Aus der Medizinischen Klinik und Poliklink für Kardiologie und Angiologie
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DISSERTATION

Prevalence and Influencing Factors of Insomnia, Anxiety, and Depression during the COVID-19 Pandemic

Prävalenz und Einflussfaktoren von Schlaflosigkeit, Angstzuständen und Depressionen während der COVID-19-Pandemie

zur Erlangung des akademischen Grades
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List of Abbreviations

BMI	Body Mass Index
COVID-19	Coronavirus disease 2019
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders-IV
GAD-2	2-Item Generalized Anxiety Disorder Scale
GAD-7	7-Item Generalized Anxiety Disorder Scale
ICOSS	The International COVID-19 Sleep Study
IHR	International Health Regulations
ISI	Insomnia Severity Index
OR	Odds ratio
RNA	Ribonucleic Acid
RKI	The Robert Koch Institute
SARS	Severe Acute Respiratory Syndrome
SD	Standard Deviation

Abstract

Abstract

Background: The coronavirus disease 2019 (COVID-19) caused serious public panic worldwide and also burdened populations with a massive shock on their sleep and psychological status. The present study aims to examine the prevalence of insomnia, depression, and anxiety among German citizens in the COVID-19 pandemic era as well as the factors that have influenced them.

Methods: This study used the International COVID-19 Sleep Study (ICOSS) self-administered questionnaire to investigate and summarize the general population's sleep status and circadian sleep patterns in Germany. The normally distributed data were reported as means ± standard deviations (SD) and subjected to a comparison among groups by t-tests, or otherwise, they were expressed as medians (quartiles) and subjected to a comparison among groups by non-parametric tests. Enumeration data were expressed as the number of cases (n) and percentages (%) and subjected to a comparison among groups by χ^2 tests or Fisher's exact tests. Correlations of the insomnia scale and the mental health scale were tested using Spearman correlation analysis. Finally, binary logistic regression analysis was used to explore the potential influencing factors.

Results: 510 questionnaires were collected for this study, with 465 usable questionnaires. The majority of respondents were married or in a relationship (72.2%) and from urban areas (88.4%). The percentage of participants with educational attainment above college education was 20%, mostly Caucasian/White 69.2%. The prevalence rate of insomnia, depression, and anxiety in the studied German population was 22.8%, 14.2%, and 14.6%, respectively. The insomnia severity and the depression or anxiety degrees showed a positive correlation ($P < 0.001$). Significant correlations were also observed between the ISI, PHQ-2, and GAD-2 scales ($P < 0.01$). The proportion of insomnia symptoms also showed statistically significant differences among places of residence, employment status, and economically shocked status. The proportion of depression symptoms showed statistically significant differences among the study participants of different gender and economically shocked status. Finally, the proportion of anxiety symptoms showed statistically significant differences among economically shocked status.

Conclusion: The present study measured the sleep quality and mental health status of the German population in the COVID-19 pandemic era. Our results show increased degrees of insomnia, anxiety, and depression incidence in the German population participating in the survey after the outbreak of the pandemic.

Zusammenfassung

Hintergrund: Die Coronavirus-Erkrankung 2019 (COVID-19) hat weltweit eine schwere öffentliche Panik ausgelöst und auch den Schlaf und den psychischen Zustand der Menschen massiv belastet. Die vorliegende Studie zielt darauf ab, die Prävalenz von Schlaflosigkeit, Depression und Angstzuständen bei deutschen Bürgern während der COVID-19-Pandemie und die Faktoren, die diese beeinflussen, zu untersuchen.

Methoden: In dieser Studie wurde der selbstausgefüllte Fragebogen der Internationalen COVID-19-Schlafstudie (ICOSS) verwendet, um den Schlafstatus und das zirkadiane Schlafmuster der Allgemeinbevölkerung in Deutschland zu untersuchen und zusammenzufassen. Die normalverteilten Daten wurden als Mittelwerte ± Standardabweichungen (SD) angegeben und mittels t-Tests einem Vergleich zwischen den Gruppen unterzogen. Andernfalls wurden sie als Mediane (Quartile) ausgedrückt und einem Vergleich zwischen den Gruppen durch nichtparametrische Tests unterzogen. Die Zählungsdaten wurden als Anzahl der Fälle (n) und Prozentsätze (%) ausgedrückt und einem Vergleich zwischen den Gruppen durch χ^2-Tests oder exakte Tests nach Fisher unterzogen. Korrelationen zwischen der Schlaflosigkeitsskala und der Skala zur psychischen Gesundheit wurden mit der Spearman-Korrelationsanalyse getestet. Schließlich wurde eine binäre logistische Regressionsanalyse verwendet, um die potenziellen Einflussfaktoren zu untersuchen.

Ergebnisse: Für diese Studie wurden 510 Fragebögen gesammelt, von denen 465 verwertbar waren. Die Mehrheit der Befragten war verheiratet oder in einer Beziehung (72,2 %) und stammte aus städtischen Gebieten (88,4 %). Der prozentuale Anteil der Teilnehmer mit einem Bildungsabschluss über dem College lag bei 20 %, wobei die meisten Kaukasier/Weiße 69,2 % waren. Die Prävalenzrate von Schlaflosigkeit, Depression und Angstzuständen in der untersuchten deutschen Bevölkerung betrug 22,8 %, 14,2 % bzw. 14,6 %. Der Schweregrad der Schlaflosigkeit und der Grad der Depression oder Angst zeigten eine positive Korrelation ($P < 0{,}001$). Signifikante Korrelationen wurden auch zwischen den Skalen ISI, PHQ-2 und GAD-2 beobachtet ($P < 0{,}01$). Der Anteil der Schlaflosigkeitssymptome zeigte auch statistisch signifikante Unterschiede zwischen den Wohnorten, dem Beschäftigungsstatus und dem ökonomischen Schockstatus. Der Anteil der Depressionssymptome zeigte statistisch signifikante Unterschiede zwischen den Studienteilnehmern unterschiedlichen Geschlechts und des ökonomischen Schockstatus.

Und schließlich wies der Anteil der Angstsymptome statistisch signifikante Unterschiede zwischen dem ökonomischen Schockstatus auf.

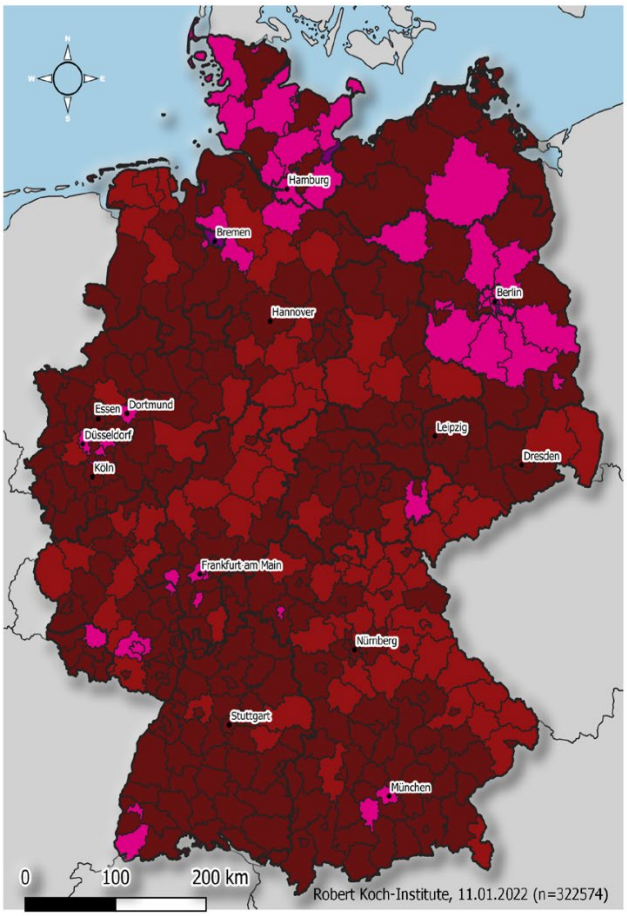
Schlussfolgerung: In der vorliegenden Studie wurden die Schlafqualität und der psychische Gesundheitszustand der deutschen Bevölkerung in der Zeit der COVID-19-Pandemie gemessen. Unsere Ergebnisse zeigen, dass in der deutschen Bevölkerung, die an der Umfrage teilnahm, nach Ausbruch der Pandemie vermehrt Schlaflosigkeit, Angstzustände und Depressionen auftraten.

1 Introduction

1.1 Current coronavirus disease 2019 (COVID-19) pandemic

In December 2019, a patient infected with coronavirus was first diagnosed in Wuhan, China, and the disease was subsequently called COVID-19 [1]. The disease was rapidly spreading around the world, affecting over two hundred countries and regions, and causing great concern worldwide. On 30 January 2020, the World Health Organization (WHO) classified the COVID-19 outbreak as a "Public Health Emergency of International Concern (PHEIC)" [2]. Then, on 11 February 2020, the WHO officially named it COVID-19 [2, 3]. On 28 February, the WHO further raised the global risk level from "high" to "very high" and subsequently announced on 11 March that COVID-19 had evolved into a "global pandemic" [4, 5].

The 21st century has seen several public health emergencies around the world. Since the promulgation of the International Health Regulations (IHR), the WHO has declared six PHEICs, the first five being the influenza A H1N1 outbreak (2009), the polio outbreak (2014), the Ebola outbreak in West Africa (2014), the Zika outbreak (2015-2016), and the Ebola outbreak in Congo (2018). Unlike the previous SARS and Ebola hemorrhagic fever outbreaks, the coronavirus causing COVID-19 is an enveloped single-positive-stranded RNA virus from a coronaviridae family called Noroviruses [6]. This novel virus is widely found in humans, other mammals, and birds [6]. COVID-19 is a respiratory disease usually accompanied by fever, dry cough, and polypnea; it can also cause a variety of intestinal, hepatic, haematological, and neurological complications [7]. COVID-19 is characterized by insidious onset, high infectivity, rapid transmission, widespread population susceptibility, interpersonal transmission, and convergent onset, leading to the most serious public health disaster in the current century [7-9]. The world is still experiencing COVID-19 spread at a relentless speed. Up to mid-January 2022, according to the WHO, over 309 million COVID-19 cases have been confirmed in over 200 countries worldwide, with over 5.4 million death cases [10]. In the United States, more than 1 million cases were diagnosed on a single day. Up to 11 January 2022, the confirmed amount of COVID-19 incidence in Germany had exceeded 7.58 million with over 110,000 total deaths (Figure 1) [11, 12].



Notified cases during the last 7 days

COVID19 INCIDENCE
As of: 11.01.2022
cases per 100,000 population

- no notified cases [0]
- >0.0 - 5.0 [0]
- >5.0 - 25.0 [0]
- >25.0 - 50.0 [0]
- >50.0 - 100.0 [0]
- >100.0 - 250.0 [84]
- >250.0 - 500.0 [271]
- >500.0 - 1,000.0 [53]
- >1,000.0 [3]

	county	cases (n)	incidence
1	SK Bremen	7139	1,260.0
2	SK Berlin Neukölln	3549	1,114.3
3	SK Lübeck	2186	1,012.8
4	SK Berlin Friedrichshain-Kreuzberg	2560	916.9
5	SK Berlin Mitte	3088	824.4
6	SK Berlin Spandau	1948	813.8
7	SK Bremerhaven	921	811.0
8	LK Verden	1115	810.5
9	SK Berlin Charlottenburg-Wilmersdorf	2521	797.2
10	SK Kiel	1957	793.6
11	SK Berlin Tempelhof-Schöneberg	2682	785.8
12	LK Dithmarschen	1024	768.5
13	SK Berlin Reinickendorf	1960	754.7
14	SK Berlin Pankow	2998	741.7
15	SK Delmenhorst	569	734.2

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Figure 1: Number and cumulative incidence of confirmed COVID-19 cases in Germany [11].

Epidemiological surveys have found that the COVID-19 incubation period is mostly 3 - 7 days (interval of 1 to 14 days) and the clinical manifestations may be dry cough, fever, and malaise [13]. In severe cases, polypnea, dyspnea, decreased oxygen saturation, as well as rapid condition deterioration to acute respiratory distress syndrome, septic shock, and even systemic multi-organ failure may occur 7 days after onset. The source of COVID-19 transmission is confirmed patients and asymptomatic infections, as well as some patients in the incubation period [14]. The novel coronavirus can also be transmitted through the environment, enabling the transmission from objects to humans [15]. Transmission occurs by respiratory droplet, aerosol, and contact, leading to general susceptibility in the population [16]. The main organ of disease for the novel coronavirus is the lung, but COVID-19 can also cause damage to other organs. Most patients have a good prognosis, but a small number of patients may develop a life-threatening condition, with advanced age and previous chronic underlying disease being key factors in the prognosis [13, 17, 18].

The rapid spread of the pandemic has posed serious challenges - and even the risk of paralysis - to healthcare systems in many countries around the world. It has also led to severe damage relating to social and economic factors worldwide, creating extensive havoc for global market transactions, jobs, the tourism industry, and transportation [19, 20].

1.2 COVID-19 pandemic influence on insomnia, depression, and anxiety

The COVID-19 pandemic has not only caused severe human and economic losses worldwide but also numerous serious sleep and psychological problems [21, 22]. As with all other outbreaks, the general population has psychologically responded with fear and panic about being infected, about family members being infected, and that the pandemic will last for a long time. Numerous studies have shown a variety of physiological or psychological stress reactions such as anxiety, depression, and insomnia under the influence of a pandemic [18, 22-24]. During the SARS pandemic, SARS-infected patients experienced varying degrees of depression, anxiety, and other traumatic stress disorders [25, 26]. The duration of isolation was correlated to the prevalence of post-traumatic stress disorders [27]. The COVID-19 pandemic has also impacted hugely on people's daily lives and psychological situation, in terms of the risk of stress, depression, and anxiety, especially in low-income adults [28].

Sleep is a biological function that is essential to human health and well-being and is necessary for a high-quality life [29]. Sleep affects health status, quality of life, functioning, autonomy, and safety [30]. Sleep deprivation or poor sleep quality can place a significant burden on individuals and society [31], with adverse impacts on health, productivity, and safety. For example, sleepiness and fatigue can raise the risk of injuries and accidents, such as those that occur in the workplace and motor vehicle crashes [32, 33]. Due to the need to prevent and control the COVID-19 pandemic, people were forced to isolate themselves, staying at home and cancelling various gatherings to reduce the chances of transmission. The lack of social interaction and entertainment naturally led to COVID-19-related loneliness and boredom. The most common problems caused by this phenomenon have been sleeping problems deteriorating the quality or quantity of sleep, which can negatively influence mental health factors [34]. Several studies have shown that COVID-19 has had a great impact on health factors such as sleep as well as mental and physical

health [35, 36]. According to a study in China, elevated levels of anxiety and stress in healthcare workers are associated with reduced sleep duration [37].

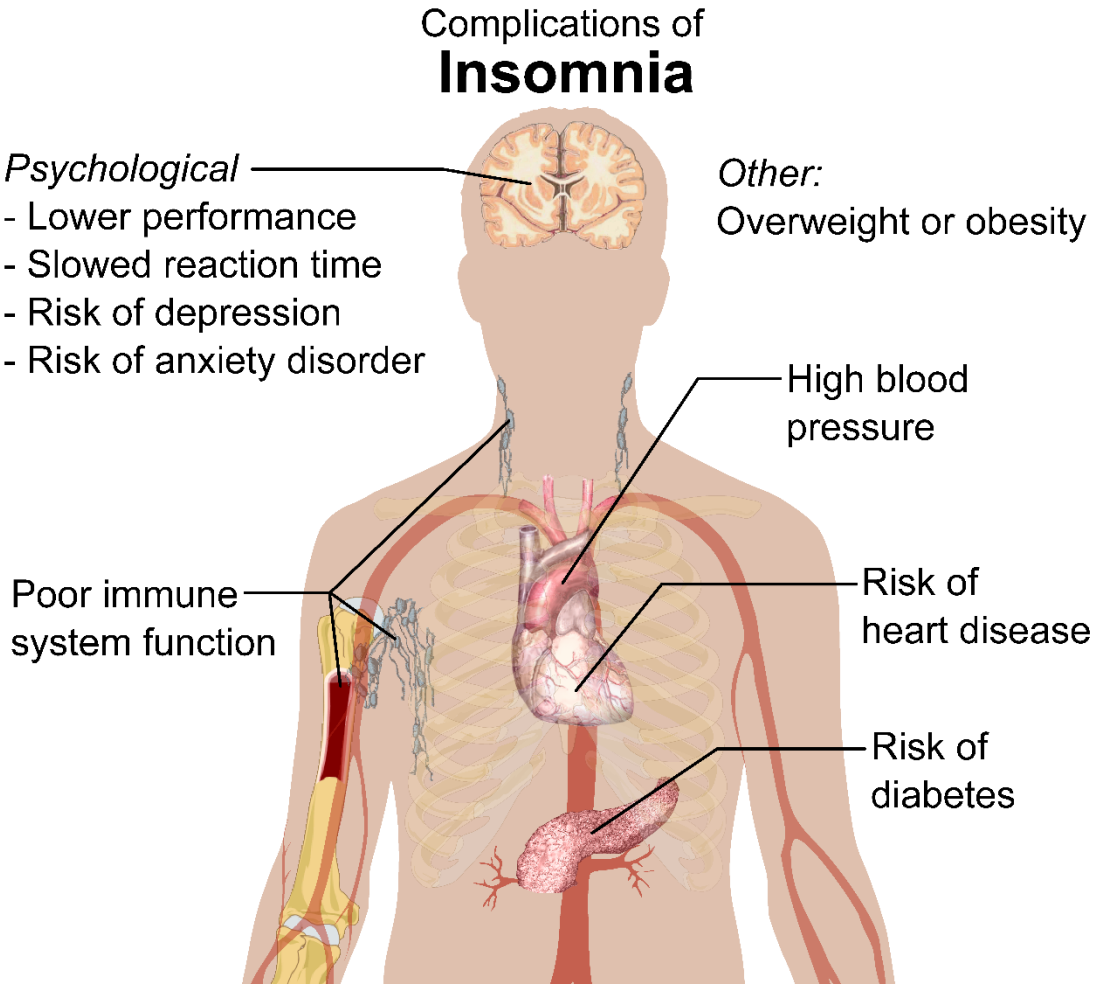

Figure 2: Potential complications of insomnia [38].

As one of the most common sleep disorders, insomnia is characterized by frequent difficulties in falling asleep or having a continuous sleep. Insomnia causes significantly decreased sleep satisfaction, placing a serious burden on both individuals and society. Chronic insomnia is the most common, affecting approximately 30% of the general population [39, 40]. According to statistics, the prevalence of insomnia in Germany was 5.7% in 2013 [41]. Insomnia causes a significant impairment of daytime waking functions, leading to fatigue, reduced motivation, irritability, depressed mood, reduced attention and memory, and drowsiness, and is a prodromal symptom as well as a maintenance factor for a variety of somatic disorders and psychiatric disorders (Figure 2) [42]. Surveys conducted among Chinese healthcare workers since the COVID-19 pandemic have shown a dramatic prevalence of insomnia (34–36%), often associated with anxiety and depression

[43, 44]. Therefore, the COVID-19 pandemic-associated insomnia increase and psychological symptoms create an urgent need to prioritize projects addressing large-scale public sleep and mental health intervention either during or after the COVID-19 pandemic [45].

Depression is another common psychological disorder and is the most predominant type of mental illness in the modern era [46]. Depression can manifest itself in a variety of symptoms, such as prolonged depressed mood, moping, grief, low self-esteem, misery, pessimism, and misanthropy. For patients with depression, daily life is tormented, leading to negativity, avoidance, and eventually even suicidal tendencies and behaviour. Depression can occur in several episodes which last from two weeks to as much as several years, with a high tendency to relapse. In Germany, it is estimated that 5% of the population (approximately 4 million people) currently suffer from depression. 2020 witnessed an increase of more than a quarter in the depression and anxiety incidence worldwide due to the COVID-19 pandemic [47]. Women and young people are the portion of the population most affected by depression and anxiety disorders.

Anxiety disorder is a common psychological disorder. The German Epidemiological Survey of Mental Disorders demonstrated a one-year prevalence of 10.3% for anxiety disorders [48]. Manifestations of anxiety that do not meet the diagnostic criteria for anxiety disorders are called anxiety symptoms. Anxiety symptoms are an emotional response that manifests in both physiological tension and arousal of sympathetic nerve function, as well as psychological worry, fear, dread, behavioural avoidance, and diminished social functioning [49]. Anxiety is a normal human psychological response to stress. However, if this emotion persists for too long and the intensity of the response is too high, anxiety disorders can develop. Following a public health emergency, most populations do not develop anxiety disorders, but rather, some symptoms of anxiety that impact on the daily life quality, which is detrimental to disease prevention and control. In the same regard, anxiety has been a very common disorder in the student population in the COVID-19 pandemic era [35]. Accordingly, anxiety is psychological distress that can cause insomnia, and lead to any stressful life events being a potential factor underlying sleep disturbance [50]. Therefore, it is necessary to explore the quality of sleep and psychological profile of the society as well as the factors influencing them during the COVID-19 pandemic, thereby achieving early identification, detection, intervention, and treatment.

The global pandemic situation creates pessimism, and concerns such as virus variation, herd immunity, and vaccine progress are depressing [51-53]. Therefore, we combined the Insomnia Severity Index (ISI) Scale, the 2-Item Patient Health Questionnaire (PHQ-2) Scale, and the 2-Item Generalized Anxiety Disorder (GAD-2) scale to evaluate the prevalence of insomnia, anxiety, and depression in the German population under the pandemic. In addition, we analyzed the factors influencing these psychological disorders. Finally, we explored variations in the sleep quality and mental health status among the population in different regions and age groups, as well as in terms of gender, work status, and economic status in the pandemic era. The present study aims to understand the changes in sleep and psychological well-being of German citizens after the COVID-19 pandemic, in order to provide targeted interventions.

1.3 The International COVID-19 Sleep Study (ICOSS) Consortium

ICOSS is an international collaboration project consisting of sleep experts from more than 14 countries that aims to investigate and summarize the direct and indirect impacts of the COVID-19 pandemic on various aspects of sleep and circadian rhythms [54]. ICOSS initiated the first worldwide questionnaire survey in 2020, with 14 participating countries and over 19,000 participants [22, 55-60]. One cross-sectional study of the articles has shown that there were increased degrees of insomnia, anxiety, and depression incidence after the outbreak of the pandemic[22]. In 2021, the ICOSS conducted the second questionnaire survey, with more participating countries and participants. This study used the ICOSS-2021 version of the questionnaire provided by the ICOSS consortium.

1.4 Scales

1.4.1 Insomnia Severity Index Scale

The ISI scale is a self-assessment evaluation that has been shown to be an effective tool for screening for insomnia patients and a clinical assessment tool to test the effectiveness of insomnia intervention studies [61]. The ISI scale is simple and easy to administer, of high validity, and extensively used in clinical studies for screening and assessing insomnia patients as well as assessing the effectiveness of insomnia treatment. The ISI scale consists of both daytime and nighttime insomnia measures and is one of the diagnostic

criteria based on the *Diagnostic and Statistical Manual of Mental Disorders-IV* (DSM-IV) for insomnia [62]. 1993 saw the development of the ISI scale by Morin and Barlow; subsequently, the ISI scale was translated into several languages and has been widely used worldwide, showing good reliability and validity across a wide range of ages and populations (patients with sleep disorders, psychiatric disorders, cancer, etc.), as well as being a reliable and valid tool for detecting cases of insomnia [63-65].

The first version of the ISI scale was in English and has since been translated into several languages. Translated versions are now available in French [66, 67], Spanish [68, 69], Persian [70], Chinese [71, 72], and German [73]. The German version of the ISI scale has been widely used in German-speaking countries. It has good psychometric properties as well as satisfactory convergent and factorial validity across age groups and gender [73]. There is a large body of research on the ISI scale, with a range of analyses of its reliability and validity for different populations in different countries [74]. The ISI reliability and validity have also been validated in studies on the sleep quality in adult populations in different communities [65, 66, 68]. In addition, ISI reliability and validity in studies on the sleep quality of patients with cancer have been high, since testing it in 210 patients demonstrated the internal consistency, temporal stability, and sensitivity to changes in treatment [64, 67]. All the above-mentioned research shows a significant consistency for the ISI scale in terms of reliability, with a *Cronbach-α* value above 0.7 [64, 66, 68, 70-72]. Moreover, the ISI scale is significantly consistent with other psychological variables, including depression and anxiety symptoms, general obesity, and psychosomatic manifestations [65, 67, 68].

1.4.2 2-Item Patient Health Questionnaire Scale

Depressive symptoms are usually referred to as a subclinical form of depression, a syndrome of self-reported depression assessed by a scale and defined by a specific cut-off score [75]. Following DSM-IV diagnosis criteria, the PHQ-2 scale includes the first two items of the 9-Item Patient Health Questionnaire (PHQ-9) Scale for screening depression [76], which asks questions about interest in doing things and low mood in the last 2 weeks. Item 1 is "little interest or pleasure in doing things" and item 2 is "feeling down, depressed, or hopeless". The PHQ-2 scale can be used as the first stage in the clinical screening of people at risk of depression, and determining whether the screened sample meets the

diagnostic criteria for depressive disorders requires further use of other diagnostic tools such as the PHQ-9 scale or a direct interview [77]. It has been shown that the diagnosis of depressive disorders showed high sensitivity (74%–96%) and specificity (75%–92%) when patients scored a total of 3 on the scale [77-79].

1.4.3 2-Item Generalized Anxiety Disorder Scale

The 7-Item Generalized Anxiety Disorder (GAD-7) scale has been used as the most common scale used to diagnose anxiety in clinical and research settings since many studies confirm that it is reliable and valid [80-82]. The GAD-2 scale consists of the first two items of the GAD-7 scale, which are also central to DSM-IV for anxiety diagnosis. Question one mentions "feeling nervous, anxious, or on edge", and question two mentions "not being able to stop or control worrying". According to the literature, the GAD-2 scale also retains the excellent psychometric properties of the GAD-7 scale [81-83]. Therefore, the GAD-2 scale is strongly recommended as the first step for screening generalized anxiety disorder [81].

2 Hypothesis and Objectives

2.1 Hypothesis

As studies on the impact of the COVID-19 pandemic on insomnia, depression, and anxiety among German citizens are to date scarce, our hypotheses are also based on the cross-sectional German questionnaire survey and our common discussions when this study was being designed. The hypotheses of this study are as follows:

(1) There were increased degrees of insomnia, anxiety, and depression incidence in the German population participating in the survey after the outbreak of the pandemic.

(2) The prevalence of insomnia, anxiety, and depression among the population of Germany may be associated with age, gender, body mass index (BMI), marital status, living areas and so on.

Numerous recent studies have shown a variety of physiological or psychological stress reactions such as anxiety, depression, and insomnia under the influence of a pandemic [18, 22-24]. An important question is: how does the COVID-19 pandemic influence the prevalence of insomnia, depression, and anxiety among German citizens?

2.2 Objectives

There was very little awareness of the COVID-19 pandemic shortly after its emergence and the general public was in a state of extreme panic, with obvious negative emotions and a general sense of insecurity. Further development of this situation can easily lead to a wide range of sleep and psychological problems. Severe insomnia and psychological stress can reduce the immunity of patients and be detrimental to the fight against the pandemic. Therefore, there is an urgent need for measuring the sleep quality and psychological stress of people during a public health emergency. Existing studies have focused more on the clinical features, imaging manifestations, etiology, and treatment methods of COVID-19. Furthermore, the psychological aspects have been studied less, and the existing studies have been mostly targeted at evaluating the mental health of frontline healthcare workers [84-86]. Moreover, fewer studies have been conducted to

assess the German population regarding the quality of sleep, depression, and anxiety. During the pandemic, an urgent need to understand the population's sleep, depression, and anxiety status has been identified in order to facilitate targeted interventions. Therefore, the following objectives were formulated:

(1) To assess the prevalence of insomnia, depression, and anxiety among the population of Germany during the COVID-19 pandemic.

(2) To explore the influencing factors for insomnia, anxiety, and depression during the COVID-19 pandemic.

(3) To understand the effect of the pandemic on the prevalence of insomnia, depression, and anxiety among the population and to provide a reference for targeted interventions in the future.

3 Participants and Methods

3.1 Data collection

This project is a cross-sectional study carried out within descriptive research. The questionnaire was collected between 1 June 2021 and 30 November 2021, during which the pandemic situation in Germany had still not significantly improved. Up to 11 January 2022, the confirmed COVID-19 cases in Germany had exceeded 7,580,000 and the number of deaths had exceeded 110,000; as of 12 January 2022, there were 45,690 new confirmed cases and 322 new deaths in Germany from the previous day, with estimated total cured cases of approximately 6,792,300 [11]. The number of new confirmed diagnoses per day is enormous. What has been even more worrying for the population is the emergence of the new virus Omicron, which has significantly reduced the effectiveness of the vaccine and led to an unpromising situation.

3.2 Study population

We conducted an online electronic questionnaire with the general population of Germany as the study population, using a convenience sampling method for those who volunteered to participate in the study, without any restrictions on age, gender, and place of residence.

(1) The respondents were included in the study if they passed the following criteria: (i) 18 years or older; (ii) informed consent to participate in this survey; (iii) German-wide respondents, regardless of nationality or race; and (iv) ability to read and communicate in the language correctly. Respondents could answer questions online using a computer, a mobile phone, or with the help of others. Or they were able to complete the paper version independently, or with the help of others.

(2) The exclusion criteria for this study were as follows: (i) those who could not read or communicate verbally correctly, could not use a computer or mobile phone to complete the online questionnaire, or could not complete the online questionnaire with the help of others; (ii) those who did not consent to be included in this study; and (iii) those with severe physical illness.

3.3 Collection methods

Links to the online scale questionnaires were prepared and scale consistency training was provided to participants to familiarize them with the study steps, use of the measurement scales, and scoring criteria prior to commencing questionnaire collection. A consistency check was conducted at the end of the research. Researchers collected data face-to-face, via telephone, or through video instruction, after confirming that participants understood the test requirements.

Both online and offline surveys were conducted in this study.

(1) Online cooperation with the Qualtrics web platform: participants scanned the assessment QR code posted in the sleep center directly or clicked on the survey link (https://educationhelsinki.eu.qualtrics.com/jfe/form/SV_57jhDo3kzgOiJFk) to complete the web questionnaire (each IP address can only be recorded once).

(2) Offline paper questionnaire: the data were recorded by researchers after the participants had completed the questionnaire.

The questionnaires were distributed throughout Germany. After excluding questionnaires with incorrect information on age and missing information, 510 questionnaires were returned and 465 were valid (298 men and 167 women).

3.4 ICOSS Assessment Questionnaire

The questionnaire used in this study was the ICOSS-2021 version provided by the ICOSS consortium. This study was based on the data on general information of participants and results from the ISI scale, PHQ-2 scale, and GAD-2 scale.

(1) General Information of participants

General information included name, gender, age, educational attainment, marital status, residence status, race, employment status, and economic shock. Clinical information included the infection status with COVID-19 and the COVID-19 test results.

(2) Insomnia Severe Index Scale

Being a self-assessment, the ISI scale consists of seven questions, each with five options from 0 to 4. Each item's score ranges from 0 to 4 and the total score of the questionnaire ranges from 0 to 28. The ranges 0 - 7, 8 - 14, 15 - 21, and 22 - 28 indicate no insomnia, mild insomnia, moderate insomnia, and severe insomnia, respectively. Generally, higher scores indicate more severe insomnia.

(3) 2-Item Generalized Anxiety Disorder Scale

The GAD-2 scale was used for assessing subjective anxiety symptoms over the past fortnight. Each question was scaled on a 4-point Likert score ranging from 0 (not at all) to 3 (almost every day). The total scores of this scale ranged between 0 and 6, and a total score ≥ 3 indicated the presence of an anxiety state [81, 82, 87].

(4) 2-Item Patient Health Questionnaire Scale

The PHQ-2 scale was applied for assessing major depression symptoms over the past fortnight. Each question was scored based on a 4-point Likert scale and ranged from 0 (not at all) to 3 (almost every day). Total scores on this scale ranged from 0 to 6, and a total score ≥ 3 was considered as the presence of a depression state [77-79].

3.5 Ethical approval

The present study was approved by the Ethics Committee of the Charité – Universitätsmedizin Berlin (Antragsnummer: EA1/162/20). The principle of voluntary participation was followed throughout the present study. We ensured that participants had signed an informed consent form voluntarily and that the principle of confidentiality was strictly observed.

3.6 Data collation and analysis

3.6.1 Data collation

After the questionnaires were collected, the questionnaires were rigorously screened by researchers and those with incomplete data were excluded.

3.6.2 Data analysis and statistical methods

Questionnaires were generally distributed among the German population, i.e., the study population, using a convenient sampling method for voluntary participants, without any restrictions on age, gender, and place of residence. All data were directly exported from the Qualtrics platform to produce corresponding Excel spreadsheets and were analyzed using SPSS 26.0 statistical software. The normally-distributed data were expressed as means ± standard deviations (SD) and subjected to a comparison among groups by t-tests. Otherwise, they were expressed as medians (quartiles) and subjected to a comparison among groups by non-parametric tests. Enumeration data were expressed as the number of cases (n) and percentages (%), and subjected to a comparison among groups by χ^2 tests or Fisher's exact tests. Insomnia and mental health scale correlations were tested using Pearson correlation analysis. Finally, binary logistic regression analysis was used for exploring influencing factors on insomnia, depression, and anxiety in the German population. A *P*-value < 0.05 was considered statistically significant.

3.7 Feasibility analysis

(1) The study was conducted among the German population and was not limited to race or place of residence. Therefore, the data were easy to obtain. The findings of the ICOSS agency provided the theoretical basis for this study. In addition, the survey instrument was highly reliable and valid.

(2) Some of the questionnaire items consisted of a large number of questions, which did not allow for adequate explanations of the items that were later questioned by participants. The quality of the items may have been uneven, as they were completed through the Qualtrics platform. Moreover, the personal background of the researchers may have influenced their social network, which may have resulted in a skewed distribution of the

data collected in terms of geography or age, as reflected in the results regarding the demographic factors of the research participants.

4 Results

4.1 Questionnaire results

This study was conducted through the Qualtrics platform and 510 questionnaires were returned. A total of 45 invalid questionnaires with incomplete data were excluded according to the exclusion criteria, yielding 465 valid questionnaires and a valid response rate of 91.2%. The specific results are shown in Table 1.

Table 1: Summary of the questionnaires

Variables	N	%
Returned questionnaires	510	100.0
Valid questionnaires	465	91.2
Invalid questionnaires	45	8.8

N = number of cases; % = percentage.

4.2 General demographic information

465 German participants completed the questionnaire in total, of whom 298 (64.1%) were men and 167 (35.9%) were women. Respondents were aged from 18 to 82 years old, the highest proportion of participants being aged from 46 to 65 years (257 cases, 55.3% of the total), and the smallest proportion of participants being aged from 18 to 25 years old (2.6% of the total). The ratio of married to unmarried participants was 336 (72.2%) to 78 (16.8%). The majority of the participants included in this study live in urban areas, with 411 cases (88.4%), which may be due to uneven distribution of media information. Therefore, regional bias may occur. The scope of this study should be further expanded to achieve a more comprehensive and extensive understanding of the current situation of the public. The educational attainment of the participants was high, with 84.41% having a college or bachelor's degree or above. 296 participants (63.7%) were students from secondary school, high school, and vocational school, and 93 (20.0%) were students from university, college, or above. Most of researchers were undergraduate and postgraduate students, there may be a possibility of education bias in this survey. The largest number

of people in this study were of Caucasian/White ethnicity, with a total of 322 cases (69.2%), which is possibly related to their native German ethnicity. The majority were employed at the time of the survey, totalling 296 (63.7%). The number of participants who were economically unaffected or only marginally affected was 204 (42.9%). The majority of people were not infected with COVID-19, totalling 400 (86.0%). Moreover, the majority tested negative for novel coronavirus, totalling 429 (92.3%), as detailed in Table 2.

Table 2: Demographic details of survey respondents

Variables		N	%
Gender			
	Male	298	64.1
	Female	167	35.9
Age (year)			
	18~25	12	2.6
	26~45	137	29.5
	46~65	257	55.3
	66~82	59	12.7
BMI (M ± SD, kg/m^2)		26.96 ± 5.83	
Marital status			
	Single	78	16.8
	Married/relationship	336	72.2
	Divorced/separated	46	9.9
	Widowed	5	1.1
Living areas			
	Urban	411	88.4
	Rural	54	11.6
Education level			
	Primary/elementary/lower secondary school	76	16.3
	Secondary school/high school/vocational school	296	63.7
	University/college, or above	93	20.0

Table 2: (Continued)

Variables		N	%
Ethnicity			
	Caucasian/White	322	69.2
	Asian	66	14.2
	African	27	5.8
	Hispanic	19	4.1
	Others	31	6.7
Employment status			
	Student	76	16.3
	Employed	296	63.7
	Unemployed	93	20.0
Financial suffering			
	None to little	204	43.9
	Somewhat	177	38.0
	Significant to severe	84	18.1
COVID-19 infection			
	No	400	86.0
	Yes	38	8.2
	Don't know	27	5.8
Tested positive for COVID-19			
	No	429	92.3
	Yes	36	7.7

N = number of cases; % = percentage; M = mean; SD = standard deviation; BMI = body mass index.

4.3 Analysis of the results from the ISI scale

Figure 3 shows the distribution of ISI scale scores. The mean ± SD of the ISI scale for the 465 participants in this study was 9.93 ± 5.8, with a skewness coefficient of 0.618 and a kurtosis coefficient of -0.259, suggesting a positive skewness distribution.

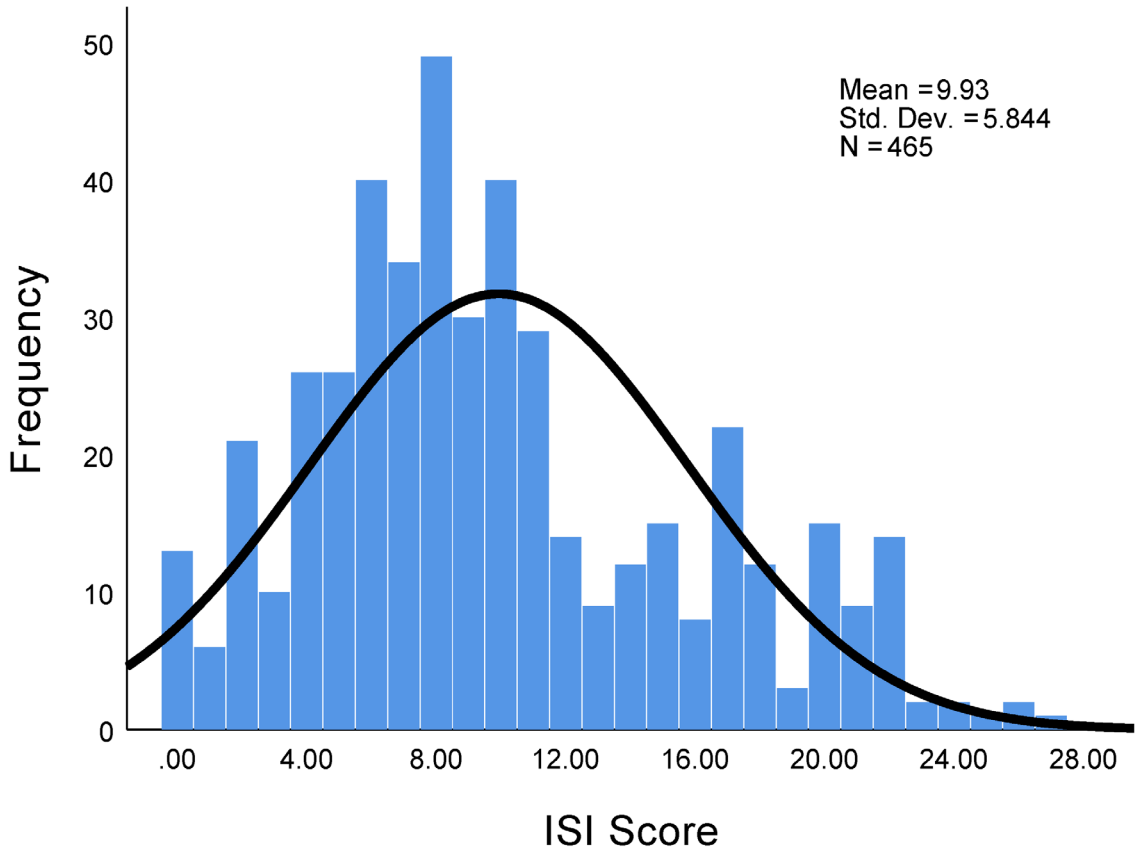

Figure 3: Distribution of ISI scores in study population.

According to Morin's cut-off score [65], among 465 participants, 176 participants were classified as no insomnia (37.8%), 183 as mild insomnia (39.4%), 84 as moderate insomnia (18.1%), and 22 as severe insomnia (4.7%), as shown in Table 3. A study has shown that on the ISI scale, a cut-off score of 15 can be used to identify potential insomnia cases [65]. In the same regard, in this research, the cut-off score of 15 proved to be effective in identifying insomnia cases. Hence, participants with ISI scores below 15 were categorized as the non-insomnia group (n = 359, 77.2%), whereas participants with ISI scores greater than or equal to 15 were classified as the insomnia group (n = 106, 22.8%), as shown in Figure 4.

Table 3: Proportions of subjects reporting different levels of insomnia (ISI) symptom severity

Variables	N	%
No insomnia	176	37.8
Subthreshold insomnia	183	39.4
Clinical insomnia	84	18.1
Severe insomnia	22	4.7

N = number of cases; % = percentage.

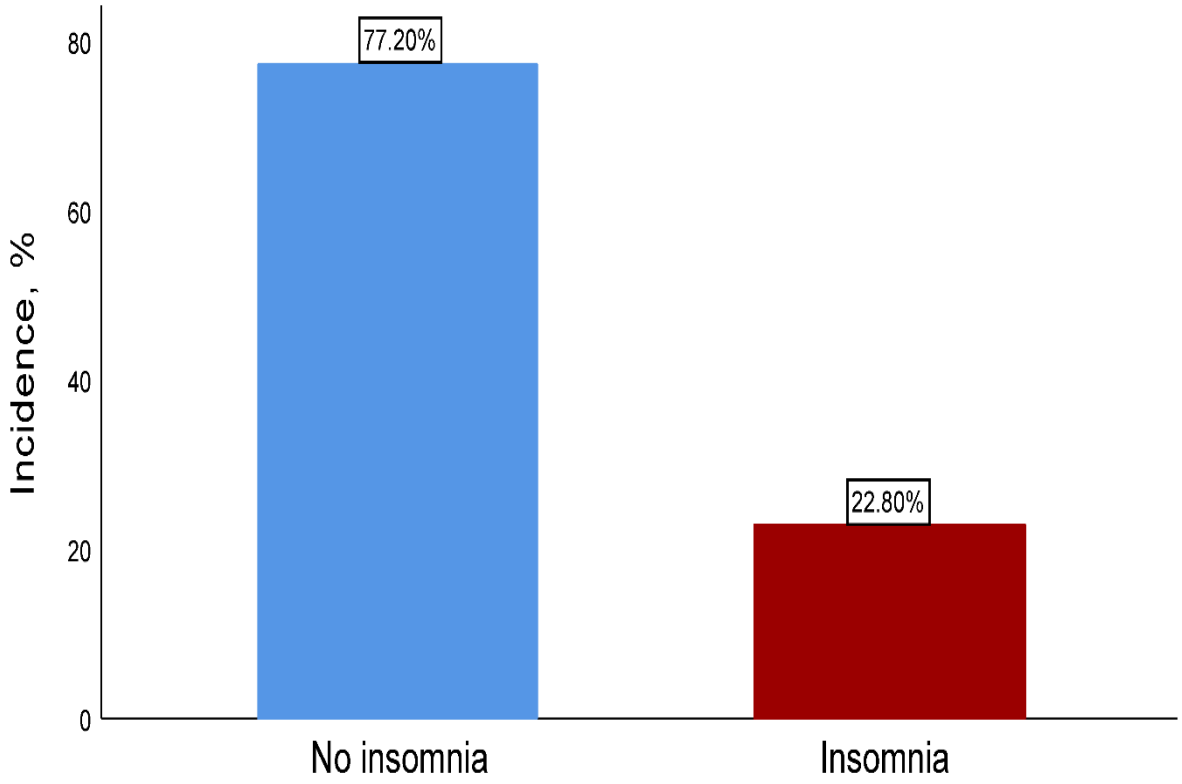

Figure 4: Incidence of insomnia in general public based on a cut-off score of 15 in the ISI.

4.4 Analysis of the results from the GAD-2 and PHQ-2 scales

Figure 5 presents the distribution of the PHQ-2 scale scores. The mean ± SD of the PHQ-2 scales for all participants (n = 465) in this study was 1.31 ± 1.36, with a skewness coefficient of 1.625 and a kurtosis coefficient of 2.934, suggesting a positive skewness distribution (Figure 5). Based on the cut-off score of 3 on the PHQ-2 scale, 14.2% of the

participants (n = 66) were classified into the depression-risk group, whereas 85.8% (n = 399) were classified into the non-depression-risk group (Figure 6).

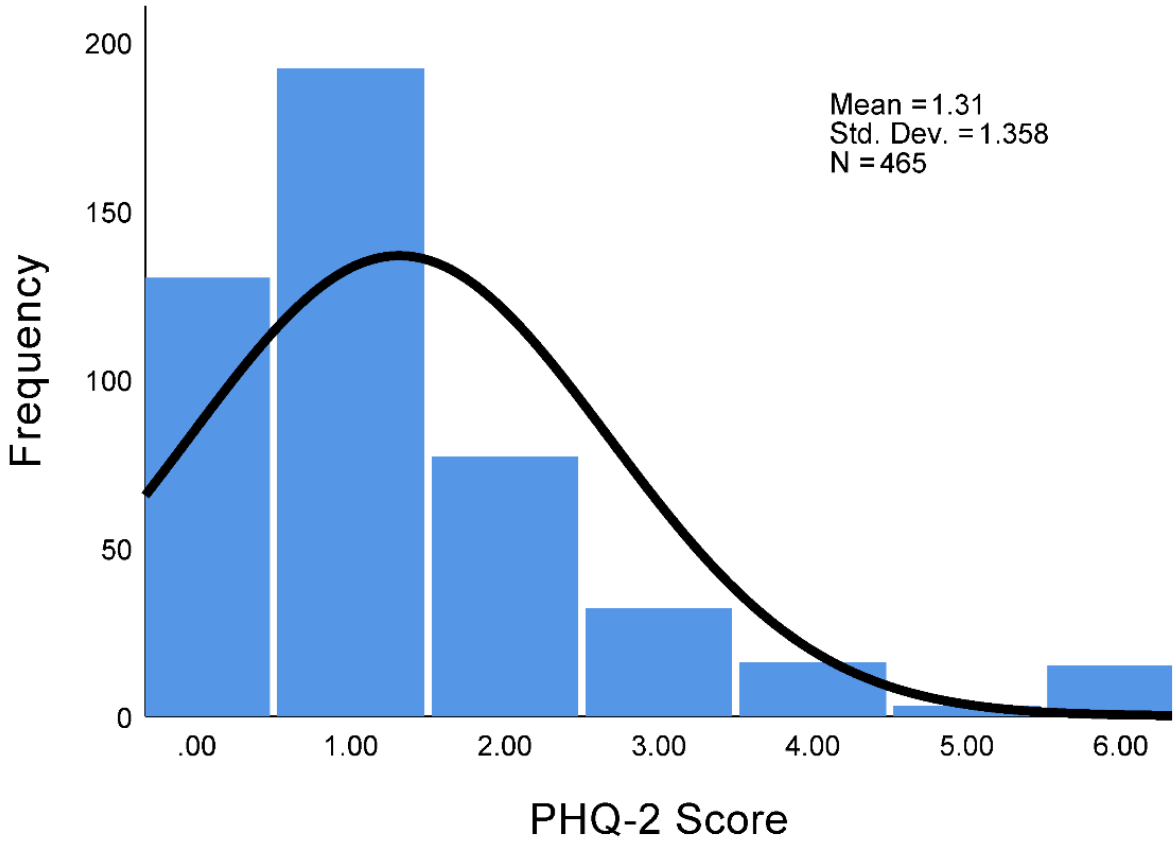

Figure 5: Distribution of PHQ-2 scores in study population.

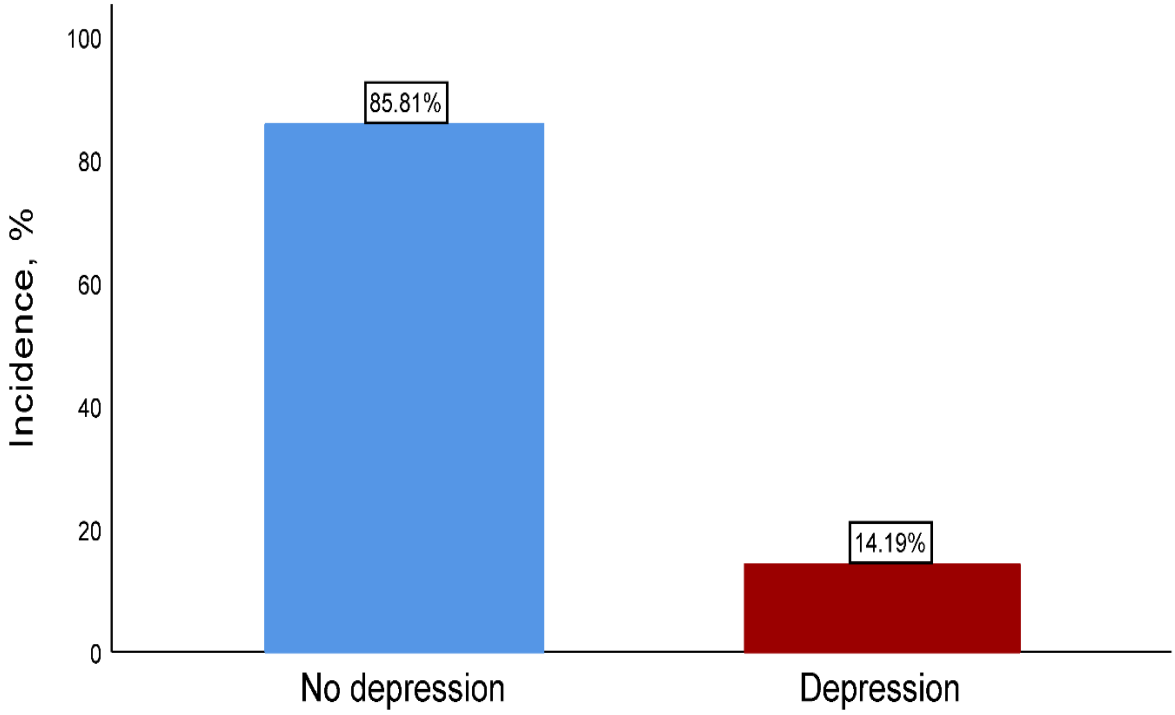

Figure 6: Incidence of depression in general public based on a cut-off score of 3 on the PHQ-2 scale.

Figure 7 presents the distribution of the GAD-2 scale scores. The mean ± SD of the PHQ-2 scale for the 465 participants in this study was 1.14 ± 1.22, with a skewness coefficient of 1.136 and a kurtosis coefficient of 0.655, suggesting a positive skewness distribution (Figure 7). Based on the cut-off score of 3 on the GAD-2 scale, 14.6% of the participants (n = 68) were classified into the anxiety-risk group, whereas 85.4% (n = 397) were classified into the non-anxiety-risk group (Figure 8).

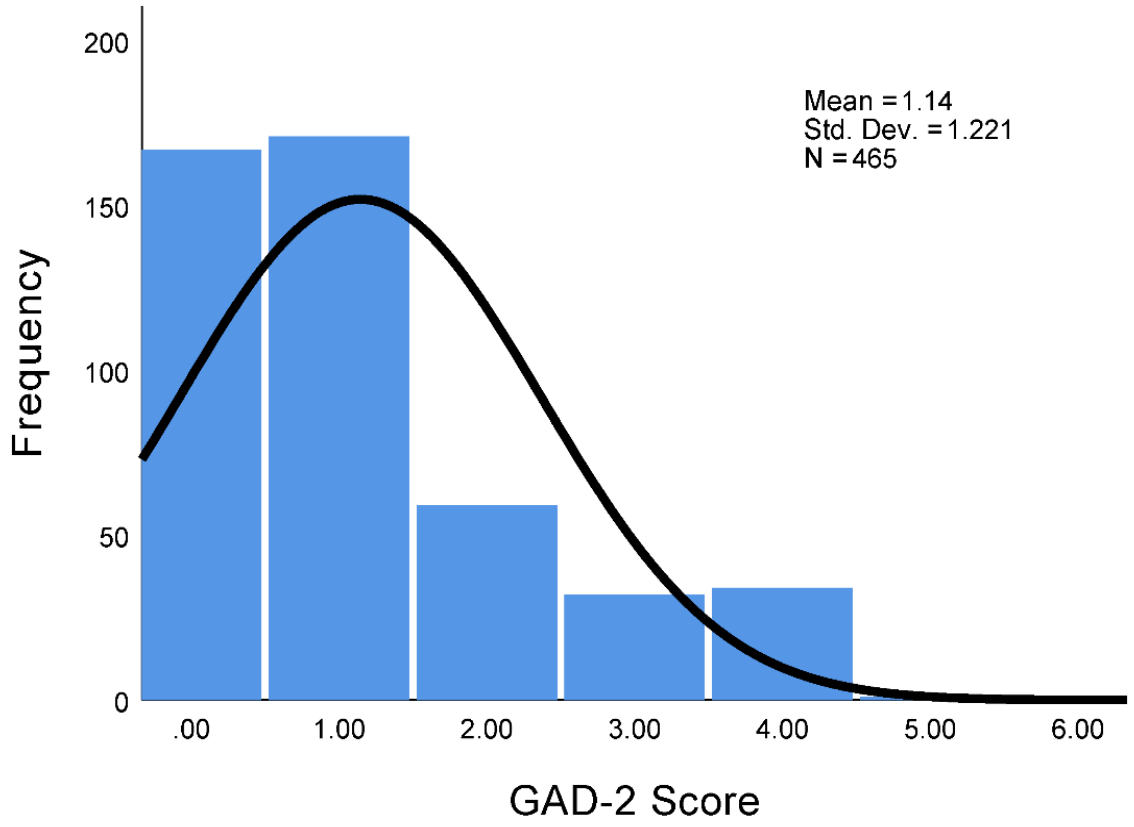

Figure 7: Distribution of GAD-2 scores in study population.

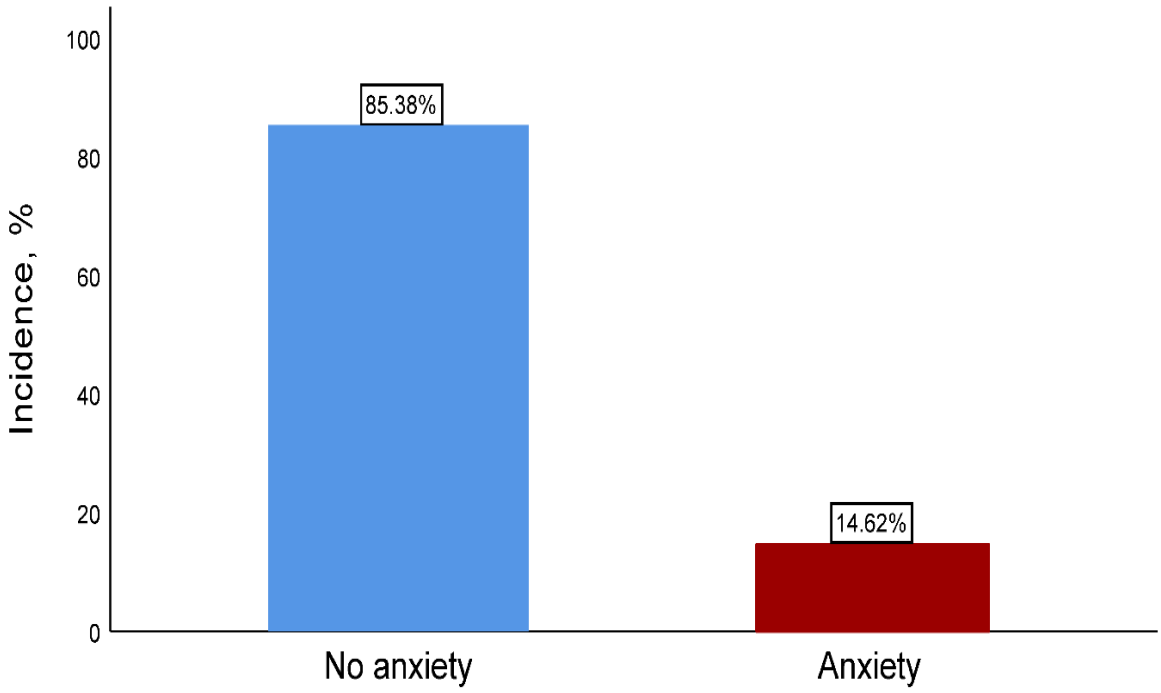

Figure 8: Incidence of anxiety in general public based on a cut-off score of 3 on the GAD-2.

As shown in Table 4, the prevalence rates of insomnia, depression, and anxiety in all respondents (n = 465) were revealed to be 22.8%, 14.2%, and 14.6%, respectively.

Table 4: The prevalence rates in ISI, PHQ-2 and GAD-2

Variables		N	%
ISI			
	< 15	359	77.2%
	≥ 15	106	22.8%
PHQ-2			
	< 3	399	85.8%
	≥ 3	66	14.2%
GAD-2			
	< 3	397	85.4%
	≥ 3	68	14.6%

N = number of cases; % = percentage; ISI = Insomnia Severity Index; PHQ = Patient Health Questionnaire; GAD = Generalized Anxiety Disorder.

The effect of anxiety and depression on insomnia was investigated by a Chi-square test using the number of anxiety and depression cases as dependent variables and insomnia cases as independent variables, as shown in Table 5. There were 18 (27.3%) and 48 (72.7%) cases of depression in the non-insomnia group (n =176) and insomnia group (n = 289), respectively, with a statistically significant difference (χ^2 = 108.963, P < 0.001). Additionally, there were 29 (42.6%) and 39 (57.4%) cases of anxiety in the non-insomnia group (n = 176) and the insomnia group (n = 289), respectively, with a statistically significant difference (χ^2 = 54.045, P < 0.001).

Table 5: Comparison of the prevalence of depression and anxiety between non-insomnia and insomnia

Variables	Non-insomnia (%) (N = 176)	Insomnia (%) (N = 289)	N	χ^2	*P*
PHQ-2					
< 3	341(85.5)	58 (14.5)	399	108.963	< 0.001
≥ 3	18 (27.3)	48 (72.7)	66		
GAD-2					
< 3	330 (83.1)	67 (16.9)	397	54.045	< 0.001
≥ 3	29 (42.6)	39 (57.4)	68		

N = number of cases; % = percentage; PHQ = Patient Health Questionnaire; GAD = Generalized Anxiety Disorder.

4.5 Analysis of ISI, PHQ-2, and GAD-2 scores

According to the results from one-way analysis of variance, the median (percentile 25, percentile 75) scores on the ISI, PHQ-2, and GAD-2 scales in all four groups (non-insomnia group, mild-insomnia group, moderate-insomnia group, and severe-insomnia group) for the most part increased gradually with the gradual increase in the severity of insomnia, showing statistically significant differences ($P < 0.01$), as illustrated in Table 6.

Table 6: ISI total score, PHQ-2 total score, and GAD-2 total score between non-insomnia and various degrees of insomnia

Variables	Non-insomnia	Subthreshold insomnia	Moderate insomnia	Severe insomnia	*F*
ISI	5 (3,6)	10 (8,11)$_{acd}$	17 (16,20)$_{ab}$	22 (22,24)$_{ab}$	409.450***
PHQ-2	1 (0,1)	1 (0,1)$_{cd}$	2 (0,4)$_{ab}$	2 (2,3)$_{ab}$	66.680***
GAD-2	1 (0,1)	1 (0,2)$_{cd}$	1 (0,3)$_{abd}$	3 (1,4)$_{abc}$	24.816***

Values are presented as median (percentile 25, percentile 75).

a: compared with no insomnia; b: compared with subthreshold insomnia; c: compared with moderate insomnia; d: compared with severe insomnia. *** = $P < 0.001$

ISI = Insomnia Severity Index; PHQ = The Patient Health Questionnaire; GAD = Generalized Anxiety Disorder.

We further analyzed the correlation between insomnia status (ISI scale) and anxiety (GAD-2 scale) as well as depression (PHQ-2 scale). Correlation analyses revealed significant correlations between ISI scale scores and PHQ-2 scores (r = 0.428, P < 0.01), ISI scale scores and GAD-2 scores (r = 0.327, P < 0.01), and PHQ-2 scale scores and GAD-2 scores (r = 0.615, P < 0.01), as shown in Table 7.

Table 7: The correlation between the total score of ISI, PHQ-2, and GAD-2

Variables	ISI	PHQ-2	GAD-2
ISI	1		
PHQ-2	0.428**	1	
GAD-2	0.327**	0.615**	1

ISI = Insomnia Severity Index; PHQ = Patient Health Questionnaire; GAD = Generalized Anxiety Disorder. ** = *P < 0.01*.

4.6 Analysis of factors influencing insomnia symptoms in the German population

A univariate test of insomnia symptoms in the German population was conducted using the insomnia subgroup (ISI subgroup) as the dependent variable, and the public's demographic and sociological information as the independent variable. The results showed statistically significant differences in age subgroup, place of residence, race, employment status, and economic shock between insomnia and non-insomnia groups (P < 0.05). However, the differences in gender, marital status, educational attainment, COVID-19 infection status, and novel coronavirus test results between insomnia and non-insomnia groups were not statistically significant (P > 0.05), as illustrated in Table 8.

Table 8: Comparison of social demographic characteristics between non-insomnia and insomnia groups

Variables	Non-insomnia (N = 176)	Insomnia (N = 289)	X^2 or Fisher value
Gender			0.456
Male	233 (230.1)	65 (67.9)	
Female	126 (128.9)	41 (38.1)	
Age (years)			6.010
18~25	11 (9.7)	1 (2.3)	
26~45	112 (110.2)	25 (26.8)	
46~65	188 (198.4)	69 (58.3)	
66~82	48 (45.6)	11 (13.4)	
Marital status			9.164*
Single	61 (60.2)	17 (17.8)	
Married/relationship	267 (259.4)	69 (76.6)	
Divorced/separated	27 (35.5)	19 (10.5)	
Widowed	4 (3.9)	1 (1.1)	
Living areas			8.220*
Urban	309 (317.3)	102 (93.7)	
Rural	50 (41.7)	4 (12.3)	
Education level			1.922
Primary/elementary/lower secondary school	63 (58.7)	13 (17.3)	
Secondary school/high school/vocational school	227 (228.1)	69 (67.5)	
University/college, or above	69 (71.8)	24 (21.2)	
Ethnicity			35.139*
Caucasian/White	231 (248.6)	91 (73.4)	
Asian	64 (51.0)	2 (15.0)	
African	24 (20.8)	3 (6.2)	
Hispanic	19 (14.7)	0 (4.3)	

Table 8: (Continued)

Variables	Non-insomnia (N = 176)	Insomnia (N = 289)	X^2 or Fisher value
Others	21 (23.9)	10 (7.1)	
Employment status			4.572
Student	27 (22.4)	2 (6.6)	
Employed	239 (240.9)	73 (71.1)	
Unemployed	93 (95.7)	31 (28.3)	
Financial suffering			49.266*
None to little	132 (157.5)	72 (46.5)	
Somewhat	167 (136.7)	10 (40.3)	
Significant to severe	60 (64.9)	24 (19.1)	
COVID-19 infection			12.871*
No	314 (308.8)	86 (91.2)	
Yes	21 (29.3)	17 (8.7)	
Don't know	24 (20.8)	3 (6.2)	
Tested positive for COVID-19			10.391*
No	339 (331.2)	90 (97.8)	
Yes	20 (27.8)	16 (8.2)	

N = number of cases; * = $P < 0.05$. The theoretical frequency is given in parentheses.

The significantly different factors in the univariate analysis were used for a further unconditional logistic regression analysis. The results showed that participants living in rural areas had a higher risk of insomnia compared to those living in urban areas (odds ratio [OR] = 2.091), while participants with employment status had a lower risk of insomnia compared to students (OR = 0.342). However, participants with severe financial loss had a lower risk of insomnia compared to those with less financial loss (OR = 0.501) (Figure 9).

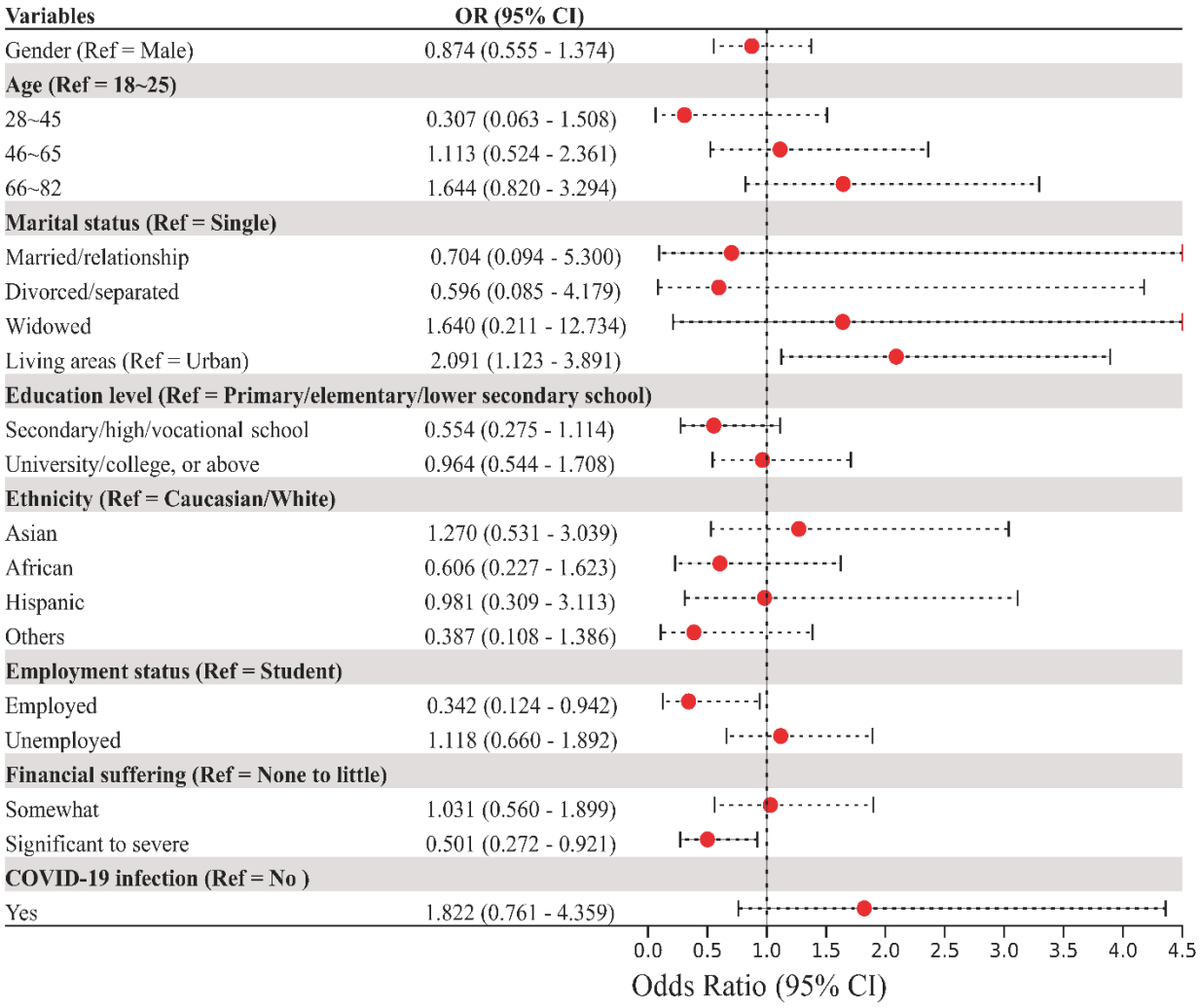

Figure 9: Forest plot of association between demographic characteristics and insomnia.

4.7 Analysis of factors influencing depression symptoms in the German population

A univariate test of depression symptoms in the German population was conducted using the depression subgroup (PHQ-2 subgroup) as the dependent variable and the public's demographic and sociological information as the independent variable. The results showed statistically significant differences in gender, educational attainment, race, and economic shock between participants belonging to the depression and non-depression groups ($P < 0.05$). However, the differences in age group, place of residence, COVID-19 infection status, and novel coronavirus test results between depression and non-depression groups were not statistically significant ($P > 0.05$), as illustrated in Table 9.

Table 9: Comparison of social demographic characteristics between non-depressed and depressed groups

Variables	Non-depressed (N = 397)	Depressed (N = 66)	X^2 or Fisher value
Gender			13.564*
Male	269 (255.7)	29 (42.3)	
Female	130 (143.3)	37 (23.7)	
Age (years)			3.652
18~25	11 (10.3)	1 (1.7)	
26~45	114 (117.6)	23 (19.4)	
46~65	219 (220.5)	38 (36.5)	
66~82	55 (60.6)	4 (8.4)	
Marital status			-
Single	65 (66.9)	13 (11.1)	
Married/relationship	286 (288.3)	50 (47.7)	
Divorced/separated	43 (39.5)	3 (6.5)	
Widowed	5 (4.3)	0 (0.7)	
Living areas			0.477
Urban	351 (352.7)	60 (58.3)	
Rural	48(46.3)	6 (7.7)	
Education level			8.919*
Primary/elementary/lower secondary school	73 (65.2)	3 (10.8)	
Secondary school/high school/vocational school	245 (254.0)	51 (42.0)	
University/college, or above	81 (79.8)	12 (13.2)	
Ethnicity			17.099*
Caucasian/White	261 (276.3)	61 (45.7)	
Asian	62 (56.6)	4 (9.4)	
African	26 (23.2)	1 (3.8)	
Hispanic	19 (16.3)	0 (2.7)	

Table 9: (Continued)

Variables	Non-depressed (N = 397)	Depressed (N = 66)	X^2 or Fisher value
Others	31 (26.6)	0 (4.4)	
Employment status			
Student	29 (24.9)	0 (4.1)	
Employed	267 (267.7)	45 (44.3)	
Unemployed	103 (106.4)	21 (17.6)	
Financial suffering			21.054*
None to little	159 (175.0)	45 (29.0)	
Somewhat	167 (151.9)	10 (25.1)	
Significant to severe	73 (72.1)	11 (11.9)	
COVID-19 infection			0.281
No	344 (343.2)	56 (56.8)	
Yes	32 (32.6)	6 (5.4)	
Don't know	23 (23.2)	4 (3.8)	
Tested positive for COVID-19			0.196
No	369 (368.1)	60 (60.9)	
Yes	30 (30.9)	6 (5.1)	

N = number of cases; * = $P < 0.05$. The theoretical frequency is given in parentheses.

The significantly different factors in the univariate analysis were used for a further unconditional logistic regression analysis. The results showed that women were less likely to develop depression than men (OR = 0.198), and participants with severe financial losses have a lower risk of depression compared to those with lower financial losses (OR = 0.235) (Figure 10).

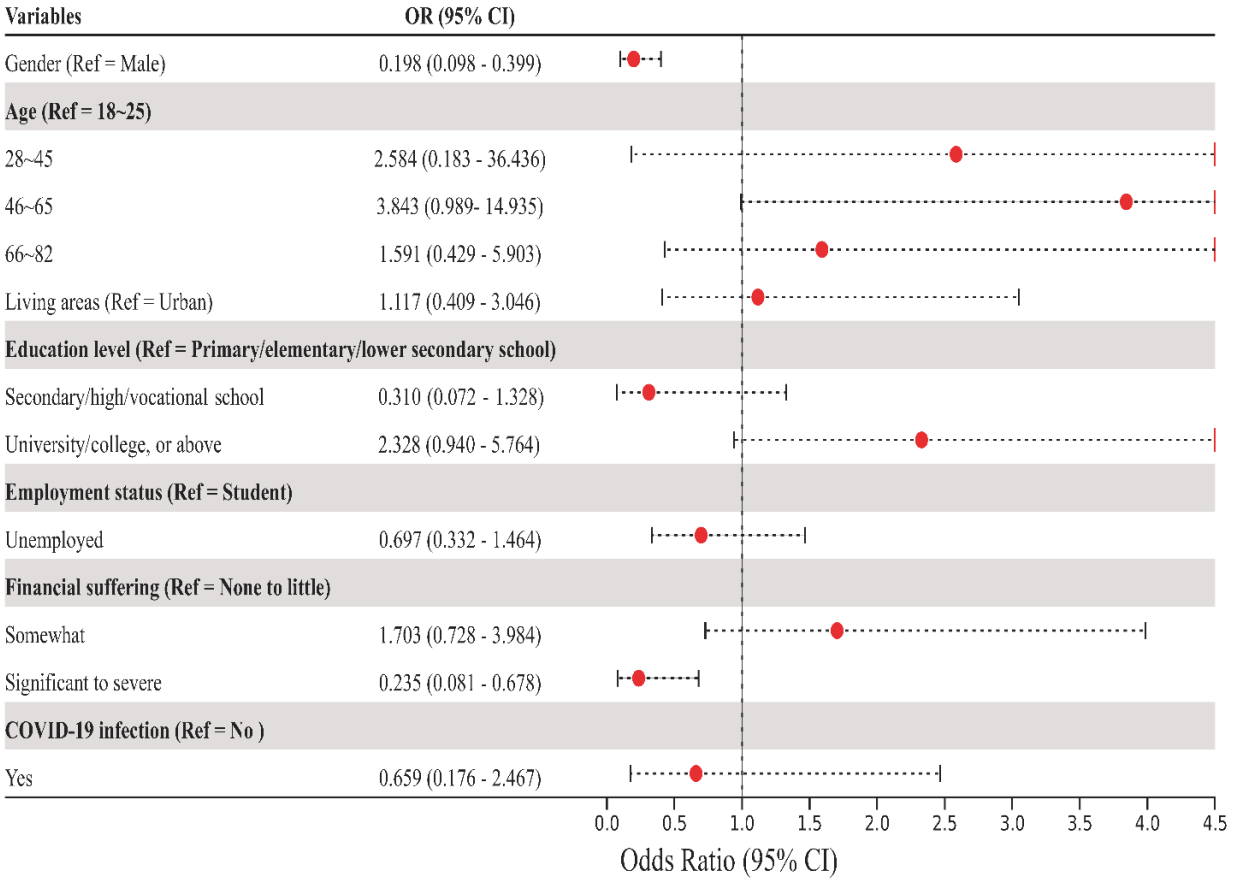

Figure 10: Forest plot of association between demographic characteristics and depression.

4.8 Analysis of factors influencing anxiety symptoms in the German population

A univariate test of anxiety symptoms in the sample German population was conducted using the anxiety subgroup (GAD-2 subgroup) as the dependent variable and the public's demographic and sociological information as the independent variable. The results showed statistically significant differences in gender, educational attainment, race, and economic shock between participants belonging to the anxiety and non-anxiety groups ($P < 0.05$). However, the differences in marital status, COVID-19 infection status, and novel coronavirus test results between anxiety and non-anxiety groups were not statistically significant ($P > 0.05$), as illustrated in Table 10.

Table 10: Comparison of social demographic characteristics between non-anxiety and anxiety groups

Variables	Non-anxiety (N = 397)	Anxiety (N = 66)	X^2 or Fisher value
Gender			0.013
Male	254 (254.4)	44 (43.6)	
Female	143 (142.6)	24 (24.4)	
Age (years)			10.548*
18~25	11 (10.2)	1 (1.8)	
26~45	106 (117.0)	31 (20.0)	
46~65	226 (219.4)	31 (37.6)	
66~82	54 (50.4)	5 (8.6)	
Marital status			-
Single	62 (66.6)	16 (11.4)	
Married/relationship	292 (286.9)	44 (49.1)	
Divorced/separated	38 (39.3)	8 (6.7)	
Widowed	5 (4.3)	0 (0.7)	
Living areas			0.002
Urban	351 (350.9)	60 (60.1)	
Rural	46 (46.1)	8 (7.9)	
Education level			3.453
Primary/elementary/lower secondary school	69 (64.9)	7 (11.1)	
Secondary school/high school/vocational school	253 (252.7)	43 (43.3)	
University/college, or above	75 (79.4)	18 (13.6)	
Ethnicity			3.431
Caucasian/White	275 (274.9)	47 (47.1)	
Asian	59 (56.3)	7 (9.7)	
African	24 (23.1)	3 (3.9)	
Hispanic	15 (16.2)	4 (2.8)	

Table 10: (Continued)

Variables	Non-anxiety (N = 397)	Anxiety (N = 66)	X^2 or Fisher value
Others	24 (26.5)	7 (4.5)	
Employment status			6.687*
Student	26 (24.8)	3 (4.2)	
Employed	258 (266.4)	54 (45.6)	
Unemployed	113 (105.9)	11 (18.1)	
Financial suffering			
None to little	170 (174.2)	34 (29.8)	12.750*
Somewhat	163 (151.1)	14 (25.9)	
Significant to severe	64 (71.1)	20 (12.3)	
COVID-19 infection			3.875
No	341 (341.5)	59 (58.5)	
Yes	30 (32.4)	8 (5.6)	
Don't know	26 (23.1)	1 (3.9)	
Tested positive for COVID-19			0.726
No	368 (366.3)	61 (62.7)	
Yes	29 (30.7)	7 (5.3)	

N = number of cases; * = $P < 0.05$. The theoretical frequency is given in parentheses.

The significantly different factors in the univariate analysis were used for a further unconditional logistic regression analysis. The results showed that participants with severe financial losses were at less risk of anxiety compared to those with lower financial losses (OR = 0.263) (Figure 11).

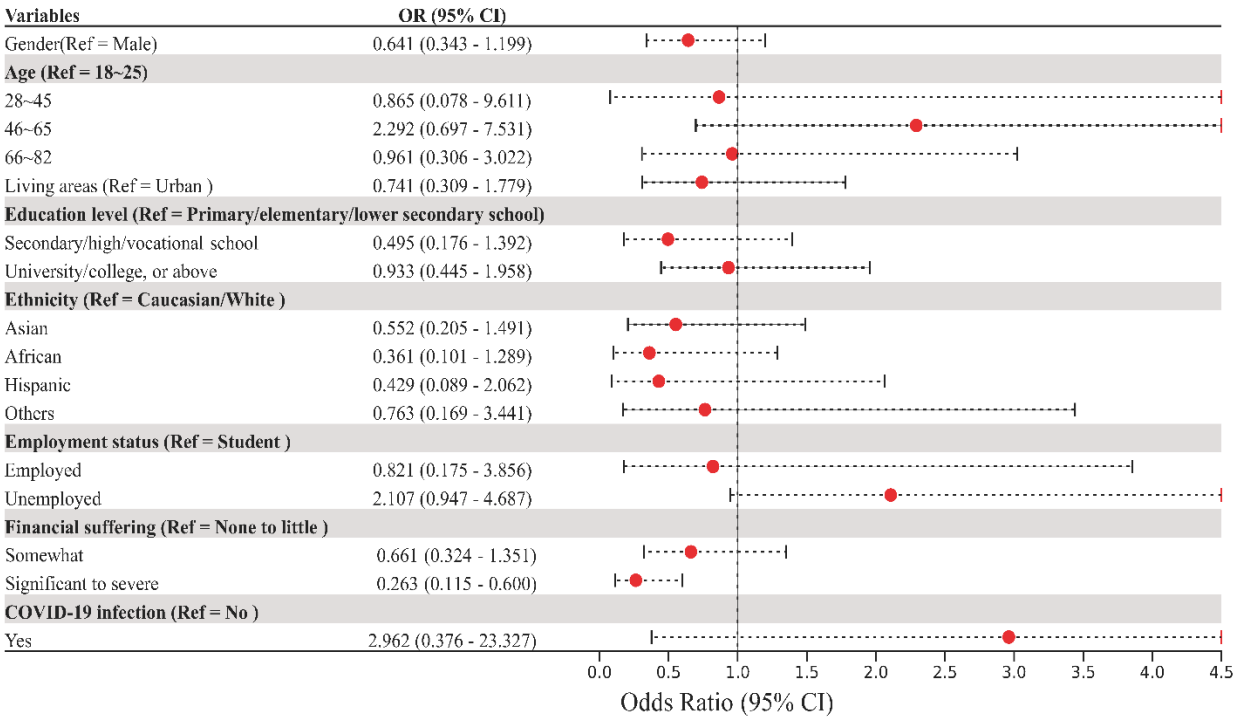

Figure 11: Forest plot of association between demographic characteristics and anxiety.

5 Discussion

Coronavirus has been a common pathogen associated with human respiratory and intestinal diseases [6]. However, these pathogens - which include HCoV-NL63, HCoV-229E, HCoV-OC43, and HKU1 - have usually caused mild symptoms, while coronavirus is also able to cause severe respiratory infections [88]. One of the most globally known diseases caused by members of coronaviruses is pneumonia, which was previously observed in the SARS-CoV and MERS pandemics [6]. Recently, in December 2019, a new type of respiratory coronavirus, SARS-CoV-2, was detected in Wuhan, China. SARS-CoV-2 triggered the epidemic of an extremely contagious respiratory infection (COVID-19) that spread rapidly across all countries [89]. On 11 March 2020, the WHO finally had to declare COVID-19 as a pandemic [90]. By mid-January 2022, over 309 million confirmed infections by SARS-CoV-2 and over 5.4 million deaths due to COVID-19 had occurred in more than 200 countries worldwide [10]. As of 11 January 2022, the amount of confirmed COVID-19 cases in Germany exceeded 7.58 million and there were more than 110,000 deaths [11]. Lacking specific drugs and vaccines, the measures for minimizing the virus exposure have been confined to social isolation, frequent hand hygiene protection, mask wearing, and isolation with quarantine [91].

Previous studies have shown that the pandemics are associated with disturbances in patients' sleep and psychological distresses, including traumatic stress, depression, and anxiety [85, 92]. Factors influencing these psychological disturbances include physical illness, mental health history, environmental stressors, isolation, and other measures to control pandemics [85, 92]. Furthermore, the available evidence from previous infectious diseases shows that the COVID-19 pandemic not only damages the structure and function of the organism's visceral tissues, but also acts as a stressful event causing emotional, behavioral, and somatic abnormalities in some patients [93, 94]. Liu et al. assessed 1,563 healthcare workers through an online mental health survey during the COVID-19 pandemic, showing the incidence rates of insomnia, depression, anxiety, and stress conditions to be 36.1%, 50.7%, 44.7%, and 73.4%, respectively [95]. Accordingly, insomnia, psychological disorders, and stress symptom prevalence increased significantly during the pandemic, and patients with pre-existing insomnia or psychological disorders were exposed to further aggravation [22, 95]. This study explored the quality of sleep and mental health status of German citizens and explored changes in their mental health status in

the COVID-19 pandemic era. Furthermore, we additionally analyzed the factors affecting them.

5.1 Prevalence of insomnia during the pandemic and factors influencing it

During the COVID-19 outbreak, insomnia was detected at higher rates in the general population and healthcare workers than before the outbreak [22, 86, 96, 97]. In a study on a total of 22,330 subjects from thirteen countries and four continents, Mori et al. revealed that over one-third of the studied population were afflicted with clinical insomnia during the COVID-19 pandemic showing a higher insomnia prevalence in females compared to males [22]. In a study by Voitsidis et al. in Greece, the insomnia prevalence during the COVID-19 pandemic was approximately 37.6%, and females and urban residents had experienced more sleep disturbances [96]. Conversely, Kokou-Kpolou et al. [98] found no correlation between the insomnia severity with either gender or place of residence; however, educational attainment showed a correlation with insomnia severity in their study. According to their results, the risk of insomnia prevalence was twice as high in those with an undergraduate degree as in those with a postgraduate degree [98]. The results of the present study showed that the prevalence of insomnia in the German population was 22.80%, a rate slightly higher than the pre-pandemic global prevalence of insomnia (3.9% to 22%) [99]. However, this result appears to be twice lower than that reported by Voitsidis et al. in Greece [96], though it is consistent with findings from China, Italy, and other countries [22, 23, 100].

A single study may not have sufficient validity to fully account for the prevalence of insomnia and the factors influencing it because of the relatively small sample size and low statistical power. Therefore, a meta-analysis of 44 studies was performed in thirteen countries with a total of 54,231 participants showing the prevalence of sleep disturbances to be 32.3%, 36.0%, and 74.8% in the general population, healthcare workers, and COVID-19-infected patients, respectively [101]. Another meta-analysis of 345,270 participants from thirty-nine countries revealed that the prevalence of sleep disturbances was 18.0%, 31.0%, and 57.0% in the general population, healthcare workers, and COVID-19-infected patients, respectively [94]. A study on insomnia among healthcare workers during the COVID-19 pandemic showed the prevalence of insomnia to be approximately 68.3% with a significantly higher rate in female healthcare workers compared to male ones (77.5%

vs. 64.4%) [97]. The insomnia prevalence among healthcare workers was significantly higher during the COVID-19 pandemic than it was during the SARS pandemic. The responsibility for this phenomenon is attributed to the fast outbreak of the COVID-19 pandemic around the world, the stressful working environment while fighting against the pandemic, and the lack of specific drugs and vaccines, especially at the early stages [97]. The above results suggest that sleep disturbances were still more common among the population, even in the later stages of the pandemic. Therefore, further attention to the sleep status of the population duting the later stages of the pandemic is needed and timely treatment should be provided to afflicted people.

5.2 Prevalence of anxiety and depression during the pandemic as well as factors influencing them

The present findings show depression and anxiety prevalence to be 14.2% and 14.6%, respectively, in the German population during the COVID-19 pandemic. Obviously, anxiety and depression have been prevalent in the German population during the COVID-19 pandemic outbreak. According to Hall et al., the mental health status of their target population was significantly affected during the Ebola pandemic [85, 102]. For the public, virus-related misinformation and rumors exacerbate fears and concerns relating to the health issues. The closure of infrastructure triggers a range of emotional stress responses, such as anxiety, depression, and other negative emotions. Healthcare professionals exposed to this new and highly infectious pathogen are burdened with excessive workloads, shortages of personal protective equipment, and a lack of support. At the COVID-19 pandemic onset, Wang et al. observed that 16.5% of participants in their study stated moderate to severe symptoms of depression and 28.8% reported moderate to severe symptoms of anxiety [103]. Another study reported the prevalence of anxiety and depression in their target population during the COVID-19 pandemic to be 16.1% and 22.7%, respectively, a result mildly higher than the results of the present study [104]. The pandemic-associated anxiety and depression symptoms may be related to fear of infection and the rapidly increasing confirmed number of cases [5, 95]. It may also be associated with financial stress, social distancing restrictions, travel restrictions, changes in daily life, and gender. The current findings suggested a meaningful association between the anxiety symptoms and economic status. Additionally, depression symptoms were differentially associated with gender and economic status.

A meta-analysis of 161,556 participants from 21 countries reported an anxiety prevalence of 25% during the COVID-19 pandemic [24]. During previous pandemics (SARS, H1N1 influenza, and Ebola), the anxiety prevalence in the population ranged between 3.2% and 12.6%, which was lower than the prevalence of anxiety found in the above-mentioned studies [84]. In past pandemics, despite high mortality rates, infection rates were low and the disease was controlled quickly [105]. The prolonged and uncertain lockdown imposed by governments during the COVID-19 pandemic may have contributed to increased anxiety, consistent with findings from a study during the SARS pandemic in Toronto, Canada [27]. Another meta-analysis that included 12 studies (30,358 participants in total) reported a prevalence of depression of 25% [106]. These results are significantly higher than the latest global prevalence of depression (2-6%) and nearly twice as high as the results of the present study [107]. However, the results from these two meta-analyses should be interpreted with caution, as the types of criteria and instruments used to determine depression - as well as the number of studies and countries included in the assessment process - can vary considerably.

5.3 Correlation between insomnia, anxiety and depression during the pandemic

The current findings suggest that as anxiety and depression scores increased, insomnia symptoms became more severe. A Japanese study of individuals' quality of sleep and psychological status found that the quality of sleep was significantly correlated with the depression severity factor, and that the risk of depression was significantly higher in the sleep-disordered group compared to the non-sleep-disordered group [108]. In another study by Latif et al., both low and high mood influenced the sleep quality and that improving low mood and using effective mood regulation strategies can improve the quality of sleep [109]. A main symptom of depression is insomnia, being the most typical sleep disturbance [110]. On the other hand, depression is the most common insomnia-associated psychiatric disorder; according to statistics, 90% of patients with depression suffer from poor quality of sleep [110, 111]. Insomnia and depression show a sequential relationship in the course of the illness, with disturbed sleep often being a precursor symptom of depression. Lack of sleepiness and early awakening are characteristic manifestations of depression, and poor mood and emotions are most pronounced on early awakening and morning rise.

As a result of the pandemic prevention and control, people go out less and their normal daily routine is disrupted. In the face of the uncertainty of the pandemic, people are prone to compulsive thinking and behavior, such as repeatedly checking the progress of the pandemic and searching for relevant information. The constant influx of information about the pandemic makes people hypervigilant, leading to intrusive thoughts before bedtime, and having adverse effects on sleep quality. The isolation of people at their residences leads to reduced contact with the outside world, resulting in limited interpersonal interactions and compromised relationships. A meta-analysis that included 26 studies showed that anxiety and depression levels increased 1.45 and 1.28 times, respectively, in patients in complete isolation [112]. Related studies have confirmed that as the severity of depression and anxiety increases, people experience varying degrees of sleep disturbance [97, 113, 114]. Several previous studies have confirmed the comorbidity and interaction between sleep and emotional disturbances [115-117], which is consistent with the findings of our research.

The results of the questionnaire used in the present cross-sectional study cannot be fully indicative of psychiatric or sleep disturbances. However, the present results may suggest the existence of multiple problems. If appropriate interventions are not made in a timely manner, they may have a detrimental effect on people [118].

5.4 Limitations

Several limitations impacted on the present study. First, the cross-sectional study, self-report questionnaires, and participant selection of methods may have led to reporting bias and/or selective bias. In addition, the type of the present study cannot determine the causal correlation between sleep quality and mental health status as well as related influencing factors. Nevertheless, this design was most appropriate due to the ongoing travel restrictions and lockdowns. Moreover, during the COVID-19 pandemic, we were unable to obtain objective indicators of the sleep testing, as well as participants' prior psychiatric history. Therefore, we cannot test the impact of this objective factor on this study. As a global public health crisis, the COVID-19 pandemic is unprecedented in the modern history. As a result, any potential direct effect it may have on sleep and mental health that may interfere with the present results remains unknown. Finally, this study did

not compare sleep and mental health status as well as their associated influences before and after the pandemic, and whether there was an evolution over time.

6 Conclusions

In this study, a self-administered questionnaire (the ISI, the PHQ-2, and the GAD-2 scale) for screening participants with insomnia, anxiety, and depression was used to assess the prevalence of insomnia, depression, and anxiety in a random sample of the German population during the COVID-19 pandemic era. Our results provide evidence that the prevalence of insomnia, anxiety, and depression in the German population increased to varying degrees during the pandemic.

In addition, we explored variations in the sleep quality and mental health status among the population of Germany in different age groups and regions, and in terms of gender, work status, and economic status during the COVID-19 pandemic. Our results demonstrate that the proportion of insomnia symptoms associated with places of residence, employment status, and economically shocked status. The proportion of depression symptoms associated with different gender and economically shocked status. The proportion of anxiety symptoms associated with economically shocked status. These findings are worrying, and further research on sleep quality and mental health as well as the factors influencing them is required.

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Statutory Declaration

“I, Ying Hung, by personally signing this document in lieu of an oath, hereby affirm that I prepared the submitted dissertation on the topic Prevalence and Influencing Factors of Insomnia, Anxiety, and Depression during the COVID-19 Pandemic / Prävalenz und Einflussfaktoren von Schlaflosigkeit, Angstzuständen und Depressionen während der COVID-19-Pandemie, independently and without the support of third parties, and that I used no other sources and aids than those stated.

All parts which are based on the publications or presentations of other authors, either in letter or in spirit, are specified as such in accordance with the citing guidelines. The sections on methodology (in particular regarding practical work, laboratory regulations, statistical processing) and results (in particular regarding figures, charts and tables) are exclusively my responsibility.

Furthermore, I declare that I have correctly marked all of the data, the analyses, and the conclusions generated from data obtained in collaboration with other persons, and that I have correctly marked my own contribution and the contributions of other persons (cf. declaration of contribution). I have correctly marked all texts or parts of texts that were generated in collaboration with other persons.

My contributions to any publications to this dissertation correspond to those stated in the below joint declaration made together with the supervisor. All publications created within the scope of the dissertation comply with the guidelines of the ICMJE (International Committee of Medical Journal Editors; www.icmje.org) on authorship. In addition, I declare that I shall comply with the regulations of Charité – Universitätsmedizin Berlin on ensuring good scientific practice.

I declare that I have not yet submitted this dissertation in identical or similar form to another Faculty.

The significance of this statutory declaration and the consequences of a false statutory declaration under criminal law (Sections 156, 161 of the German Criminal Code) are known to me.”

Date	Signature

Curriculum Vitae

My curriculum vitae does not appear in the electronic version of my paper for reasons of data protection.

Publication List

1. **Huang Ying**, Hennig Steve, Fietze Ingo, Penzel Thomas, Veauthier Christian. The Psychomotor Vigilance Test Compared to a Divided Attention Steering Simulation in Patients with Moderate or Severe Obstructive Sleep Apnea [J]. Nature and Science of Sleep, 2020, Volume 12:509-524. 23 Jul. 2020. doi:10.2147/NSS.S256987
2. **Ying Huang**, Philipp Aumüller, Ingo Fietze, Thomas Penzel and Christian Veauthier. Comparison of the Oxford sleep resistance test and the multiple sleep latency test [J]. Physiological Measurement, 2020;41(10):104005. Published 2020 Nov 6. doi:10.1088/1361-6579/ab9feb
3. Xia Mengdi, Liu Tong, Chen Dongming, **Huang Ying**. Efficacy and safety of renal denervation for hypertension in patients with chronic kidney disease: a meta-analysis [J]. Int J Hyperthermia. 2021;38(1): 732-742.doi:10.1080/02656736.2021.1916100
4. **Huang Ying**, Fietze Ingo, Penzel Thomas. Analysis of the correlations between insomnia and mental health during the COVID-19 pandemic in Germany [J]. Somnologie (Berl). 2022;26(2):1-8. doi: 10.1007/s11818-022-00347-7.

Book Chapter

Huang Ying, Fietze Ingo, Penzel Thomas. Obstructive Sleep Apnea with COVID-19. In: Penzel Thomas, Hornero Roberto (eds.). Advances in the Diagnosis and Treatment of Sleep Apnea: Filling the Gap Between Physicians and Engineers. Cham: Springer Nature Switzerland. 2022, in press.

Conference

Huang Ying, Fietze Ingo, Penzel Thomas. During the COVID-19 epidemic, the relationship between Insomnia and mental health-related factors among the general in Germany. The 16th Word Sleep Congress, 2022, Rome, Italy.

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Certificate of Accredited Statistician

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Bescheinigung

Hiermit bescheinige ich, dass Frau *Ying Huang* innerhalb der Service Unit Biometrie des Instituts für Biometrie und klinische Epidemiologie (iBikE) bei mir eine statistische Beratung zu einem Promotionsvorhaben wahrgenommen hat. Folgende Beratungstermine wurden wahrgenommen:

- Termin 1: *22.02.2022*

Folgende wesentliche Ratschläge hinsichtlich einer sinnvollen Auswertung und Interpretation der Daten wurden während der Beratung erteilt:

- Darstellung der Regressionsergebnisse überarbeiten
- Verwendung der Spearman-Korrelation
- Hinweise allgemeiner Art zum Aufbau und Struktur der Arbeit

Diese Bescheinigung garantiert nicht die richtige Umsetzung der in der Beratung gemachten Vorschläge, die korrekte Durchführung der empfohlenen statistischen Verfahren und die richtige Darstellung und Interpretation der Ergebnisse. Die Verantwortung hierfür obliegt allein dem Promovierenden. Das Institut für Biometrie und klinische Epidemiologie übernimmt hierfür keine Haftung.

Datum: 22.02.2022 Name des Beraters: Lukas Mödl

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