based symptoms aroused by COVID-19-related information and thoughts (e.g., "I felt dizzy, lightheaded, or faint, when I read or listened to news about the coronavirus.") on a five-point scale from "not at all" [1] to "nearly every day over the last 2 weeks" [5]. Responses to the three items were averaged to calculate the total score, with possible values ranging between 1 and 5. Reliability was good (Cronbach's $\alpha = .85$).

2.2.4 | Self-reported COVID-19 knowledge

Knowledge about the symptoms and consequences of COVID-19 was measured with the item, "My knowledge of the symptoms and effects of Corona is..." "very low" [0] to "very high" [10] (cf., Sattler et al., 2017).

2.3 | Statistical analysis

Two moderated mediation models were computed using the PROCESS macro (Model 7) (Hayes, 2017) in SPSS (IBM Statistics for Windows, Version 28.0.1.0) to examine whether COVID-19-related anxiety mediates the effect of perceived risk group membership (risk of exposure and risk of poor prognosis) on problems with sleep and daytime functioning (total score of the AIS-NCA) and whether the effect of risk group on COVID-19-related anxiety is moderated by self-reported COVID-19 knowledge. The tested pathways of the two moderated mediation models that were computed are shown in Figure 1. Additional analyses with the subscores (sleep problems and impaired daytime functioning), confirming the results presented here, are reported in Tables S1–S2 of the Supporting Information. When testing the direct and indirect effects as well as the index of moderated mediation, 95% percentile bootstrap confidence intervals (*95% CI_{Boot}*) ($N = 10{,}000$) were used, thereby a *95% CI_{Boot}* that does not include zero indicates a statistically significant effect. We report the conditional indirect effects of risk group membership at three different values of COVID-19-related anxiety ("low" at 1 *SD* below the mean, "average" at the mean, and "high" at 1 *SD* above the mean). All reported

[1]In an elaborate scoring and control process, the panel is subjected to permanent quality control.

effects are unstandardized coefficients. We included age and sex as control variables since both variables have been shown to play a role in relation to membership to the aforementioned risk groups (eg., Rommel et al., 2021), fear of COVID-19 (eg., Niño et al., 2021), and sleep (eg., Luca et al., 2015).

3 | RESULTS

3.1 | Descriptive findings

Nearly every fifth (18.33%) respondent perceived themselves as being at risk of exposure to COVID-19, while three out of ten (30.19%) perceived themselves as being at risk of a poor COVID-19 prognosis. While the majority of the respondents (89.3%) reported they (almost) never experience anxiety symptoms, approximately 1% did so almost every day during the past 2 weeks. No or hardly any problems with sleep and daytime functioning occurred in 16.3% of the respondents, while 5.3% reported (very) severe problems. More of such problems were reported by people who perceived themselves at high risk of exposure to COVID-19 or a poor COVID-19 prognosis (see Figure 2). Self-reported COVID-19 knowledge was high, with 22.7% of the respondents choosing the two highest options (very high knowledge) on the 11-point scale, while only 1.0% indicated the two lowest options (very low knowledge). See Table 1 for further descriptive statistics and pairwise correlations of the examined variables.

3.2 | Risk of exposure to COVID-19

The mediator model reported in Model 1 (Table 2) reveals a statistically significant positive conditional main effect of risk of COVID-19 exposure on COVID-19-related anxiety, i.e., when self-reported knowledge was minimal, risk of exposure was linked to higher levels of anxiety (i.e., 0.711 points higher on a 5-point scale). For individuals not at risk of exposure, knowledge about COVID-19 did not affect anxiety ($B = 0.006$; see also bars for "No risk of exposure" in Figure 3). The statistically significant negative interaction effect between risk of exposure and knowledge ($B = -0.064$) suggests that the effect of risk of exposure on COVID-19-related anxiety decreases as knowledge increases (see bars for "Risk of exposure" in Figure 3).

The dependent variable model (Model 3 in Table 3) demonstrates that individuals who perceived themselves at risk of exposure to COVID-19 reported statistically significantly higher levels of problems with sleep and daytime functioning (on average 0.080 points higher on a 5-point scale) compared to individuals who do not perceive themselves at risk, when controlling for the mediator, COVID-19-related anxiety. The mediator anxiety also showed a statistically significant ($B = 0.329$) positive direct effect on problems with sleep and daytime functioning.

Moreover, we found a statistically significant conditional indirect effect of perceived risk of COVID-19 exposure on problems with sleep and daytime functioning via COVID-19-related anxiety ($B = -0.021$). This indicates that belonging to the risk group worsened sleep and daytime functioning via increased anxiety levels, and that this effect was stronger in participants reporting lower knowledge about COVID-19 (as indicated by the confidence intervals of the pairwise contrasts that did not include zero).

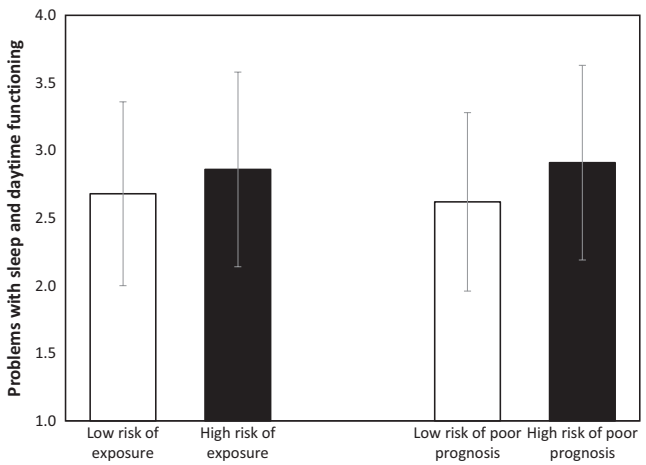

FIGURE 2 Mean values (with standard deviations) of problems with sleep and daytime functioning (AIS-NCA) by risk of exposure to COVID-19 (left) and risk of poor COVID-19 prognosis (right). Notes: The range of the AIS-NCA is 1–5, with higher scores indicating more problems with sleep and daytime functioning

3.3 | Risk of poor COVID-19 prognosis

The mediator model reported in Model 2 (Table 2) reveals a statistically significant positive conditional main effect of risk of poor prognosis on COVID-19-related anxiety, thus individuals who perceived themselves as at risk of poor prognosis in case of a COVID-19 infection reported higher levels of COVID-19-related anxiety (on average 0.345 points higher) than those who did not identify as risk group members. This effect was not statistically significantly moderated by self-reported knowledge about COVID-19 ($B = -0.011$). As in Model 1, knowledge had no conditional main effect on COVID-19-related anxiety ($B = -0.003$).

The dependent variable model in Table 3 (Model 4) shows that individuals who perceived themselves to be at risk of poor COVID-19 prognosis reported statistically significantly higher levels of problems with sleep and daytime functioning compared to individuals who did not report such risk (on average 0.286 points higher on a 5-point scale), when controlling for the mediator COVID-19-related anxiety. Similar to Model 3, the mediator had a statistically significant positive direct effect on problems with sleep and daytime functioning ($B = 0.305$). We also found indirect effects of risk of poor prognosis on problems with sleep and daytime functioning via COVID-19-related anxiety (confidence intervals did not include zero); these indirect effects were, however, not moderated by

TABLE 1 Pairwise correlations and descriptive statistics ($N = 4167$)

	Pairwise correlations and Chronbach's α (in diagonal)							Descriptive statistics	
	1)	2)	3)	4)	5)	6)	7)	Mean (SD) or proportion	Min-Max
1) Perceived exposure risk (yes)	---[a]							0.18	0–1
2) Perceived poor prognosis risk (yes)	0.169***	---[a]						0.30	0–1
3) COVID−19-related anxiety	0.143***	0.112***	0.85					1.36 (0.69)	1–5
4) Problems with sleep and daytime functioning	0.100***	0.191***	0.349***	0.85				2.71 (0.69)	1–5
5) Self-reported COVID−19 knowledge	0.035*	0.046**	−0.023	−0.033*	---[a]			7.20 (1.87)	0–10
6) Sex (woman)	0.045**	−0.024	0.037*	0.136***	0.080***	---[a]		0.49	0–1
7) Age (years)	−0.045**	0.301***	−0.144***	−0.083***	0.093***	0.025	---[a]	45.8 (15.5)	18–74

*$p < .05$, **$p < .01$, ***$p < .001$. p-values have been adjusted for multiple comparisons using the Benjamini-Hochberg correction.

[a]Not applicable. Pearson's coefficients are reported. For categorical variables, descriptive statistics are reported for the category indicated in parenthesis.

TABLE 2 Mediator variable models of the conditional mediation model with self-reported COVID-19 knowledge as moderating variable ($N = 4167$)

	Model 1: risk of exposure			Model 2: risk of poor prognosis		
	Effect	SE_{Boot}	95% CI_{Boot}	Effect	SE_{Boot}	95% CI_{Boot}
Mediator variable models for the outcome COVID-19-related anxiety						
Risk group[a]	**0.711**	0.157	[0.403, 1.014]	**0.345**	0.114	[0.122, 0.568]
Self-reported COVID-19 knowledge	0.006	0.006	[−0.005, 0.018]	−0.003	0.006	[−0.015, 0.010]
Risk group*self-reported COVID-19 knowledge	**−0.064**	0.020	[−0.103, −0.024]	−0.011	0.015	[−0.041, 0.019]
Constant	**1.516**	0.055	[1.410, 1.627]	**1.659**	0.061	[1.538, 1.781]

Note: Effects in bold indicate that the respective *95% CI_{Boot}* does not include zero and are thus considered statistically significant. Effects are unstandardized coefficients. Results controlled for age and sex.

[a]The respective type of risk group is indicated in the header of the table; pathway a moderated by self-reported COVID-19 knowledge; *95% CI_{Boot}*, 95% percentile bootstrap confidence interval ($N = 10{,}000$); SE_{Boot}, percentile bootstrap standard error.

self-reported COVID-19 knowledge (as indicated by the confidence intervals of the pairwise contrasts that included zero).

4 | DISCUSSION

Previous research suggests that the COVID-19 pandemic had heterogenous effects on sleep health in the population (Lin et al., 2021). In their recent scoping review, Simonelli et al. (2021) identified several risk factors (e.g., young age, female sex, low socio-economic status, pre-pandemic psychological problems) that rendered some individuals more prone to develop sleep problems.

In search of further risk factors, as well as mediating and moderating factors, we investigated the effect of risk group membership on problems with sleep and daytime functioning for two particularly vulnerable groups of individuals, those who perceived themselves at increased risk of COVID-19 exposure and poor COVID-19 prognosis. In sum, our results showed that perceived risk group membership was associated with increased problems with sleep and daytime functioning. This effect was mediated via elevated levels of COVID-19-related anxiety. Moreover, knowledge about COVID-19 buffered the negative effect of risk group on anxiety and ultimately on sleep, but only for individuals who rated themselves at higher risk of COVID-19 exposure.

More specifically, we found that two in ten individuals classified themselves as being at increased risk of COVID-19 exposure and three in ten as being at increased risk of poor COVID-19 prognosis. Our finding of elevated levels of COVID-19-related anxiety in both risk groups (especially in those at risk of exposure) is in line with previous studies which found positive correlations between perceived risk of contracting the virus/perceived severity of the virus and fear/anxiety related to COVID-19 (Harper et al., 2020; Lin et al., 2020).

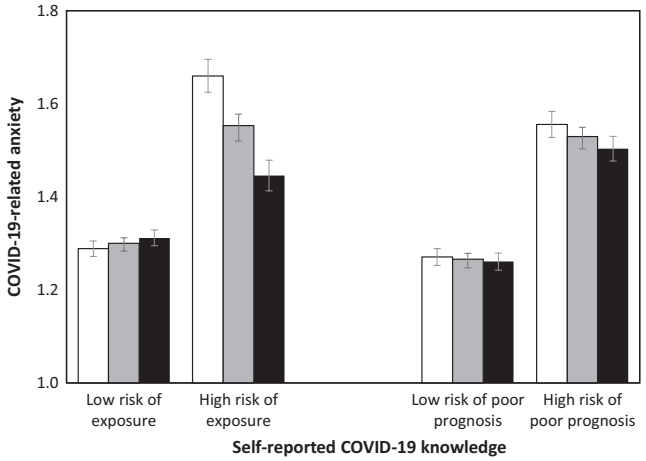

FIGURE 3 Predicted values (with standard errors) of COVID-19-related anxiety (CAS) depending on risk of exposure to COVID-19 (left) and risk of poor COVID-19 prognosis (right) and as a function of different levels of self-reported COVID-19 knowledge. Notes: The range of the COVID-19-related anxiety scale is 1–5, with higher scores indicating higher levels of anxiety. Self-reported COVID-19 knowledge is predicted at three different values: "low" at 1 SD below the mean □, "average" at the mean ▫, and "high" at 1 SD above the mean ■.

Anxiety levels were also positively associated with sleep problems and daytime malfunctioning, consistent with previous studies (Al-Ajlouni et al., 2020; Cellini et al., 2020), and mediated the relationship between perceived risk and sleep. Individuals who perceived themselves at increased risk of COVID-19 exposure (especially those with low self-reported knowledge about COVID-19) reported increased COVID-19 anxiety levels, which in turn negatively impacted their sleep. The same mediation pathway (without the moderating effect of knowledge) was found for individuals at risk of poor prognosis. We also found a residual direct effect of risk group membership on sleep, indicating that belonging to one of the two risk groups was associated with sleep problems independent of anxiety. A potential cause of the direct effect of risk of exposure on sleep could be the increased workload that individuals in certain jobs faced because of the pandemic (Bell et al., 2021). Similarly, pre-pandemic research shows that many chronic illnesses (e.g., heart disease and high blood pressure which are risk factors for poor COVID-19 prognosis) are associated with insomnia (Taylor et al., 2007).

As previously mentioned, self-reported knowledge about COVID-19 moderated the association between risk of exposure and COVID-19-related anxiety. Information about how to prevent infection from COVID-19 (e.g., social distancing and wearing

TABLE 3 Dependent variable models of the conditional mediation model with self-reported COVID-19 knowledge as moderating variable and problems with sleep and daytime functioning (total score) as outcome variable ($N = 4167$)

	Model 3: risk of exposure			Model 4: risk of poor prognosis		
	Effect	**SE_{Boot}**	**95% CI_{Boot}**	**Effect**	**SE_{Boot}**	**95% CI_{Boot}**
Problems with sleep and daytime functioning (total score)						
Risk group[a]	**0.080**	0.027	[0.028, 0.132]	**0.286**	0.024	[0.237, 0.332]
COVID-19-related anxiety	**0.329**	0.017	[0.297, 0.362]	**0.305**	0.017	[0.272, 0.337]
Constant	**2.244**	0.041	[2.164, 2.323]	**2.327**	0.041	[2.248, 2.409]
Conditional indirect effects of risk group via COVID-19-related anxiety at different values of self-reported COVID-19 knowledge						
Low knowledge	**0.122**	0.020	[0.085, 0.162]	**0.087**	0.013	[0.062, 0.114]
Medium knowledge	**0.083**	0.012	[0.060, 0.108]	**0.080**	0.009	[0.063, 0.099]
High knowledge	**0.044**	0.015	[0.015, 0.075]	**0.074**	0.012	[0.052, 0.098]
	Contrast	**SE_{Boot}**	**95% CI_{Boot}**	**Contrast**	**SE_{Boot}**	**95% CI_{Boot}**
Pairwise contrasts between conditional indirect effects of COVID-19-related anxiety at different values of self-reported COVID-19 knowledge						
Medium vs. low knowledge	**−0.039**	0.013	[−0.064, −0.014]	−0.006	0.009	[−0.023, 0.011]
High vs. low knowledge	**−0.078**	0.026	[−0.128, −0.028]	−0.013	0.017	[−0.046, 0.021]
High vs. medium knowledge	**−0.039**	0.013	[−0.064, −0.014]	−0.006	0.009	[−0.023, 0.011]
	Effect	**SE_{Boot}**	**95% CI_{Boot}**	**Effect**	**SE_{Boot}**	**95% CI_{Boot}**
Index of moderated mediation						
	−0.021	0.007	[−0.034, −0.008]	−0.003	0.005	[−0.012, 0.006]

Note: Effects in bold indicate that the respective *95% CI_{Boot}* does not include zero and are thus considered statistically significant. Effects are unstandardized coefficients. Results controlled for sex and age.

[a]The respective type of risk group is indicated in the header of the table; pathway *a* moderated by self-reported COVID-19 knowledge; *95% CI_{Boot}*, 95% percentile bootstrap confidence interval ($N = 10{,}000$); SE_{Boot}, percentile bootstrap standard error.

masks) has been available and communicated to everyone almost from the beginning of the pandemic. This means that clear guidelines on how to easily and effectively prevent an infection could be obtained, although information uptake might vary (Alsan et al., 2020). Thus, understanding the virus, how to prevent a COVID-19 infection and how to apply the precautionary measures in everyday life could have helped individuals with high exposure risk to, nevertheless, feel safe, which in turn reduced their anxiety levels. Such a buffering effect of knowledge on COVID-19-related anxiety was not observed in the poor prognosis risk group. The reason for this could be that treatment and prevention options were not available at the time of the survey. For instance, only 200,000 individuals in Germany had received their first dose of vaccine by December 31st, 2020. Thus, general knowledge about the virus was probably not helpful to decrease anxiety levels in individuals at risk of poor prognosis because there was no clear evidence available on how to prevent poor prognosis in case of infection. Our results are in line with a recent study that found a similar relationship between lower anxiety levels and the perception of being sufficiently informed about the pandemic (Cheng et al., 2021). The study also highlights the challenges of obtaining correct and reliable information, as well as the complex interaction between information coping styles and strategies in determining how individuals respond to the overwhelming amount of information available.

4.1 | Limitations and avenues for future research

We also acknowledge the limitations of our study. First, we used single-item instruments to assess perceived risk group membership concerning exposure to the COVID-19 virus and poor prognosis in case of infection. Although we provided respondents with exemplary indicators, future studies could provide a full list of indicators to improve the validity of such self-attributed categorizations. Similarly, we also assessed subjective knowledge about COVID-19 with one-single item, which only captured general knowledge, and could be improved using a more detailed assessment with multiple items (e.g., about effective ways to prevent infection, treatment options, consequences of specific symptoms, or local incidence rates). Second, the aforementioned measures as well as the sleep and anxiety measures were subjective, thus prone to self-report biases. Although subjective measures are highly relevant (especially when assessing psychological health), future studies could complement them with objective measures (e.g., actimetry to assess sleep and knowledge tests to assess knowledge about COVID-19). A third limitation of this study concerns self-selection into online surveys, which could be addressed in future studies by using probability samples drawn from the general population. In addition, given the retrospective and cross-sectional nature of the data, longitudinal research re-examining the relationships found in this study is warranted. Longitudinal analyses are also needed to identify long-term effects of the pandemic on sleep and other indicators of physical and psychological health.

5 | CONCLUSION

Altogether, this study contributes to our understanding of how the COVID-19 pandemic has particularly affected specific groups of individuals and stimulates ideas for possible interventions. Sleep quality of individuals that perceived themselves at risk of COVID-19 exposure or at risk of poor COVID-19 prognosis could be improved by decreasing COVID-19-related anxiety levels. Public health campaigns which provide information about the virus and protection measures (Anker et al., 2016) could be one strategy not only to prevent infections, but also to provide the general population, and especially individuals at risk, with practical tools to protect themselves while simultaneously lowering their anxiety levels. Decreasing anxiety levels and, thereby, improving sleep quality is an important goal to promote well-being, given the central role of sleep in mental and physical health (Freeman et al., 2020).

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

Giulia Zerbini: statistical analysis, data curation, writing – original draft, writing – review and editing; Shannon Taflinger: writing – original draft, writing – review and editing; Philipp Reicherts: writing – review and editing; Miriam Kunz: writing – review and editing; Sebastian Sattler: Conceptualization, methodology, investigation, statistical analysis, data curation, visualization; writing – original draft, writing – review and editing, project administration, and funding acquisition.

ETHICAL APPROVAL

Ethics approval was received from the Faculty of Management, Economics and Social Sciences of the University of Cologne (ethics approval numbers: 200015DM_extension).

CONSENT TO PARTICIPATE

Informed consent was obtained from all study participants.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in "PUB-Publikationen an der Universität Bielefeld" (Zerbini et al., 2022).

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