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An Investigation into Sleep Environment as a Multi-Functional Space

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Abstract: The purpose of this study is to evaluate the multi-functional use of the domestic sleep environment (bedroom) and present evidence on outcomes that can be identified. By looking at the sleep environment in a broader context and considering the use of the bedroom space besides sleeping, this research responds to an information gap in sleep studies. A survey with multiple-choice questionnaire items was conducted with 304 participants in Australia to investigate the relationship between occupants' use of the bedroom space and their sleep habits. We found evidence that today's bedrooms are used for more than just sleeping, reflecting the respondents' multi-functional needs. Of the respondents, 60% agreed to have a consistent sleeping routine, while 49% answered they have/might have a sleep problem. The mean hours spent in a sleeping environment are 9.31, while the sleeping mean hours are 7.12. While 40% reported using the bedroom as their living space, 61% said they prefer to use it only for sleep. Age, occupation and the bedroom's location affect bedroom use and preferences. This study provides an initial inquiry into developing design strategies and understanding on the intertwined relationship between sleep and its environment.

Keywords: sleep environment; bedroom; multi-functional use; workspace; sleep hygiene

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1. Introduction

Sleep is a fundamental biological requirement for humans. Seven to nine hours of sleep is recommended for adults [1] and humans spend a third of their lives asleep. In fact, the sleep environment is one of the rooms in which humans spend most of their time, but it has not been much investigated both theoretically and empirically [2]. Time-use research from New Zealand firmly establishes the fact that we spend more than 50% of our time at home in the bedroom, followed by a distant second in the kitchen [3]. Yet the kitchen, as a place of production for food and nourishment, has been closely studied and analyzed [4]. These studies supported designers and users to know about the kitchen triangle, the ideal height of cupboards and work benches, lighting, appliance placement and kitchen layout. Yet bedrooms, the rooms that we sleep in, which are also referred to as sleep environment, remain an unexplored area of research. Within this perspective, this study aims to offer a better understanding of today's sleep environments and how this environment is used by different demographic groups.

Bedrooms are defined as rooms containing a bed and studies confirm that people spend most of their time in these rooms of the house [4]. Sleep studies have determined that the sleep environment and lifestyle factors can influence sleep [5–7] and insufficient sleep has many consequences affecting health across all age groups [8]. However, the dynamic nature of the spatial experience, and its possible effects on sleep habits are rarely considered in previous studies, therefore it has shaped the framework of this study. In

their 2017 study, Bjorvatn et al. (2017) highlighted the gap in sleep studies referring to the PubMed database and mentioned that most previous studies concerned electronic media use in the bedroom in association with sleep deprivation [9], but there were few to no publications investigating sleep habits and the spaces in which sleep occurs. Their findings show that sleeping habits differ with age and sex and there are major differences in sleeping preferences, such as most people prefer a specific body position when trying to sleep. However, the authors highlighted that there should be further investigation if habitual differences may influence sleep and cause sleep disorders [9].

The act of sleeping and its phases, sleep disorders, and sleep-related social practices were empirically investigated; however, the dynamic nature of the spatial experience (i.e., of the actual bedroom set up and user experience) and its possible effects on sleep habits in a bedroom environment were rarely considered in previous studies. Research mainly focused on the optimal physical characteristics of the sleep environment, such as lighting [10] and temperature [11], while acknowledging that none of these parameters are experienced separate from each other during sleep. In fact, the complex nature of humans' spatial experience and its multi-sensory aspects requires a holistic understanding of how a sleep environment is used. The spatial experience might be influenced by distinctive parameters; for example, the bedroom proportions and/or size might cause a claustrophobic feeling, or the materiality of surfaces, window security bars, or orientation of the bed/bedhead in relation to the openings, or the height of the bed off the floor, the type and kind of furnishings, etc., might be some of the factors that might impact sleep quality.

A few studies highlighted this gap in research and further investigated spatial preferences concerning furnishings but limited them to graphic representations [2]. Hong et al. interviewed architects to find out their perspectives on favorable bedroom configurations. The observation was that often design outputs corresponded to Feng Shui principles [12]. A questionnaire study of 306 urban elderly concluded with specific recommendations for bedroom materials, colors, soft furnishings, flooring, orientation and in building location, i.e., floor level, and noted that men seem to pay more attention to light quality, whereas women paid more attention to the acoustic properties of their bedrooms [13]. The authors stated that the quality of life and wellbeing can be improved with better design methods affecting both physical and mental health. Another study demonstrated that having a private sleep environment contributed to the mental wellbeing of psychiatric inpatients, which supports the argument that the spatial experience of the bedroom is critical for mental well-being [14]. The bedroom is often the first space where growing children can develop a sense of autonomy and self apart from the family, and a study by Lincoln et al. investigated teenage bedrooms and the role they play in personality development, socialization and having a private space to explore culture and one's relationship with it [15].

Bedrooms today allow for a degree of personalization, and they have been significant multi-functional spaces especially for children to reflect and explore, facilitating activities of play and study [16]. Bedrooms have been complex systems throughout history, mainly linked to changing social and wellbeing needs. The idea of a bedroom being a private place is relatively new in 20th century. Sleeping used to be a much more communal and public affair. While the beds have changed little in time in accordance with manufacturing methods and technologies, a bedroom has always been a representative site of social norms [17]. Differentiated needs were addressed in distinctive conditions. Some historic examples are the design of sanatoriums and wellness environments in the early 20th century [18]. Those bedrooms in sanatoriums were designed as a complete environment down to sinks, ceilings, window, floor intersections and bed position in relation to the views from the bed and controlled exposure to the natural environment. However, little empirical data are available even today, and today's bedrooms are not simply spaces where people sleep. For example, studio apartments in high-rise buildings, where "the bed either folds away into the wall or else has reemerged in the home's public spaces" [19].

By primarily addressing the multi-functional use of the sleep environments, this research investigates how differentiated use of the bedroom space affects the spatial expe-

rience, and hence sleep habits. The initial aim with this preliminary research is to better understand the use of bedroom space today, evaluate the spatial needs of users and what outcomes can be identified regarding its effects on sleep.

2. Bedroom as a Sleeping Environment

Sleep hygiene has been defined as a list of behaviors, environmental conditions and other sleep-related factors that are believed to promote improved quantity and quality of sleep [20]. Peter Hauri was first to use 'sleep hygiene' as a term, and he noted sleep hygiene rules and recommendations in 1977, including 'curtailing time in bed a bit seems to solidify sleep'. He suggested avoiding an excessively long time in bed which might cause shallow sleep; adding that a warm room, or occasional loud noises disturb sleep. Hauri's studies on insomnia patients showed the importance of individual sleep hygiene suggestions, which were reported as useful to around 70 percent [20,21].

An appropriate sleep environment plays a critical role in achieving an adequate sleep hygiene, and research shows evidence that there are optimal characteristics for noise, temperature, lighting and air quality [6]. Sleep environment research mainly addresses an optimization of physical requirements, with a focus on individual parameters such as the light, temperature, noise and comfort of the mattress. It is quite significant to understand how each of these parameters influence sleep quality, which has been the major concern in sleep environment studies. Research findings show that light is a major synchronizer of circadian rhythm and sleeping with the light on has an impact on sleep quality, causing shallow sleep [10]. Humid heat exposure during sleep increases thermal load and wakefulness and the heat stress during sleep should be considered in combination with humidity [11]. Another parameter that plays a significant role in sleep hygiene is air quality. When bedroom air quality was improved in the experiments, the subjects' sleep quality and performance was improved [22]. One of the major factors affecting sleep is noise, and noise louder than 40 dB during sleep was found to be the strongest risk factor of sleep quantity [5]. The room layout and spatial experience of the room can be considered part of the contributing factors for sleep quality. Evolutionary psychologists Spörrle and Stich presented their experiment findings that shows participants preferred a self-chosen layout, and the positioning of the bed was explored as an important factor for people to feel safer. However, this has not been tested in real life, as the study was undertaken based on graphic representations of the bedroom layout [2]. This approach is similar to exploring the application of the Form Feng Shui Model in a Sleep Environment, which supported human preferences for the sleep environment [12]. The findings also show that the bedroom habits differ with age and sex and the demographics have an influence in bedroom preferences [9].

While the optimal characteristics of a sleep environment was the main area of research, some studies highlighted the importance of the changing conditions in sleep environments. By investigating the relationship between the sleep environment and sleep quality in subjects' bedrooms, one study observed the seasonal changes, and the findings demonstrated that people sleep well in spring [23]. As another example of the changing conditions, the COVID-19 pandemic has altered the work environment in favor of remote working, and studies showed how this change influenced workers' sleep quality [24]. A recent study by Xu et al. proposed five hypotheses concerned with sleep environment and sleep quality; two of them questioned if decorations in the bedroom and surrounding environment of building could affect the sleep quality [25]. A significant correlation existed between plants and sleep quality, resulting in people living in a bedroom without plants having a 74.5% chance of getting better sleep. Another finding the study suggested was opened doors during sleep could improve respondents' sleep quality—while the effect of opened windows was unclear. While the study suggested valuable information on how outdoor surroundings such as highway and active airport could affect sleep, the indoor environment questions were limited with furniture items and decoration, and also considering as if they are stable elements in a sleep environment. However, it is evident that the changing circumstances and/or activities taking place in the bedroom might affect sleep quality.

Some previous studies have shown that there is a relationship between lack of sleep and the activities taking place in the bedroom, affecting sleep quality, such as the excessive use of the mobile phone [7]. For a healthy sleep, experts suggest maintaining a dark and gadget-free bedroom and getting rid of distractions in the room that might affect sleep [26].

This research focuses on the hidden bias of bedroom use to explore how today's sleep environments are being used. Figure 1 illustrates the main titles covered by previous studies about the sleep environment. On the left side, research focusing on optimal sleep conditions are mentioned briefly, such as temperature, air quality, and exposure to noise. On the right side, the titles that are rarely mentioned in these studies are highlighted, which are more about the spatial experience that this study aims to reveal. Within this perspective, this study aims to: (1) Analyse the relationship between age groups and bedroom usage; (2) Understand sleep habits to inquire about the association between the bedroom space use and sleep and (3) Have a better understanding on the present spatial needs (the furniture/objects and the type of activities that take place in a bedroom today).

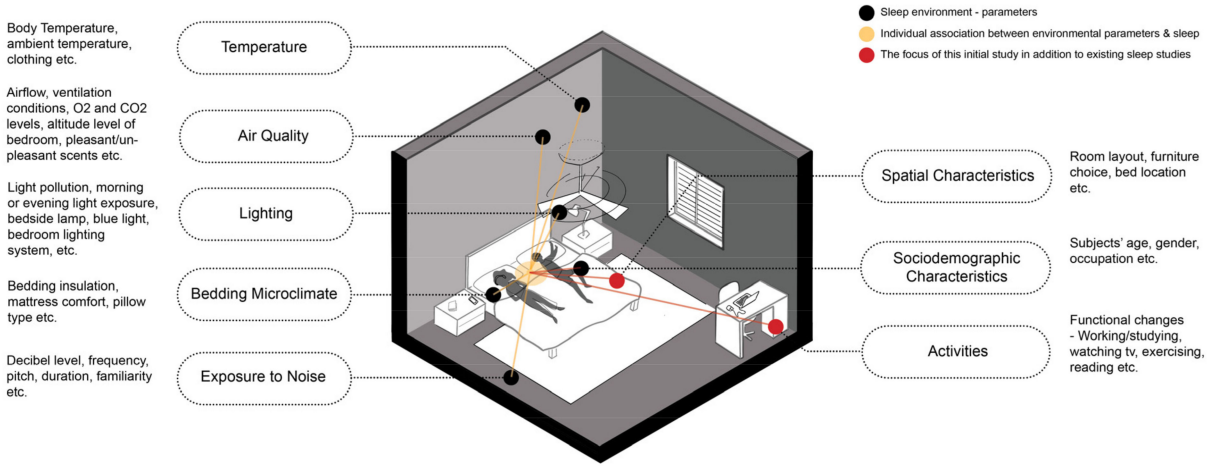

Figure 1. An evaluation of the literature review on sleep environment, illustrated by the authors.

3. Methodology

This research applies a mixed-methods approach with an initial analysis of previous studies and surveys. Literature was examined to identify critical issues that would be relevant for further investigation of previous sleep studies, and a survey was designed that included qualitative and quantitative questions. This paper focuses on the quantitative data results of the survey, and the details of the survey design process are presented below.

3.1. Study Design

The data collected for this research are based on 304 people's sleep environment experience in the post-COVID era. There is limited information on the changing use of the sleep environment and its possible effects on sleep. For that reason, a survey with multiple-choice and text entry questionnaire items was conducted to understand the use of bedrooms comprehensively. The survey was designed to gain three types of information: (1) Sociodemographic characteristics of survey participants; (2) The properties and use of the domestic sleep environment and (3) Sleep habits of the participants. Each part of the survey questionnaire and how the questions were determined are explained in detail below.

3.1.1. Socio-Demographic Properties

The first section of the questionnaire related to a range of socio-demographic questions including age group, gender, employment status and location (Table 1).

Table 1. Questionnaire items: Descriptive Properties.

Question	Question Type	Answers
Which age group are you in?	Multiple-choice question type, one answer	• 18 to 24 years old • 24 to 44 years old • 45 to 64 years old • 65 and over
How do you define your gender?	Multiple-choice question type, one answer	• Male • Female • Prefer not to say
Which of the following categories best describes your employment status?	Multiple-choice question type, one answer	• Employed part/full time, working from home • Employed part/full time, working from a workspace (out of home) • Employed, working hybrid (both home and office) • Unemployed • Homemaker • Student • Retired • Other–please specify
What is the postcode of the house where you live in?	Single response, select the region and auto-code	• ACT (Australian Capital Territory) • NSW (New South Wales) • NT (Northern Territory) • QLD (Queensland) • SA (South Australia) • TAS (Tasmania) • VIC (Victoria) • WA (Western Australia)

The socio-demographic questions were prepared with reference to the National Sleep Foundation sleep survey, prepared by the Adelaide Institute for Sleep Health in 2016 [8]. Their study provides a comprehensive analysis of the Australian community and their sleep problems, to assess the scale of the health and social consequences of insufficient sleep and sleep disorders. As this study aims to have a general understanding of the Australian community's use of the bedrooms today, the authors wanted to revisit the demographics questions that were reported from the previous years. For a comparative study to evaluate the changes within the years, the same sociodemographic characteristics ratio was kept as much as possible, based on the previous reports and ABS population estimates [27].

3.1.2. Spatial Use of the Sleep Environment and Sleep Habits

For designing sleep hygiene related questions in the survey, three questionnaires were taken as references for this study to conduct a general understanding of participants' sleep habits: (1) Pittsburg Sleep Quality Index (PSQI) [28]; (2) The Sleep Hygiene Index (SHI) [29] and (3) The National Sleep Foundation sleep survey [8].

The Pittsburg Sleep Quality Index is a self-rated questionnaire and studies found that the PSQI is easy to use, and it could be used to monitor sleep and evaluate the relationship between sleep quality and other variables [30]. The PSQI components 1 and 2, which are based on sleep quality and sleep duration [28], were used to design the sleep habits questions as shown in Table 2. As the aim of this study was to have an initial understanding of the relationship between the changing use of the sleep environment and sleep among other variables, the PSQI was not used to conduct a sleep scoring, but more to demonstrate the self-assessment of participants' sleep habits. The Likert-scales sleep questionnaire items listed in Table 2 were based on The Sleep Hygiene Index (SHI) questionnaire [29].

Table 2. Questionnaire items related to participants' sleep habits.

Question	Question Type	Answers
During the post-COVID era, how long (in minutes) did it usually take you to fall asleep at night?	Multiple-choice question type, one answer	• Less than 15 min • 15–30 min • 30–60 min • More than 60 min
During the post-COVID era, how many hours of actual sleep did you get at night on a weekday? (This may be different than the number of hours you spend in bed.) For ex. 8 h 30 min.	Text entry	Hour: . . . Minute: . . .
Do you think you have a sleep problem?	Multiple-choice question type, one answer	• Yes • No • Maybe/Don't know
Please rate the following statements regarding your general experience in bedroom space.	Matrix table, 5 Likert Scale: Never-Always	• I have a consistent sleeping routine. • I use an eye mask and/or earplugs to help me sleep. • I listen to music/podcast to sleep.

The Sleep Hygiene Index (SHI) questionnaire includes 13 items to assess the presence of behaviors that are thought to compromise sleep quality [29]. Studies of the SHI questionnaire confirmed that it demonstrated reliability and validity [31]. The SHI questions numbers 2 and 3 (I go to bed at different times from day to day, I get out of bed at different times from day to day.) were detailed as numeric questions in our survey, in relation to understanding the total hours spent in the sleep environment and asleep. Some of the SHI questions were based on the activities taking place in the sleep environment, such as question number 4 which is about exercise, and question 9, the use of bed in general, such as watching television or reading.

The National Sleep Foundation survey included questionnaire items about the prevalence of activities conducted in the hour before going to bed, such as work-related activities; however, the sleep-environment relationship of these activities were not specified, and it was limited to a time reference to count its effects on sleep [8]. Therefore, we preferred to detail SHI questions in the format of sub-questions, following a Likert-scale agreement ranking. The activities that the bedroom is used for, such as studying and eating, were prepared as a multiple-choice question (Table 3).

Table 3. Questionnaire items related to spatial characteristics and participants' use of the sleep environment.

Question	Question Type	Answers
Which of the following categories best describes where your bedroom is?	Multiple-choice question type, one answer	• I live in a bedsit/studio • I have my own bedroom in a shared flat/house • I have a shared bedroom (not partner) • I have my own bedroom in my own flat/house • Other (please specify)
Please choose what applies to you in general.	Multiple-choice question type, multiple answers	• I sleep in my bedroom. • I sleep in a spare room. • I sleep in a car.
On a daily basis, how long (in hours) do you spend in your bedroom?	Text entry	Hours: . . .

Table 3. *Cont.*

Question	Question Type	Answers
What activities do you use your bedroom for?	Multiple-choice question type, multiple answers	• Sleeping • Studying/Working • Exercising • Eating • Reading • Watching TV • Entertaining • Other (Please specify)
Please tell us which of the following you have in your bedroom in general:	Multiple-choice question type, allow multiple answers	• Bed-mattress • Sofa-bed • Armchair/Chair • Bedside table • Study/work desk • Wardrobe • Television • Computer/laptop • Music players/speakers • Artwork/pictures • Blackout curtains/blinds • Bedside table lamp • Carpeting • Floorboards • Other (Please specify)
Please rate the following statements regarding your general experience in bedroom space.	Matrix table 5 Likert Scale: Never-Always	• I use my bed for eating. • I use my bed for work/study. • I use my bedroom as a living space. • I use my bedroom as a working/studying area. • I use specialied lighting in my bedroom. • I use an air filter/humidifier in the bedroom.
Please rate the following statements regarding your use of the bedroom (considering as the room you sleep).	Matrix table 5 Likert Scale: Strongly Disagree–Strongly Agree	• I prefer I could use my bedroom only for sleep. • Working and sleeping in the same room is not a problem for my sleep.

3.2. Data Collection and Analysis Method

The study was reviewed and approved by the UNSW Human Ethics Committee. Participants were recruited through an online research panel, which included an active panel (participant number) of 700 K to circulate the survey. Respondents received an invitation which did not include specific project details to avoid self-selection bias, and the project details were disclosed later. The survey invitations provided basic links and information that is non-leading. The data was collected via an online survey which could be filled in using a mobile phone or a web browser. The data was collected non-identifiably, as per the negligible risk UNSW Research Ethic Guidelines.

The participants were restricted by two criteria: (1) 18 years of age and older and (2) Australia resident. Participants were recruited through a research panel administered by the survey company, using weighted randomization based on demographic information collected through registration. The survey was pretested with 10 people to ensure appropriate interpretation of the questions. The number of participants included in the study is defined as 300, resulting in 304. A larger sample is preferable; however, the sample size is sufficient to meet this research's aims because this study intends to have an initial understanding of differentiated uses of bedroom space in Australian population.

Data from 304 participants were collected, using weighted randomization based on age, gender and location. The quantitative data were analyzed by statistical methods, using IBM SPSS Statistics for Windows, Version 28.0, and the statistical significance level was chosen as $p < 0.05$. First, descriptive statistics were conducted for gender, age and occupational status of the participants, to determine links between descriptive characteristics and use of

bedroom space. The relationship between responses and socio-demographic variables was assessed with 1-way analysis of variance (ANOVA), Kruskal–Wallis one-way analysis of variance test (the nonparametric equivalent of ANOVA) and Mann–Whitney U test (non-parametric equivalent of independent samples *t*-test). Fisher's exact test and Pearson's chi-square test were used to determine the possible statistically significant differences in the categorical variables. Univariate and multivariate logistic regression analyses were performed to evaluate the association between the socio-demographic variables and the responses to the survey.

4. Results

The results are organized in three sections: (1) Demographic characteristics of the participants, followed by (2) Analysis of sleep environment and sleep habits, which presents the characteristics of the sleep environment, activities taking place in the bedroom, sleep habits of the participants and an analysis of the association between these parameters and the last subtitle includes (3) A detailed discussion on the results.

4.1. Demographic Characteristics of Survey Participants

The variation in demographic characteristics is as described in Table 4, and the sample was generally representative of the Australian population with regards to age, gender and geographic location across states and metropolitan and rural locations. Among the respondents, 49% defined their gender as male (n = 146) and 51% responded as female (n = 158). Thirty-eight respondents were aged 18–24 (12.5%), 119 were aged 25–44 (39.1%), 101 were aged 45–64 (33.2%) and 46 were aged 65 and above (15.1%). Regarding occupation, 178 (58.5%) respondents were employed, 84 (27.6%) were working from home, 76 (25%) were working out of home from a workspace and 18 were working hybrid (both from home and office) (5.9%). A total of 95 responders (31.3%) were based in NSW, followed by 24.7% in VIC, 18.8% in QLD and 218 of 304 respondents lived in a metro area (71.7%).

Table 4. Demographic characteristics of the respondents.

	Variable	Frequency	Percentage
Gender	Male	146	49%
	Female	158	51%
Age	18 to 24 years	38	12.5%
	25 to 44 years	119	39.1%
	45 to 64 years	101	33.2%
	65 and over	46	15.1%
Occupation	Employed, working from home	84	27.6%
	Employed, working from a workspace (out of home)	76	25%
	Employed, working hybrid	18	5.9%
	Unemployed	20	6.6%
	Homemaker	25	8.2%
	Student	16	5.3%
	Retired	58	19.1%
	Other	7	2.3%
State	ACT	6	2%
	NSW	95	31.3%
	NT	5	1.6%
	QLD	57	18.8%
	SA	30	9.9%
	TAS	8	2.6%
	VIC	75	24.7%
	WA	28	9.2%
Location	Metro	218	71.7%
	Regional	86	28.3%

The sociodemographic characteristics of the Australian survey participants that were presented in the Sleep Health Foundation report were: 49.8% male, 50.2% female. The

weighting of age-categories 18–24 ages reported as 12.2%, and 45–64 as 33.2% which were approximately the same as the Australian population estimates: [27].

4.2. Analysis of Sleep Environment and Sleep Habits

4.2.1. Sleep Environment

Of the 304 respondents, 294 (90.20%) replied that they use their bedrooms for sleeping, while 3 (0.90%) respondents mentioned sleeping in a car, and 29 (8.90%) were sleeping in a spare bedroom. Across conditions, 72.7% of the participants mentioned that they have their own bedrooms in their own flat/house (n = 221), and 20.4% have a bedroom, but in a shared flat/house (n = 62) (Table 5).

Table 5. Questions related to sleep environment and its location.

	Frequency	Percent
I live in a bedsit/studio	13	4.3
I have my own bedroom in a shared flat/house.	62	20.4
I have a shared bedroom (not partner).	5	1.6
I have my own bedroom in my own flat/house	221	72.7
Other	3	1
I sleep in my bedroom.	294	90.2
I sleep in a spare room.	29	8.9
I sleep in a car.	3	0.90

4.2.2. Activities in Bedroom

A similar question to evaluate whether participants' sleep in a bedroom-space was asked for a second time in the multi-choice activity question (Which activities do you use bedroom for?) and 295 respondents confirmed that they sleep in a bedroom, while 9 respondents did not choose this option (Figure 2). Among the other activities taken place in their sleep environment, watching TV was the highest activity after sleeping (n = 147), followed by reading (n = 91), studying/working (n = 80), eating (n = 57) and exercising (n = 31).

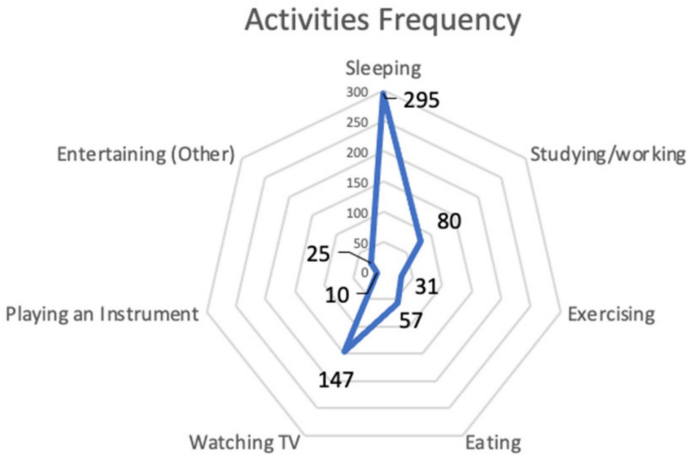

Figure 2. Representation of the activity frequencies in the sleep environment.

4.2.3. Items in Bedroom

Responses represented in Figure 3 show that most of the respondents mentioned having a bed in their sleep environments (n = 278); however, it should be highlighted that among these respondents, 17 of them mentioned having a sofa-bed, and 8 respondents chose only a sofa-bed, not having a bed. As shown in the diagram below, 214 respondents had bedside tables, 205 had wardrobes. Participants (47%) expressed having their phones (n = 145), and 34% mentioned having their laptops in the bedroom (n = 104). The number of respondents who mentioned having a desk in their bedrooms was 59. Other than the

items shown in the diagram, 174 respondents' bedroom flooring was carpet, while 56 had floorboards.

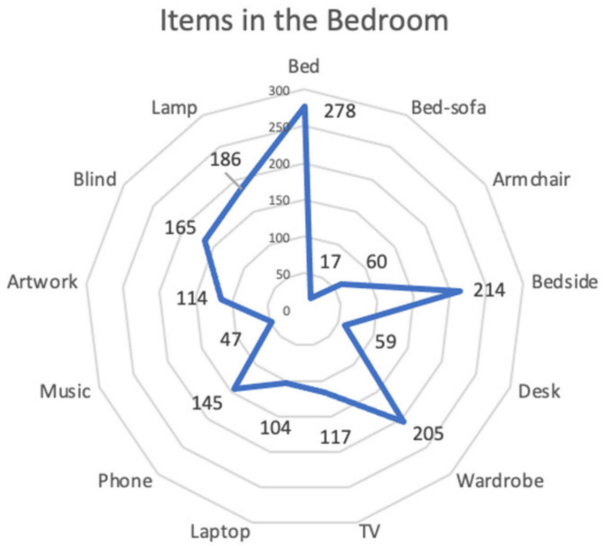

Figure 3. Representation of the items in the bedroom.

4.2.4. Sleep Habits

The findings suggest that the mean hours spent in sleep environment are 9.31, and the sleeping mean hours are 7.12 with a minimum of 1, and a maximum of 10 h of sleep (Table 6). Responses showed that 44.7% of the participants (n = 136) spend 15–30 min before falling asleep, followed by 25% (n = 76) who spend less than 15 min. However, 10.9% of respondents (n = 33) mentioned the fact that it takes more than 60 min for them to sleep. The majority of respondents (60.9%) sleep 7–8 h (n = 185), which might be considered as the ideal sleeping length according to the National Sleep Foundation [1]. Respondents sleeping 6 or less hours were calculated as 31.9%, which is lower than the suggested sleep duration (Table 7).

Table 6. Hours spent in the sleeping environment and during sleep.

	n	Min	Max	Mean	Std. Error
Hours spent in sleep environment	304	1	24	9.31	0.202
Hours for sleep	304	1	10	7.12	0.083

Table 7. Sleep habits of the respondents.

		Frequency	Percent
Time to sleep	Less than 15 min	76	25
	15–30 min	136	44.7
	30–60 min	59	19.4
	More than 60 min	33	10.9
Sleep duration	Less than 3 h	7	2.3
	3–4 h	14	4.6
	5–6 h	76	25
	7–8 h	185	60.9
	9 h and more	22	7.2
Sleep problem	Yes	69	22.7
	No	155	51
	Maybe/Don't know	80	26.3

4.2.5. Analysis of the Association between Spatial Characteristics and Sleep Parameters

Binary logistic regression was performed to ascertain the effect of sleep duration on the likelihood that participants have sleep problems. According to the results, sleeping less than 4 h was associated with an increased likelihood of exhibiting sleep problems; OR = 10.44 (95% CI, 2.95 to 36.86), Wald $\chi 2(1) = 13.28$, $p < 0.001$. Furthermore, sleeping 5–6 h increased the likelihood of exhibiting sleep problems 4.16-fold when compared to sleeping more than 7 h (95% CI, 2.35 to 7.37); Wald $\chi 2(1) = 24.03$, $p < 0.001$.

Figure 4 shows that 40% of the respondents never use their bedroom as a living space, and the majority of the respondents reported that they would prefer to use their bedroom only for sleeping (61% agree range, 27% neutral, averaging score 3.79 on a 5-scale assessing agreement). This data suggest that less people: listen to music/podcasts to sleep (2.09), use an air filter in the room (1.96) or an eye mask/earplug (1.86) to help sleeping. The respondents tended to agree that they have a consistent sleeping routine (averaging score 3.62) with an agree-range of 60%, while 51% of the respondents reported that they do not have a sleep problem. Two of the survey questions focused on the use of the bed, and approximately half of respondents mentioned that they never use their bed for working/studying or eating.

To analyze if there were any differences in the hours spent in the bedroom space, a nonparametric test was applied. As shown in Figure 5, participants between 18–24 years of age spent more time in the bedroom space than the other age groups. There was not a significant difference between those participants aged 45–64 years or 65 and older. The results suggested that the median sample of 18–24 years old's bedroom usage (hours) ranks were statistically significant than other age groups, $p < 0.001$. A non-parametric Mann–Whitney U test conducted to analyze if there was a significant difference between the time spent in the bedroom and gender. Findings showed that there was no statistically significant difference (U = 10,185.5, $p > 0.05$) between gender and the amount of time spent in the bedroom.

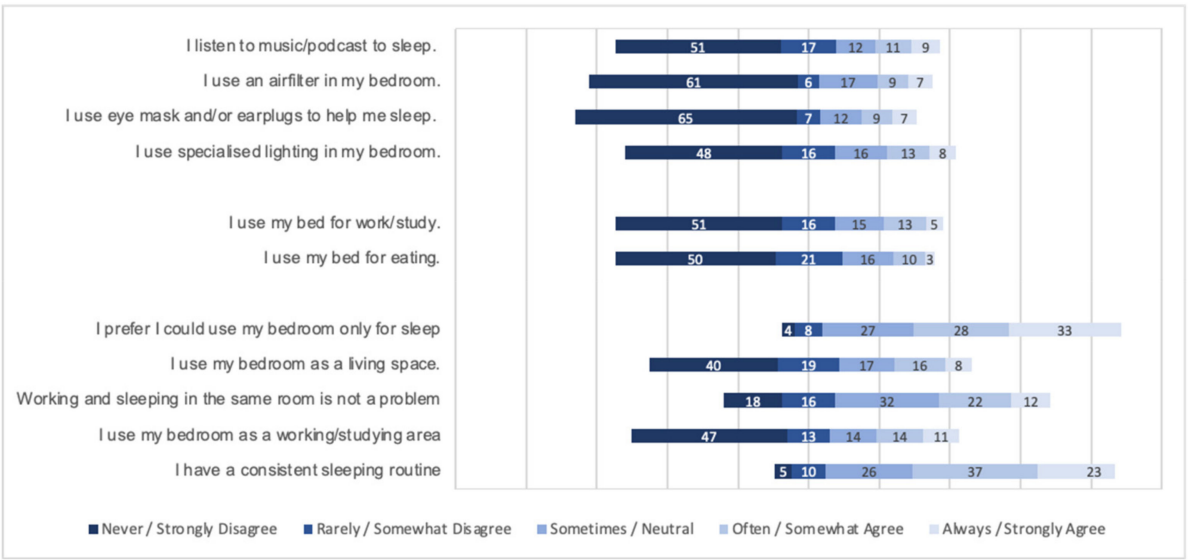

Figure 4. Analysis of the Likert-scale questions based on bedroom use.

A Kruskal–Wallis H test showed that there was a statistically significant difference in preference for bedroom use as a living space between age groups; H(3) = 70.839, $p < 0.001$. Pairwise comparisons with a Bonferroni adjustment revealed that, as the age increased, the preference for using the bedroom as a living space decreased statistically significantly (Figure 6).

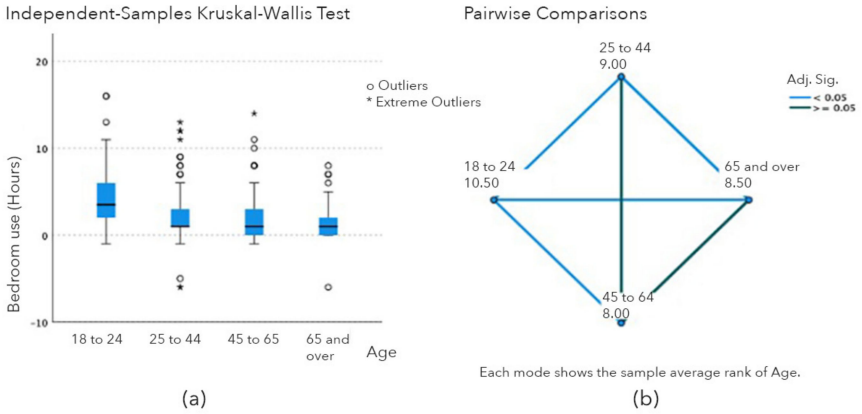

Figure 5. Analysis of the association between bedroom use and age groups: (**a**) Independent samples Kruskal–Wallis Test results; (**b**) Pairwise comparison.

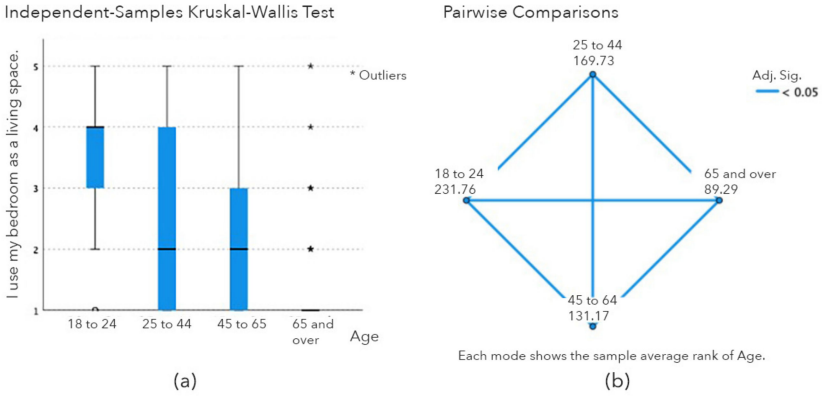

Figure 6. Analysis of the association between "using the bedroom as a living space" and age groups: (**a**) Independent samples Kruskal–Wallis Test results (**b**) Pairwise comparison.

As ANOVA assumptions (normality and homogeneity) were not met, the Kruskal–Wallis test was conducted to analyze the relationship between sleep duration and age groups (Table 8). There were no statistically significant differences between age groups and the amount of sleep that responders had; ($H(3) = 3.087$, $p > 0.05$).

Table 8. Total sleep duration for age groups.

	n	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper bound		
18 to 24 years	38	440.21	98.90759	16.04	407.70	472.72	121	570
25 to 44 years	119	422.99	89.74649	8.22	406.69	439.28	60	590
45 to 64 years	101	426.36	82.82714	8.24	410.01	442.71	75	540
65 and over	46	428.13	78.65526	11.59	404.77	451.48	210	600

Univariate ordinal logistic regression analysis revealed that the amount of people using the bedroom as a working area decreased in unemployed, homemaker and retired groups, when compared to respondents who were working from home. For unemployed with an odds ratio of 0.37 (95% CI, 0.15 to 0.94), Wald $\chi2(1) = 4.32$, $p < 0.05$; for homemakers OR 0.40 (95% CI, 0.17 to 0.92), Wald $\chi2(1) = 4.58$, $p < 0.05$ and for retired OR 0.08 (95% CI, 0.03 to 0.19), Wald $\chi2(1) = 35.54$, $p < 0.001$. However, there was an increase in students and their use of the bedroom as a working area when compared to respondents who were working from home, with an odds ratio of 4.10 (95% CI, 1.53 to 10.98), Wald $\chi2(1) = 7.90$, $p < 0.05$. In addition, when bedroom location is taken into consideration, respondents who live in a bedsit/studio had a 10.32-fold increase in using the bedroom as a working area when compared to respondents who have their own bedroom in their own flat/house, (95%

CI, 3.66 to 29.12), Wald $\chi 2(1) = 19.46$, $p < 0.001$. There was a 6.13-fold increase in using the bedroom as a working area for the respondents who have their own bedroom in a shared flat/house (95% CI, 3.58 to 10.48), Wald $\chi 2(1) = 43.86$, $p < 0.001$.

Additionally, regression analysis revealed that respondents preferred working in their bedrooms more as the age declined. In 18 to 24 years, there was a 45.77-fold increase in working in bedrooms when compared to 65 and over (95% CI, 16.41 to 127.65), Wald $\chi 2(1) = 53.38$, $p < 0.001$. Furthermore, in the 25 to 44 years and 45 to 64 years groups, there were 10.38-fold and 4.23-fold increase, respectively, in preference to using bedrooms as a working place (95% CI, 4.32 to 24.95), Wald $\chi 2(1) = 27.39$, $p < 0.001$.and (95% CI, 1.73 to 10.32), Wald $\chi 2(1) = 10.07$, $p < 0.005$, respectively.

4.3. Discussion on Findings

Some of the conclusive results that this study might guide and provide a ground for further studies are organized as three steps of inquiry. First, sleep studies need to analyze the physical conditions of the sleep environment in today's world, and address how this environment responds to users' differentiated needs. Secondly, the spatial experience of the sleep environment needs to be considered regarding the dynamic use of the bedroom as a multi-functional space. Lastly, further studies are needed to highlight how the physical and spatial conditions of the sleep environment might affect the quality of sleep. Each of these steps are discussed in subtitles below.

What is the sleep environment?

Understanding the distinctive conditions and preferences of the sleep environment are significant factors, before conducting an evaluation on optimal sleep conditions. The results showed that 90% of the respondents use their bedroom for sleeping, while the others either do not have a bedroom space for sleeping, or they use the bedroom space for activities other than sleeping. It is critical to phrase the sleep-related questions in a way that today's sleep environment might not be merely a room including a bed. Although the ratio of participants who mentioned sleeping in spaces other than a permanent bedroom were not high, such as sleeping in a car or in a spare room, these might be quite significant factors to highlight before a discussion is held on optimal bedroom conditions affecting their sleep. In addition, results showed that some participants only use a sofa-bed for sleep. In addition, some of the respondents mentioned that their bedrooms were shared spaces (not partner) or bedsit/studio spaces. Most of the sleep questionnaires do not inquire about spatial circumstances of the sleep environment, assuming that the sleep environment is a stable bedroom space, that there is a bed used for sleeping while questioning optimal physical conditions if they are close to be achieved. Our first suggestion is to include a comprehensive analysis within a time period of what a bedroom consists of and how the subjects' sleep environment is configured.

Dynamic use of the bedroom: Bedroom as a Multi-functional space

The results of this study demonstrate that the bedroom habits differ amongst the Australian general public. Our results represent the dynamic and changing use of the sleep environment. Age significantly influenced participants' use and preferences of the sleep environment space. About 40% of the respondents mentioned using their bedrooms as a living space. As the age increased, the preference of using the bedroom as a living space decreased statistically significantly and the majority of the respondents reported that they prefer to use their bedroom only for sleep. An alternative explanation for our findings is that younger age groups more often use the bedroom space for activities other than sleep, which relates to the previous findings [15]. There was no statistical significance between gender and the amount of time spent in the bedroom. Watching TV was the second highest ranked activity taking place in a sleep environment. The Sleep Health Foundation report showed that 52% of participants watch TV before going to bed [8] and in this research, we wanted to investigate where watching TV takes place. Our findings show that 48.35% of participants ($n = 147$) watch TV in their bedrooms.

The occupation of the participants and their bedroom's location were also significant factors affecting the use of the bedroom. Students use the bedroom more as a working area as an expected result, but in addition, students use the bedroom space more than respondents who mentioned working from home. Furthermore, living in a bedsit/studio means respondents use their bedrooms as a working area, and there is an increase in using the bedroom as a working area within the respondents who live in a shared flat/house. In addition, two of the questionnaire items in our survey focused on the use of the bed, rather than the bedroom. The findings showed that, while approximately 50% of the respondents do not use the bed for studying, working or eating, the rest of the respondents mentioned that they sometimes/always use the bed for such activities. Only 59 respondents stated having a desk in their bedrooms, while 80 mentioned studying/working from their bedrooms, and 104 participants mentioned using their laptops, which might be linked to the use of beds.

On the other hand, leaving technology out of bedroom is a losing battle, and future technology might support home-networked devices (lighting and thermostats) to track and synchronize with people's circadian rhythm [26]. In parallel, bedrooms might be even more multi-functional spaces in the future, which should be considered in the process of developing such technologies.

Sleep environment & Sleep

While we cannot establish a direct relationship between sleep problems and the use of the room, the majority of the respondents mentioned they prefer that they could use the bedroom only for sleep. Another significant outcome to highlight is, while 60% of the respondents agreed to have a consistent sleeping routine, 51% of the total respondents mentioned not having a sleep problem, and 26% of others were not sure whether they have a sleep problem or not. The results shared in the 2016 Sleep Foundation Report showed that 24% of adults think that they had a sleep problem [8]. Comparison of the results from this report showed increases in the prevalence of sleep problems in Australia and there was little difference by gender. In addition, the results showed that the majority of Australians have carpets in their sleep environment. Carpets may act as a repository for pollutants which might affect people with asthma and allergies [32]; in fact, its effect on sleep might be further investigated.

Most of the respondents do not use air filters or specialized lighting in their bedrooms, or eye masks or earplugs to help sleep. While this study did not focus on the use of sleep medication or aids in detail, further studies might be needed to evaluate people's awareness about sleep hygiene and their possible individual contribution regarding environmental conditions; especially considering 49% answered they might have, or they have a sleep problem.

According to 2016 results, the mean hours' sleep duration on working days were 7.01 and non-working days were 7.6 [8]. Our questionnaire has not made a separate evaluation on workdays but included the general use of the bedroom space. The mean time spent in a sleeping environment is 9.31 h, while the sleeping mean is 7.12 h. An alternative explanation of this finding might be that 38.8% of a day is being spent in the sleep environment. In addition, our findings suggest that it takes less than 30 min to get to sleep for most of the respondents (69.7%). Considering that 53 respondents mentioned spending twelve or more hours in the rooms they sleep in, we suggest that the intertwined relationship between sleep and its environment requires further investigation. This might lead to future design strategies to address the multi-functional needs and uses of the bedroom.

5. Conclusions

Previous sleep studies have discussed that the sleep environment plays a significant role in the quality of sleep, and findings show how diverse aspects of sleep hygiene are linked to optimal conditions in bedrooms. However, limited studies have specifically addressed the changing use of the sleep environment (especially during the post-COVID era), and what sleep environment means in today's world. This study aimed to present a

more detailed analysis of what a sleep environment is today, and what characteristics could be outlined from the participants' spatial experience. It could be argued that, while the significance of the sleep environment and its effect on sleep quality is highlighted in various research projects, studies mainly focus on the act of sleeping by considering environmental conditions as if they are independent factors.

In the absence of comprehensive studies on the physical bedroom environment, this paper aimed to provide initial data for an improved bedroom design and by implication better sleep. The present results encourage further investigation of the changing spatial preferences of the sleep environment, as too little attention has been paid to the dynamic use of today's bedrooms.

The bedroom today might be considered as a multi-function environment, and its current designation is not accurately conveying its actual broader use. Research about sleeping environments, which mainly refers to bedrooms, should not be limited to an understanding of a room for sleeping. In line with predictions, today's bedrooms are beyond being rooms hosting a bed, and limited to sleeping; but act more as living spaces, especially for, but not limited to, younger age groups. We suggest that a holistic understanding of the sleep environment is needed, as bedrooms are whole systems in themselves today, accommodating the changing needs of people. Furthermore, it could be questioned how the multi-functional use of the bed and its room influences the sleeping cycles for different age groups. The encouraging results obtained from this initial study pave the way for additional research involving detailed analyses of bedroom use in different socio-demographic groups. We argue that sleep studies should start with a comprehensive analysis of what the sleep environment consists of and how today's bedrooms are used and configured, before focusing on separate environmental parameters that affect sleep.

The main actors of the bedrooms, beds, are difficult to explain purely by their functionality, merely as furniture items used for sleep. To come back to our earlier example of the kitchen, a well laid-out and well-equipped kitchen is no guarantee for tasty meals, but it provides better prerequisite conditions and makes it easier to cook better-tasting meals than a badly equipped and ill laid-out one. We argue that the same can be said for beds and their rooms. Future designs of beds might consider the role of the bed beyond its role of hosting sleep, but rather as a part of a whole bedroom system. In addition, the system of bedrooms might be re-thought and re-designed regarding their current context of use as 'living environments', in which sleep is one but not the main actor.

6. Study Limitations

This study was limited to 304 people and residents of Australia. The number of respondents were large enough for this study as we aimed to have an initial understanding of bedroom use. Although we used a weighted randomization, based on previous studies conducting a national survey of Australians, a larger sample would provide a more detailed analysis. Like other surveys, the limitations of a self-report survey may have affected our results, and tests in the actual bedroom environment would allow researchers to gather a different sort of data, such as more detailed use of bedroom space. Specific sleep problems, such as sleep apnea or insomnia, were not surveyed, and the general health conditions of the participants were not considered.

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Institutional Review Board Statement: The study was conducted according to the guidelines of The University of New South Wales Human Research Ethics and approved by the Ethics Committee (HREAP, protocol code HCS220091 and project title "Bedroom as a Multi-functional Environment", April 2022).

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