

# BMJ Open Sleep duration and multimorbidity in Luxembourg: results from the European Health Examination Survey in Luxembourg, 2013–2015

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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 sociodemographic and behavioural 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 6.95 hours/night during work days, nearly 1 hour less than during non-work days (7.86 hours/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 to 14.51; OR 7.30, 95% CI 2.35 to 22.58; OR 6.79, 95% CI 2.15 to 21.41 for 1, 2 and  $\geq 3$  chronic conditions/diseases, respectively), independently of socioeconomic and behavioural characteristics.

**Conclusions** Health promotion programmes 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.

## 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.<sup>1–3</sup> Short sleep duration, poor sleep quality and sleep-related disorders can result in sleep deficiency and impact on individual health.<sup>4</sup> According to the Centers for Disease Control and Prevention, 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.<sup>5</sup> Adequate sleep duration is one of the dimensions needed for good sleep health.<sup>6</sup> The American Academy of Sleep Medicine and Sleep Research

## 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, 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.

Society consider that for an adult, an average sleep duration of at least 7 hours per night should be recommended.<sup>4</sup> However, a high percentage of the population sleeps less than the recommended 7 hours.<sup>7</sup>

Several factors may affect sleep such as physical activity patterns or eating behaviours, but also socioeconomic factors including job status, marital status and ethnicity.<sup>8,9</sup> Studies have observed an association of lower education and unemployment with both short and long sleep duration,<sup>10,11</sup> while factors such as physical activity and healthy diet seem to improve sleep quality.<sup>12,13</sup> 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 (eg, time and hours of intake) and variations in hormones related to appetite, such as leptin.<sup>14</sup>

Epidemiological data suggest an association of abnormal sleep duration and poor sleep quality with cardiometabolic problems (eg, hypertension, diabetes, obesity, cardiovascular diseases), mental disorders (eg, depression) and mortality.<sup>15–18</sup> The observed relationship between short sleep duration and mortality would be especially critical in adults



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under 65 years of age.<sup>18</sup> Few studies so far have focused on possible relationships between sleep patterns and multimorbidity.<sup>19 20</sup> Multimorbidity is defined as the presence of two or more chronic diseases in the same individual,<sup>21</sup> and is associated with disability, functional decline, frailty, poor quality of life and mortality.<sup>22</sup> In the context of ageing societies, multimorbidity is an increasing global phenomenon<sup>23</sup>; its occurrence usually increases with age, though a large proportion of individuals younger than 65 are also affected.<sup>24</sup> 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.<sup>22</sup>

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 sociodemographic and behavioural 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 behaviours. 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). Institutionalised individuals (eg, 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%).<sup>25</sup> Of them, seven participants did not report their sleep habits. A total of 1501 participants had information on multimorbidity and sleep habits. Participants were interviewed by trained nurses who also conducted medical examinations. Questionnaires included several health modules (eg, sleep and nutritional habits, healthcare, 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 generalised to the population of Luxembourg in terms of age, sex and district of residence.

### Patient involvement

Participants were not involved in the development of the research question, study design, recruitment or the conduction of the study. On 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.<sup>26 27</sup> Responses were categorised as short sleep duration (<6 hours/night), medium sleep duration (6–9 hours/night) and long sleep duration (>9 hours/night), in line with previously published studies and sleep time duration recommendations.<sup>4 8 28</sup>

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  $\geq 11$  on the Epworth Sleepiness Scale.<sup>29</sup>

### Multimorbidity

Participants were asked if they ever had a chronic disease or condition diagnosed by a medical doctor (eg, 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 diseases or conditions. 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 categorised in non-immigrant, 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;  $\leq 3$  hours/week of sports, fitness and/or recreational activities which lasted at least 10 consecutive minutes;  $> 3$  hours/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;  $\text{kg}/\text{m}^2$ ). BMI was categorised as normal body weight ( $< 25 \text{ kg}/\text{m}^2$ ), overweight ( $25\text{--}29.99 \text{ kg}/\text{m}^2$ ) and obesity ( $\geq 30 \text{ kg}/\text{m}^2$ ).

### 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  $\chi^2$  test or a two-way analysis of variance (ANOVA) were used to analyse 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 6–9 hours per night) adjusted for sociodemographic characteristics, behavioural risk factors (eg, BMI, smoking, alcohol consumption and physical activity), as well as for measures of sleep disorders and sleep quality. We considered a  $p$  value  $< 0.05$  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 V.14.0 and SAS V.9.4 (SAS Institute, Cary, North Carolina, 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 7.86 hours/night when they did not have to work the next day, nearly 1 hour more than when they had to work the next day (6.95 hours/night). Moreover, 5.13% of the Luxembourg population reported

sleeping less than 6 hours/night and 1.79% reported sleeping more than 9 hours/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 with 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 with 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  $25 \text{ kg}/\text{m}^2$ .

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 ( $< 6$  hours) were 7.30 and 6.79 times as likely to report having two and three 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 online supplementary 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,<sup>28 30</sup> although in countries such as Brazil the prevalence of short sleep duration was nearly 22%,<sup>31</sup> and in Portugal values of short sleep duration defined as  $\leq 5$  hours reached up to 20% in 2015–2016.<sup>32</sup> 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



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

	N (%) / mean ± 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)
No 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*	118 (7.89)
Have difficulties in sleeping the night through	510 (33.89)
Sleeping medication	64 (4.26)
Sleep duration	
Total sleep duration (n=1170)	
<6 hours/night	60 (5.13%)
6–9 hours/night	1089 (93.08%)
>9 hours/night	21 (1.79%)
Hours when you have to work the next day (n=1152–working)	6.95±0.97
Hours when you do not work the next day (n=1501)	7.86±1.30

Missing values ranged from 2 to 13 observations.

\*Measured with Epworth Sleepiness Scale.

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.<sup>22</sup> 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,



**Table 2** Participant characteristics by chronic conditions/diseases: European Health Examination Survey in Luxembourg (n=1508)

	Chronic conditions/diseases				
	0	1	2	≥3	P value*
Sex					
Male	199 (27.72)	199 (27.72)	143 (19.92)	177 (24.65)	<0.001
Female	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)	
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)	
Fruit and vegetable 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)	
≥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
≤3 hours/week	151 (29.84)	130 (25.69)	77 (15.22)	148 (29.25)	
>3 hours/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±SD for continuous variables.

\* $\chi^2$  test for categorical variables, t-test for continuous variables. Missing values ranged from 8 to 13 observations.

BMI, body mass index.

**Table 3** Participant's characteristics by sleep duration: European Health Examination Survey in Luxembourg

	Sleep duration (n=1170)			
	<6 hours/night	6–9 hours/night	>9 hours/night	P value*
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)	
Fruit and vegetable 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
≤3 hours/week	12 (2.86)	401 (95.48)	7 (1.67)	
>3 hours/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±SD for continuous variables.

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

BMI, body mass index.

**Table 4** Results of multinomial logistic regression measuring the association between sleep duration and chronic 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=1170)

	Sleep duration			
	Short (<6 hours)		Long (>9 hours)	
	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)
Chronic conditions/diseases				
0	1.00	1.00	1.00	1.00
1	4.55 (1.49 to 13.88)	4.65 (1.48 to 14.51)	2.94 (0.93 to 9.19)	2.66 (0.80 to 8.85)
2	7.65 (2.55 to 22.91)	7.30 (2.35 to 22.58)	0.86 (0.16 to 4.54)	0.82 (0.14 to 4.67)
≥3	9.45 (3.25 to 27.41)	6.79 (2.15 to 21.41)	1.27 (0.31 to 5.24)	0.73 (0.13 to 3.88)
Immigration				
Luxembourg		1.00		1.00
Portugal		1.66 (0.71 to 3.89)		0.86 (0.14 to 5.08)
Other		1.96 (1.00 to 3.82)		1.80 (0.61 to 5.31)
Sex				
Men		1.00		1.00
Women		0.48 (0.24 to 0.93)		4.57 (1.22 to 17.09)
Age				
		0.99 (0.95 to 1.02)		0.98 (0.93 to 1.04)
Education				
Primary		1.00		1.00
Secondary		0.77 (0.35 to 1.71)		1.79 (0.36 to 8.85)
Tertiary		0.36 (0.12 to 1.11)		1.07 (0.14 to 7.85)
Job status				
Unemployed				
Managers/professionals		1.00		1.00
Technicians/clerical/service occupation		1.17 (0.50 to 2.68)		1.47 (0.40 to 5.39)
Skilled/unskilled workers		0.96 (0.36 to 2.55)		2.00 (0.33 to 11.91)
Physical activity				
Never		1.00		1.00
≤3 hours/week		0.47 (0.22 to 0.98)		0.33 (0.10 to 1.09)
>3 hours/week		0.73 (0.34 to 1.56)		0.23 (0.04 to 1.08)
BMI				
Normal		1.00		1.00
Overweight		1.49 (0.74 to 2.98)		0.29 (0.06 to 1.39)
Obese		0.94 (0.40 to 2.16)		1.25 (0.35 to 4.40)
Smoking				
Never		1.00		1.00
Current		0.92 (0.46 to 1.84)		1.13 (0.30 to 4.15)
Ex-smokers		0.88 (0.42 to 1.86)		3.30 (0.98 to 11.00)
Alcohol consumption				
Never		1.00		1.00
Drink		2.21 (0.39 to 12.48)		0.60 (0.05 to 7.13)
Ex-drinker		1.14 (0.31 to 4.10)		0.32 (0.07 to 1.44)
Sleeping medication				
		1.89 (0.56 to 6.35)		NA
Sleep disorder diagnosis				
		1.39 (0.55 to 3.49)		NA
Difficulties in sleeping the night				
		2.12 (1.14 to 3.92)		1.34 (0.45 to 3.90)
Sleepiness				
		3.37 (1.57 to 7.21)		1.09 (0.20 to 5.77)

AOR, adjusted OR; BMI, body mass index; NA, not available.

behavioural 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 (eg, over 50 years old).<sup>19 33</sup> As observed by Koyanagi *et al*, sleep problems increase with the number of diseases in both low-income and high-income countries independent of their economic development.<sup>19</sup> 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.<sup>18</sup> It is not clear if sleep problems are a consequence of chronic diseases (eg, conditions affecting sleep) or part of the cause (sleep predisposes 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.<sup>34</sup> 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.<sup>15 16</sup> Pain caused by certain chronic diseases as well as the medications/treatments used and mood disorders (eg, anxiety, depression) could have an impact on sleep.<sup>35</sup> In turn, sleep disturbances could worsen the health status. Experimental evidence corroborates the plausibility of deleterious effects of lack of sleep on endocrine, immune, neurovegetative and inflammatory pathways.<sup>1-3</sup> Sustained short sleep duration could be related to chronic conditions through its impact on the circadian rhythm and its association with hormonal (eg, insulin resistance and decreased leptin) and autonomic nervous system changes (increased activity of the sympathetic nervous system).<sup>36</sup> 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 well-being 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.<sup>37 38</sup> In our study, Portuguese immigrants were more likely to sleep less than 6 hours per night during workdays and less than 7 hours during non-working days. Portuguese are the largest immigrant community in Luxembourg, accounting for 16% of the 46% immigrant population living in Luxembourg. Compared with

Luxembourgish natives, Portuguese immigrants have a lower socioeconomic status<sup>39</sup> (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.<sup>40</sup> However, this relationship is complex and could depend on family composition (eg, single parents have shorter sleep duration, particularly women).<sup>41</sup>

In addition, short sleep duration often cluster with other behavioural 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.<sup>12 42</sup>

Limitations of the present study include the subjective measure of sleep duration (self-reported number of hours of sleep) instead of an objective measure (eg, 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,<sup>43</sup> but may be attenuated based on certain individual characteristics (eg, presence of conditions such as depression, sociodemographic characteristics).<sup>44</sup> Other limitations include the fact that we did not include other sleep problems such as insomnia or sleep apnoea 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 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 generalisability 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 well-being and general health status of the population. Sleep hygiene should be considered as an additional important health behaviour 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 programmes should be developed to improve and promote healthy lifestyles among the general population to improve sleep habits as well as decrease multimorbidity.

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