Running title: Sleep problems LCA

Title: Self-reported sleep problems among the elderly: A latent class analysis

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Highlights

- **Four different profiles of sleep problems are observed among the elderly**
- **These profiles do not differ in terms of demographics**
- **Multiple concurrent sleep problems are linked to elevated depression and anxiety**

Abstract

The present study utilized a person-centered approach to examine the different profiles of problem sleepers in a community sample of elderly. In addition, this study also explores how demographic and psychiatric variables may be related to these different profiles of sleep problems. A total of 515 participants (Mean age =67 years, SD=5) were administered self-report measures of sleep problems, depression and anxiety. Among them, 230 who reported significant problems in any of five selected sleep components were entered into a latent class analysis. The remaining 285 participants were assigned to a comparison control group. The profiles of 'inadequate sleep', 'disturbed sleep', 'trouble falling asleep' and 'multiple problems' were identified. The 'multiple problems' group had significantly higher levels of depression and anxiety relative to the control group. Regression analyses indicated that these different profiles had contributed to a significant increase in variance explained in anxiety but not depression levels, on top of the severity of sleep problems and demographic variables. Although sleep problems occur among the elderly with considerable heterogeneity, they can generally be classified into four different profiles. Furthermore, the inclusion of sleep problem profiles can significantly enhance the prediction of anxiety symptoms.

1. Introduction

Sleep is adversely affected by aging, as observed via the decreased rapid eye movement sleep and sleep efficiency, as well as increased sleep latency (Ohayon, 2004). These sleep-related issues are further exacerbated by the health problems commonly associated with old age, resulting in frequently reported sleep problems among the elderly (Ancoli-Israel et al., 2008). Thus it is not surprising that as many as 77% of an elderly Chinese population were reported to sleep poorly (Lo and Lee, 2012).

Although there has been a wealth of research on such sleep problems among elderly populations, such research had generally adopted variable-centered approaches. That is, the goal of these research was to investigate relationships between sleep and other variables, which was typically achieved via regression analysis, structural equal modeling or factor analysis. While they have revealed much about sleep in relation to aging, they provided limited information about the common patterns of sleep problems among the elderly. For example, do all these different sleep-related issues occur uniformly across the elderly population? Or do different groups of elderly experience different clusters of sleep issues? If so, what are these clusters? These are some questions that cannot be adequately answered by these variable-centered studies. Person-centered studies which could provide some insight into how these sleepers can be classified according to their cluster of sleep problems are scarce. The need to identify these different clusters cannot be understated, given the heterogeneity of sleep complaints observed by previous research. For instance, in a large sampled epidemiological study that examined the prevalence of four different sleep problems — difficulty initiating sleep, difficulty maintaining sleep, early morning awakening and nonrestorative sleep, the researchers found that these problems existed in many different possible combinations (Roth et al., 2006). In another study

(Jean-Louis et al., 2001), significant heterogeneity was similarly observed in the sleep complaints reported among older adults— even within ethnic groups, and the authors suggested that sleep problems are expressed rather differently across individuals as a result of different lifestyle, cultural, economic, and environmental factors. To these ends, the identification of the different profiles of sleep problems would go a long way in making sense of this heterogeneity.

One effective way to identify the different profiles of sleep problems is with the use of Latent Class Analysis (LCA). LCA is a useful statistical method to examine the structure of heterogeneous diagnostic entities and delineate their subgroups in a systematic manner. LCA has been commonly used to examine subtypes in psychiatric disorders such as depression (Li et al., 2014), Posttraumatic Stress Disorder (Wolf et al., 2012) and schizophrenia (Bora et al., 2016). Within the sleep literature, notwithstanding two studies that looked at profiles of sleep-related characteristics among individuals with Obstructive Sleep Apnea using other cluster analytic methods (Joosten et al., 2012; Ye et al., 2014), there has only been one study (Leigh et al., 2015) that examined the different clusters of sleep problems in the general population. In Leigh et al.'s (Leigh et al., 2015) study, the authors classified a large sample of elderly participants into four different subtypes, namely the 'troubled sleepers', 'early wakers', 'trouble falling asleep', and 'untroubled sleepers', as defined by their profile of sleep problems. Nevertheless, there were some limitations with their findings. Firstly some of the variables used in their model may not be very useful or informative. For instance, 'lying awake at night' and 'trouble falling asleep' were two such variables; these two are somewhat similar in meaning. Additionally, 'sleep badly' was another problematic variable included in their analyses. The meaning of this variable is too broad; it does not refer to any specific sleep-related issue. Taken together, these overlapping or unspecific variables may have resulted in a less than optimal categorization of the participants.

Secondly, an all-female sample was used which may limit generalization to the general population. Despite these limitations, their findings provided an interesting preliminary insight into how sleepers can be subtyped. In the current study, with the use of items from a more widely used sleep measure and a sample with both genders, we aim to have another look at how sleepers can be subtyped according to their profile of sleep problems. The subtyping of these problem sleepers will inform future efforts to develop more targeted interventions as well as utilize resources more efficiently in doing so.

Previous variable-centered studies have identified demographic (Mazzotti et al., 2012) and psychiatric (Chang et al., 2014; Paudel et al., 2008; Yu et al., 2016) correlates of self-reported sleep problems. In the present study, we intend to verify and augment these findings with the examination of these variables among the different subtypes of problem sleepers. Hence, a secondary objective of this study explores if the demographic (specifically age, sex, education and socio-economic status) and psychiatric characteristics are associated with the various subtypes of problem sleepers. Additionally, we are also interested in examining the usefulness of these subtypes in predicting depression and anxiety symptoms significantly on top of the severity of sleep problems in general.

2. Methods

2.1. Measures

The Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989) was used to assess sleep variables. This index consisted of 19 items that assessed the problems in domains such as subjective sleep quality, sleep duration, sleep latency, habitual sleep efficiency, sleep disturbances, use of sleeping medication and daytime dysfunction. Each of these components was scored from 0 (better) to 3 (worse), and a global score was obtained by adding up the components' scores. The PSQI had demonstrated good psychometric properties in a similar Asian population (Tsai et al., 2005) and its three-factor structure has been confirmed in the local context (Koh et al., 2015). For the purpose of this study, the 'sleep quality' component will not be included in the LCA. This is because unlike the other PSQI components which relate to concrete sleep-related issues, sleep quality is inherently unspecific and vague. Other sleep problems could potentially load on to this "sleep quality" component (Harvey et al., 2008); essentially certain sleep problems could be 'counted twice' if this "sleep quality" component was included. Additionally, similar to Leigh et al. (2015), the 'use of sleep medications' component was also not included in the LCA because it was thought to have a confounding effect on the problems reported in the other sleep domains. For the LCA, scores in the five studied PSQI components were dichotomized into scores of <2 and ≥2, to indicate the presence of a problem in these components.

The 15-item version (Sheikh and Yesavage, 1986) of the Geriatric Depression Scale (GDS) was used to index the level of depressive symptoms. This scale consisted of 15 yes/no questions, each worth a point, giving a maximum total score of 15. This version of the GDS had demonstrated good psychometric validity in the local context (Nyunt et al., 2009). The Geriatric Anxiety Inventory (GAI; Pachana et al., 2007) was used to index the level of anxiety. There are 20 agree/disagree items in the GAI, each worth a point, giving a maximum possible total score of 20. The GAI was validated and had shown good psychometric properties in a similar Asian population (Yan et al., 2014). For these three questionnaires, higher scores corresponded to worse outcomes.

2.2. Participants and procedures

The participants of the current study were part of the Aging in a Community Environment Study (ACES) cohort. Recruitment of elderly participants (aged ≥ 60 years) in the ACES was carried out via door to door visits by nurses within geographically defined districts in Jurong, Singapore. Participants who expressed interest were subsequently invited to a community research center where their written informed consent was obtained and trained research nurses would administer the test measures and a demographics questionnaire to the participants. Baseline recruitment and data collection of the ACES cohort were conducted under the Diet and Healthy Ageing study protocol from 2011 to 2016. The study protocol was approved by the National University of Singapore Institutional Review Board. Each participant was assigned a unique code number for identification; no personal identifiers were used in the data entry.

At the time of writing, the ACES cohort consisted of valid data from 635 participants, not including 18 participants with incomplete data. From this dataset, we excluded 74 participants who had previous or pre-existing neurological conditions, as well as those who were diagnosed with dementia. Another 32 who were previously or currently diagnosed with psychiatric disorders were also excluded. Then, we excluded a further 14 participants who scored 1 and above on the 'use of medication' PSQI component. Among the remaining 515 participants, 285 of them who scored less than 2 in all five of the studied PSQI domains were assigned to a comparison control group. The other 230 participants were then entered into the LCA for subsequent analyses.

2.3. Statistical analysis

Participants with missing data were excluded from the analyses. Such data are assumed to be missing at random. Since the missing rate is less than 5%, its influence can be assumed to be inconsequential (Schafer, 1999). The PSQI components, with the exception of sleep quality and medications, were first dichotomized into 1s or 0s to correspond to the presence of a problem in the respective sleep domains before entering into the LCA model. Then, LCA was conducted using the poLCA package in R (Linzer and Lewis, 2011) to fit one to six latent class solutions to the data. The best solution was selected after examining fit indices such as the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), sample size adjusted BIC (aBIC), consistent Akaike Information Criterion (cAIC) and entropy values, as well as considering the interpretability and parsimony of the solutions. The adjusted Lo-Mendell-Rubin Likelihood Ratio Test was used to assess if adding an additional class to the model significantly improved the model fit (Lo et al., 2001). Participants were then assigned to their most probable latent classes. Following which, group differences in the demographic and psychiatric variables among the LCA identified classes and the control group were analyzed via bootstrapped analysis of variance (ANOVA) and Chi-square tests. Post-hoc analyses were conducted with Tukey's tests and pair-wise Chi-square tests where necessary. Separate bootstrapped hierarchical multiple regression analyses were conducted for GDS and GAI scores. In these analyses, demographic variables such as age, gender, years of education and housing type were entered in step 1. Following which, PSQI global scores were entered in step 2 and finally, dummy coded variables (Suits, 1957) representing the groups of sleepers were entered in step 3. Bootstrapping was carried out using the Bias-Corrected and Accelerated approach with 5000 bootstrap samples. These analyses, apart from the LCA, were carried out in the Statistical Package for the Social Sciences (SPSS version 22) software. Statistical significance is set at $p < .05$.

3. Results

3.1. Participants characteristics

The mean age of the 515 included participants (147 males, 368 females) was 67 years (SD=5), and they had an average of 5 years of education (SD=4.4). They were mostly of Chinese ethnicity (497 Chinese, two Malays, one Indian, 7 of other ethnicities, and one preferred not to disclose). Most of them were either retired (N=260) or housewives (N=158), while the rest of them were working in various part-time and full-time jobs (N=94); three participants did not disclose their current employment status. Most participants (N= 379) resided in four or five room public housing apartments; the rest stayed in one to three room public housing apartments (N= 72) or Maisonette/Condominium/Landed Housing (N=62); two participants did not disclose their housing type. Most of the participants were married (N=356), 105 were widowed, 33 divorced/separated and 19 single; two did not disclose their current marital status. The most commonly self-reported health conditions in this sample included high cholesterol (N=273), high blood pressure (N=254) and cataracts/glaucoma (N=171).

3.2. Model selection

INSERT TABLE 1 AND FIGURE 1 HERE

The four class solution was selected while taking into consideration of the fit statistics (see Table 1) as well as the parsimony and interpretability of the solutions. In terms of the fit statistics, this solution had generally exhibited low information criterion values and high entropy, suggesting that the model had fitted well and the latent classes were adequately differentiated. The four profiles of the PSQI component scores are presented in Figure 1. The first class consisted of 50 participants who had high probabilities of reporting low sleep duration. This class was thus labeled as 'Inadequate sleep'. The second class consisted of 33 participants who had high probabilities of reporting a sleep disturbance problem; this group was labeled as ‘Disturbed sleep’. The third class consisted of 61 participants who had high probabilities of reporting a sleep latency problem. They were hence labeled as ‘Trouble falling asleep’. The final and largest group consisted of 86 participants who had high probabilities of reporting high sleep latency and, low sleep duration and sleep efficiency; they were labeled as ‘multiple problems’. These labels were determined according to our subjective interpretation of the data and were given for the purpose of facilitating subsequent references to these groups.

3.3. Between-group analyses

INSERT TABLE 2 HERE

The descriptive statistics and between-group statistics are presented in Table 2. The groups were not significantly different in terms of age, sex, education levels and housing type. Significant F statistics emerged in the between-group analyses of GDS, GAI and PSQI scores. These significant F statistics were then followed up with post-hoc Tukey’s tests. These post-hoc tests showed that the multiple problems group had significantly higher GDS and GAI scores as compared to the control group. In addition, the multiple problems group had significantly higher PSQI scores relative to the control, ‘inadequate sleep’, ‘disturbed sleep’ and ‘trouble falling asleep’ groups. The latter three groups also had significantly higher PSQI scores as compared to the control group.

3.4. Regression analyses

INSERT TABLE 3 HERE

Prior to the regression analyses, the different groups were dummy-coded. For instance, in the dummy variable for ‘inadequate sleep’, the ‘inadequate sleep’ group was coded as ‘1’, while all the other groups including the control group were coded as ‘0’. The other three LCA identified groups were coded in a similar manner. As seen from Table 3, the addition of the four dummy variables on top of PSQI global scores and demographic variables resulted in a significant increase in R^2 in the regression equation predicting GAI scores, but not GDS scores. The final regression models predicting GDS and GAI were both significant; $F_{GDS}(9, 500) = 3.38$, $p <.001$, $F_{GAI}(9, 500) = 5.36$, $p <.001$.

4. Discussion

The present study sought primarily to identify the different profiles of sleep problems among the elderly. Using LCA, we have identified four different profiles of sleep problems namely 'inadequate sleep', 'disturbed sleep', 'trouble falling asleep' and 'multiple problems'. These findings suggest that although the different sleep problems do occur in a rather heterogeneous manner among the elderly, they can generally be classified into four different profiles.

The present findings share some similarities with those reported by Leigh et al. (2015). Firstly, like Leigh et al. the 'trouble falling asleep' group, which was defined largely by its increased sleep latency had similarly emerged in the current study. Secondly, we have also identified a 'multiple problems' group as defined by its low sleep efficiency, increased sleep latency and decreased sleep duration; this profile of sleepers roughly corresponded to Leigh et al.'s 'troubled sleepers' which was defined by increased sleep latency, early awakening, low perceived sleep quality. In addition to these two groups, the current report has also identified the 'inadequate sleep' and 'disturbed sleep' groups which did not emerge in Leigh et al.'s analyses; they are defined by the decreased duration of sleep and increased sleep disturbances respectively. The methodology of the current study might have enabled better detection of such subgroups of problem sleepers in two ways. Firstly, in Leigh et al.'s study, the 'minimal symptom' group was included in the LCA whereas we have excluded a similar minimal symptom group in our LCA. Hence the current approach is more adept at identifying different subtypes of problem sleepers. Secondly, we used items from the PSQI which were relatively distinct among each other in our analyses; the PSQI has been reviewed to be more interpretable as compared to other self-reported sleep measures (Devine et al., 2005).

In this study, we have also investigated if the different LCA identified classes and the control group differed significantly in their demographics and psychiatric characteristics. Our results suggested that these groups do not differ significantly in their age, sex, education levels and housing type. These results are not consistent with previous studies that noted demographic differences in the sleep patterns among the elderly. For instance, a large sampled British study found sleep efficiency to be lower among female and older participants, and sleep difficulties were more commonly reported among participants with lower education levels (Leng et al., 2014). Furthermore, a multinational study spanning across seven European countries found certain age groups (i.e. 55 to 64 years and 74 -84 years) to be associated with low sleep duration (Ohayon, 2004). There may be a few explanations for the differences in findings. Firstly, our identified sleep profiles, which take into account of multiple sleep variables simultaneously, may not relate well to the sleep variables examined individually in these studies. Hence such sleep profiles may mask the demographics differences associated with the individual sleep variables. Secondly, as discussed in the latter study, the inter-country variation in the influence of demographic factors on these sleep variables may be attributed to differences in socio-cultural factors, such as those relating to the employment of both genders. Additionally, the current study had fitted a single latent class structure to participants of different age groups and gender. It is possible that the latent class structure is different across age groups and gender. As a result, the fitted single latent class structure might have masked the differences in age and sex across the groups. Future studies may consider carrying out a multi-group (across age groups and gender) structural equation model to clarify such a speculation. Finally, the effects sizes of these demographic factors are typically very small; given the relatively small sample sizes in the current study, it is unlikely that such weak effects could be detected.

In terms of psychiatric symptoms, the 'multiple problems' group have reported significantly higher levels of depression and anxiety relative to the control group. Notwithstanding the low levels of self-reported psychiatric symptoms across all groups, such findings are generally consistent with the variable-centered studies on sleep and depression/anxiety (Chang et al., 2014; Paudel et al., 2008; Yu et al., 2016) in showing that greater severity of sleep problems corresponds to greater depression and anxiety levels. Beyond this, the current results have also shown that anxiety symptoms are significantly predicted by the different profiles collectively even after controlling for the severity of all sleep problems. This suggests that there is some additional utility in using sleep problem profiles in predicting anxiety symptoms. Unfortunately, the same could not be said for depression symptoms. Alvaro et al. (2013) reviewed the literature on sleep, depression, and anxiety and noted that the relationship between sleep and depression, and that of sleep and anxiety differed in magnitude. These findings, taken together with those of the present may suggest the possibility that certain sleep variables may be weighted more heavily than others in predicting anxiety symptoms. Whereas in predicting depression symptoms, the different sleep variables may be approximately equal in weights. Future research is needed to clarify on such a speculation.

These findings present two major implications. Firstly, given that sleep is significantly related to physical and mental health among the elderly (Reid et al., 2006), the identification of different profiles of sleep problems would aid future researchers in studying how a certain profile might be related to various psychiatric and physical health related conditions. Furthermore, these profiles relate to not just to a single symptom but a cluster of symptoms, hence they might serve as more specific sleep markers to related health conditions, relative to those reported in variable-centered studies. Secondly, given the heterogeneity of sleep problems in the general population (Jean-Louis et al., 2001), the needs of individuals with sleep-related problems could not be addressed in a one-size-fits-all approach. The identification of these different profiles of sleep problems will inform future research in tailoring interventions specifically for these different profiles, so as to maximize intervention outcomes.

The findings of the current study are subjected to some limitations. First, sleep problems are assessed purely via subjective means, and they may not accurately reflect participants' actual sleep problems. Second, the exclusion of participants who had present or previous psychiatric conditions or consumed sleep medications may limit generalization to elderly individuals afflicted with psychiatric conditions or more severe sleep problems. Third, there may be a participant selection bias in the current study. Relative to those who agreed to participate, participants who did not express interest in taking part in this study may be of poorer health or different in terms of demographics. Fourth, we did not control for participants' physical health status in our analyses, and this may be a potential confound; certain health conditions were previously reported to predict sleep difficulty among the elderly (Leigh et al., 2016). Fifth, the relatively small sample sizes of the subgroups may result in limited statistical power in detecting significant effects. Finally, given that this is a cross-sectional study, no causal inference can be made regarding the relationship between the different sleep profiles and depression/anxiety. Relatedly, such cross-sectional measures are inadequate in differentiating between chronic and acute sleep problems/psychiatric symptom. The latter may be associated with transient stressors such as widowhood among the elderly (Wilcox et al., 2003), which are arguably relevant in our studied sample.

5. Conclusion

In conclusion, we have identified four different profiles of self-reported sleep problems among the elderly. Among these four profiles, the 'multiple problems' group exhibited significantly elevated depression and anxiety symptoms relative to the controls. Furthermore, these different sleep profiles are predictive of anxiety symptoms even after the severity of sleep problems in general has been controlled for.

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Funding sources had no role in study design or in the collection, analysis and interpretation of data; or in the writing of this report.

Conflicts of interest

None

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Table 1. Fit statistics of LCA solutions

No. of classes	**residual df**	**AIC**	**BIC**	**aBIC**	**cAIC**	**Entropy**	**LMR LRT (*p* value)**
1	26	1341	1358	1307	1363	-	-
2	20	1304	1342	1307	1353	0.75	<.001
3	14	1282	1340	1286	1357	0.85	<.001
4	8	1257	1336	1263	1359	0.94	<.001
5	2	1255	1355	1263	1384	1.00	<.001
6	-4	1255	1376	1265	1411	1.00	.094

Note. df= degrees of freedom; AIC=Akaike Information Criterion; BIC= Bayesian Information Criterion, aBIC=adjusted Bayesian Information Criterion; cAIC= consistent Akaike Information Criterion; LMR LRT = adjusted Lo-Mendell-Rubin Likelihood Ratio Test.

Table 2. Descriptive statistics and between group statistics

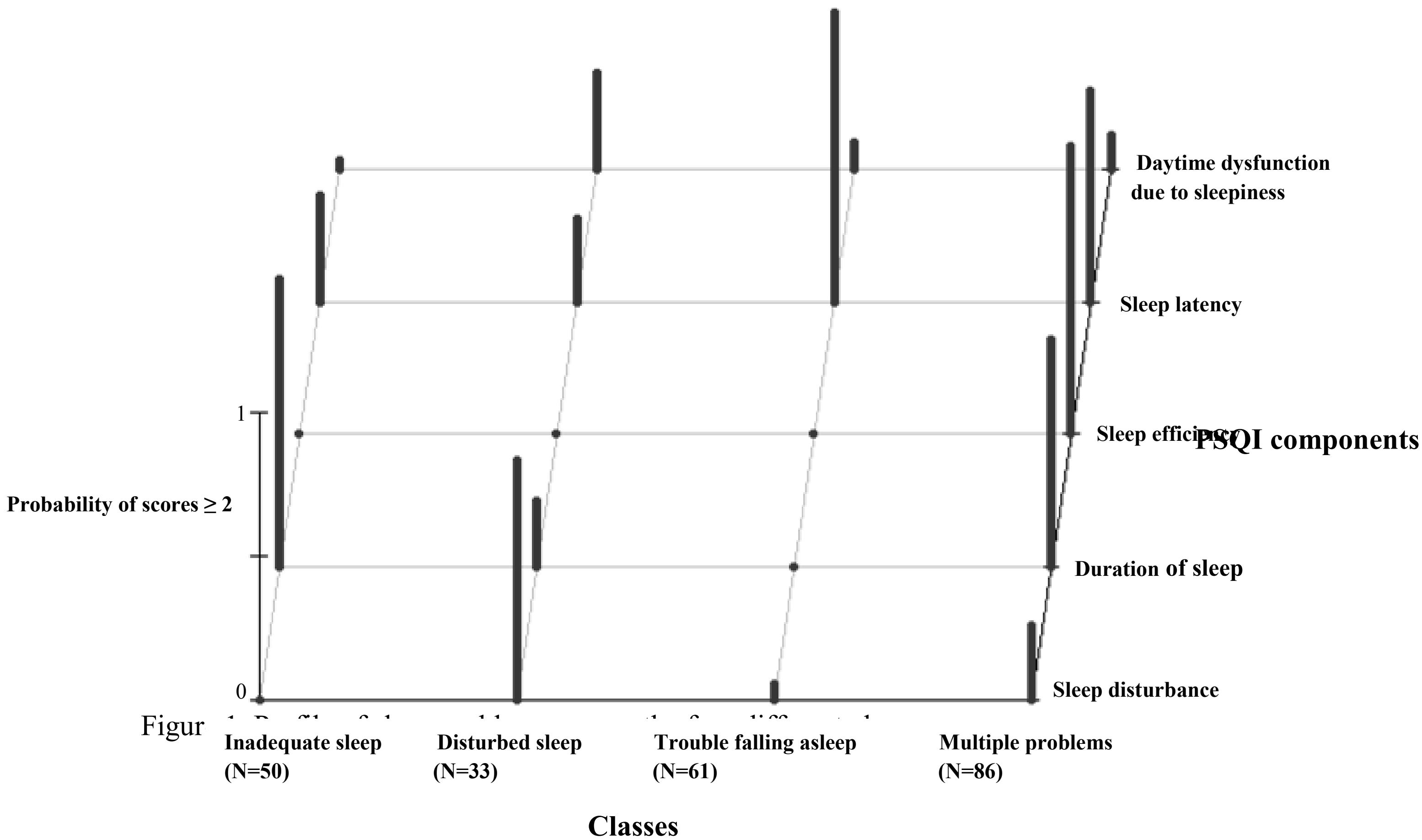
	Groups						
	1.Control group (N=285)	2.Inadequate sleep (N=50)	3.Disturbed sleep (N=33)	4.Trouble Falling asleep (N=61)	5.Multiple problems (N=86)	**Between-group statistics (*F* or χ^2 (*p*))**	**Post-hoc tests**
Mean age (SD)	67.5 (5.3)	67.0 (4.7)	68.3 (5.7)	67.7 (6.2)	66.5 (4.9)	1.04 (.384)	-
Gender							
Males	90	12	7	20	18	5.45 (.244)	-
Females	195	38	26	41	68		
Housing type[a]							
1 to 3-room PH	34	12	4	11	11	14.3 (.074)	-
4 to 5-room PH	213	31	28	39	68		
Maisonette/ Condominium/ Landed housing	38	6	1	11	6		
Mean years of education	5.2 (4.6)	4.2 (3.9)	5.4 (4.7)	5.2 (4.1)	4.5 (4.2)	1.11 (.352)	-
Mean GDS (SD)	1.3 (4.8)	1.4 (1.9)	1.9 (2.1)	1.9 (2.2)	2.3 (2.8)	4.78 (.001)	5>1
Mean GAI (SD)	1.0 (2.2)	1.0 (2.1)	2.0 (2.4)	1.9 (3.0)	1.8 (3.3)	3.72 (.005)	5>1
Mean PSQI (SD)	2.2 (1.4)	5.6 (1.9)	5.9 (2.6)	5.2 (1.5)	9.6 (2.9)	278 (<.001)	5>2,3,4>1

PH= Public Housing; SD = Standard Deviation; MMSE = Mini-Mental State Examination; GDS = Geriatric Depression Scale; GAI = Geriatric Anxiety Inventory; PSQI= Pittsburgh Sleep Quality Index. [a]Total frequency counts may not correspond to sample sizes due to missing data.

Table 3. Predictors of GAI and GDS scores

Predictors	**GDS**		**GAI**	
	ΔR^2	β	ΔR^2	β
Step 1	.011		.022*	
Gender		.005		.054
Age		-.029		-.070
Years of education		.019		-.085
Housing type		-.096*		-.088
Step 2	.042**		.045**	
PSQI global score		.206**		.215**
Step 3	.005		.021*	
Dummy variable for 'inadequate sleep'		-.044		-.113*
Dummy variable for 'disturbed sleep'		.021		-.005
Dummy variable for 'trouble falling asleep'		.042		-.179*
Dummy variable for 'multiple problems'		.034		.014

PSQI = Pittsburgh Sleep Quality Index; GDS = Geriatric Depression Scale; GAI = Geriatric Anxiety Inventory. *p <.05. **p <.001.



Daytime dysfunction
due to sleepiness
Sleep latency
Sleep effici
PSQI components
Duration of sleep
Sleep disturbance
Probability of scores ≥ 2
1
0
Inadequate sleep
(N=50)
Disturbed sleep
(N=33)
Trouble falling asleep
(N=61)
Multiple problems
(N=86)
Classes

Figur