Original Article

Snoring and breathing pauses during sleep: interview survey of a United Kingdom population sample reveals a significant increase in the rates of sleep apnoea and obesity over the last 20 years - data from the UK sleep survey

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ABSTRACT

Study objectives: (1) To determine the prevalence of snoring, breathing pauses during sleep and obstructive sleep apnoea syndrome in the United Kingdom (UK) and determine the relation between these events and obesity and other sociodemographic variables. (2) To compare and integrate this data with published UK population data.
Methods: A total of 664 women and 575 men aged 18—100 years who formed a representative sample of the non-institutionalised UK population participated in an online interview survey directed by a previously validated computerised system.
Results: Overall, 38% of men and 30.4% of women report that they snore at night. Furthermore, 8.7% of men and 5.6% of women state that they stop breathing at night. Comparing our data to published data from the 1990s, this study observes a highly significant increase in the rates of reported breathing pauses during sleep (sleep apnoea) in the UK over the last 20 years ($p < 0.0001$). In addition, we observe a highly significant increase in the prevalence of obesity (BMI>30) in the UK population between 1994 and 2015 ($p < 0.0001$). Integration of our data with NHS and public health England data on obesity confirms this increase.
Conclusions: Our data demonstrate a significant increase in the rates of reported breathing pauses during sleep (sleep apnoea) and obesity in the UK over the last 20 years. Sociodemographic and behavioural changes have likely contributed to this. Moreover, our data also suggests that sleep disordered breathing (SDB) is widely underdiagnosed in the UK.

1. Introduction

Sleep disordered breathing (SDB) comprises a spectrum of disorders, ranging from simple snoring to severe obstructive sleep apnoea (OSA), with a significant burden to health care systems in high income countries [1]. If left untreated, obstructive sleep apnoea has significant cumulative, long-term health consequences. Decades of research have shown that affected individuals are at increased risk of hypertension, diabetes, obesity, cardiovascular disease, depression, heart attack, cognitive dysfunction, road traffic accidents, work accidents, dementia and stroke [2—7].

The association of obesity with obstructive sleep apnoea is particularly intriguing, as obesity has been implicated both as a cause and consequence of OSA. Obesity alters the anatomy and collapsibility of the upper airway and ventilatory control as well as increases respiratory workload, thereby contributing to the

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pathogenesis of SDB [8]. At the same time, there is now an increasing body of evidence that OSA itself contributes to the development of obesity via changes to energy expenditure during sleep and wake periods, dietary habits, neurohormonal mechanisms that control satiety and hunger and sleep duration arising from fragmented sleep [9]. Moreover, both OSA and obesity lead to the activation of inflammatory pathways, a key mechanism in cardiovascular and metabolic disease processes [8]. Rates of obesity have significantly increased in high income countries over the last few decades [10]. Recent data from Public Health England suggest that over 25% of the population in England is obese [11] and this figure is likely to rise substantially over the coming years. Further, obesity and snoring were both strongly associated with a diagnosis of OSA. After adjusting for confounders, those with a BMI recorded of >40 kg/m^2 were shown 27.39 times more likely to have OSA [12].

In 1997, Ohayon et al., published one of the first study on the rates of snoring and OSA in a UK population sample [13]. They showed that 40% of the population reported snoring regularly and 3.8% reported breathing pauses during sleep. Based on minimal criteria of the International Classification of Sleep Disorders (1990), 1.9% of the sample had obstructive sleep apnoea syndrome. The aim of this research is to present a follow-up study 20 years later, to determine how the prevalence of snoring, breathing pauses during sleep, and obstructive sleep apnoea syndrome have evolved during that time frame using a well-matched UK population sample. We also assess the relation between these events and sociodemographic variables and other health problems. In addition, we aim to compare our data on obesity with NHS and Public Health England data obtained from recent years.

2. Subjects and methods

2.1. Survey participants

In this study, 1239 subjects from the 2015 census belonging to the non-institutionalised population aged 18 and above were used as the standard population. Instead of telephone interviews which were used in the 1990s, an electronic questionnaire was administered to a sample of 1239 individuals representative of the UK population via Surveysampling UK. Seventeen entries were excluded from analysis due to lack of data for either height or weight, resulting in a total number of 1222 subjects used for analysis. This study was deemed exempt from requirement for Research Ethics Committee approval on the basis that data collection was anonymised and no vulnerable participants were included (UCL/UCLH REC and Harrow REC).

Questionnaire: The online questionnaire consisted of 61 questions assessing the most common sleep disorder symptoms on insomnia, hypersomnolence and sleep breathing disorders and some aspects on the use of technology such as smartphones. Participants answered on a frequency scale ranging from never to 6–7 nights/days per week. A symptom was considered present when it occurred at least three times per week.

Information was also collected regarding sociodemographic characteristics as well as weight, height and medical conditions.

2.2. Statistical analyses

Statistical comparisons between population percentages were performed using a 2-sample test for equality of proportions with continuity correction, using the prop.test function in R. 95% confidence intervals for population estimates were calculated using a 1-sample proportions test with continuity correction, using prop.test,

Logistic regression, linear regression models and figures. Moreover, all other statistical comparisons were performed in R using lm, glm, ggplot2 and prop.test functions (https://cran.r-project.org/). Logistic regressions were performed using the binomial (logit) function and adjusting for significant covariates. Data tabulations were performed using xtabs.

3. Results

3.1. Demographics

Of the 1222 subjects used for analysis (Table 1), 569 were men (46.56%) and 653 were women (53.43%). More than half of subjects were married and the geographical distribution of collected data matches the population estimates of the countries of the United Kingdom. Almost half of the subjects currently smoke tobacco or smoked tobacco in the past. More than two thirds of subjects drink at least one unit of alcohol per week.

Table 1
Demographic characteristics of the sample.

	N	%
Age		
18 to 24	125	10.23
25 to 34	191	15.63
35 to 44	215	17.59
45 to 54	225	18.41
55 to 64	212	17.35
65 to 74	183	14.98
75 or older	71	5.81
Gender		
Men	569	46.56
Women	653	53.44
Marital status		
Single	383	31.34
Married	657	53.76
Separated or Divorced	127	10.39
Widowed	55	4.50
Area of residence		
England	947	77.50
Northern Ireland	37	3.03
Scotland	138	11.29
Wales	100	8.18
Level of education		
Less than high school	30	2.45
Some high school	67	5.48
A-Levels or equivalent	208	17.02
Degree Level (eg, BA or BSc)	285	23.32
GCSEs or equivalent	267	21.85
Higher Educational Qualification (below degree level)	134	10.97
Post Graduate Degree	117	9.57
Vocational Qualifications (eg, NVQ)	114	9.33
Ethnicity		
White	980	80.20
Asian and Asian British	97	7.94
Black or Black British	61	4.99
Chinese or Chinese British or other ethnic group	33	2.70
Mixed Race	19	1.55
Prefer not to answer	26	2.13
Unknown	6	0.49
Smoking status		
Current smoker or chewing tobacco	267	21.85
Ex-smoker or previous tobacco chewing	347	28.40
Never smoked/chewed tobacco	583	47.71
Prefer not to answer	25	2.05
Alcohol intake (units/week)		
>21	59	4.83
15 to 21	104	8.51
1 to 14	689	56.38
Never drink alcohol	345	28.23
Prefer not to answer	25	2.05
TOTAL	1222	

Table 2
Proportion of men and women snorers by age groups.

	% Female	% Male	P-value
18 to 24	12.63	21.43	NS
25 to 34	33.61	31.34	NS
35 to 44	33.63	37.50	NS
45 to 54	33.64	42.20	0.014
55 to 64	34.88	44.83	0.002
65 to 74	36.14	37.63	NS
75 or older	22.86	30.30	NS
Total	30.41	38.01	<0.0001

3.2. Snoring

Based on this survey, 38% of men and 30.4% of women state that they snore at least three nights per week. The number of men snoring is significantly higher than women (Table 2). Compared with the 1990s data set [11], the number of subjects that state that they snore has decreased from 40.3% to 33.9% in our study (p-value < 0.0001; 2-sample test for equality of proportions with continuity correction; Fig. 1). Moreover, we detect significant gender differences for three groups ("45–54", "55–64" and "Total") compared to seven groups for the previous study [11] (which includes all participants >65 years old in one group, for this segment we separate two categories in our analysis).

3.3. Reported breathing pauses during sleep

In our study, 8.7% of men and 5.6% of women state that they stop breathing at night at least three times per week. The number

of men with breathing pauses is significantly higher than women (Table 3). This is a significant increase in the rates compared with the Ohayon data from 1997 [13], when breathing pauses during sleep were reported by 3.8% of the sample which has increased to 7.0% (p-value < 0.001; 2-sample test for equality of proportions with continuity correction; Fig. 2). The association of both snoring and breathing pauses was reported by 5.56% of the sample. A total of 3.43% of the population did not know whether they snored or had breathing pauses during sleep.

3.4. Comparison of obesity (BMI>30) in the UK population between 1994 and 2015

In our study, we report a significant increase in the percentage of obesity in the UK population, and further demonstrate that this finding is in line with NHS/Public Health England data (Fig. 3; Tables 4 and 5). This confirms that our study has captured statistics from a representative sample of the UK population which is in dynamic change, experiencing similar rises in obesity to those of other populations in western countries.

3.5. Results from logistic regression analysis of the datasets

Logistic regression analysis was applied on the datasets on snoring (Table 6) and breathing pauses (Table 7). As seen in Table 6, being a male and increasing age were associated with snoring. Smoking, was also associated with an increased likelihood of snoring. Individuals having high blood pressure and those reporting daytime sleepiness were two times more likely to report snoring during sleep.
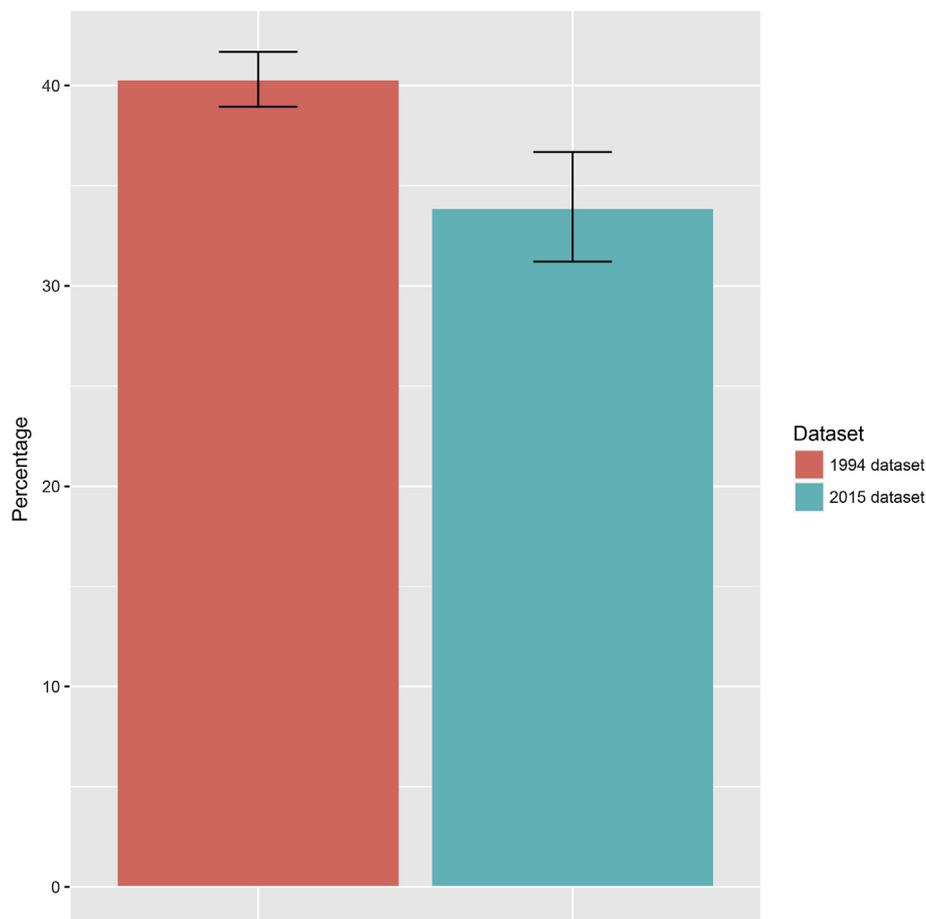

Fig. 1. Comparison of the percentage of snorers between our dataset and the 1994 dataset, including 95% CI (error bars).

Table 3
Proportions of men and women with breathing pauses by age groups.

	% Female	% Male	P-value
18 to 24	7.37	14.29	NS
25 to 34	9.24	17.91	NS
35 to 44	8.85	7.29	NS
45 to 54	2.80	6.42	NS
55 to 64	3.49	7.83	NS
65 to 74	2.41	7.53	NS
75 or older	0.00	3.03	NS
Total	5.64	8.69	<0.0001

Similarly, an increase in Body Mass Index (BMI) was associated to a greater likelihood of snoring; for each 1 unit increase in the body mass index, the risk of snoring increased by a factor of 1.05.

Similar to snoring reports, males and individuals aged 45 y.o. and older were more likely to report breathing pauses during sleep (Table 7). Individuals drinking more than four alcoholic beverages per day had a higher likelihood of having breathing pauses in their sleep, as were also smokers. Individuals with high blood pressure and those suffering from chronic obstructive lung disease were more likely to have breathing pauses during their sleep. Sleepiness and increase in BMI were also associated with having breathing pauses during their sleep.

3.6. Daytime drowsiness and owning a smartphone

Of note, we find a highly significant association between daytime drowsiness and owning a smartphone (p = 0.008, 2-sample test for equality of proportions). A high proportion of study subjects (932 individuals, 76.27%) reported owning a smartphone, in agreement with UK population estimates.

4. Discussion

Our data demonstrate a significant increase in the rates reported breathing pauses during sleep (sleep apnoea) and obesity in the UK over the last 20 years, compared with Ohayon et al.'s data published in 1997 [13]. The increasing rates of obesity which we observe agree with NHS and Public Health England data [11] and other data on obesity worldwide that show the same trend [12].

An intriguing hypothesis is that the increase of the rates of sleep apnoea is a result of the increasing rates of obesity [8]; yet, at the same time it is now well understood that the cumulative long-term effects of sleep loss and sleep disorders have been associated with a wide range of deleterious health consequences [2–5], including an increased risk of obesity. Taking our data into account, it can be speculated that increasing rates of obesity and obstructive sleep apnoea in the UK population are contributing to increasing rates of some of the above conditions (eg, hypertension and diabetes), which are observed in the UK. Effective treatment of sleep apnoea may provide a benefit for some of these conditions [14].

Looking at our results in more detail, snoring and obstructive sleep apnoea are associated with male sex, age, marital status, significant alcohol intake, obesity and certain comorbidities (eg, high blood pressure). Both the data from 1994 and a recent systematic review, including patient data from 24 PubMed and Embase listed studies, confirms that advancing age, male sex and
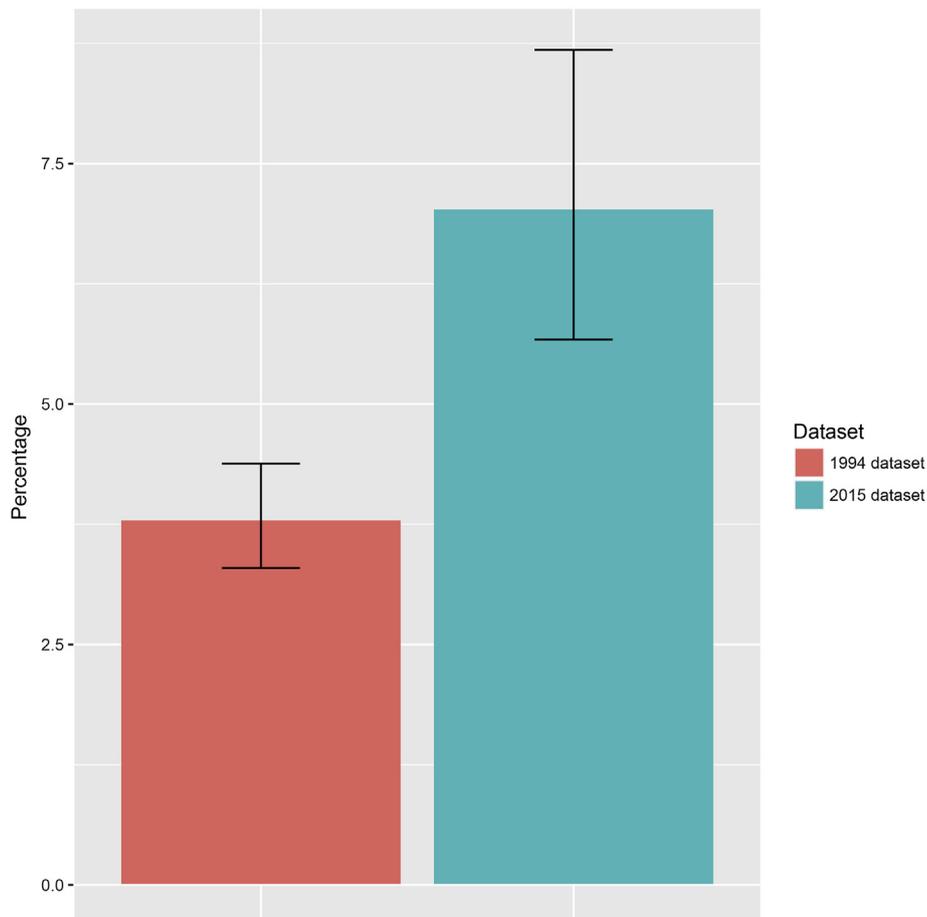

Fig. 2. Comparison of the percentage of subjects reporting breathing pauses during sleep between our dataset and the 1994 dataset, including 95% CI (error bars).
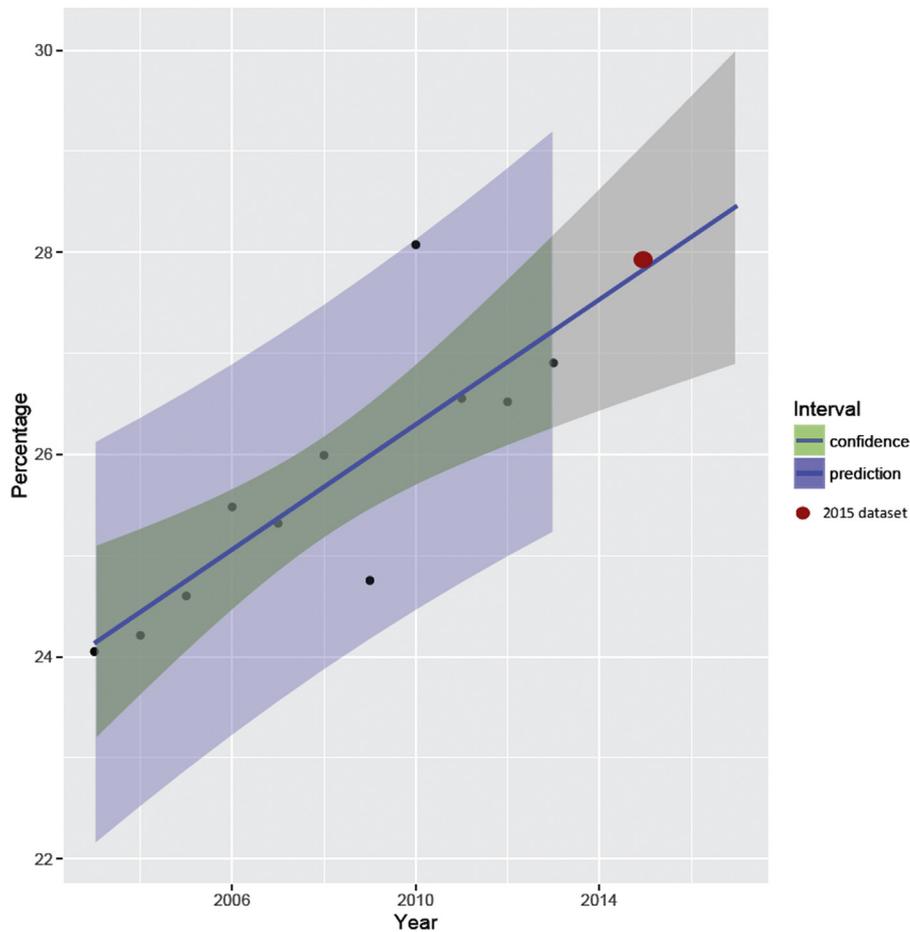
Fig. 3. 2015 study data are located in grey predicted area (the 95% confidence interval of the linear regression estimates based on 2003–2013 NHS/Public Health England data from http://content.digital.nhs.uk/catalogue/PUB16077). 2015 study data is located within the 95% confidence interval, showing that population estimates from our study are in agreement with NHS/Public Health England data from a similar time period.

Table 4
Comparison of obesity rates by age group between 1994 and 2015. Data point to a significant increase in the prevalence of obesity between 1994 and 2015 (*significant at FDR 0.05; Benjamini-Hochberg correction).

Age	Sex	1994		2015		P-value
		N	% BMI ≥30	N	% BMI ≥30	
15–24 (18–24 for 2016)	Female	422	0.9	96	13.54	<0.0001
	Male	431	3.7	29	6.90	n.s.
25–34	Female	473	6.6	120	20.00	<0.0001
	Male	462	6.0	71	14.08	=0.03
35–44	Female	430	6.5	113	17.70	=0.0004
	Male	425	8.0	102	34.31	<0.0001
45–54	Female	356	11.8	114	32.46	<0.0001
	Male	355	13.8	111	40.54	<0.0001
55–64	Female	323	10.5	89	24.72	=0.001
	Male	308	12.0	123	40.65	<0.0001
65+	Female	587	9.0	121	15.70	=0.0001
	Male	393	11.2	133	33.08	<0.0001

Table 5
Comparison of obesity rates between 1994 and 2015 for all subjects. Data suggest a highly significant increase in obesity prevalence between 1994 and 2016 for the UK population (p-value = 2.2e-16, Fisher's exact test).

	Total N	BMI ≥ 30	% BMI ≥ 30
1994	4965	400	8.06
2015	1222	341	27.91

higher body-mass index are associated with an increase in OSA prevalence [15]. In the context of our obesogenic society, this shows that health services will need to provide more funding for the diagnosis and treatment of OSA in order to prevent long-term sequelae. Moreover, this reinforces the need for intervention to control the increasing rates of obesity which are associated with significant costs for healthcare systems.

Notably, we found a significant association between daytime drowsiness and owning a smartphone. Blue light has been shown to induce waking through the activation of intrinsically photosensitive retinal ganglion cells (ipRGCs) in the human retina [16,17]. In addition, the development of blue light LEDs have been one of the main advances leading to efficient screens in current mobile phones and televisions [18]. However, it could be suggested that this innovation has also led to a negative impact. We report a highly significant association between smartphone use and increased daytime drowsiness. These findings are in line with recent work, showing that artificial outdoor night-time lights are associated with altered sleep behaviour in the American population [19] and that daily touchscreen use in infants and toddlers is associated with reduced sleep and delayed sleep onset [20]. In the light of this finding, we recommend that public health agencies take the initiative to increase public awareness on blue light emission through technological devices such as mobile phones in order to improve sleep hygiene.

Table 6
Logistic regression analysis (snoring data).

	Estimate	OR (95% confidence interval)	Pr (>|z|)
Gender			
Female		1.00	
Male	0.207	1.23 [0.89–1.70]	0.209
Marital status			
Married		1.00	
Separated or Divorced	−0.004	1.00 [0.57–1.71]	0.988
Single	−0.539	0.58 [0.40–0.85]	0.005
Widowed	−0.040	0.96 [0.40–2.17]	0.926
Alcohol consumption			
≤4 drinks/units in a day		1.00	
>4 drinks/units in a day	0.037	1.04 [0.75–1.43]	0.822
Age groups			
18 to 24		1.00	
25 to 34	0.708	2.03 [1.01–4.25]	0.053
35 to 44	0.618	1.85 [0.92–3.89]	0.092
45 to 54	0.419	1.52 [0.75–3.21]	0.258
55 to 64	0.260	1.30 [0.61–2.82]	0.503
65 to 74	0.283	1.33 [0.61–2.97]	0.481
75 or older	−0.527	0.59 [0.22–1.58]	0.297
Smoking status			
Currently smoke/chew tobacco		1.00	
Ex-smoker or previous tobacco chewing	−0.638	0.53 [0.35–0.80]	0.002
Never smoked/chewed tobacco	−0.608	0.54 [0.37–0.80]	0.002
Thyroid disease	0.099	1.10 [0.59–2.03]	0.752
High blood pressure	0.604	1.83 [1.26–2.65]	0.001
Chronic Obstructive Lung Disease	0.521	1.68 [0.86–3.33]	0.130
Feel sleepy or drowsy during the daytime	0.422	1.53 [1.11–2.11]	0.011
BMI	0.045	1.05 [1.02–1.07]	0.001

Table 7
Logistic regression analysis (breathing pause data).

	Estimate	OR (95% confidence interval)	Pr (>|z|)
Gender			
Female		1.00	
Male	0.838	2.31 [1.19–4.63]	0.015
Marital status			
Married		1.00	
Separated or Divorced	0.638	1.89 [0.62–5.21]	0.235
Single	−1.189	0.30 [0.13–0.65]	0.003
Widowed	−14.904	0.01 [0.01->40.0]	0.988
Alcohol consumption			
≤4 drinks/units in a day		1.00	
>4 drinks/units in a day	0.850	2.34 [1.17–4.94]	0.020
Age groups			
18 to 24		1.00	
25 to 34	−0.134	0.87 [0.29–2.77]	0.815
35 to 44	−0.705	0.49 [0.16–1.62]	0.234
45 to 54	−1.616	0.20 [0.05–0.72]	0.014
55 to 64	−2.291	0.10 [0.02–0.42]	0.002
65 to 74	−1.769	0.17 [0.04–0.70]	0.015
75 or older	−2.860	0.06 [0.00–0.50]	0.025
Smoking status			
Currently smoke/chew tobacco		1.00	
Ex-smoker or previous tobacco chewing	−1.133	0.32 [0.14–0.69]	0.005
Never smoked/chewed tobacco	−0.892	0.41 [0.19–0.86]	0.019
Thyroid disease	0.846	2.33 [0.83–6.23]	0.100
High blood pressure	0.778	2.18 [1.05–4.44]	0.033
Chronic Obstructive Lung Disease	1.714	5.55 [2.22–13.72]	0.001
Feel sleepy or drowsy during the daytime	0.795	2.21 [1.10–4.77]	0.033
BMI	0.058	1.06 [1.01–1.11]	0.010

Our study had several strengths. First, that our data is representative of the UK population. Furthermore, study design has specifically sought to cover participants representative of the different sociodemographic groups that form the UK population. The application of the appropriate statistics for analysis shows consistent and intriguing results. Moreover, this study is highly topical, addressing a significant public health problem in the UK. However, we would like to acknowledge some limitations of our study.

Comparing our data with the data from the Ohayon study, it has to be acknowledged that our study setup was slightly different, ie, online forms vs. telephone interviews, which is also a product of technological advances over the last 20 years. The number of subjects included in our study is lower than that reported in the 1990s, but by integrating our data with data from other studies we clearly show our data is representative of the UK population and that we can be confident that the highly significant differences of the rates which we demonstrate are valid in view of study power and the significant effect size. Comparing and integrating our data with NHS and Public Health England data [11] and other data on obesity worldwide [12] we show the same trend. In addition, we would like to state that rates of snoring are not thought to be related to rates of sleep apnoea [21], a trend which we observe in our analysis as well, and that cardiovascular patients often underreport symptoms of sleep apnoea [22].

In summary, our data demonstrate a significant increase in the rates of reported breathing pauses in the UK over the last 20 years. This may be driven by a difference in obesity prevalence, habits and other factors in the current population. As described above, obesity has been on the rise in United Kingdom in recent decades and our data reinforce this observation. Notably, certain factors complicating sleep such as the use of smartphones and other bright screens were not under consideration when the previous study was conducted and one can speculate that these may have an influence as well. Further studies are needed to address these interesting questions.

5. Conclusion

Our data demonstrate a significant increase in the rates of reported breathing pauses during sleep (sleep apnoea) and obesity in the UK over the last 20 years. Sociodemographic and behavioral changes have likely contributed to this. Our data also suggests that SDB is widely underdiagnosed in the UK.

Details of contributors

All authors have designed the study and serve as guarantors for the study. We thank our public and patient involvement volunteers and our study participants.

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Statement of significance

Our data demonstrate a significant increase in the rates of reported breathing pauses during sleep (sleep apnoea) and obesity in the UK over the last 20 years, compared with Ohayon et al.'s data published in 1997. The data reinforce the known association of these two significant public health problems. Of note, we observed a significant association between daytime drowsiness and owning a smartphone, revealing certain factors potentially complicating sleep that were not under consideration when the previous study was conducted. Our data also suggests that sleep disordered breathing is widely underdiagnosed and taking into account adverse health effects caused by untreated obstructive sleep apnoea, this indicates an urgent need for policy makers to increase efforts addressing this problem.

Acknowledgments

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2018.08.029.

References

[1] Tarasiuk A, Reuveni H. The economic impact of obstructive sleep apnea. Curr Opin Pulm Med 2013;19:639–44.

[2] Colten HR, Altevogt BM. Sleep disorders and sleep deprivation: an unmet public health problem. In: Colten HR, Altevogt BM, editors. Sleep disorders and sleep deprivation: an unmet public health problem. Washington (DC); 2006.

[3] Kales SN, Czeisler CA. Obstructive sleep apnea and work accidents: time for action. Sleep 2016;39:1171–3.

[4] Stradling J. Driving and obstructive sleep apnoea. Thorax 2008;63:481–3.

[5] Ancoli-Israel S, Palmer BW, Cooke JR, et al. Cognitive effects of treating obstructive sleep apnea in Alzheimer's disease: a randomized controlled study. J Am Geriatr Soc 2008;56:2076–81.

[6] Fox H, Purucker HC, Holzhacker I, et al. Prevalence of sleep-disordered breathing and patient characteristics in a coronary artery disease cohort undergoing cardiovascular rehabilitation. J Cardiopulm Rehabil Prev 2016;36: 421–9.

[7] Arzt M, Woehrle H, Oldenburg O, et al. Prevalence and predictors of sleep-disordered breathing in patients with stable chronic heart failure: the SchlaHF registry. JACC Heart Fail 2016;4:116–25.

[8] Ryan S, Crinion SJ, McNicholas WT. Obesity and sleep-disordered breathing–when two 'bad guys' meet. QJM 2014;107:949–54.

[9] Ong CW, O'Driscoll DM, Truby H, et al. The reciprocal interaction between obesity and obstructive sleep apnoea. Sleep Med Rev 2013;17:123–31.

[10] Ng M, Fleming T, Robinson M, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2014;384:766–81.

[11] Public_Health_England. Prevalence of obesity among adults aged 16+ years. 2014.

[12] Wall H, Smith C, Hubbard R. Body mass index and obstructive sleep apnoea in the UK: a cross-sectional study of the over-50s. Prim Care Respir J 2012;21: 371–6.

[13] Ohayon MM, Guilleminault C, Priest RG, et al. Snoring and breathing pauses during sleep: telephone interview survey of a United Kingdom population sample. BMJ 1997;314:860–3.

[14] Oldenburg O, Fox H, Wellmann B, et al. Automatic positive airway pressure for treatment of obstructive sleep apnea in heart failure. Somnologie (Berl) 2017;21:273–80.

[15] Senaratna CV, Perret JL, Lodge CJ, et al. Prevalence of obstructive sleep apnea in the general population: a systematic review. Sleep Med Rev 2017 Aug;34: 70–81.

[16] Wong KY, Dunn FA, Berson DM. Photoreceptor adaptation in intrinsically photosensitive retinal ganglion cells. Neuron 2005;48:1001–10.

[17] Lockley SW, Evans EE, Scheer FA, et al. Short-wavelength sensitivity for the direct effects of light on alertness, vigilance, and the waking electroencephalogram in humans. Sleep 2006;29:161–8.

[18] Nakamura S, Mukai T, Senoh M. Candela-class high-brightness InGaN/AlGaN double-heterostructure blue-light-emitting diodes. Appl Phys Lett 1994;64: 1687–9.

[19] Ohayon MM, Milesi C. Artificial outdoor nighttime lights associate with altered sleep behavior in the american general population. Sleep 2016;39: 1311–20.

[20] Cheung CH, Bedford R, Saez De Urabain IR, et al. Daily touchscreen use in infants and toddlers is associated with reduced sleep and delayed sleep onset. Sci Rep 2017;7:46104.

[21] Mayer G, Arzt M, Braumann B, et al. German S3 guideline nonrestorative sleep/sleep disorders, chapter "sleep-related breathing disorders in adults", short version: German sleep society (Deutsche Gesellschaft Fur Schlafforschung und Schlafmedizin, DGSM). Somnologie (Berl) 2017;21:290–301.

[22] Bitter T, Westerheide N, Hossain SM, et al. Symptoms of sleep apnoea in chronic heart failure–results from a prospective cohort study in 1,500 patients. Sleep Breath 2012;16:781–91.