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SLEEP DURATION AND MULTIMORBIDITY IN LUXEMBOURG. RESULTS FROM THE EUROPEAN HEALTH EXAMINATION SURVEY, 2013-2015

Journal:	BMJ Open
Manuscript ID	bmjopen-2018-026942
Article Type:	Research
Date Submitted by the Author:	28-Sep-2018
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Keywords:	EPIDEMIOLOGY, PUBLIC HEALTH, SLEEP MEDICINE



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Word count: 316	53; Abstract: 207; Tables: 4; References: 40
Funding: The stu Institute of Healtl	dy was funded by the Directorate and Ministry of Health and the Luxembount.

BMJ Open: first published as 10.1136/bmjopen-2018-026942 on 21 August 2019. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES)

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Contributorship statement

MRC and SS conceptualized and designed the study. MRC and VB performed the statistical analysis. MRC, SS and T.T.M interpreted the data. MRC drafted the article. SS supervised the study. All authors participated in the revision of the article. All authors contributed to and have approved the final manuscript.

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Abstract

Objectives: We estimated the prevalence of short sleep duration and multimorbidity in Luxembourg, and assessed whether sleep duration was associated with multimorbidity after adjusting for socio-demographic and behavioral characteristics.

Design: Cross-sectional study.

Participants: Data from 1508 Luxembourg residents (48% men and 52% women) aged 25 to 64 years came from the European Health Examination Survey 2013-2015.

Outcome measures: Short sleep duration and multimorbidity.

Results: Participants reported sleeping 7.86hrs/night when not having to work the next day, nearly 1hr more than during work days. Nearly half of participants reported having been diagnosed with \geq 2 chronic conditions/diseases. Short sleep duration was linearly associated with the number of chronic conditions when participants did not have work the next day (OR: 2.52, 95% CI: 1.44, 4.41 and OR: 2.78, 95% CI: 1.65, 4.68 for 2, and \geq 3 chronic conditions/diseases, respectively), independently of socioeconomic and behavioral characteristics. The effect was stronger when participants had to work the next day (OR: 3.03, 95% CI: 1.34, 6.84, and OR: 3.46, 95% CI: 1.56, 7.66, for 2 and \geq 3 chronic conditions/diseases, respectively).

Conclusions: Health promotion programs should aim at improving and promoting healthy sleeping and its possible benefits on chronic disease outcomes, which in turn can help reducing the risk of multimorbidity in middle-aged adults.

Keywords: Sleep duration; multimorbidity; chronic diseases; Luxembourg; European Health Examination Survey

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Strengths and limitations of this study

- This is the first study in Luxembourg on the prevalence of sleep patterns, with a focus on short and long sleep duration, and their relationship with multimorbidity.
- Short sleep duration, difficulties in sleeping through the night, sleep disorders and sleeping medication, all are a public health challenges in Luxembourg.
- In the present study, short sleep duration was linearly associated with the number of chronic conditions
- As both sleep problems and multimorbidity are highly prevalent in Luxembourg, health promotion programs should be addressed to improve and promote healthy sleeping habits among the general population, which in turn may help reducing the risk of multimorbidity
- Limitations of the present study include the subjective measure of sleep duration, the cross-sectional design of the study (not allow to establish a causal link) and the low participation rate.

Data sharing statement: Extra data can be accessed by emailing Dr Laetitia Huiart, Head of the Population Health Department, LIH (laetitia.huiart@lih.lu) and the Principal Investigator of EHES-LUX2013-2015, Dr Maria Ruiz-Castell (maria.ruiz@lih.lu) and fill out a request form.

Introduction

A healthy lifestyle includes healthy sleep habits. Sleep patterns influence several physiological and psychological processes such as inflammation, cognitive function, glucose regulation and energy balance (1-3). Short sleep duration, poor sleep quality, and sleep-related disorders can result in sleep deficiency and impact on individual health (4). According to the Centers for Disease Control and Prevention (CDC), insufficient sleep is associated with health problems such as chronic diseases, poor quality of life, mental health, risk of accidents, and lower productivity at work (5). Adequate sleep duration is one of the dimensions needed for a good sleep health (6). The American Academy of Sleep Medicine and Sleep Research Society considers that for an adult it is recommended at least 7 hours of sleep per night (4). However, a high percentage of the population sleeps less than the recommended 7 hours (7).

Several factors may affect sleep such as physical activity or eating behaviors, but also socioeconomic factors including job status, marital status and ethnicity (8, 9). Studies have observed an association between lower education, unemployment and both short and long sleep duration (10, 11), while factors such as physical activity and healthy diet seem to improve sleep quality (12, 13). Moreover, diet intake (energy and total fat intake) and nutrients seem to be associated with both short and long sleep duration through multifactorial factors including behaviors (e.g., time and hours of intake) and variations in hormones related to appetite, such as leptin (14).

Epidemiologic data suggest an association between sleep duration and poor sleep quality with cardiometabolic health (e.g. hypertension, diabetes, obesity, cardiovascular diseases), mental problems (e.g. depression), and mortality (15-18). The observed relationship between short sleep duration and mortality would be especially critical in adults under 65 years of age (18). Few studies so far have focused on possible relationships between sleep patterns and multimorbidity (19, 20). Multimorbidity is defined as the presence of two or more chronic diseases in the same individual (21), and is associated with disability, functional decline, frailty, poor quality of life and mortality (22). In the context of ageing societies, multimorbidity is an increasing global phenomenon (23); although its occurrence usually increases with age, a large proportion of individuals younger than 65 are also affected (24). Definitions of multimorbidity vary, however, and the prevalence differs based on changing definitions, which in turn present significant challenges when attempting to compare results between populations and studies (22).

The aim of the present study was to estimate the prevalence of short sleep duration and multimorbidity in Luxembourg, as well as to assess whether sleep duration was associated with multimorbidity after adjusting for socio-demographic and behavioral characteristics.

Methods

Study population and recruitment

Data was drawn from the European Health Examination Survey in Luxembourg (EHES-LUX). EHES-LUX is a representative cross-sectional population-based survey carried out by the Luxembourg Institute of Health with the objectives of assessing the health status of the population of the Grand-Duchy of Luxembourg, develop national and European health indicators, identify the needs of the population, and evaluate health behaviors. EHES-LUX was conducted between February 2013 and January 2015. Individuals were randomly selected in a one-stage sampling procedure from the national health insurance registry (95% social coverage). Institutionalized individuals (e.g. hospitals, elderly homes) were not included. A total of 1508 residents (excluding 21 pregnant women) of Luxembourg aged 25 to 64 participated in the survey (participation rate of 24.1%) (25). Of them, 7 participants did not reported their sleep habits. A total of 1501 participants had information on multimorbidity and sleep habitsParticipants signed an informed consent and were interviewed by trained nurses who also conducted medical examinations. Questionnaires included several health modules (e.g. sleep habits, nutritional habits, health care, working and living conditions) as well as demographic and socioeconomic characteristics. Medical examinations included measurements such as blood pressure and anthropometry. Sampling weights were calculated to be generalized to the population of Luxembourg in terms of age, sex and district of residence. The study national research ethics committee (Comité national d'éthique de Recherche-CNER) approved the study and it was notified to the Luxemburgish National Commission for Data Protection.

Patient involvement

Participants were not involved in the development of the research question, study design, recruitment or the conduction of the study. Upon request, results from the medical examination were forwarded to the study participants and their medical doctors. General results were presented to the general public in national health activities

Sleep

Sleep duration was assessed using two questions: 1) "How many hours do you normally sleep at night when you have to work the next day?", and 2) "How many hours do you normally sleep at

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night when you don't have to work the next day?". Responses to the first question were categorized in short sleep duration (<6hrs/night), medium sleep duration (6-7hrs/night), and long sleep duration (>7hrs/night), in line with most of previously published studies. Responses to the second question were categorized in short sleep duration (<7hrs/night), medium sleep duration (7-8hrs/night), and long sleep duration (>8hrs/night).

Difficulty in sleeping the night was assessed based on the question "Do you have difficulties in sleeping through the night?". Diagnosis of sleep disorders was assessed using the question "Have you ever been told by a doctor or another health professional that you have a sleep disorder?". Sleep medication was assessed using the question "In the past 2 weeks, have you used other types of medicines that were prescribed to you, such as sleeping tablets?". Sleepiness was defined as a score of ≥ 11 on the Epworth Sleepiness Scale (26).

Multimorbidity

Participants were asked if they ever had a chronic disease or condition diagnosed by a medical doctor (e.g., hypertension, high cholesterol, diabetes, coronary heart disease or angina pectoris, heart attack or its chronic consequences, stroke or its chronic consequences, stomach or duodenal ulcer, cirrhosis or other liver disease, urinary incontinence, kidney problems, chronic back or neck disorder, rheumatoid arthritis, arthrosis, osteoporosis, cancer, severe headache as migraine or chronic anxiety). Based on this information, the variable "ever being diagnosed with a chronic disease or condition" was generated with four categories: 0, 1, 2 and \geq 3 chronic disease or conditions diagnosed by a medical doctor.

Explanatory variables

Sociodemographic characteristics included age, sex and immigration status. As Portuguese are the largest immigrant community in Luxembourg, immigration status was categorized in nonimmigrant, immigrant born in Portugal and immigrant born in other countries. Socioeconomic status included education (primary, secondary and tertiary education completed) and job status (unemployed; managers/professionals; technical/clerical/service occupation; skilled/unskilled workers).

Lifestyles included smoking (never; current; ex-smokers), alcohol consumption (never; ex-drinkers; drinkers), physical activity (never; \leq 3hrs/week of sports, fitness, and/or recreational activities which lasted at least 10 consecutive minutes; >3hrs/week of sports, fitness, and/or recreational activities which lasted at least 10 consecutive minutes), and vegetable and fruit consumption (< 1 portion/ day, 1–4 portions/day, \geq 5 portions/day). Weight and height were measured by trained

nurses and used to calculate body mass index (BMI; kg/m²). BMI was categorized as normal body weight ($\leq 25 \text{ kg/m}^2$), overweight (25-29.99 kg/m²) and obesity ($\geq 30 \text{ kg/m}^2$).

Statistical data analysis

Means and frequencies were used for descriptive purposes. We calculated the prevalence of sleep disorders, short and long sleep duration, chronic conditions/diseases and multimorbidity. Percentages did not include missing values. A chi-square test (χ 2) or Student t-test were used to analyze associations between the prevalence of sleep duration and covariates and the prevalence of multimorbidy and covariates. The association between sleep duration and chronic conditions/diseases was assessed using multinomial logistic regression models (reference for sleep duration when having to work the next day was 6-7h per night and reference for sleep duration when not having to work the next day was 7-8h) adjusted for sociodemographic characteristics, socieconomic status and physical activity. We considered a P<0.05 statistically significant. To be representative of the population and avoid biased estimates, the observations were weighted. Participants with missing values on sleep habits and or multimorbidity were not included in the present analysis. Analyses were performed using STATA 14.0 and and SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Table 1 shows the prevalence of chronic conditions/diseases, multimorbidity, sleep duration and sleep disorders. Nearly half of participants reported being diagnosed with two or more chronic conditions/ diseases, and nearly a third of participants reported being diagnosed with three or more chronic conditions/diseases. More than 8% of participants were diagnosed with a sleep disorder and a third reported having difficulties in sleeping through the night. Participants reported sleeping 7.86hrs/night when they did not have to work the next day, nearly one hour more than when they had to work the next day (6.95hrs/night).

Participant characteristics by chronic conditions/diseases are shown in **Table 2**. More men than women presented three or more chronic diseases. Higher number of chronic diseases/conditions increased with age: those aged 55 to 64 presented more chronic conditions compared to those aged 25-34. Immigrants born in Portugal presented more chronic conditions than non-immigrants and other immigrants. Participants being less educated and unemployed presented more chronic conditions compared to those employed and highly educated. Participants being less physically active and with a lower BMI.

Participant characteristics by sleep duration are shown in **Table 3**. When participants had to work the following day, more men than women reported a medium sleep duration. Short sleep duration was more likely among immigrants born in Portugal, participants with lower education and skilled/unskilled workers. Short sleep duration was less common among those being physically active and with a BMI less than 25 Kg/m². When participants did not have to work the next day, short sleep duration was more common among older individuals, immigrants born in Portugal, unemployed people, and those being less physically active. Long sleep duration was observed among participants with lower education. No differences in sleep duration were observed between men and women.

Table 4 shows results from multinomial logistic regression analyses examining the association between sleep duration and chronic conditions/diseases, and adjusted by sociodemographic characteristics, socioeconomic position and physical activity. Among participants who reported sleep hours when they did not have to work the next day, those sleeping less hours (<7h) were 2.35 and 2.85 times as likely to report having 2 and 3 or more chronic conditions after adjusting for covariates. In models adjusted for different indicators of socioeconomic status, sociodemographic and physical activity, the strength of associations between sleep duration and multimorbidity remained statistically significant. The same association (although more accentuated) was observed in those participant with a job at the moment of the survey who reported the number of sleep hours when they had to work the next day: those sleeping less hours (<6h) were 3.07 and 3.70 times as likely to report having 2 and 3 or more chronic conditions after adjusting for covariates. Estimates of sleep problems and chronic conditions are presented in Table S1. The prevalence of sleep problems was high, with 1 out 3 participants having difficulties in sleeping the night through, nearly 8% of participants diagnosed with a sleep disorder and 4.26% taking sleeping medication. In all cases, the percentage of participants with sleep problems increased with the number of chronic diseases.

Discussion

Sleep problems are highly prevalent in Luxembourg, where nearly 34% of the resident population aged 25-64 reported having difficulties sleeping through the night, 8.21% having been diagnosed a sleep disorder, and 4.26% taking sleep medication. Moreover, 6.08% and 28.82% of the Luxembourg population reported sleeping respectively less than 6 hours and less than 7 hours per night during working days. The latter decreased to 13.52% when participants did not have to work on the following day. Luxembourg residents sleep on average 6.95hrs/night when they have to work the following day, nearly one hour less than when they do not have to work the next day. Results

are similar to those observed in other countries (27, 28), although in countries such as Brazil the prevalence of short sleep duration was of nearly 22% (29), and in the United States values reached up to 34.8% in 2014 (30). However, in the present study the age range from 25 to 64 years must be taken into account since it does not include adults over 65 years old who usually sleep less hours. This means that the prevalence of the Luxembourg population sleeping less than the recommended hours is likely to be higher.

Multimorbidity was also highly prevalent in Luxembourg, especially when taking into account the fact that the study population was up to 65 years, which represents a relatively young population since multimorbidity prevalence naturally increases with age (22). Nearly half of participants had two or more chronic diseases and 31% had three or more chronic diseases/conditions. The most prevalent diseases were chronic low back disorder or other chronic back defect followed by hypercholesterolemia, arthrosis and hypertension.

Short sleep duration was also more common among immigrants. The relationship between immigration status and sleep patterns remains unclear, with some studies showing a protective effect and others observing an opposite effect, possibly related to the stress linked to the migratory processes, cultural adaptation, or working conditions in the host country (31, 32). In our study, Portuguese immigrants were more likely to sleep less than 6h per night during work days. Portuguese are the most important immigrant community in Luxembourg, accounting for 16% of the 46% immigrant population living in Luxembourg. Compared to Luxembourgish natives, Portuguese immigrants have a lower socioeconomic status (33) (including income, education and employment) which could partly explain why the Portuguese have a greater likelihood of being short sleepers. Job status seems to play an important role, since the effect is not significant when compared to short sleep duration when not having to work the next day.

In our study, long sleep duration was more common in women. This was in line with other studies which showed that men usually sleep less hours, though women reported having more sleep problems (34). However, this relationship is complex and could depend on family composition (e.g. single parents have shorter sleep duration, particularly women) (35).

Physical activity was associated with sleep duration but only during days when not having to work the next day. Physical activity would reduce the likelihood of short and/or long sleep duration and maintain an optimal duration. Studies have observed an association between physical activity and sleep, improving quality of sleep, sleep efficiency, and total sleep time (12, 36).

In our study we observed that short sleep duration was significantly linearly associated with the number of chronic conditions independently of socioeconomic and behavioral characteristics, an

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effect accentuated during working days, when sleep hours are reduced. Our results are in line with those from other studies that have observed an association between sleep and number of chronic diseases, although previous studies have been usually performed in populations of older adults (e.g. over 50 years old) (19, 37). As observed by Koyanagi et al., sleep problems increase with the number of diseases in both low and high income countries independent of their economic development (19). These associations could explain the observed relationship of sleep duration (below the recommended 7 hours) and poor sleep quality with mortality, even among adults younger than 65 years old (18). It is not clear if sleep problems are a consequence of chronic diseases (e.g. pathologies themselves affect sleep) or part of the cause (sleep predispose the individual to more diseases or exacerbates the symptoms), although it is plausible that sleep problems and chronic diseases are linked by a bidirectional association (38).

Although both sleep problems and the number of chronic diseases increase with age, and are more prevalent in older adults, our study shows that the prevalence is also high in adults under 65 and the association begins much earlier. It is therefore necessary to detect these problems earlier in order to improve individual health and general wellbeing and reduce mortality, particularly in the context of ageing populations burdened by the accumulation of multiple chronic conditions over time. In terms of potential mechanisms to corroborate the biological plausibility of the link between sleep problems and multimorbidity, sleep deprivation has been associated with a number of chronic conditions, including cardio-metabolic and neurodegenerative disease, cancer, musculoskeletal disorders, and mental problems (15, 16). In addition, sleep problems often cluster with major behavioral risk factors such as cigarette smoking, heavy drinking, and physical inactivity, which may in turn increase the risk of chronic disease. Furthermore, there is experimental evidence corroborating the plausibility of deleterious effects of lack of sleep on endocrine, immune, neurovegetative and inflammatory pathways (1-3).

Limitations of the present study include the subjective measure of sleep duration (self-reported number of hours of sleep) instead of an objective measure (e.g. actigraphy, polysomnography). However, in the absence of an objective measure, there is a moderate correlation between both objective and subjective measurements, a correlation that is high during weekdays possibly due to routines (39), but may be attenuate based on certain individual characteristics (e.g. presence of pathologies such as depression, sociodemographic characteristics) (40). Other limitations include the fact that we did not include other sleep problems such as insomnia or sleep apnea nor environmental factors such as noise, traffic or commuting, all of which could affect sleep duration. In addition, multimorbidity was also self-reported and due to a limited predetermined list of

diseases in the questionnaire, participants may have not reported some conditions they may have had and underestimate the prevalence of multimorbidity. Information on non- responders was not available and despite being a representative sample of the Luxembourg population (in terms of age, sex and district) we could not determine the possibility of a non-response bias. Finally, it should be noted that the design of the study (cross-sectional) does not allow to ascertain a causal link between sleep and multimorbidity; in addition, the low participation rate may affect the generalizability of our results.

This is the first study in Luxembourg on the prevalence of sleep patterns, with a focus on short and long sleep duration, and their relationship with multimorbidity. Short sleep duration, having difficulties in sleeping the night through, sleep disorders and sleeping medication are a public health problem, especially when associated with a number of chronic conditions and diseases, thus producing a negative impact on the wellbeing and general health status of the population. As both sleep problems and multimorbidity are highly prevalent in Luxembourg, health promotion programs should be addressed to improve and promote healthy sleeping habits among the general population, which in turn may be beneficial on a number of chronic disease outcomes.

Acknowledgements

We are grateful to the population of Luxembourg and to all the EHES-LUX team who have contributed to this study. We would like to thank Kuemmerle A, Barre J, Dincau M, Delagardelle C, Michel G, Schlesser M, Mormont D, Chioti A, Gantenbein M, Lieunard C, Columeau A, Kiemen M, Weis J, Ambrozet G, Billy A, Larcelet M, Marcic D, Gauthier C, and Viau-Courville M for their valuable contributions.

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	N (%) / Mean \pm SI
Hypertension	250 (16.59)
High cholesterol	458 (30.39)
Diabetes	69 (4.58)
Coronary heart disease or angina pectoris	26 (1.73)
Myocardial infarction or chronic consequences of myocardial infarction	14 (0.93)
Stroke or chronic consequences of stroke	11 (0.73)
Stomach or duodenal ulcer	81 (5.37)
Cirrhosis of the liver or other liver disease	46 (3.05)
Urinary incontinence, problems in controlling the bladder	74 (4.91)
Kidney problems	108 (7.17)
Chronic low back disorder or other chronic back defect	489 (32.47)
Chronic neck disorder or other chronic neck defect	246 (16.32)
Rheumatoid arthritis	88 (5.85)
Arthrosis	292 (19.38)
Osteoporosis	44 (2.92)
Cancer	54 (3.59)
Severe headache such as migraine	271 (17.98)
Chronic anxiety	98 (6.50)
Depression	204 (13.54)
Number of chronic diseases	
0	405 (27.00)
1	362 (24.13)
≥ 2 (multimorbidity)	733 (49.00)
≥ 3	465 (31.00)
Sleep	
Diagnosis of sleep disorder	122 (8.21)
Sleepiness ^a	118 (7.89)
Have difficulties in sleeping the night through	510 (33.89)
Sleeping medication	64 (4.26)

Hours when you have to work the next day (N=1,152-working)	6.95±0.97
<6hrs/night	70 (6.08)
6-7hrs/night	761 (66.06)
>7hrs/night	321 (27.86)
Hours when you don't work the next day (N=1,501)	7.86±1.30
<7hrs/night	203 (13.52)
7-8hrs/night	878 (58.49)
>8hrs/night	420 (27.98)

N=number, SD=standard deviation

toret torion only ^a Measured with Epworth Sleepiness Scale

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	Chronic conditions/diseases						
	0	1	2	≥3	P ^a		
Sex							
Men	199 (27.72)	199 (27.72)	143 (19.92)	177 (24.65)	< 0.001		
Women	206 (26.34)	163 (20.84)	125 (15.98)	288 (36.83)			
Age							
25-34	130 (43.62)	86 (28.86)	48 (16.11)	34 (11.41)	< 0.001		
35-44	156 (34.29)	119 (26.15)	69 (15.16)	111 (24.40)			
45-54	83 (18.16)	111 (24.29)	98 (21.44)	165 (36.11)			
55-64	36 (12.41)	46 (15.86)	53 (18.28)	155 (53.45)			
Immigration							
Luxembourg	184 (23.44)	197 (25.10)	144 (18.34)	260 (33.12)	< 0.001		
Portugal	52 (23.85)	42 (19.27)	45 (20.64)	79 (36.24)			
Other	169 (34.00)	123 (24.75)	79 (15.90)	126 (25.35)			
Education							
Primary	68 (18.38)	75 (20.27)	64 (17.30)	163 (44.05)	< 0.001		
Secondary	133 (23.05)	142 (24.61)	106 (18.37)	196 (33.97)			
Tertiary	203 (37.04)	145 (26.46)	97 (17.70)	103 (18.80)			
Job							
Not working	58 (16.67)	56 (16.09)	58 (16.67)	176 (50.57)	< 0.001		
managers/professionals	168 (35.59)	138 (29.24)	73 (15.47)	93 (19.70)			
technicians/clerical/service occupation	119 (29.38)	89 (21.98)	76 (18.77)	121 (29.88)			

8).

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skilled/unskilled workers	60 (21.90)	79 (28.83)	61 (22.26)	74 (27.01)	
Smoking					
Never	239 (29.25)	209 (25.58)	145 (17.75)	224 (27.42)	0.026
Current	90 (26.01)	75 (21.68)	63 (18.21)	118 (34.10)	
Ex-smoker	74 (22.09)	78 (23.28)	60 (17.91)	123 (36.72)	
Alcohol					
Never	30 (27.78)	21 (19.44)	20 (18.52)	37 (34.26)	0.055
Drinkers	365 (27.53)	328 (24.74)	234 (17.65)	399 (30.09)	
Ex-drinkers	8 (12.50)	13 (20.31)	14 (21.88)	29 (45.31)	
Fruits and vegetables consumption					
<1 portion/day	126 (27.39)	112 (24.35)	87 (18.91)	135 (29.35)	0.597
1-4 portions/day	223 (27.81)	183 (22.82)	142 (17.71)	254 (31.67)	
\geq 5 portions/day	55 (23.31)	66 (27.97)	39 (16.53)	76 (32.20)	
Physical Activity					
Never	130 (21.35)	133 (21.84)	125 (20.53)	221 (36.29)	< 0.001
<=3h/week	151 (29.84)	130 (25.69)	77 (15.22)	148 (29.25)	
>3h/week	121 (31.84)	98 (25.79)	65 (17.11)	96 (25.26)	
BMI	25.27 ± 4.06	26.04 ± 4.89	26.66 ± 4.96	28.07 ± 5.56	< 0.001
<25	212 (33.02)	169 (26.32)	112 (17.45)	149 (23.21)	< 0.001
25-30	152 (27.39)	131 (23.60)	100 (18.02)	172 (30.99)	
>=30	41 (13.62)	61 (20.27)	55 (18.27)	144 (47.84)	

Values are: numbers (%) for categorical variables and means±standard deviation for continuous variables. BMI: Body Mass Index.^a $\chi 2$ test for categorical variables, t-test for continuous variables.

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	Sleep hours	s when you have	e to work the ne	xt day	Sleep hours when you do NOT work the n			
		(N=1,152-w	orking)			(N=1,50	01)	
	6-7hrs/night	<6hrs/night	>7hrs/night	P ^a	7-8hrs/night	<7hrs/night	>8hrs/night	
Sex								
Men	419 (70.78)	41 (6.93)	132 (22.30)	< 0.001	442 (56.52)	106 (13.55)	234 (29.92)	
Women	342 (61.07)	29 (5.18)	189 (33.75)		436 (60.64)	97 (13.49)	186 (25.87)	
Age	43.08 ± 9.04	45.18 ± 8.90	42.66 ± 9.01	0.107	45.47 ± 10.01	48.44 ± 9.62	42.38 ± 9.74	
25-34	168 (64.62)	10 (3.85)	82 (31.54)	0.452	157 (52.86)	22 (7.41)	118 (39.73)	
35-44	264 (67.52)	23 (5.88)	104 (26.60)		272 (59.78)	51 (11.21)	132 (29.01)	
45-54	252 (65.80)	27 (7.05)	104 (27.15)		270 (58.82)	70 (15.25)	119 (25.93)	
55-64	77 (65.25)	10 (8.47)	31 (26.27)		179 (61.72)	60 (20.69)	51 (17.59)	
Immigration								
Luxembourg	406 (66.56)	28 (4.59)	176 (28.85)	0.011	500 (63.61)	77 (9.80)	209 (26.59)	
Portugal	104 (62.65)	20 (12.05)	42 (25.30)		105 (48.17)	48 (22.02)	65 (29.82)	
Other	251 (66.76)	22 (5.85)	103 (27.39)		273 (54.93)	78 (15.69)	146 (29.38)	
Education								
Primary	147 (63.36)	25 (10.78)	60 (25.86)	0.004	186 (50.27)	89 (24.05)	346 (62.91)	
Secondary	278 (65.11)	28 (6.56)	121 (28.34)		343 (59.55)	76 (13.19)	37 (6.73)	
Tertiary	335 (68.37)	17 (3.47)	128 (28.16)		346 (62.91)	157 (27.26)	167 (30.36)	
Job								
Not working	NA	NA	NA		204 (58.62)	92 (26.44)	52 (14.94)	

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managers/professionals	319 (67.58)	16 (3.39)	137 (29.03)	0.023	292 (61.73)	31 (6.55)	150 (31.71)	
technicians/clerical/serv						× ,		
ice occupation	267 (65.60)	29 (7.13)	111 (27.27)		239 (58.44)	43 (10.51)	127 (31.05)	
skilled/unskilled								
workers	175 (64.10)	25 (9.16)	73 (26.74)		143 (52.77)	37 (13.65)	91 (33.58)	
Smoking								
Never	431 (65.11)	38 (5.74)	193 (29.15)	0.736	477 (58.46)	92 (11.27)	247 (30.27)	0.013
Current	179 (68.32)	18 (6.87)	65 (24.81)		193 (55.46)	59 (16.95)	96 (27.59)	
Ex-smoker	151 (66.52)	14 (6.17)	62 (27.31)		207 (61.61)	52 (15.48)	77 (22.92)	
Alcohol								
Never	41 (60.29)	4 (5.88)	23 (33.82)	0.037	59 (54.13)	17 (15.60)	33 (30.28)	0.005
Drinkers	702 (66.79)	60 (5.71)	289 (27.50)		790 (59.44)	168 (12.64)	371 (27.92)	
Ex-drinkers	18 (54.55)	6 (18.18)	9 (27.27)		29 (46.77)	18 (29.03)	15 (24.19)	
Fruits and vegetables consu	mption							
<1 portion/day	246 (66.13)	23 (6.18)	103 (27.69)	0.903	257 (55.75)	66 (14.32)	138 (29.93)	0.438
1-4 portions/day	403 (65.53)	40 (6.50)	172 (27.97)		485 (60.40)	108 (13.45)	210 (26.15)	
\geq 5 portions/day	111 (67.68)	7 (4.27)	46 (28.05)		135 (57.20)	29 (12.29)	72 (30.51)	
Physical Activity								
Never	288 (63.86)	40 (8.87)	123 (27.27)	0.016	319 (52.21)	119 (19.48)	173 (28.31)	< 0.001
<=3h/week	272 (65.70)	17 (4.11)	125 (30.19)		302 (59.80)	46 (9.11)	157 (31.09)	
>3h/week	200 (70.42)	12 (4.23)	72 (25.35)		254 (66.67)	38 (9.97)	89 (23.36)	
BMI	26.50 ± 5.00	27.64 ± 4.61	25.82 ± 4.62	0.0097	26.57 ± 5.06	27.56 ± 5.38	26.13 ± 4.78	0.004
<25	329 (65.93)	18 (3.61)	152 (30.46)	0.008	382 (59.50)	72 (11.21)	188 (29.28)	0.183

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25-30	280 (64.22)	35 (8.03)	121 (27.75)	316 (57.14)	81 (14.65)	156 (28.21)
>=30	151 (69.91)	17 (7.87)	48 (22.22)	179 (58.88)	49 (16.12)	76 (25.00)

Values are: numbers (%) for categorical variables and means±standard deviation for continuous variables. BMI: Body Mass Index. NA: not available.

^a χ^2 test for categorical variables, t-test for continuous variables.

bles, t-test for comme

		Sleep duration w	ork the next day		S	leep duration do N	OT work the next da	ay
		(N=1,152	-working)			(N=	1,501)	
	Short (<6	bhrs/night)	Long (>7	'hrs/night)	Short (<7	'hrs/night)	Long (>8	hrs/night)
	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)
Chronic conditions/diseases	C							
0	1	1	1	1	1	1	1	1
1	1.51 (0.66, 3.46)	1.50 (0.65, 3.50)	0.90 (0.64, 1.26)	0.91 (0.64, 1.28)	1.53 (0.88-2.63)	1.48 (0.84-2.59)	0.79 (0.58, 1.08)	0.84 (0.61, 1.16
2	3.34 (1.52, 7.33)	3.07 (1.36, 6.92)	0.95 (0.65, 1.40)	0.94 (0.63, 1.40)	2.63 (1.54, 4.50)	2.35 (1.34, 4.12)	0.88 (0.62, 1.24)	1.01 (0.70, 1.44
≥3	3.68 (1.75, 7.69)	3.70 (1.66, 8.22)	0.89 (0.62, 1.27)	0.82 (0.56, 1.21)	3.84 (2.39, 6.15)	2.85 (1.69, 4.81)	0.74 (0.54, 1.01)	0.98 (0.70, 1.38
Immigration								
Luxembourg		1		1		1		1
Portugal		2.13 (1.01-4.48)		0.85 (0.53-1.37)		1.77 (1.07-2.93)		1.15 (0.76-1.73)
Other		1.72 (0.93-3.20)		0.92 (0.68-1.25)		2.47 (1.68-3.64)		1.28 (0.97-1.69)
Sex								
Men		1		1		1		1
Women		0.63 (0.36-1.09)		1.79 (1.36-2.36)		0.79 (0.56-1.12)		1.28 (1.00-1.64)
Age		1.00 (0.97-1.03)		1.00 (0.98-1.01)		1.00 (0.98-1.02)		0.97 (0.96-0.99)
Education								
Primary		1		1		1		1
Secondary		0.80 (0.40-1.59)		0.96 (0.62-1.50)		0.58 (0.38-0.88)		0.85 (0.59-1.23)
Tertiary		0.45 (0.17-1.18)		0.94 (0.55-1.60)		0.31 (0.17-0.56)		0.76 (0.48-1.19)
Job status								
Unemployed						1		1
managers/professionals		1		1		0.59 (0.33-1.04)		1.92 (1.24-2.96)
technicians/clerical/service occupation		1.46 (0.68-3.11)		0.88 (0.62-1.26)		0.59 (0.37-0.94)		1.83 (1.23-2.73)
skilled/unskilled workers		0.97 (0.39-2.42)		1.07 (0.66-1.75)		0.44 (0.26-0.74)		2.10 (1.34-3.30)
Physical Activity								
								24

Pag	e 25 of 30		BMJ Open		
1 2 3 4 5 6 7	Never ≤3h/week >3h/week	1 0.61 (0.33-1.14) 0.59 (0.29-1.19)	1 1.09 (0.79-1.50) 0.93 (0.65-1.33)	1 0.60 (0.40-0.91) 0.54 (0.34-0.83)	1 0.96 (0.72-1.28) 0.70 (0.51-0.97)
 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 	Note. OR: Odds ratio; AOR	: Ajusted Odds ratio; 95% CI: 95% cor	fidence interval.		
21 22 23 24 25 26 27 28 29 30 31 32 32					
 33 34 35 36 37 38 39 40 41 42 43 					25
44 45 46 47	اع, 2025 at Agence Bibliographique de l seigolon.	anuL no \moɔ.imd.nəqoimd\rankı ur (ABES) data,ໝining,basaga,agaiainar techi data,ໝining,basaga,agaiainar techi	absolnwod .eros tzuguA rs no st Enseignement Superie ມີເອີ້ນອງ ເວັ້ນອີ່ງອີ່ງອີ່ງອີ່ງອີ່ງອີ່ງອີ່ງອີ່ງອີ່ງອີ່ງ	λeð20-8102-neqoįmd∖ð£11.01 ≳s be Jaຫi _{⊀t} ij∯pi≀qoວ γd berວeror¶	Asilduq tərit :nəqO LMB

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SupplementaryTable S1. Sleep problems and duration by ch	ronic conditior	ns/diseases: Eu	ropean Health	Exemination S	Survey in Luxe	mbourg.	
			Chronic dise	esgconditions			
Variables	Total	0	1 for use	21 Augu	<u>≥</u> 3	Р	
Diagnosis of sleep disorder (N=1486)	122 (8.21)	11 (9.02)	13 (10.66) E	(18.03)	76 (62.30)	< 0.001	
Sleepiness	118 (7.89)	25 (21.19)	26 (22.03) to	ement (15.25)	49 (41.53)	0.071	
Have difficulties in sleeping the night through (N=1505)	510 (33.89)	84 (16.63)	79 (15.64) text an	Suppose (18.42)	249 (49.31)		
Sleep duration	Sleep duration						
Num sleep hours when you have to work the next day			minin	m http BES)			
(N=1,152-working)			g, Al tr	.//bmjo			
<6h	70 (6.08)	10 (14.29)	13 (18.57) aining	(27.14)	28 (40.00)	0.006	
6-7h	761 (66.06)	232 (30.73)	206 (27.28) and s	1 33 (17.62)	184 (24.37)		
$\geq 8h$	321 (27.86)	103 (32.09)	87 (27.10) and	5 5 (17.45)	75 (23.36)		
Num sleep hours when you do NOT work the next day			techno	une 13			
(N=1,501)			logies	, 2025			
≤6h	203 (13.52)	25 (12.38)	34 (16.83)	at 4 26 (21.29)	100 (49.50)	< 0.001	
7-8h	878 (58.49)	245 (28.00)	227 (25.94)	1 1 (17.14)	253 (28.91)		
>8h	420 (27.98)	133 (31.89)	100 (23.98)	51 7 2 7 3 7 3 7 3 7 3	109 (26.14)		
For peer review only - http://www.com/u-http://wwwww.com/u-http://www	o://bmiopen.hmi	com/site/about//	nuidelines vhtml	shique de			

Values are: numbers (%) ^a χ 2 test for categorical variable

BMU Open 6) ^a χ² test for categorical variable 6) ^b χ² test for categorical variable



	Item No	Recommendation	Page No
Title and abstract	1	(<i>a</i>) Indicate the study's design with a commonly used term in the title or the abstract	3
		(b) Provide in the abstract on informative and balanced summary of what	2
		(b) Flowide in the abstract an informative and balanced summary of what	5
Introduction		was une and what was found	
Background/rationale	2	Explain the scientific background and rationale for the investigation being	5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods		Saw sponto objection, normanig any prospontou hypotheore	0
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of	6
5 B		recruitment, exposure, follow-up, and data collection	Ũ
Participants	6	(<i>a</i>) Give the eligibility criteria, and the sources and methods of selection	6
		of participants	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders,	6-7
		and effect modifiers. Give diagnostic criteria, if applicable	
Data sources/	8*	For each variable of interest, give sources of data and details of methods	6-7
measurement		of assessment (measurement). Describe comparability of assessment	
		methods if there is more than one group	
Bias	9	Describe any efforts to address potential sources of bias	8, 12
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If	6-8
		applicable, describe which groupings were chosen and why	
Statistical methods	12	(a) Describe all statistical methods, including those used to control for	8
		confounding	
		(b) Describe any methods used to examine subgroups and interactions	
		(c) Explain how missing data were addressed	8
		(d) If applicable, describe analytical methods taking account of sampling	
		strategy	
		(<u>e</u>) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers	6
		potentially eligible, examined for eligibility, confirmed eligible, included	
		in the study, completing follow-up, and analysed	
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical,	Table
		social) and information on exposures and potential confounders	and 3
		(b) Indicate number of participants with missing data for each variable of	
		interest	
Outcome data	15*	Report numbers of outcome events or summary measures	8
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted	Table
		estimates and their precision (eg, 95% confidence interval). Make clear	
		which confounders were adjusted for and why they were included	

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		(b) Report category boundaries when continuous variables were	7-8
		categorized	
		(c) If relevant, consider translating estimates of relative risk into absolute	
		risk for a meaningful time period	
Other analyses	17	Report other analyses done-eg analyses of subgroups and interactions,	
		and sensitivity analyses	
Discussion			
Key results 18 Summarise key results with		Summarise key results with reference to study objectives	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential	11
		bias or imprecision. Discuss both direction and magnitude of any potential	
		bias	
Interpretation	20	Give a cautious overall interpretation of results considering objectives,	9-11
		limitations, multiplicity of analyses, results from similar studies, and other	
		relevant evidence	
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study	6
		and, if applicable, for the original study on which the present article is	
		based	

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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SLEEP DURATION AND MULTIMORBIDITY IN LUXEMBOURG. RESULTS FROM THE EUROPEAN HEALTH EXAMINATION SURVEY IN LUXEMBOURG, 2013-2015

Journal:	BMJ Open
Manuscript ID	bmjopen-2018-026942.R1
Article Type:	Research
Date Submitted by the Author:	12-Jun-2019
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Primary Subject Heading :	Epidemiology
Secondary Subject Heading:	Public health
Keywords:	EPIDEMIOLOGY, PUBLIC HEALTH, SLEEP MEDICINE

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THE EUROPEAN HEALTH I	EXAMINATION SURVEY IN LUXEMBOURG, 2013-2015
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Word count: 3401; Abstract: 2	02; Tables: 4; References: 43
Funding: The study was funded Institute of Health.	by the Directorate and Ministry of Health and the Luxembourg
Conflict of interest: The author	s declare that they have no conflict of interest.

Contributorship statement

MRC and SS conceptualized and designed the study. MRC and VB performed the statistical analysis. MRC, SS and T.T.M interpreted the data. MRC drafted the article. SS supervised the study. All authors participated in the revision of the article. All authors contributed to and have approved the final manuscript.

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Abstract

Objectives: We estimated the prevalence of short sleep duration and multimorbidity in Luxembourg, and assessed whether sleep duration was associated with multimorbidity after adjusting for socio-demographic and behavioral characteristics.

Design: Cross-sectional study.

Participants: Data from 1508 Luxembourg residents (48% men and 52% women) aged 25 to 64 years came from the European Health Examination Survey 2013-2015.

Outcome measures: Short sleep duration and multimorbidity.

Results: Participants reported sleeping 6.95hrs/night during work days, nearly 1hr less than during non-work days (7.86hrs/night). Nearly half of participants reported having been diagnosed with ≥ 2 chronic conditions/diseases. Short sleep duration was linearly associated with the number of chronic conditions when participants did not have to work the next day (OR: 1.93, 95% CI: 1.09, 3.40 and OR: 1.77, 95% CI: 1.02, 3.07 for 2, and ≥ 3 chronic conditions/diseases, respectively), independently of socioeconomic and behavioral characteristics. The effect was stronger when participants had to work the next day (OR: 2.89, 95% CI: 1.27, 6.56, and OR: 2.98, 95% CI: 1.30, 6.87, for 2 and ≥ 3 chronic conditions/diseases, respectively).

Conclusions: Health promotion programs should aim at improving and promoting healthy sleeping and its possible benefits on chronic disease outcomes, which in turn can help reducing the risk of multimorbidity in middle-aged adults.

Keywords: Sleep duration; multimorbidity; chronic diseases; Luxembourg; European Health Examination Survey
Strengths and limitations of this study

- This is the first study in Luxembourg on the prevalence of sleep patterns, with a focus on short and long sleep duration, and their relationship with multimorbidity.
- The present study was drawn from the European Health Examination Survey in Luxembourg (EHES-LUX), a representative cross-sectional population-based survey.
- Limitations of the present study include the subjective self-reported measure of sleep duration, the cross-sectional design of the study (not allowing to establish a causal link), and the low participation rate.

Data sharing statement: Extra data can be accessed by emailing Dr Laetitia Huiart, Head of the Population Health Department, LIH (laetitia.huiart@lih.lu) and the Principal Investigator of EHES-LUX2013-2015, Dr Maria Ruiz-Castell (maria.ruiz@lih.lu) and fill out a request form.

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Introduction

A healthy lifestyle includes healthy sleep habits. Sleep patterns influence several physiological and psychological processes such as inflammation, immune responses, mental and cognitive function, glucose regulation and energy balance (1-3). Short sleep duration, poor sleep quality, and sleeprelated disorders can result in sleep deficiency and impact on individual health (4). According to the Centers for Disease Control and Prevention (CDC), insufficient sleep is associated with health problems such as chronic diseases, poor quality of life, mental health, risk of accidents, and lower productivity at work (5). Adequate sleep duration is one of the dimensions needed for good sleep health (6). The American Academy of Sleep Medicine and Sleep Research Society considers that for an adult an average sleep duration of at least 7 hours per night should be recommended (4). However, a high percentage of the population sleeps less than the recommended 7 hours (7). Several factors may affect sleep such as physical activity patterns or eating behaviors, but also socioeconomic factors including job status, marital status and ethnicity (8, 9). Studies have observed an association of lower education and unemployment with both short and long sleep duration (10, 11), while factors such as physical activity and healthy diet seem to improve sleep quality (12, 13). Moreover, diet intake (energy and total fat intake) and nutrients seem to be associated with both short and long sleep duration through multifactorial factors including eating patterns (e.g., time and hours of intake) and variations in hormones related to appetite, such as leptin (14).

Epidemiologic data suggest an association of abnormal sleep duration and poor sleep quality with cardiometabolic problems (e.g. hypertension, diabetes, obesity, cardiovascular diseases), mental disorders (e.g. depression), and mortality (15-18). The observed relationship between short sleep duration and mortality would be especially critical in adults under 65 years of age (18). Few studies so far have focused on possible relationships between sleep patterns and multimorbidity (19, 20). Multimorbidity is defined as the presence of two or more chronic diseases in the same individual (21), and is associated with disability, functional decline, frailty, poor quality of life and mortality (22). In the context of ageing societies, multimorbidity is an increasing global phenomenon (23); its occurrence usually increases with age, though a large proportion of individuals younger than 65 are also affected (24). Definitions of multimorbidity vary, however, and the prevalence differs based on changing definitions, which in turn present significant challenges when attempting to compare results between populations and studies (22).

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The aim of the present study was to estimate the prevalence of short sleep duration and multimorbidity in Luxembourg, as well as to assess whether sleep duration was associated with multimorbidity after adjusting for socio-demographic and behavioral characteristics.

Methods

Study population and recruitment

Data were drawn from the European Health Examination Survey in Luxembourg (EHES-LUX). EHES-LUX is a representative cross-sectional population-based survey carried out by the Luxembourg Institute of Health with the objectives of assessing the health status of the population of the Grand-Duchy of Luxembourg, develop national and European health indicators, identify the needs of the population, and evaluate health behaviors. EHES-LUX was conducted between February 2013 and January 2015. Individuals were randomly selected in a one-stage sampling procedure from the national health insurance registry (95% social coverage). Institutionalized individuals (e.g. hospitals, elderly homes) were not included. A total of 1508 residents (excluding 21 pregnant women) of Luxembourg aged 25 to 64 participated in the survey (participation rate of 24.1%) (25). Of them, 7 participants did not reported their sleep habits. A total of 1501 participants had information on multimorbidity and sleep habits. Participants signed an informed consent and were interviewed by trained nurses who also conducted medical examinations. Questionnaires included several health modules (e.g. sleep and nutritional habits, health care, working and living conditions) as well as demographic and socioeconomic characteristics. Medical examinations included measurements such as blood pressure and anthropometry. Sampling weights were calculated to be generalized to the population of Luxembourg in terms of age, sex and district of residence. The study national research ethics committee (Comité national d'éthique de Recherche-CNER) approved the study and it was notified to the Luxemburgish National Commission for Data Protection.

Patient involvement

Participants were not involved in the development of the research question, study design, recruitment or the conduction of the study. Upon request, results from the medical examination were forwarded to the study participants and their medical doctors. General results were presented to the general public in a range of dissemination activities.

Sleep

Sleep duration was assessed using two questions: 1) "How many hours do you normally sleep at night when you have to work the next day?", and 2) "How many hours do you normally sleep at

night when you don't have to work the next day?". Responses to the first question were categorized as short sleep duration (<6hrs/night), medium sleep duration (6-8hrs/night), and long sleep duration (>8hrs/night), in line with previously published studies (8, 26, 27). Responses to the second question were categorized in short sleep duration (\leq 6hrs/night), medium sleep duration (7-8hrs/night), and long sleep duration (>8hrs/night). The main reason why we used two different cutoffs was due to the marked difference observed between sleep hours during workdays and non-work days (approximately one-hour difference). Therefore, the number of participants who were at the extremes (e.g. < 6 hours and >8hours during the days when not having to work the next day) had very small sample size.

Sleep disorders and sleep quality were assessed with the following variables: difficulty in sleeping the night, diagnosis of sleep disorders, sleep medication and sleepiness. Difficulty in sleeping the night was assessed based on the question "Do you have difficulties in sleeping through the night?". Diagnosis of sleep disorders was assessed using the question "Have you ever been told by a doctor or another health professional that you have a sleep disorder?". Sleep medications were assessed using the question "In the past 2 weeks, have you used other types of medicines that were prescribed to you ?". The question was aimed at answering about several medications including sleep tablets. Sleepiness was defined as a score of ≥ 11 on the Epworth Sleepiness Scale (28). *Multimorbidity*

Participants were asked if they ever had a chronic disease or condition diagnosed by a medical doctor (e.g., hypertension, high cholesterol, diabetes, cardiovascular diseases, stomach or duodenal ulcer, cirrhosis or other liver disease, urinary incontinence, kidney problems, chronic back or neck disorder, rheumatoid arthritis, arthrosis, osteoporosis, cancer, severe headache as migraine or chronic anxiety). Cardiovascular diseases included coronary heart disease or angina pectoris, heart attack or its chronic consequences, stroke or its chronic consequences. Based on this information, the variable "ever being diagnosed with a chronic disease or condition" was generated with four categories: 0, 1, 2 and \geq 3 chronic disease or condition. Multimorbidity was defined as having two or more chronic diseases or conditions diagnosed by a medical doctor.

Explanatory variables

Sociodemographic characteristics included age, sex and immigration status. As Portuguese are the largest immigrant community in Luxembourg, immigration status was categorized in nonimmigrant, immigrant born in Portugal, and immigrant born in other countries. Socioeconomic status included education (primary, secondary and tertiary education completed) and job status

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(unemployed; managers/professionals; technical/clerical/service occupation; skilled/unskilled workers).

Lifestyles included smoking (never; current; ex-smokers), alcohol consumption (never; ex-drinkers; drinkers), physical activity (never; \leq 3hrs/week of sports, fitness, and/or recreational activities which lasted at least 10 consecutive minutes; >3hrs/week of sports, fitness, and/or recreational activities which lasted at least 10 consecutive minutes), and vegetable and fruit consumption (< 1 portion/ day, 1–4 portions/day, \geq 5 portions/day). Weight and height were measured by trained nurses and used to calculate body mass index (BMI; kg/m²). BMI was categorized as normal body weight (<25 kg/m²), overweight (25-29.99 kg/m²) and obesity (\geq 30kg/m²).

Statistical data analysis

Means and frequencies were used for descriptive purposes. We calculated the prevalence of sleep disorders, short and long sleep duration, chronic conditions/diseases and multimorbidity. Percentages did not include missing values. A chi-square test (γ 2) or Student t-test were used to analyze associations between the prevalence of sleep duration and covariates and the prevalence of multimorbidy and covariates. The association between sleep duration and chronic conditions/diseases was assessed using multinomial logistic regression models (reference for sleep duration when having to work the next day was 6-8hrs per night and reference for sleep duration when not having to work the next day was 7-8hrs) adjusted for sociodemographic characteristics, behavioural risk factors (e.g. BMI, smoking, alcohol consumption and physical activity), as well as for measures of sleep disorders and sleep quality. We did sensitivity analysis using the same categories for sleep duration for working days and days when not having to work the following day (<6hrs/night; 6-8hrs/night; >8hrs/night). We considered a P<0.05 statistically significant. To be representative of the population and avoid biased estimates, the observations were weighted. Participants with missing values on sleep habits and or murltimorbidity were not included in the present analysis. Analyses were performed using STATA 14.0 and and SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Table 1 shows the prevalence of chronic conditions/diseases, multimorbidity, sleep duration and sleep disorders. Nearly half of participants reported being diagnosed with two or more chronic conditions/ diseases, and nearly a third of participants reported being diagnosed with three or more chronic conditions/diseases. The most prevalent diseases were chronic low back disorder or other chronic back defect followed by hypercholesterolemia, arthrosis and hypertension. More than 8% of participants were diagnosed with a sleep disorder, a third reported having difficulties in sleeping

through the night and 4.3% reported taking sleep medication. Participants reported sleeping 7.86hrs/night when they did not have to work the next day, nearly one hour more than when they had to work the next day (6.95hrs/night). Moreover, 6.08% of the Luxembourg population reported sleeping less than 6 hours during working days, a percentage that was reduced to almost half (3.93%) when participants did not have to work the next day.

Participant characteristics by chronic conditions/diseases are shown in **Table 2**. More men than women presented three or more chronic diseases. Higher number of chronic diseases/conditions increased with age: those aged 55 to 64 presented more chronic conditions compared to those aged 25-34. Immigrants born in Portugal presented more chronic conditions than non-immigrants and other immigrants. Participants being less educated and unemployed presented more chronic conditions compared to those employed and highly educated. Participants being less physically active and with obesity presented more chronic conditions/diseases than those being more physically active and with a lower BMI.

Participant characteristics by sleep duration are shown in **Table 3**. When participants had to work the following day, more men than women reported a medium sleep duration. Short sleep duration was more likely among immigrants born in Portugal, participants with lower education and skilled/unskilled workers. Short sleep duration was less common among those being physically active and with a BMI less than 25 Kg/m². When participants did not have to work the next day, short sleep duration was more common among older individuals, immigrants born in Portugal, unemployed people, and those being less physically active. Long sleep duration was observed among participants with lower education. No differences in sleep duration were observed between men and women.

Table 4 shows results from multinomial logistic regression analyses examining the association between sleep duration and chronic conditions/diseases, and adjusted by sociodemographic characteristics, behavioural risk factors, socioeconomic position, as well as for measures of sleep disorders and sleep quality. Among participants who reported sleep hours when they did not have to work the next day, those sleeping less hours (\leq 6h) were 1.93 and 1.77 times as likely to report having 2 and 3 or more chronic conditions after adjusting for covariates. In fully adjusted models, the strength of associations between sleep duration and multimorbidity remained statistically significant. The same association (although more accentuated) was observed in those participant with a job at the moment of the survey who reported the number of sleep hours when they had to work the next day: those sleeping less hours (<6h) were 2.89 and 2.98 times as likely to report having 2 and 3 or more chronic conditions after adjusting for covariates.

Estimates of sleep problems and chronic conditions are presented in **Table S1**. The prevalence of sleep problems was high, with one out of three participants having difficulties in sleeping the night through and nearly 8% of participants diagnosed with a sleep disorder. In all cases, the percentage of participants with sleep problems increased with the number of chronic diseases. Sensitivity analysis examining the association between sleep duration and chronic conditions/diseases are presented in **Table S2**, using the same cut points for sleep duration categories for both workdays and non-work days. We observed the same trend as in Table 4 with consistent associations of short sleep duration with the number of chronic conditions.

Discussion

Results from the present nationwide population-based study show for the first time in Luxembourg the prevalence of sleep patterns, with a focus on short and long sleep duration, as well as their association with multimorbidity. The prevalence of short sleep duration in Luxembourg is 6.08% when having to work the following day, and 3.93% when not having to work the following day. Results are similar to those observed internationally (27, 29), although in countries such as Brazil the prevalence of short sleep duration was nearly 22% (30), and in Portugal and the United States values reached up to 20% in 2015-2016 and 11.8% in 2014, respectively (31, 32). However, in the present study the age range from 25 to 64 years must be considered since it does not include adults over 65 years old who generally sleep less hours. This means that the overall prevalence of the Luxembourg population sleeping less than the recommended hours is likely to be higher, when including older adults as well.

Multimorbidity is highly prevalent in Luxembourg, especially when taking into account the fact that the study population was up to 65 years, which represents a relatively young population, as multimorbidity prevalence naturally increases with age (22). Nearly half of participants had two or more chronic diseases and 31% had three or more chronic diseases/conditions.

In our study, we observed that short sleep duration was significantly associated with the number of chronic conditions independently of socioeconomic, behavioral characteristics and sleep disorders, an effect accentuated during working days, when sleep hours are reduced. Our results are in line with those from other studies that observed an association between sleep and number of chronic diseases, although previous studies have been usually performed in populations of older adults (e.g. over 50 years old) (19, 33). As observed by Koyanagi et al., sleep problems increase with the number of diseases in both low and high income countries independent of their economic development (19). These associations could explain the observed relationship between sleep duration (under the recommended 7 hours) and poor sleep quality with mortality, even among

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adults younger than 65 years old (18). It is not clear if sleep problems are a consequence of chronic diseases (e.g. conditions affecting sleep) or part of the cause (sleep predispose the individual to more diseases or exacerbates the symptoms), although it is plausible that both sleep problems and chronic diseases are linked by a bidirectional association (34). Although both sleep deprivation and the number of chronic diseases increase with age, and are more prevalent in older adults, our study shows that the prevalence is also high in adults under 65 and the association begins much earlier. It is therefore necessary to detect these problems earlier in order to improve individual health and general wellbeing and reduce mortality, particularly in the context of ageing populations burdened by the accumulation of multiple chronic conditions over time. In our study, we also observed that short sleep duration was associated with immigration status, at least for the sleep categories during non-working days. The relationship between immigration status and sleep patterns remains unclear, possibly related to stress linked to the migratory process, cultural adaptation, or working conditions in the host country (35, 36). In our study, Portuguese immigrants were more likely to sleep less than 6h per night during workdays and less than 7h during non-working days. Portuguese are the largest immigrant community in Luxembourg, accounting for 16% of the 46% immigrant population living in Luxembourg. Compared to Luxembourgish natives, Portuguese immigrants have a lower socioeconomic status (37) (including income, education and employment) which could partly explain why they have a greater likelihood of being short sleepers. However, after adjusting for sleep disorders the association with short sleep duration was only maintained for non-work-days. In our study, long sleep duration was more common in women. This was in line with other studies showing that men usually sleep less hours, although women reported having more sleep problems (38). However, this relationship is complex and could depend on family composition (e.g. single parents have shorter sleep duration, particularly women) (39).

In terms of potential mechanisms to corroborate the biological plausibility of the link between short sleep duration and multimorbidity, sleep deprivation has been associated with a number of chronic conditions, including cardio-metabolic and neurodegenerative disease, cancer, musculoskeletal disorders, and mental problems (15, 16). Experimental evidence corrobores the plausibility of deleterious effects of lack of sleep on endocrine, immune, neurovegetative and inflammatory pathways (1-3). Sustained sleep deprivation could be related to chronic conditions through its impact on the ciercadian rhythm and its association with hormonal (e.g. insulin resistance and decrease leptin) and autonomic nervous system changes (increase the activity of the sympathetic nervous system) (40).

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In addition, sleep deprivation often cluster with other behavioral risk factors such as cigarette smoking, heavy drinking, and physical inactivity, which may in turn increase the risk of chronic disease. However, in our study, we only observed an association between physical activity and short sleep duration during days when not having to work the following day, with no association observed between short sleep duration and smoking or alcohol consumption. Regular physical activity would reduce the likelihood of short and/or long sleep duration and maintain an optimal duration. Studies have observed an association between physical activity and sleep, improving quality of sleep, sleep efficiency, and total sleep time (12, 41).

Limitations of the present study include the subjective measure of sleep duration (self-reported number of hours of sleep) instead of an objective measure (e.g. actigraphy, polysomnography). However, in the absence of an objective measure, there is a moderate correlation between objective and subjective measurements, a correlation that is high during weekdays possibly due to routines (42), but may be attenuated based on certain individual characteristics (e.g. presence of conditions such as depression, sociodemographic characteristics) (43). Other limitations include the fact that we did not include other sleep problems such as insomnia or sleep apnea nor environmental factors such as noise, traffic or commuting, all of which could affect sleep duration. In addition, multimorbidity was also self-reported based on a restricted list of diseases in the questionnaire, therefore participants may have not reported additional conditions, which may produce a possible underestimation of multimorbidity prevalence. Information on non-responders was not available, and despite being a representative sample of the Luxembourg population (in terms of age, sex and district), we could not determine the possibility of a non-response bias. In our study, we only included the number of sleep hours during the night, without including nap times. For this reason, the categories used here are slightly different from the recommendations of daily sleep hours. Finally, it should be noted that the study design (cross-sectional) does not allow to ascertain a causal link between sleep and multimorbidity; in addition, the low participation rate may affect the generalizability of our results.

This is the first study in Luxembourg on the prevalence of sleep patterns, with a focus on short and long sleep duration, and their relationship with multimorbidity. Sleep deprivation, having difficulties in sleeping the night through, sleep disorders and sleeping medication represent a neglected public health problem, especially when associated with a number of chronic conditions and diseases, thus producing a negative impact on the wellbeing and general health status of the population. Sleep hygiene should be considered as an additional important health behavior along with diet, smoking and physical activity, both in clinical and public health practice. As both sleep

problems and multimorbidity are highly prevalent in Luxembourg, health promotion programs should be developed to improve and promote healthy sleeping habits among the general population, which in turn may be beneficial in the prevention and management of a number of chronic disease outcomes, including the occurrence of multimorbidity.

Acknowledgements

We are grateful to the population of Luxembourg and to all the EHES-LUX team who have contributed to this study. We would like to thank Kuemmerle A, Barre J, Dincau M, Delagardelle C, Michel G, Schlesser M, Mormont D, Chioti A, Gantenbein M, Lieunard C, Columeau A, Kiemen M, Weis J, Ambrozet G, Billy A, Larcelet M, Marcic D, Gauthier C, and Viau-Courville M for their or opper terrer only valuable contributions.

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Table	1.	Chronic	diseases/conditions,	multimorbidity	and	sleep:	European	Health	Examination
Survey	' in	Luxembo	ourg (N =1508).						

	N (%) / Mean \pm SD
Hypertension	250 (16.59)
High cholesterol	458 (30.39)
Diabetes	69 (4.58)
Coronary heart disease or angina pectoris	26 (1.73)
Myocardial infarction or chronic consequences of myocardial infarction	14 (0.93)
Stroke or chronic consequences of stroke	11 (0.73)
Stomach or duodenal ulcer	81 (5.37)
Cirrhosis of the liver or other liver disease	46 (3.05)
Urinary incontinence, problems in controlling the bladder	74 (4.91)
Kidney problems	108 (7.17)
Chronic low back disorder or other chronic back defect	489 (32.47)
Chronic neck disorder or other chronic neck defect	246 (16.32)
Rheumatoid arthritis	88 (5.85)
Arthrosis	292 (19.38)
Osteoporosis	44 (2.92)
Cancer	54 (3.59)
Severe headache such as migraine	271 (17.98)
Chronic anxiety	98 (6.50)
Depression	204 (13.54)
Number of chronic diseases	
0	405 (27.00)
1	362 (24.13)

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≥ 2 (multimorbidity)	733 (49.00)
≥3	465 (31.00)
Sleep	
Diagnosis of sleep disorder	122 (8.21)
Sleepiness ^a	118 (7.89)
Have difficulties in sleeping the night through	510 (33.89)
Sleeping medication	64 (4.26)
Sleep duration	
Hours when you have to work the next day (N=1,152-working)	6.95±0.97
<6hrs/night	70 (6.08)
6-8hrs/night	1,040 (90.28)
>8hrs/night	42 (3.65)
Hours when you don't work the next day $(N=1,501)$	7.86±1.30
≤6hrs/night	203 (13.52)
7-8hrs/night	878 (58.49)
>8hrs/night	420 (27.98)
N=number, SD=standard deviation	
- Measured with Epworth Steepiness Scale	

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······································	uiseases. Europ	eall fiealul Exa	initiation Surve		g (N -1
		Chronic	conditions/dise		
	0	1	2	g for 21 ≥3	Pa
Sex				use En	
Men	199 (27.72)	199 (27.72)	143 (19.92)	s reign 27 (24.65)	< 0.00
Women	206 (26.34)	163 (20.84)	125 (15.98)		
Age				o tex	
25-34	130 (43.62)	86 (28.86)	48 (16.11)	an <u>e</u> an <u>a</u> an <u>a</u> a a a a a a a a a a a a a a a a a a	< 0.00
35-44	156 (34.29)	119 (26.15)	69 (15.16)		
45-54	83 (18.16)	111 (24.29)	98 (21.44)	Bing 5 (36.11)	
55-64	36 (12.41)	46 (15.86)	53 (18.28)	•155 (53.45)	
Immigration				omjor Al tra	
Luxembourg	184 (23.44)	197 (25.10)	144 (18.34)	20 (33.12)	< 0.00
Portugal	52 (23.85)	42 (19.27)	45 (20.64)	ang 7 (36.24)	
Other	169 (34.00)	123 (24.75)	79 (15.90)	sin 126 (25.35)	
Education				on Ju	
Primary	68 (18.38)	75 (20.27)	64 (17.30)	ng 163 (44.05)	< 0.00
Secondary	133 (23.05)	142 (24.61)	106 (18.37)	126 (33.97)	
Tertiary	203 (37.04)	145 (26.46)	97 (17.70)	¹ 1 9 3 (18.80)	
Job				Agen	
Not working	58 (16.67)	56 (16.09)	58 (16.67)	1 26 (50.57)	< 0.00
managers/professionals	168 (35.59)	138 (29.24)	73 (15.47)	9 5 (19.70)	
technicians/clerical/service occupation	119 (29.38)	89 (21.98)	76 (18.77)	1 <u>2</u> 1 (29.88)	

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skilled/unskilled workers	60 (21.90)	79 (28.83)	right, 61 (22.26) in	• 78 (27.01)	
Smoking			sludi	942 o	
Never	239 (29.25)	209 (25.58)	145 (17.75) đơ	. 2 ² / ₂ / ₄ (27.42)	0.026
Current	90 (26.01)	75 (21.68)	63 (18.21) s	на (34.10)	
Ex-smoker	74 (22.09)	78 (23.28)	60 (17.91)		
Alcohol			ated	019. [
Never	30 (27.78)	21 (19.44)	20 (18.52) _g	(34.26)	0.055
Drinkers	365 (27.53)	328 (24.74)	234 (17.65) and		
Ex-drinkers	8 (12.50)	13 (20.31)	14 (21.88) da	(45.31)	
Fruits and vegetables consumption			a mi		
<1 portion/day	126 (27.39)	112 (24.35)	87 (18.91) ,	·135 (29.35)	0.597
1-4 portions/day	223 (27.81)	183 (22.82)	142 (17.71) A	2 4 (31.67)	
\geq 5 portions/day	55 (23.31)	66 (27.97)	39 (16.53)	75 (32.20)	
Physical Activity			y, and	mj.o	
Never	130 (21.35)	133 (21.84)	125 (20.53)	221 (36.29)	< 0.001
<=3h/week	151 (29.84)	130 (25.69)	77 (15.22) ar	148 (29.25)	
>3h/week	121 (31.84)	98 (25.79)	65 (17.11)	9 1 (25.26)	
BMI	25.27 ± 4.06	26.04 ± 4.89	26.66 ± 4.96	2807 ± 5.56	< 0.001
<25	212 (33.02)	169 (26.32)	112 (17.45) [©]	149 (23.21)	< 0.001
25-30	152 (27.39)	131 (23.60)	100 (18.02)	1 \$ (30.99)	
>=30	41 (13.62)	61 (20.27)	55 (18.27)	144 (47.84)	

Values are: numbers (%) for categorical variables and means±standard deviation for continuous variables. MI: Body Mass Index.^a χ2 test for categorical variables, t-test for continuous variables. For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

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Table 3. Participant's characteristics	by Sleep duration:	European Healt	th Examination	Survey	In Luxembouig 942 on 21 ft	(N =1508).		
	Sleep hours v	when you have	to work the nex	xt day	Sleep hours	when you do N	OT work the ne	ext dag
	<6hrs/night	(N=1,152-wo 6-8hrs/night	rking) >8hrs/night	P a	esnseu genseu ≤6hrs/n∰egt≥	(N=1,50 7-8hrs/night)1) >8hrs/night	P
Sex					ated			
Men	41 (6.93)	537 (90.71)	14 (2.36)	0.031	97 (13.491	436 (60.64)	186 (25.87)	0.19
Women	29 (5.18)	503 (89.82)	28 (5.00)			442 (56.52)	234 (29.92)	
Age	45.18 ± 8.90	43.02 ± 9.02	41.40 ± 9.40	0.072	$48.44 \pm aded fr$	45.47 ± 10.01	42.38 ± 9.74	<0.0
25-34	10 (3.85)	237 (91.15)	13 (5.00)	0.264	22 (7.4) 22	157 (52.86)	118 (39.73)	<0.0
35-44	23 (5.88)	352 (90.03)	16 (4.09)		51 (11. 2 19	272 (59.78)	132 (29.01)	
45-54	27 (7.05)	347 (90.60)	9 (2.35)		70 (15.25) 😽	270 (58.82)	119 (25.93)	
55-64	10 (8.47)	104 (88.14)	4 (3.39)		60 (20. 👼) 📑	179 (61.72)	51 (17.59)	
Immigration					ainir			
Luxembourg	28 (4.59)	558 (91.48)	24 (3.93)	0.015	77 (9.8)	500 (63.61)	209 (26.59)	<0.0
Portugal	20 (12.05)	139 (83.73)	7 (4.22)		48 (22.62) 3	105 (48.17)	65 (29.82)	
Other	22 (5.85)	343 (91.22)	11 (2.93)		78 (15.69) 💐	273 (54.93)	146 (29.38)	
Education					ilar J			
Primary	25 (10.78)	198 (85.34)	9 (3.88)	0.002	89 (24. § 5) he	186 (50.27)	346 (62.91)	<0.0
Secondary	28 (6.56)	380 (88.99)	19 (4.45)		ۍ (13. 5 9) آ	343 (59.55)	37 (6.73)	
Tertiary	17 (3.47)	459 (93.67)	14 (2.86)		157 (27මු 6) පූ	346 (62.91)	167 (30.36)	
Job					5 at es.			
Not working	NA	NA	NA	0.004	92 (26.44) A	204 (58.62)	52 (14.94)	<0.0
managers/professionals	16 (3.39)	440 (93.22)	16 (3.39)		31 (6.55) B	292 (61.73)	150 (31.71)	
technicians/clerical/service occupation	29 (7.13)	367 (90.17)	11 (2.70)		43 (10.51) B	239 (58.44)	127 (31.05)	
skilled/unskilled workers Smoking	25 (9.16)	233 (85.35)	15 (5.49)		37 (13.65) ^{og} raphiq	143 (52.77)	91 (33.58)	
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Never	38 (5.74)	597 (90.18)	27 (4.08)	0.850	92 (11.27) 22	477 (58.46)	247 (30.27)	0.013	
Current	18 (6.87)	237 (90.46)	7 (2.67)		59 (16.5) X	193 (55.46)	96 (27.59)		
Ex-smoker	14 (6.17)	205 (90.31)	8 (3.52)		52 (15. 8) S	207 (61.61)	77 (22.92)		
Alcohol	× ,	`` ,	~ /		y for	× ,			
Never	4 (5.88)	58 (85.29)	6 (8.82)	0.006	17 (15. ອົູບງ ເອັ້	59 (54.13)	33 (30.28)	0.005	
Drinkers	60 (5.71)	957 (91.06)	34 83.24)		168 (12 5 4) 5	790 (59.44)	371 (27.92)		
Ex-drinkers	6 (18.18)	25 (75.76)	2 (6.06)		18 (29.63	29 (46.77)	15 (24.19)		
Fruits and vegetables consumption	n				ed to be determined to be determined and the determ				
<1 portion/day	23 (6.18)	337 (90.59)	12 (3.23)	0.858	66 (14. j 2 j	257 (55.75)	138 (29.93)	0.438	
1-4 portions/day	40 (6.50)	551 (89.59)	24 (3.90)		108 (13 🛱 🗿 📓	485 (60.40)	210 (26.15)		
\geq 5 portions/day	7 (4.27)	151 (92.07)	6 (3.66)		29 (12.29 e	135 (57.20)	72 (30.51)		
Physical Activity					fror ata				
Never	40 (8.87)	387 (85.81)	24 (5.32)	0.002	119 (19 🗐 🖏 🛓	319 (52.21)	173 (28.31)	< 0.001	
<=3h/week	17 (4.11)	385 (93.00)	12 (2.90)		46 (9.1)	302 (59.80)	157 (31.09)		
>3h/week	12 (4.23)	266 (93.66)	6 (2.11)		38 (9.94)	254 (66.67)	89 (23.36)		
BMI	27.64 ± 4.61	26.33 ± 4.89	25.52 ± 5.01	0.049	27.56 ± 💐 3😽	$26.57\pm\ 5.06$	26.13 ± 4.78	0.004	
<25	18 (3.61)	457 (91.58)	24 (4.81)	0.011	72 (11.21)	382 (59.50)	188 (29.28)	0.183	
25-30	35 (8.03)	390 (89.45)	11 (2.52)		81 (14. 🛃	316 (57.14)	156 (28.21)		
>=30	17 (7.87)	192 (88.89)	7 (3.24)		49 (16. 6 2) 🖁	179 (58.88)	76 (25.00)		

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Page 1 2 3 4 5	23 of 31			I	BMJ Open		mjopen-2018-026942 on 1 by copyright, including		
6 7 8 9 10	Table 4 . Resultsfor participants so	of multinomial 1 ocieconomic cha	ogistic regression	n measuring the a	ssociation betweer European Health E	n sleep duration a xamination Surve	ng chronic cond use space with the second contraction of the second co	itions in models rg (N =1508).	adjusted
11		Slee	p duration work the	next day (N=1,146-w	vorking)	Sleep	്പ്പ്പ് ഗ് duration do NOT w	ork the next day (N=	=1,501)
12		Short	(<6h)	Long	g (>8h)	Short	୦⊐ୁ୦ (କ୍ଲିଆ)≦	Long	(>8h)
13 14		OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)	OR (95% CI)	a (95% CI)	OR (95% CI)	AOR (95% CI)
15	Chronic conditions/diseases			6			nded		<u>·</u>
16 17	0	1.00	1.00	1.00	1.00	1.00	r (A fro 1.00	1.00	1.00
17	1	1.72 (0.76, 3.87)	1.68 (0.72, 3.88)	1.88 (0.84, 4.21)	1.84 (0.79, 4.26)	1.53 (0.88, 2.63)	1 , 0 , 3 , 1	0.79 (0.58, 1.08)	0.84 (0.61, 1.16)
19	2	3.22 (1.47, 7.05)	2.89 (1.27, 6.56)	1.99 (0.83, 4.76)	1.87 (0.75, 4.65)	2.63 (1.54, 4.50)	E .93 (1.09, 3.40)	0.88 (0.62, 1.24)	1.11 (0.77, 1.59)
20	≥3	4.06 (1.95, 8.43)	2.98 (1.30, 6.87)	0.86 (0.31, 2.43)	0.94 (0.31, 2.89)	3.84 (2.39, 6.15)	≥ 77 3 1.02, 3.07)	0.74 (0.54, 1.01)	1.10 (0.76, 1.60)
21 22	Immigration						njop		
22	Luxembourg		1.00		1.00		n in 1 .00		1.00
24	Portugal		1.64 (0.88, 3.06)		0.70 (0.25, 1.94)		1 .89 1 .09, 3.27)		1.24 (0.81, 1.89)
25	Other		1.90 (0.87, 4.16)		0.68 (0.31, 1.50)		9 .50 3 1.66, 3.76)		1.27 (0.95, 1.68)
26 27	Sex						simi		
28	Men		1.00		1.00		1.00		1.00
29	Women		0.48 (0.26, 0.87)		2.32 (1.12, 4.80)		<u>8</u> .67 . 0.45, 0.99)		1.33 (1.02, 1.73)
30	Age		0.99 (0.96, 1.02)		0.98 (0.95,1.02)		<u>¥</u> .00, 4 0.98, 1.02)		0.97 (0.96, 0.99)
31	Education						202 ogi		
33	Primary		1.00		1.00		ອີ້ <u>ສ</u> 1.00		1.00
34	Secondary		0.85 (0.41, 1.78)		1.43 (0.53, 3.88)		0.6620.41, 1.04)		0.90 (0.61, 1.31)
35 36	Tertiary		0.50 (0.18, 1.37)		0.97 (0.26, 3.65)		0.35 3 0.18, 0.66)		0.75 (0.47, 1.20)
37	Job status						e B		
38	Unemployed						bi 1.00		1.00
39	managers/professionals		1.00		1.00		0.56 20.31, 1.02)		2.08 (1.33, 3.25)
40 41 42	technicians/clerical/service occupation		1.51 (0.70, 3.27)		0.63 (0.24, 1.64)		0.61 <u>국</u> 0.37, 0.95) 연		1.99 (1.32, 3.01)
42 43 44 45 46			For peer revi	ew only - http://bmjo	open.bmj.com/site/al	bout/guidelines.xhtr	e de nl e		23

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1 2	skilled/unskilled workers	1.14 (0.45, 2.90)	1.96 (0.64, 5.99)	, दू ⊈:49फ़्20.28, 0.86)	2.17 (1.36, 3.47)
3	Physical Activity			594 <u>2</u>	
4	Never	1.00	1.00	ding 01.00	1.00
6	≤3h/week	0.60 (0.32, 1.15)	0.47 (0.22, 1.00)	8 :64 ² (0.41, 0.99)	0.91 (0.67, 1.22)
7	>3h/week	0.64 (0.31, 1.34)	0.40 (0.16, 1.04)		0.69 (0.50, 0.97)
8	BMI			inse ses i	
9 10	Normal	1.00	1.00	relation 201.00	1.00
11	Overweight	1.55 (0.82, 2.93)	0.61 (0.28, 1.32)	a a b c 0.66 , 1.52)	1.06 (0.80, 1.40)
12	Obese	1.12 (0.52, 2.41)	0.64 (0.25, 1.66)	1 , 7 , 90 ,46, 1.23)	0.84 (0.59, 1.20)
13	Smoking			ext Sup	
14 15	Never	1.00	1.00	and eride 1.00	1.00
16	Current	0.94 (0.51, 1.76)	0.63 (0.26, 1.57)	a f 2 1 0 .73, 1.71)	0.89 (0.65, 1.22)
17	Ex-smokers	0.81 (0.40, 1.63)	1.14 (0.49, 2.66)	9 0.63, 1.50)	0.85 (0.61, 1.18)
18	Alcohol			http://www.inirianalianalianalianalianalianalianali	
19 20	Never	1.00	1.00	Ģ · :	1.00
21	Drink	3.82 (0.78, 18.70)	1.13 (0.19, 6.70)	2 29 2 0.89, 5.90)	1.21 (0.53, 2.77)
22	Ex-drinker	1.29 (0.37, 4.56)	0.45 (0.16, 1.24)	<u>8</u> :29% 0.64, 2.61)	1.10 (0.67, 1.80)
23 24	Sleeping medication	2.61 (0.87, 7.87)	0.00 (0.00, >999.99)	d .61 d 0.78, 3.32)	1.58 (0.75, 3.32)
24 25	Sleep disorder diagnosis	0.99 (0.40, 2.51)	0.83 (0.14, 4.74)	<u><u>3</u></u> .32,0.76, 2.30)	1.04 (0.61, 1.78)
26	Difficulties in sleeping the	1.72 (0.97, 3.04)	0.90 (0.42, 1.93)	± ±35₹1.62, 3.42)	0.62 (0.46, 0.83)
27	night	2 93 (1 30 5 79)			0.71 (0.42, 1.10)
28	Sleepiness	2.83 (1.39, 5.78)	0.88 (0.23, 3.20)	2.45 (1.42, 4.25) 6 5	0.71 (0.42, 1.19)
30 31 32 33 34 35 36 37 38 39 40 41 42	Note. OR: Odds ratio; A0	DR: Ajusted Odds ratio; 95% CI: 9	95% confidence interval.	e 13, 2025 at Agence Bibliographique d chnologies.	24
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		Chronic dise	sesgconditions	5	
Total	0		A 2	≥3	
122 (8.21)	11 (9.02)	13 (10.66)		76 (62.30)	<
118 (7.89)	25 (21.19)	26 (22.03)	(15.25)	49 (41.53)	(
1505) 510 (33.89)	84 (16.63)	79 (15.64)	ແມ່ນ ເມື່ອ ເມື່ອ ເມື່ອ ເມື່ອ ເມື່ອ ເມື່ອ ເມື່ອ ເມື່ອ ເມື່ອ ເມື່ອ ເມື່ອ ເມື່ອ ເມື່ອ ເມື່ອ ເມື່ອ ເມື່ອ ເມື່ອ ເປັນ ເປັນ ເປັນ ເປັນ ເປັນ ເປັນ ເປັນ ເປັນ	249 (49.31)	
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761 (66.06)	232 (30.73)	206 (27.28)		184 (24.37)	
321 (27.86)	103 (32.09)	87 (27.10)	50 (17.45)	75 (23.36)	
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			, 2025		
203 (13.52)	25 (12.38)	34 (16.83)	4 2 4 2 4 2 (21.29)	100 (49.50)	<
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420 (27.98)	133 (31.89)	100 (23.98)	قا 7 گ ر 817.99)	109 (26.14)	
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9						reig	#		
10		Slee	p duration work the	next day (N=1,146-w	vorking)	States of the second se	ration do NOT wor	k the next day (N=1	,501)
11 12		Short	(<6h)	Lon	g (>8h)	ä n Short	 <6h)	Long	; (>8h)
12		OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)	OR (95% Co	AOR (95% CI)	OR (95% CI)	AOR (95% CI)
14	Chronic conditions/diseases					: an	oac		
15	0	1.00	1.00	1.00	1.00	1.00 d e	1.00	1.00	1.00
16 17	1	1.72 (0.76, 3.87)	1.68 (0.72, 3.88)	1.88 (0.84, 4.21)	1.84 (0.79, 4.26)	3.08 (0.65, 14 25	o 2.61 (0.53, 12.95)	0.77 (0.57, 1.05)	0.83 (0.60, 1.14)
18	2	3.22 (1.47, 7.05)	2.89 (1.27, 6.56)	1.99 (0.83, 4.76)	1.87 (0.75, 4.65)	6.03 (1.35, 26	3 3.59 (0.75, 17.23)	0.83 (0.59, 1.15)	1.04 (0.73, 1.49)
19	≥3	4.06 (1.95, 8.43)	2.98 (1.30, 6.87)	0.86 (0.31, 2.43)	0.94 (0.31, 2.89)	17.27 (4.36, 6, 47)	5.38 (1.20, 24.13)	0.65 (0.48, 0.88)	1.06 (0.74, 1.53)
20	Immigration					, A	/bm		
21 22	Luxembourg		1.00		1.00	trai	1.00		1.00
23	Portugal		1.64 (0.88, 3.06)		0.70 (0.25, 1.94)	nin	2.74 (1.02, 7.37)		1.16 (0.77, 1.74)
24	Other		1.90 (0.87, 4.16)		0.68 (0.31, 1.50)	g, a ,	2.90 (1.37, 6.15)		1.16 (0.88, 1.53)
25	Sex					nd s	<u>§</u>		
26 27	Men		1.00		1.00	simi	o 1.00		1.00
28	Women		0.48 (0.26, 0.87)		2.32 (1.12, 4.80)	lar	0.44 (0.21, 0.90)		1.38 (1.06, 1.78)
29	Age		0.99 (0.96, 1.02)		0.98 (0.95,1.02)	tect	1.01 (0.97, 1.05)		0.98 (0.96, 0.99)
30	Education					Inol	- <u>-</u> 		
31 32	Primary		1.00		1.00	ogi	1.00		1.00
33	Secondary		0.85 (0.41, 1.78)		1.43 (0.53, 3.88)	es.	1.00 (0.45, 2.24)		0.98 (0.68, 1.41)
34	Tertiary		0.50 (0.18, 1.37)		0.97 (0.26, 3.65)		a 0.52 (0.16, 1.66)		0.87 (0.55, 1.37)
35	Job status						lenc		
30 37	Unemployed						b 1.00		1.00
38	managers/professionals		1.00		1.00		0.42 (0.13, 1.35)		2.21 (1.42, 3.44)
39	technicians/clerical/service occupation		1.51 (0.70, 3.27)		0.63 (0.24, 1.64)	c c	0.84 (0.37, 1.88)		2.16 (1.44,3.24)
40	skilled/unskilled workers		1.14 (0.45, 2.90)		1.96 (0.64, 5.99)	-	0.17 (0.05, 0.62)		2.35 (1.49, 3.70)
41 42						-			
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Page 29 of 31		В	BMJ Open			
1				pyright,		
2	Physical Activity			inc	5 5 5	
3 4	Never	1.00	1.00	clud	1.00	1.00
5	≤3h/week	0.60 (0.32, 1.15)	0.47 (0.22, 1.00)	ing	0.58 (0.25, 1.33)	0.96 (0.72, 1.28)
6	>3h/week	0.64 (0.31, 1.34)	0.40 (0.16, 1.04)	for	0.79 (0.34, 1.82)	0.74 (0.54, 1.03)
7	BMI				2	
8 Q	Normal	1.00	1.00	nsei S r	1.00	1.00
9 10	Overweight	1.55 (0.82, 2.93)	0.61 (0.28, 1.32)	elat	0.95 (0.44, 2.04)	1.06 (0.80, 1.39)
11	Obese	1.12 (0.52, 2.41)	0.64 (0.25, 1.66)	ed t	0.66 (0.27, 1.59)	0.87 (0.61, 1.23)
12	Smoking					
13	Never	1.00	1.00	Sup	1.00	1.00
14	Current	0.94 (0.51, 1.76)	0.63 (0.26, 1.57)	ade and	1.06 (0.49, 2.30)	0.89 (0.66, 1.20)
16	Ex-smokers	0.81 (0.40, 1.63)	1.14 (0.49, 2.66)	dat	0.70 (80.31, 1.61)	0.85 (0.62, 1.17)
17	Alcohol			a n	-	
18	Never	1.00	1.00	ES)	1.00	1.00
19 20	Drink	3.82 (0.78, 18.70)	1.13 (0.19, 6.70)	., BL	1.39 (0.32, 6.08)	1.02 (0.46, 2.27)
21	Ex-drinker	1.29 (0.37, 4.56)	0.45 (0.16, 1.24)		0.68 (0.22, 2.09)	1.04 (0.65, 1.69)
22	Sleeping medication	2.61 (0.87, 7.87)	0.00 (0.00, >999.99)	ain 'ain	1.72 (0.64, 4.65)	1.46 (0.72, 2.99)
23	Sleep disorder diagnosis	0.99 (0.40, 2.51)	0.83 (0.14, 4.74)	ing,	1.69 (0.76, 3.78)	0.99 (0.60, 1.67)
24 25	Difficulties in sleeping the night	1.72 (0.97, 3.04)	0.90 (0.42, 1.93)	an	6.47 (2.83, 14.80)	0.57 (0.43, 0.77)
25 26	Sleepiness	2.83 (1.39, 5.78)	0.86 (0.23, 3.20)	d sin	1.32 (0.49, 3.57)	0.62 (0.37, 1.01)
27 28	Note. OR: Odds ratio; AOR: A	Ajusted Odds ratio; 95% CI: 95% confi	dence interval.	milar		
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STROBE Statement—Checklist of items that should be included in reports of <i>cross-sectional stu</i>	dies
STRODE Statement Checkinst of items that should be meruded in reports of cross sectional sta	nico

	Item No	Recommendation	Page No
Title and abstract	1	(<i>a</i>) Indicate the study's design with a commonly used term in the title or the abstract	3
		(b) Provide in the abstract an informative and balanced summary of what	3
		was done and what was found	5
Introduction			
Background/rationale 2 Explain the scientific background and rationale for the investigation h		5	
	2	reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of	6
		recruitment, exposure, follow-up, and data collection	
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection	6
		of participants	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders,	6-7
		and effect modifiers. Give diagnostic criteria, if applicable	
Data sources/	8*	For each variable of interest, give sources of data and details of methods	6-7
measurement		of assessment (measurement). Describe comparability of assessment	
		methods if there is more than one group	
Bias	9	Describe any efforts to address potential sources of bias	8, 12
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If	6-8
		applicable, describe which groupings were chosen and why	
Statistical methods	12	(a) Describe all statistical methods, including those used to control for	8
		confounding	
		(b) Describe any methods used to examine subgroups and interactions	
		(c) Explain how missing data were addressed	8
		(d) If applicable, describe analytical methods taking account of sampling	
		strategy	
		(<u>e</u>) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers	6
		potentially eligible, examined for eligibility, confirmed eligible, included	
		in the study, completing follow-up, and analysed	
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical,	Table 2
		social) and information on exposures and potential confounders	and 3
		(b) Indicate number of participants with missing data for each variable of	
		interest	
Outcome data	15*	Report numbers of outcome events or summary measures	8
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted	Table 4
		estimates and their precision (eg, 95% confidence interval). Make clear	
		which confounders were adjusted for and why they were included	

		(b) Report category boundaries when continuous variables were	7-8
	-	categorized	
		(c) If relevant, consider translating estimates of relative risk into absolute	
		risk for a meaningful time period	
Other analyses	17	Report other analyses done-eg analyses of subgroups and interactions,	
		and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential	11
		bias or imprecision. Discuss both direction and magnitude of any potential	
		bias	
Interpretation	20	Give a cautious overall interpretation of results considering objectives,	9-11
		limitations, multiplicity of analyses, results from similar studies, and other	
		relevant evidence	
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study	6
		and, if applicable, for the original study on which the present article is	
		based	

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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SLEEP DURATION AND MULTIMORBIDITY IN LUXEMBOURG. RESULTS FROM THE EUROPEAN HEALTH EXAMINATION SURVEY IN LUXEMBOURG, 2013-2015

Journal:	BMJ Open
Manuscript ID	bmjopen-2018-026942.R2
Article Type:	Research
Date Submitted by the Author:	23-Jul-2019
Complete List of Authors:	Ruiz-Castell, Maria; Luxembourg Institute of Health, Epidemiology and Public Health Research Unit, Department of Population Health Makovski, Tatjana; Luxembourg Institute of Health, Epidemiology and Public Health Research Unit, Department of Population Health; Care and Public Health Research Institute, Maastricht University, Department of Family medicine Bocquet, Valéry; Luxembourg Institute of Health, Competence Center in Methodology and Statistics, Department of Population Health Stranges, Saverio; , Schulich School of Medicine & Dentistry, Western University, Department of Epidemiology & Biostatistics; Schulich School of Medicine
Primary Subject Heading :	Epidemiology
Secondary Subject Heading:	Public health, Epidemiology
Keywords:	EPIDEMIOLOGY, PUBLIC HEALTH, SLEEP MEDICINE

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SLEEP DURATION AND MULTIMORBIDITY IN LUXEMBOURG. RESULTS FROM
THE EUROPEAN HEALTH EXAMINATION SURVEY IN LUXEMBOURG, 2013-2015
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Word count: 3170; Abstract: 162; Tables: 4; References: 44
Funding: The study was funded by the Directorate and Ministry of Health and the Luxembourg Institute of Health.
Conflict of interest: The authors declare that they have no conflict of interest.

Contributorship statement

MRC and SS conceptualized and designed the study. MRC and VB performed the statistical analysis. MRC, SS and T.T.M interpreted the data. MRC drafted the article. SS supervised the study. All authors participated in the revision of the article. All authors contributed to and have approved the final manuscript.

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Abstract

Objectives: We estimated the prevalence of short sleep duration and multimorbidity in Luxembourg, and assessed whether sleep duration was associated with multimorbidity after adjusting for socio-demographic and behavioral characteristics.

Design: Cross-sectional study.

Participants: Data from 1508 Luxembourg residents (48% men and 52% women) aged 25 to 64 years came from the European Health Examination Survey 2013-2015.

Outcome measures: Short sleep duration and multimorbidity.

Results: Participants reported sleeping 6.95hrs/night during work days, nearly 1hr less than during non-work days (7.86hrs/night). Nearly half of participants reported having been diagnosed with \geq 2 chronic conditions/diseases. Short sleep duration was associated with the number of chronic conditions (OR: 4.65, 95% CI: 1.48, 14.51, OR: 7.30, 95% CI: 2.35, 22.58, OR: 6.79, 95% CI: 2.15, 21.41 for 1, 2, and \geq 3 chronic conditions/diseases, respectively), independently of socioeconomic and behavioral characteristics.

Conclusions: Health promotion programs should aim at improving and promoting healthy lifestyles among the general population to improve sleep habits as well as decrease multimorbidity in middle-aged adults.

Keywords: Sleep duration; multimorbidity; chronic diseases; Luxembourg; European Health Examination Survey

Strengths and limitations of this study

- This is the first study in Luxembourg on the prevalence of sleep patterns, with a focus on short and long sleep duration, and their relationship with multimorbidity.
- The present study was drawn from the European Health Examination Survey in Luxembourg (EHES-LUX), a representative cross-sectional population-based survey.
- Limitations of the present study include the subjective self-reported measure of sleep duration, the cross-sectional design of the study (not allowing to establish a causal link), and the low participation rate.

Data sharing statement: Extra data can be accessed by emailing Dr Laetitia Huiart, Head of the Population Health Department, LIH (laetitia.huiart@lih.lu) and the Principal Investigator of EHES-LUX2013-2015, Dr Maria Ruiz-Castell (maria.ruiz@lih.lu) and fill out a request form.

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Introduction

A healthy lifestyle includes healthy sleep habits. Sleep patterns influence several physiological and psychological processes such as inflammation, immune responses, mental and cognitive function, glucose regulation and energy balance (1-3). Short sleep duration, poor sleep quality, and sleeprelated disorders can result in sleep deficiency and impact on individual health (4). According to the Centers for Disease Control and Prevention (CDC), insufficient sleep is associated with health problems such as chronic diseases, poor quality of life, mental health, risk of accidents, and lower productivity at work(5)[5] (5). Adequate sleep duration is one of the dimensions needed for good sleep health (6). The American Academy of Sleep Medicine and Sleep Research Society considers that for an adult an average sleep duration of at least 7 hours per night should be recommended (4). However, a high percentage of the population sleeps less than the recommended 7 hours (7). Several factors may affect sleep such as physical activity patterns or eating behaviors, but also socioeconomic factors including job status, marital status and ethnicity (8, 9). Studies have observed an association of lower education and unemployment with both short and long sleep duration (10, 11), while factors such as physical activity and healthy diet seem to improve sleep quality (12, 13). Moreover, diet intake (energy and total fat intake) and nutrients seem to be associated with both short and long sleep duration through multifactorial factors including eating patterns (e.g., time and hours of intake) and variations in hormones related to appetite, such as leptin (14).

Epidemiologic data suggest an association of abnormal sleep duration and poor sleep quality with cardiometabolic problems (e.g. hypertension, diabetes, obesity, cardiovascular diseases), mental disorders (e.g. depression), and mortality (15-18). The observed relationship between short sleep duration and mortality would be especially critical in adults under 65 years of age (18). Few studies so far have focused on possible relationships between sleep patterns and multimorbidity (19, 20). Multimorbidity is defined as the presence of two or more chronic diseases in the same individual (21), and is associated with disability, functional decline, frailty, poor quality of life and mortality (22). In the context of ageing societies, multimorbidity is an increasing global phenomenon (23); its occurrence usually increases with age, though a large proportion of individuals younger than 65 are also affected (24). Definitions of multimorbidity vary, however, and the prevalence differs based on changing definitions, which in turn present significant challenges when attempting to compare results between populations and studies (22).

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The aim of the present study was to estimate the prevalence of short sleep duration and multimorbidity in Luxembourg, as well as to assess whether sleep duration was associated with multimorbidity after adjusting for socio-demographic and behavioral characteristics.

Methods

Study population and recruitment

Data were drawn from the European Health Examination Survey in Luxembourg (EHES-LUX). EHES-LUX is a representative cross-sectional population-based survey carried out by the Luxembourg Institute of Health with the objectives of assessing the health status of the population of the Grand-Duchy of Luxembourg, develop national and European health indicators, identify the needs of the population, and evaluate health behaviors. EHES-LUX was conducted between February 2013 and January 2015. Individuals were randomly selected in a one-stage sampling procedure from the national health insurance registry (95% social coverage). Institutionalized individuals (e.g. hospitals, elderly homes) were not included. A total of 1508 residents (excluding 21 pregnant women) of Luxembourg aged 25 to 64 participated in the survey (participation rate of 24.1%) (25). Of them, 7 participants did not reported their sleep habits. A total of 1501 participants had information on multimorbidity and sleep habits. Participants signed an informed consent and were interviewed by trained nurses who also conducted medical examinations. Questionnaires included several health modules (e.g. sleep and nutritional habits, health care, working and living conditions) as well as demographic and socioeconomic characteristics. Medical examinations included measurements such as blood pressure and anthropometry. Sampling weights were calculated to be generalized to the population of Luxembourg in terms of age, sex and district of residence. The study national research ethics committee (Comité national d'éthique de Recherche-CNER) approved the study and it was notified to the Luxemburgish National Commission for Data Protection.

Patient involvement

Participants were not involved in the development of the research question, study design, recruitment or the conduction of the study. Upon request, results from the medical examination were forwarded to the study participants and their medical doctors. General results were presented to the general public in a range of dissemination activities.

Sleep

Sleep duration was assessed using two questions: 1) "How many hours do you normally sleep at night when you have to work the next day?", and 2) "How many hours do you normally sleep at

night when you don't have to work the next day?". We calculated a weighted average of sleep duration for each participant by assigning weights of 5/7 to working days and 2/7 to non-working days (26, 27). Responses were categorized as short sleep duration (<6hrs/night), medium sleep duration (6-9hrs/night), and long sleep duration (>9hrs/night), in line with previously published studies and sleep time duration recommendations (4, 8, 28).

Sleep disorders and sleep quality were assessed with the following variables: difficulty in sleeping the night, diagnosis of sleep disorders, sleep medication and sleepiness. Difficulty in sleeping the night was assessed based on the question "Do you have difficulties in sleeping through the night?". Diagnosis of sleep disorders was assessed using the question "Have you ever been told by a doctor or another health professional that you have a sleep disorder?". Sleep medications were assessed using the question "In the past 2 weeks, have you used other types of medicines that were prescribed to you ?". The question was aimed at answering about several medications including sleep tablets. Sleepiness was defined as a score of ≥ 11 on the Epworth Sleepiness Scale (29). *Multimorbidity*

Participants were asked if they ever had a chronic disease or condition diagnosed by a medical doctor (e.g., hypertension, high cholesterol, diabetes, cardiovascular diseases, stomach or duodenal ulcer, cirrhosis or other liver disease, urinary incontinence, kidney problems, chronic back or neck disorder, rheumatoid arthritis, arthrosis, osteoporosis, cancer, severe headache as migraine or chronic anxiety). Cardiovascular diseases included coronary heart disease or angina pectoris, heart attack or its chronic consequences, stroke or its chronic consequences. Based on this information, the variable "ever being diagnosed with a chronic disease or condition" was generated with four categories: 0, 1, 2 and \geq 3 chronic disease or condition. Multimorbidity was defined as having two or more chronic diseases or conditions diagnosed by a medical doctor.

Explanatory variables

Sociodemographic characteristics included age, sex and immigration status. As Portuguese are the largest immigrant community in Luxembourg, immigration status was categorized in nonimmigrant, immigrant born in Portugal, and immigrant born in other countries. Socioeconomic status included education (primary, secondary and tertiary education completed) and job status (unemployed; managers/professionals; technical/clerical/service occupation; skilled/unskilled workers).

Lifestyles included smoking (never; current; ex-smokers), alcohol consumption (never; ex-drinkers; drinkers), physical activity (never; \leq 3hrs/week of sports, fitness, and/or recreational activities which lasted at least 10 consecutive minutes; >3hrs/week of sports, fitness, and/or recreational

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activities which lasted at least 10 consecutive minutes), and vegetable and fruit consumption (< 1 portion/ day, 1–4 portions/day, \geq 5 portions/day). Weight and height were measured by trained nurses and used to calculate body mass index (BMI; kg/m²). BMI was categorized as normal body weight (<25 kg/m²), overweight (25-29.99 kg/m²) and obesity (\geq 30kg/m²).

Statistical data analysis

Means and frequencies were used for descriptive purposes. We calculated the prevalence of sleep disorders, short and long sleep duration, chronic conditions/diseases and multimorbidity. Percentages did not include missing values. A chi-square test (χ 2) or a two-way analysis of variance (ANOVA) were used to analyze associations between the prevalence of sleep duration and covariates and the prevalence of multimorbidity and covariates. The association between sleep duration and chronic conditions/diseases was assessed using multinomial logistic regression models (reference for sleep duration was 6-9hrs per night) adjusted for sociodemographic characteristics, behavioural risk factors (e.g. BMI, smoking, alcohol consumption and physical activity), as well as for measures of sleep disorders and sleep quality We considered a P<0.05 statistically significant. To be representative of the population and avoid biased estimates, the observations were weighted. Participants with missing values on sleep habits and or murltimorbidity were not included in the present analysis. Analyses were performed using STATA 14.0 and and SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Table 1 shows the prevalence of chronic conditions/diseases, multimorbidity, sleep duration and sleep disorders. Nearly half of participants reported being diagnosed with two or more chronic conditions/ diseases, and nearly a third of participants reported being diagnosed with three or more chronic conditions/diseases. The most prevalent diseases were chronic low back disorder or other chronic back defect followed by hypercholesterolemia, arthrosis and hypertension. More than 8% of participants were diagnosed with a sleep disorder, a third reported having difficulties in sleeping through the night and 4.3% reported taking sleep medication. Participants reported sleeping 7.86hrs/night when they did not have to work the next day, nearly one hour more than when they had to work the next day (6.95hrs/night). Moreover, 5.13% of the Luxembourg population reported sleeping less than 6 hours/night and 1.79% reported sleeping more than 9hours/night. Participant characteristics by chronic conditions/diseases are shown in **Table 2**. More men than women presented three or more chronic diseases. Higher number of chronic diseases/conditions increased with age: those aged 55 to 64 presented more chronic conditions than non-immigrants and

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other immigrants. Participants being less educated and unemployed presented more chronic conditions compared to those employed and highly educated. Participants being less physically active and with obesity presented more chronic conditions/diseases than those being more physically active and with a lower BMI.

Participant characteristics by sleep duration are shown in **Table 3**. More men than women reported a medium sleep duration. Short sleep duration was more likely among immigrants born in Portugal, participants with lower education and skilled/unskilled workers. Short sleep duration was less common among those being physically active and with a BMI less than 25 Kg/m².

Table 4 shows results from multinomial logistic regression analyses examining the association between sleep duration and chronic conditions/diseases, and adjusted by sociodemographic characteristics, behavioural risk factors, socioeconomic position, as well as for measures of sleep disorders and sleep quality. Participants sleeping less hours (<6h) were 7.30and 6.79 times as likely to report having 2 and 3 or more chronic conditions after adjusting for covariates. In fully adjusted models, the strength of associations between sleep duration and multimorbidity remained statistically significant.

Estimates of sleep problems and chronic conditions are presented in **Table S1**. The prevalence of sleep problems was high, with one out of three participants having difficulties in sleeping the night through and nearly 8% of participants diagnosed with a sleep disorder. In all cases, the percentage of participants with sleep problems increased with the number of chronic diseases.

Discussion

Results from the present nationwide population-based study show for the first time in Luxembourg the prevalence of sleep patterns, with a focus on short and long sleep duration, as well as their association with multimorbidity. The prevalence of short sleep duration in Luxembourg is 5.13%. Results are similar to those observed internationally (28, 30), although in countries such as Brazil the prevalence of short sleep duration was nearly 22% (31), and in Portugal values of short sleep duration defined as \leq 5hrs reached up to 20% in 2015-2016 (32). However, in the present study the age range from 25 to 64 years must be considered since it does not include adults over 65 years old who generally sleep less hours. This means that the overall prevalence of the Luxembourg population sleeping less than the recommended hours is likely to be higher, when including older adults as well.

Multimorbidity is highly prevalent in Luxembourg, especially when taking into account the fact that the study population was up to 65 years, which represents a relatively young population, as

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multimorbidity prevalence naturally increases with age (22). Nearly half of participants had two or more chronic diseases and 31% had three or more chronic diseases/conditions.

In our study, we observed that short sleep duration was significantly associated with the number of chronic conditions independently of socioeconomic, behavioral characteristics and sleep disorders. Our results are in line with those from other studies that observed an association between sleep and number of chronic diseases, although previous studies have been usually performed in populations of older adults (e.g. over 50 years old) (19, 33). As observed by Koyanagi et al., sleep problems increase with the number of diseases in both low and high income countries independent of their economic development (19). These associations could explain the observed relationship between sleep duration (under the recommended 7 hours) and poor sleep quality with mortality, even among adults younger than 65 years old (18). It is not clear if sleep problems are a consequence of chronic diseases (e.g. conditions affecting sleep) or part of the cause (sleep predispose the individual to more diseases or exacerbates the symptoms), although it is plausible that both sleep problems and chronic diseases are linked by a bidirectional association (34). In terms of potential mechanisms to corroborate the biological plausibility of the link between short sleep duration and multimorbidity, reduced sleep duration has been associated with a number of chronic conditions, including cardiometabolic and neurodegenerative disease, cancer, musculoskeletal disorders, and mental problems (15, 16). Pain caused by certain chronic diseases, as well as the medications/treatments used and mood disorders (e.g. anxiety, depression) could have an impact on sleep (35). In turn, sleep disturbances could worsen the health status. Experimental evidence corrobores the plausibility of deleterious effects of lack of sleep on endocrine, immune, neurovegetative and inflammatory pathways (1-3). Sustained short sleep duration could be related to chronic conditions through its impact on the circadian rhythm and its association with hormonal (e.g. insulin resistance and decrease leptin) and autonomic nervous system changes (increase the activity of the sympathetic nervous system) (36). Although both reduced sleep duration and the number of chronic diseases increase with age, and are more prevalent in older adults, our study shows that the prevalence is also high in adults under 65 and the association begins much earlier. It is therefore necessary to detect these problems earlier in order to improve individual health and general wellbeing and reduce mortality, particularly in the context of ageing populations burdened by the accumulation of multiple chronic conditions over time. In our study, we also observed that short sleep duration was associated with immigration status. The relationship between immigration status and sleep patterns remains unclear, possibly related to stress linked to the migratory process, cultural adaptation, or working conditions in the host country (37, 38). In our study, Portuguese immigrants were more

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likely to sleep less than 6h per night during workdays and less than 7h during non-working days. Portuguese are the largest immigrant community in Luxembourg, accounting for 16% of the 46% immigrant population living in Luxembourg. Compared to Luxembourgish natives, Portuguese immigrants have a lower socioeconomic status (39) (including income, education and employment) which could partly explain why they have a greater likelihood of being short sleepers. However, after calculating the weight average for sleep hours and adjusting for sleep disorders, the association with short sleep duration disappeared.

In our study, long sleep duration was more common in women. This was in line with other studies showing that men usually sleep less hours, although women reported having more sleep problems (40). However, this relationship is complex and could depend on family composition (e.g. single parents have shorter sleep duration, particularly women) (41).

In addition, short sleep suration often cluster with other behavioral risk factors such as cigarette smoking, heavy drinking, and physical inactivity, which may in turn increase the risk of chronic disease. However, in our study, we only observed an association between physical activity and short sleep duration, with no association observed between short sleep duration and smoking or alcohol consumption. Regular physical activity would reduce the likelihood of short and/or long sleep duration and maintain an optimal duration. Studies have observed an association between physical activity and sleep, improving quality of sleep, sleep efficiency, and total sleep time (12, 42). Limitations of the present study include the subjective measure of sleep duration (self-reported number of hours of sleep) instead of an objective measure (e.g. actigraphy, polysomnography). However, in the absence of an objective measure, there is a moderate correlation between objective and subjective measurements, a correlation that is high during weekdays possibly due to routines (43), but may be attenuated based on certain individual characteristics (e.g. presence of conditions such as depression, sociodemographic characteristics) (44). Other limitations include the fact that we did not include other sleep problems such as insomnia or sleep apnea nor environmental factors such as noise, traffic or commuting, all of which could affect sleep duration. In addition, multimorbidity was also self-reported based on a restricted list of diseases in the questionnaire, therefore participants may have not reported additional conditions, which may produce a possible underestimation of multimorbidity prevalence. Information on non-responders was not available, and despite being a representative sample of the Luxembourg population (in terms of age, sex and district), we could not determine the possibility of a non-response bias. In our study, we only included the number of sleep hours during the night, without including nap times. Moreover, we did not have information on the number of days that participants were working and assumed that most

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were working 5 days per week. Finally, it should be noted that the study design (cross-sectional) does not allow to ascertain a causal link between sleep and multimorbidity; in addition, the low participation rate may affect the generalizability of our results.

This is the first study in Luxembourg on the prevalence of sleep patterns, with a focus on short and long sleep duration, and their relationship with multimorbidity. Short sleep duration, having difficulties in sleeping the night through, sleep disorders and sleeping medication represent a neglected public health problem, especially when associated with a number of chronic conditions and diseases, thus producing a negative impact on the wellbeing and general health status of the population. Sleep hygiene should be considered as an additional important health behavior along with diet, smoking and physical activity, both in clinical and public health protect. As both sleep problems and multimorbidity are highly prevalent in Luxembourg, health promotion programs should be developed to improve and promote healthy lifestyles among the general population to improve sleep habits as well as decrease multimorbidity.

Acknowledgements

We are grateful to the population of Luxembourg and to all the EHES-LUX team who have contributed to this study. We would like to thank Kuemmerle A, Barre J, Dincau M, Delagardelle C, Michel G, Schlesser M, Mormont D, Chioti A, Gantenbein M, Lieunard C, Columeau A, Kiemen M, Weis J, Ambrozet G, Billy A, Larcelet M, Marcic D, Gauthier C, and Viau-Courville M for their valuable contributions.

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Table 1. Chronic diseases/conditions, multimorbidity and sleep: European Health Examination Survey in Luxembourg (N =1508).

	N (%) / Mean \pm SD
Hypertension	250 (16.59)
High cholesterol	458 (30.39)
Diabetes	69 (4.58)
Coronary heart disease or angina pectoris	26 (1.73)
Myocardial infarction or chronic consequences of myocardial infarction	14 (0.93)
Stroke or chronic consequences of stroke	11 (0.73)
Stomach or duodenal ulcer	81 (5.37)
Cirrhosis of the liver or other liver disease	46 (3.05)
Urinary incontinence, problems in controlling the bladder	74 (4.91)
Kidney problems	108 (7.17)
Chronic low back disorder or other chronic back defect	489 (32.47)
Chronic neck disorder or other chronic neck defect	246 (16.32)
Rheumatoid arthritis	88 (5.85)
Arthrosis	292 (19.38)
Osteoporosis	44 (2.92)
Cancer	54 (3.59)
Severe headache such as migraine	271 (17.98)
Chronic anxiety	98 (6.50)
Depression	204 (13.54)
Number of chronic diseases	
0	405 (27.00)
1	362 (24.13)

≥ 2 (multimorbidity)	733 (49.00)
≥ 3	465 (31.00)
Sleep	
Diagnosis of sleep disorder	122 (8.21)
Sleepiness ^a	118 (7.89)
Have difficulties in sleeping the night through	510 (33.89)
Sleeping medication	64 (4.26)
Sleep duration	
Total sleep duration (N=1,170)	
<6hrs/night	60 (5.13%)
6h-9hrs/night	1089 (93.08%)
>9hrs/night	21 (1.79%)
Hours when you have to work the next day (N=1,152-working)	6.95±0.97
Hours when you don't work the next day (N=1,501)	7.86±1.30
N=number, SD=standard deviation	
^a Measured with Epworth Sleepiness Scale	
Missing values ranged from 2 to 13 observations	

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Survey in Luxembourg (N =1	508).					
		Chronic conditions/diseases				
- } -	0	1	2	<u>≥</u> 3	Pa	
5 Sex						
Men	199 (27.72)	199 (27.72)	143 (19.92)	177 (24.65)	< 0.001	
Women	206 (26.34)	163 (20.84)	125 (15.98)	288 (36.83)		
Age						
4 5 25-34	130 (43.62)	86 (28.86)	48 (16.11)	34 (11.41)	< 0.001	
35-44	156 (34.29)	119 (26.15)	69 (15.16)	111 (24.40)		
45-54	83 (18.16)	111 (24.29)	98 (21.44)	165 (36.11)		
55-64	36 (12.41)	46 (15.86)	53 (18.28)	155 (53.45)		
Immigration						
Luxembourg	184 (23.44)	197 (25.10)	144 (18.34)	260 (33.12)	< 0.001	
Portugal	52 (23.85)	42 (19.27)	45 (20.64)	79 (36.24)		
Other	169 (34.00)	123 (24.75)	79 (15.90)	126 (25.35)		
Education						
Primary	68 (18.38)	75 (20.27)	64 (17.30)	163 (44.05)	< 0.001	
Secondary	133 (23.05)	142 (24.61)	106 (18.37)	196 (33.97)		
Tertiary	203 (37.04)	145 (26.46)	97 (17.70)	103 (18.80)		
Job						
Not working	58 (16.67)	56 (16.09)	58 (16.67)	176 (50.57)	< 0.001	
managers/professionals	168 (35.59)	138 (29.24)	73 (15.47)	93 (19.70)		

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technicians/clerical/service occupation	119 (29.38)	89 (21.98)	76 (18.77)	121 (29.88)	
skilled/unskilled workers	60 (21.90)	79 (28.83)	61 (22.26)	74 (27.01)	
Smoking					
0 Never 1	239 (29.25)	209 (25.58)	145 (17.75)	224 (27.42)	0.026
² ₃ Current	90 (26.01)	75 (21.68)	63 (18.21)	118 (34.10)	
4 5 Ex-smoker	74 (22.09)	78 (23.28)	60 (17.91)	123 (36.72)	-
7 Alcohol					
9 Never	30 (27.78)	21 (19.44)	20 (18.52)	37 (34.26)	0.055 ද
¹ ₂ Drinkers	365 (27.53)	328 (24.74)	234 (17.65)	399 (30.09)	y,
3 4 Ex-drinkers	8 (12.50)	13 (20.31)	14 (21.88)	29 (45.31)	
⁶ Fruits and vegetables consumption					g
<pre>8 9 <1 portion/day</pre>	126 (27.39)	112 (24.35)	87 (18.91)	135 (29.35)	0.597
1 1-4 portions/day	223 (27.81)	183 (22.82)	142 (17.71)	254 (31.67)	
$\frac{3}{4} \geq 5$ portions/day	55 (23.31)	66 (27.97)	39 (16.53)	76 (32.20)	
⁵ ₆ Physical Activity					
8 Never	130 (21.35)	133 (21.84)	125 (20.53)	221 (36.29)	<0.001
0 <=3h/week	151 (29.84)	130 (25.69)	77 (15.22)	148 (29.25)	ÿ
$^{2}_{3}$ >3h/week	121 (31.84)	98 (25.79)	65 (17.11)	96 (25.26)	2
4 5 BMI	25.27 ± 4.06	26.04 ± 4.89	26.66 ± 4.96	28.07 ± 5.56	<0.001
6 7 <25	212 (33.02)	169 (26.32)	112 (17.45)	149 (23.21)	<0.001
9 25-30	152 (27.39)	131 (23.60)	100 (18.02)	172 (30.99)	
$\frac{1}{2} >= 30$	41 (13.62)	61 (20.27)	55 (18.27)	144 (47.84)	
Values are: numbers (%) for cates Values are: numbers (%) for cates variables. BMI: Body Mass Index.	gorical variable ^a χ2 test for cate	es and means±sta	andard deviations, t-test for con	on for continuo tinuous variable	us es.

Missing values ranged from 8 to 13 observations.

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3	Table 3. Particip
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5	Luxembourg.
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13	Sex
14	Men
15	Women
16 17	Age
17	25.24
19	25-54
20	35-44
21	45-54
22	55-64
23	Immigration
24	Luxembourg
25	
20 27	Portugal
27 28	Other
29	Education
30	Primary
31	Secondary
32	Tortiory
33	Tertiary
34	Job
35	Not working
30 27	managers/prof
38	technicians/cle
39	skilled/unskille
40	SKIIICU/ UIISKIII C
41	Smoking
42	Never
43	Current
44	Ex-smoker
45 46	Alcohol
40 47	Never
48	
49	Drinkers
50	Ex-drinkers
51	Fruits and vegeta
52	<1 portion/day
53	1-4 nortions/de
54	5 nortions/de
55 56	≤ 3 portions/da
50 57	Physical Activity
58	Never
59	<=3h/week
60	

ant's characteristics by Sleep duration: European Health Examination Survey in

		Sleep dur	ation	
		(N=1,1)	70)	
	<6hrs/night	6-9hrs/night	>9hrs/night	Pa
Sex				
Men	35 (5.85)	559 (93.48)	4 (0.67)	0.007
Women	25 (4.37)	530 (92.66)	17 (2.97)	
Age	44.88 ± 8.53	43.00 ± 9.04	42.11 ± 10.43	0.26
25-34	8 (3.03)	251 (95.08)	5 (1.89)	0.50
35-44	22 (5.53)	367 (92.21)	9 (2.26)	
45-54	22 (5.70)	360 (93.26)	4 (1.04)	
55-64	8 (6.56)	111 (90.98)	3 (2.46)	
Immigration				
Luxembourg	23 (3.75)	581 (94.78)	9 (1.47)	0.02
Portugal	17 (10.00)	151 (88.82)	2 (1.18)	
Other	20 (5.17)	357 (92.25)	10 (2.58)	
Education				
Primary	21 (8.90)	212 (89.83)	3 (1.27)	0.007
Secondary	25 (5.81)	395 (91.86)	10 (2.33)	
Tertiary	14 (2.80)	478 (95.60)	8 (1.60)	
Job				
Not working	0 (0.00)	19 (95.00)	1 (5.00)	0.05
managers/professionals	15 (3.18)	450 (95.34)	7 (1.48)	
technicians/clerical/service occupation	23 (5.64)	376 (92.16)	9 (2.21)	
skilled/unskilled workers	22 (8.15)	244 (90.37)	4 (1.48)	
Smoking				
Never	32 (4.79)	625 (93.56)	11 (1.65)	0.84
Current	15 (5.60)	249 (92.91)	4 (1.49)	
Ex-smoker	13 (5.58)	214 (91.85)	6 (2.58)	
Alcohol				
Never	4 (5.63)	63 (88.73)	4 (5.63)	0.03
Drinkers	52 (4.89)	996 (93.61)	16 (1.50)	
Ex-drinkers	4 (11.43)	30 (85.71)	1 (2.86)	
Fruits and vegetables consumption				
<1 portion/day	19 (5.04)	351 (93.10)	7 (1.86)	0.72
1-4 portions/day	36 (5.76)	578 (92.48)	11 (1.76)	
≥5 portions/day	5 (2.99)	159 (95.21)	3 (1.80)	
Physical Activity				
Never	36 (7.81)	413 (89.59)	12 (2.60)	0.003
<=3h/week	12 (2.86)	401 (95.48)	7 (1.67)	

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>3h/week	12 (4.15)	275 (95.16)	2 (0.69)	
BMI	27.57 ± 4.80	26.36 ± 4.87	25.27 ± 6.53	0.10
<25	16 (3.16)	477 (94.27)	13 (2.57)	0.003
25-30	30 (6.80)	409 (92.74)	2 (0.45)	
>=30	14 (6.31)	202 (90.99)	6 (2.70)	

Values are: numbers (%) for categorical variables and means±standard deviation for continuous variables. BMI: Body Mass Index. NA: not available.

 $^{a}\chi^{2}$ test or Fisher's exact test for categorical variables, ANOVA for continuous variables.

to beet teries only

BMJ Open **Table 4**. Results of multinomial logistic regression measuring the association between sleep duration and cloconic conditions in models adjusted

for participants sociodemographic characteristics, behavioural risk factors and measures of sleep disorders and sleep quality: European Health Examination Survey in Luxembourg (N=1,170).

N			019. ated	
		Sleep du	uration of the	
	Short	(<6h)	ex en se Long	g (>9h)
	OR (95% CI)	AOR (95% CI)	OR (95% (ei)	AOR (95% CI)
Chronic conditions/diseases			ed fr eur c	
0	1.00	1.00	1. A	1.00
1	4.55 (1.49-13.88)	4.65 (1.48-14.51)	2.94 (0. § 87 9)	2.66 (0.80-8.85)
2	7.65 (2.55-22.91)	7.30 (2.35-22.58)	0.86 (0.454)	0.82 (0.14-4.67)
≥3	9.45 (3.25-27.41)	6.79 (2.15-21.41)	1.27 (0.3) -524)	0.73 (0.13-3.88)
Immigration			rain ope	
Luxembourg		1.00	ing	1.00
Portugal		1.66 (0.71-3.89)	, an	0.86 (0.14-5.08)
Other		1.96 (1.00-3.82)	d si m	1.80 (0.61-5.31)
Sex			mil: on	
Men		1.00	- Ju	1.00
Women		0.48 (0.24-0.93)	ne) echi	4.57 (1.22-17.09)
Age		0.99 (0.95-1.02)	nolc	0.98 (0.93-1.04)
Education			2028 ogie	
Primary		1.00	s. at	1.00
Secondary		0.77 (0.35-1.71)	Age	1.79 (0.36-8.85)
Tertiary		0.36 (0.12-1.11)	enco	1.07 (0.14-7.85)
Job status			е В	
Unemployed			blio	
managers/professionals		1.00	ogra	1.00
technicians/clerical/service occupati	on	1.17 (0.50-2.68)	lphiqu	1.47 (0.40-5.39)
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skilled/unskilled workers Physical Activity Never ≤3h/week >3h/week BMI	0.96 (0.36-2.55) 1.00 0.47 (0.22-0.98) 0.73 (0.34-1.56))18-026942 on 21 / ight, including for	2.00 (0.33-11.91) 1.00 0.33 (0.10-1.09)
Physical Activity Never ≤3h/week >3h/week BMI	1.00 0.47 (0.22-0.98) 0.73 (0.34-1.56)	942 on 21 / luding for	1.00 0.33 (0.10-1.09)
Never ≤3h/week >3h/week BMI	1.00 0.47 (0.22-0.98) 0.73 (0.34-1.56)	on 21 / ing for	1.00 0.33 (0.10-1.09)
≤3h/week >3h/week BMI	0.47 (0.22-0.98) 0.73 (0.34-1.56)	for	0.33(0.10-1.09)
>3h/week BMI	0.73 (0.34-1.56)		()
BMI		use	0.23 (0.04-1.08)
		ust isei is re	
Normal	1.00	201 gne elat	1.00
Overweight	1.49 (0.74-2.98)	9. E ed t	0.29 (0.06-1.39)
Obese	0.94 (0.40-2.16)	io te	1.25 (0.35-4.40)
Smoking		sup stra	
Never	1.00	ade erie and	1.00
Current	0.92 (0.46-1.84)	d fr dat	1.13 (0.30-4.15)
Ex-smokers	0.88 (0.42-1.86)	a m	3.30 (0.98-11.00)
Alcohol consumption		ES)	
Never	1.00		1.00
Drink	2.21 (0.39-12.48)	Att	0.60 (0.05-7.13)
Ex-drinker	1.14 (0.31-4.10)	aini	0.32 (0.07-1.44)
Sleeping medication	1.89 (0.56-6.35)	n.br	NA
Sleep disorder diagnosis	1.39 (0.55-3.49)	ano ^{nj.} c	NA
Difficulties in sleeping the night	2.12 (1.14-3.92)	d si	1.34 (0.45-3.90)
Sleepiness	3.37 (1.57-7.21)	mila	1.09 (0.20-5.77)
Difficulties in sleeping the night Sleepiness Note. OR: Odds ratio; AOR: Ajusted Odds ratio; 95% CI: 95% c	2.12 (1.14-3.92) 3.37 (1.57-7.21) onfidence interval.	om/ on June 13, 20; d similar technologi	1.34 (0.45- 1.09 (0.20-



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					convrict		
SupplementaryTable S1. Sleep problem	ns and duration by cl	hronic condition	ns/diseases: Eu	ropean Health	Exomination S	Survey in Luxe	emb
				Chronic dise	ses seconditions	8	
Variables		Total	0	1	for lise	≥3	
Diagnosis of sleep disorder (N=1486)		122 (8.21)	11 (9.02)	13 (10.66)		76 (62.30)	<
Sleepiness		118 (7.89)	25 (21.19)	26 (22.03)	199 (15.25)	49 (41.53)	(
Have difficulties in sleeping the night th	rough (N=1505)	510 (33.89)	84 (16.63)	79 (15.64)	support (18.42)	249 (49.31)	
Sleep duration					ded fro		
Num sleep hours when you have to w	ork the next day				om http ABES)		
(N=1,152-working)				y I	a Altr		
<6h		70 (6.08)	10 (14.29)	13 (18.57)	2000 (27.14)	28 (40.00)	(
6-7h		761 (66.06)	232 (30.73)	206 (27.28)	183 (17.62)	184 (24.37)	
≥8h		321 (27.86)	103 (32.09)	87 (27.10)	5 (17.45)	75 (23.36)	
Num sleep hours when you do NOT v	work the next day				une 13		
(N=1,501)					, 2025 .		
≤6h		203 (13.52)	25 (12.38)	34 (16.83)	4 2 4 2 4 2 (21.29)	100 (49.50)	<
7-8h		878 (58.49)	245 (28.00)	227 (25.94)	1 1 (17.14)	253 (28.91)	
>8h		420 (27.98)	133 (31.89)	100 (23.98)	שו המי 817.99)	109 (26.14)	

Values are: numbers (%) ^a χ 2 test for categorical variable



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	Item No	Recommendation	Page No
Title and abstract	1	(<i>a</i>) Indicate the study's design with a commonly used term in the title or the abstract	3
		(<i>b</i>) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of	6
C		recruitment, exposure, follow-up, and data collection	
Participants	6	(<i>a</i>) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders,	6-7
		and effect modifiers. Give diagnostic criteria, if applicable	
Data sources/	8*	For each variable of interest, give sources of data and details of methods	6-7
measurement		of assessment (measurement). Describe comparability of assessment	
		methods if there is more than one group	
Bias	9	Describe any efforts to address potential sources of bias	8, 12
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If	6-8
		applicable, describe which groupings were chosen and why	
Statistical methods	12	(a) Describe all statistical methods, including those used to control for	8
		confounding	
		(b) Describe any methods used to examine subgroups and interactions	
		(c) Explain how missing data were addressed	8
		(<i>d</i>) If applicable, describe analytical methods taking account of sampling	
		strategy	
		(<u>e</u>) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers	6
		potentially eligible, examined for eligibility, confirmed eligible, included	
		in the study, completing follow-up, and analysed	
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical,	Table 2
		social) and information on exposures and potential confounders	and 3
		(b) Indicate number of participants with missing data for each variable of	
		interest	
Outcome data	15*	Report numbers of outcome events or summary measures	8
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted	Table 4
		estimates and their precision (eg, 95% confidence interval). Make clear	
		which confounders were adjusted for and why they were included	

		(b) Report category boundaries when continuous variables were	7-8
	-	categorized	
		(c) If relevant, consider translating estimates of relative risk into absolute	
		risk for a meaningful time period	
Other analyses	17	Report other analyses done-eg analyses of subgroups and interactions,	
		and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential	11
		bias or imprecision. Discuss both direction and magnitude of any potential	
		bias	
Interpretation	20	Give a cautious overall interpretation of results considering objectives,	9-11
		limitations, multiplicity of analyses, results from similar studies, and other	
		relevant evidence	
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study	6
		and, if applicable, for the original study on which the present article is	
		based	

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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