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Nightshift Rotation Schedule and Fatigue in U.K. and Italian Nurses

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Abstract

Background: *Whether hours on shift might impact adaptation to night shift work is still controversial.* **Methods:** *We conducted a pooled analysis of two studies, including 170 hospital nurses working night shifts, 116 from a United Kingdom study working 12-hour rotating shifts, and 54 from Italy working 8-hour shifts. Both studies used the Epworth Sleepiness Scale (ESS) to detect sleepiness during routine daytime activities as an indicator of fatigue. We compared the prevalence of daytime sleepiness, as indicated by an ESS score≥11, resulting from either shift work schedule. We used logistic regression to calculate the risk of daytime sleepiness associated with 12-hour vs. 8-hour nightshifts, adjusting by age, sex, and parenting children aged≤4.* **Results:** *When comparing similar work circumstances, nightshifts prolonged to 12 hours did not increase the risk of daytime sleepiness compared to 8 hours (OR=0.9, 95% CI 0.32, 2.59).* **Conclusions:** *Our results suggest that 12-hour rotating nightshifts with additional rest days and 8-hour rotating shift schedules do not differ in their impact on daytime sleepiness. Further research is warranted on what strategies might effectively contrast fatigue, circadian misalignment, and the related metabolic changes leading to adverse health outcomes, including cancer.*

1. Introduction

Working against the regular circadian rhythm has well-recognized detrimental effects on worker's health, including sleep problems, cardiovascular disorders, and metabolic disorders, and it is classified as a probable human carcinogen by the International Agency for Research on Cancer (IARC) [1]. Nonetheless, continuous care of patients requires hospital workers to rotate on a 24-hour schedule, including night shifts, defined as work for more than three hours between 23:00 - 6:00 am.

Nightshift work-induced circadian disruption can lead to sleep loss, poor sleep quality, and excessive daytime sleepiness. During the night shift, sleep deprivation may cause drowsiness and fatigue in the healthcare staff, resulting in poor work performance, diminished healthcare quality, higher risk of medical errors, and road traffic accidents in commuting back home [2]. Such events are well described in nurses working night shifts [3, 4]. Epidemiological studies of chronic circadian disruption are complicated by internal and external factors that modulate the adaptation of the internal clock to changes in the light/

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dark cycle when moving closer to the Earth's poles, or crossing time zones or its alignment to maintain a vigilant state of active wake at nighttime when engaged in nightshift work. Internal factors include gene polymorphisms, including the clock genes [5] expressing the individual chronotype, age, sex, and health issues; external factors enlist brightness and wavelength of lighting during working hours, the possibility of regular, resting sleep in the daytime in a quiet and dark ambient, and social restraint. Intrinsic characteristics of shift work schedules, such as shift duration, the direction of shift rotation, the number of consecutive night shifts, and days of rest in the rotation scheme contribute to accelerating or delaying nightshift work adaptation [6]. Studies on nightshift work and cancer were conducted in different latitudes, populations, and workplaces with diverse shift work schedules; results were not always consistent, which might reflect the challenge posed by the complex intertwining of multiple factors [1, 7, 8], including variations in the shift duration and rotation schedule.

In the 1990s, several countries, including the United States and the United Kingdom, adopted daily 12-hour rotating work shifts to overcome hospital staff shortages and reduce the cost of healthcare. Currently, such a scheme extends to 45% of hospitals in the United Kingdom and 70% in the United States, while it is less frequent in Europe (16%) and Oceania [9]. Initially, the introduction of 12-hour shifts was well received, particularly among female nurses with children, because of the reduction of weekly work shifts and more days off work, substantial savings in money for childcare, travel, and time, and potential improvement in life balance [10].

However, it is still unclear whether any increase in daytime sleepiness, fatigue, and metabolic changes, typical of circadian disruption, might result from adopting a 12-hour instead of 8-hour nightshift schedule. A survey among 152 Australian nurses showed that the proportion of those satisfied with the shift schedule rose three times after introducing 12-hour shifts [10]. Most participants reported beneficial health effects of 12-hour shifts: the communication with senior staff improved, the number of hours of professional development leave increased, and the annual sick and family leave days decreased. Adverse health outcomes in the patients did not increase in frequency after introducing the 12-hour shift roster [10]. However, in a U.S. survey covering 71 acute care nonfederal hospitals in Illinois and North Carolina, longer working hours were associated with fatigue, decreased alertness, and higher frequency of adverse health outcomes in the patients [11]. Also, nurses' sleeping hours were significantly less following a 12-hour shift, and sleepiness during the working hours increased from the beginning to the end of each night shift and with the number of night shifts throughout the week [12].

An extensive European survey showed that nurses from 12 countries perceived the 12-hour shift and working overtime as linked to lower quality and safety at work [13]. Compared to nurses on 8-hour shifts, those engaged in 12-hour shifts rated the quality of nursing and patients' safety as poor 30% more frequently and the care left incomplete at the end of the work shift 13% more frequently [13].

We pooled data from two reports on sleep quality and alertness in nurses using the same methodology in the United Kingdom [14] and Italy [15]. The U.K. study results showed a correlation between work safety issues and accidents when driving to commute back home after a night shift [14]. The Italian study suggested an excess risk of daytime sleepiness among female but not male nurses [15]. As different shift duration and rotation schemes were applied in the U.K. and Italian hospitals contributing to those studies, we selected nurses engaged in nightshift work from the respective database to explore whether longer hours on shift might increase the risk of daytime sleepiness, taken as an indicator of fatigue and sleep loss.

2. METHODS

We pooled the data from two published reports on fatigue among nurses and midwives in the United Kingdom and Italy [14, 15]. Both studies had a cross-sectional study design, relied on voluntary participation, and, following the signature of an informed consent form, used an anonymous, self-administered questionnaire and the

Epworth Sleepiness Scale (ESS) to assess daytime sleepiness.

The ESS is a validated tool to assess daytime sleepiness at all ages, consisting of eight items that evaluate, on a scale from 0 to 3, the propensity to fall asleep in different situations of daily life, such as in front of the TV, while driving, or in a public place. Therefore, the sum of the scores on the scale can range from 0-24. A higher ESS score relates to an increased level of daytime sleepiness, with values ≥ 11 indicative of abnormal sleepiness [16].

Apart from using the same protocol, an additional reason for combining two study populations from different countries was that exploring the effect of a longer duration of the night shift would have been impossible in Italy, where work contracts stipulated between the unions and the association of employers regulate nationwide matters such as working hours and the shift schedule. In the United Kingdom, 229 nurses and midwives (211 female and 18 male, 12% of the total workforce) from the Newcastle-upon-Tyne NHS Hospitals Foundation Trust working night shifts participated in the study. Data collection lasted from 16/03/2020 to 01/06/2020 [14]. The rota varies between wards and individual staff, with no uniform schedule or policy. Following a sharp rise in the proportion of U.K. nurses working 12 hours or longer in NHS hospitals, from 31% in 2005 to 51% in 2009 [17], night-shifts typically start anytime between 7-10 pm and run for 10-12 hours [18]. Twenty-two participants who worked permanently at night and 91 who had worked three or more consecutive nights were excluded from this analysis, leaving 116 subjects available for study. The U.K. study was conducted in the months of exponential growth of the COVID-19 pandemic when the doubling time for infection was 2.2 days [19]. Therefore, to account for the emergency circumstances that might have contributed to sleep deprivation, fatigue and daytime sleepiness in the frontline departments, we divided the U.K. nurses into two groups: 1. frontline departments (No.=46), including the 34 respondents from Anaesthetics & Critical Care, and 12 from Medicine units; and 2, other departments where the admissions were less affected by the pandemic (No.=70), including the 38 respondents from the Paediatric and Neonatal care, 19 from Surgery, and 13 from Obstetrics and Gynecology.

In the Italian study, all 43 female and 22 male nurses from the Cagliari University Hospital, whose annual visit with the occupational physician to assess their fitness for the job was scheduled in June -July 2018, had filled out a similar questionnaire [15]. We excluded ten female and one male participants, who only worked fixed daytime shifts five days a week. The remaining 54-night shift workers 54 (33 females and 21 males, 83%) were included in this pooled analysis. The following regular 8-hour forward rotating shift schedule was applied: two consecutive morning shifts (M), two consecutive postmeridian shifts (E), one single night shift (N), and two rest days (R) (MMEENRR). Night shifts typically start at 10:00 pm and end at 6:00 am. Because of the staff shortage during the holidays, the August and December rota included two consecutive night shifts before the rest days (MMEENNRR).

2.1. Statistical Methods

We used the median and interquartile range (IQR) to compare the central tendency and spread of the ESS score among the UK and Italian nurses and the Mann-Whitney test. We compared categorical variables between the two study populations with Pearson's chi-square or a goodness-of-fit chi-square test when categories were more than two. The 5% α error threshold was assumed to reject the null hypothesis. First, we used univariable analysis to explore the association between the covariates and daytime sleepiness as defined by an ESS score ≥ 11. Then, we used logistic regression analysis to investigate whether the 12-hour nightshift schedule used in the U.K. hospitals might increase the risk of daytime sleepiness compared to the 8-hour shift adopted in the Italian hospitals, adjusting by age and parenting children aged ≤ 4. BMI did not show an association nor decrease the residual variance of the model once included as a covariate. The Odds Ratio and its 95% Confidence Interval (95% CI) was the measure of association.

The two studies were conducted according to the indications of the Declaration of Helsinki and approved by the local Ethics Committees, the

Comitato Etico Indipendente of the Cagliari University Hospital (Protocol No. PG/2018/17165) and the University of Manchester Research Ethics Committee (2020-8652-12800). The UK study also received approval from the Health Research Authority (HRA) – Research and Development (R&D) for NHS research through the Integrated Research Application System (IRAS) (268824) in 2020.

3. Results

Table 1 shows selected features of the two study populations. The average duration of the night shift was 12 hours (range 10.5–13) for the U.K. nurses and 8 hours for Italian. Nurses from the U.K. hospital were more frequently female, with ≤4-year-old children, and overweight/obese. The age distribution and the prevalence of daytime sleepiness, as detected by an ESS score≥11, did not differ significantly between the two hospitals (χ^2=3.58, degrees of freedom [df]=6, p=0.733 and χ^2=1.35, df=1, p=0.246, respectively).

In the univariable analysis, having ≤4-year-old children was associated with an increase in the risk of daytime sleepiness (OR=2.1, 95% CI 0.97, 4.71). Overall, men were half as likely as women to suffer from daytime sleepiness (OR=0.5, 95% CI 0.16, 1.43). However, among the U.K. nurses, the prevalence of an ESS score ≥ 11 did not vary by sex;

Table 1. Selected variables among the nurses of two hospitals in the United Kingdom, working 12-hour nightshifts, and Italy, working 8-hour nightshifts.

	United Kingdom (N=116)	**Italy (N=54)**	
	N (%)	**N (%)**	***p* - value**
Age			
≤ 29 years	43 (37.1)	17 (31.5)	0.733
30 – 39 years	36 (31.0)	16 (29.6)	
40 – 49 years	23 (19.8)	15 (27.8)	
≥ 50 years	14 (12.1)	6 (11.1)	
BMI			
≤ 24.9	43 (37.1)	43 (79.6)	<0.001
25 – 29.9	43 (37.1)	7 (13.0)	
≥ 30	30 (25.8)	4 (7.4)	
Sex			
Women	109 (94.0)	33 (61.1)	< 0.001
Men	7 (6.0)	21 (38.9)	
Parenting children aged ≤ 4			
yes	32 (27.6)	4 (7.4)	0.003
no	84 (72.4)	50 (92.6)	
Department			
Non- frontline	38 (32.8)	-	
Frontline	78 (67.2)	-	
ESS score			
≥ 11	31 (26.7)	10 (18.5)	0.244
≤ 10	85 (73.3)	44 (81.5)	

*Note: P-values from χ^2 tests; * p < 0.05.*

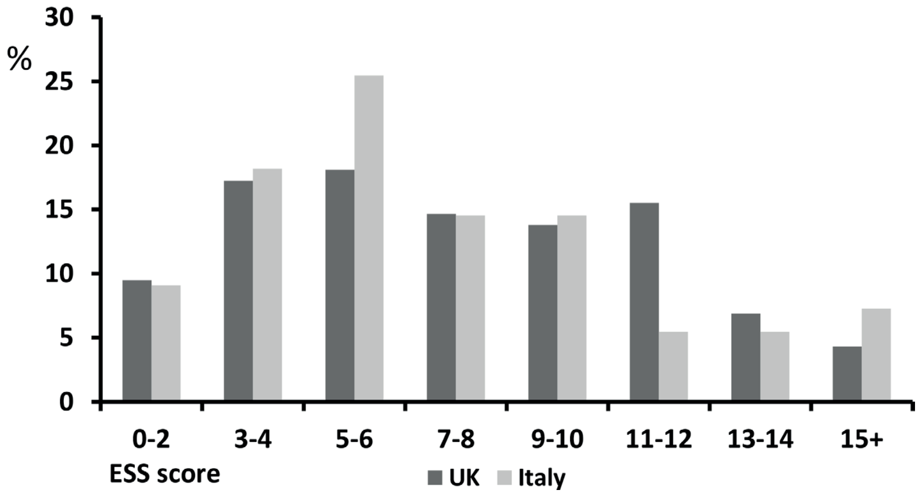

Figure 1. Frequency distribution of the ESS score in UK and Italian nurses.

however, male nurses among the 116 selected for this analysis were only 7.

To double-check whether the occurrence of the COVID-19 pandemic at the time of recruiting the U.K. study population increased fatigue, sleep deprivation, and daytime sleepiness in the frontline hospital departments, we compared the prevalence of ESS scores≥11 among U.K. nurses in critical care units (Anaesthetics and Critical Care and Medicine), *vs.* other departments (Paediatrics and Neonatology, Obstetrics and Gynaecology, and Surgery). The univariable analysis suggested that, over the whole study population, daytime sleepiness was slightly more prevalent among the U.K. than the Italian nurses (OR=1.6, 95% CI=0.72-3.57).

However, the graph in Figure 1 shows that the frequency distribution of the ESS score between U.K. and Italian nurses is substantially similar; the median ESS score was 7 (interquartile range [IQR] 4-11) among the U.K. nurses and 6 (IQR 4-9.75) among the Italian and (Mann Whitney test=-0.61, p=0.542).

In the multivariable logistic regression analysis to predict an ESS score suggestive of daytime sleepiness, we included the following covariates to reciprocally adjust the respective effects: age, sex, parenting children aged ≤4, and a binary category for shift duration, 12 hours in the U.K. and 8 in Italy. To account for the additional burden due to the stressful working conditions associated with the COVID-19 pandemic at the time of recruiting the U.K. study population, we first run a model including all study subjects, then after excluding the U.K. nurses working in frontline or non-frontline departments, alternatively. Table 2 shows the results. In all instances, the statistical power was insufficient to exclude chance as the determinant of the observed point estimates. Still, the results suggest that a 10-year increase in age, female sex, and parenting children aged ≤ 4 were risk factors for daytime sleepiness (OR=1.3, 95% CI 0.94–1.90; OR=1.8, 95% CI 0.54, 6.04; and OR=2.1, 95% CI 0.90, 4.75, respectively). Overall, the risk of daytime sleepiness was not elevated in U.K. nurses working 12-hour night shifts compared to the Italian nurses working 8-hour night shifts (OR=1.2, 95% CI 0.50–2.97). It lowered after excluding the frontline U.K. nurses during the COVID-19 pandemic (OR=0.9, 95% CI 0.32, 2.59). U.K. nurses in the frontline during the pandemic had a moderate increase in the risk of daytime sleepiness, which was similar compared to the Italian nurses (OR=1.5, 95% CI 0.56, 4.06) and the U.K. colleagues working in other departments (OR=1.5, 95% CI 0.63, 3.75) (not shown in the Table).

4. Discussion

Several features of shift work might imply more or less severe fatigue and circadian disruption; these

Table 2. Results of the logistic regression analysis on the risk of daytime sleepiness, as indicated by an ESS score ≥ 11, associated with nightshift duration (12 hours vs. 8 hours) and personal covariates. The first column includes all the UK nurses; the second includes only the UK nurses in non-frontline departments; the third includes only the UK nurses in the frontline departments.

Covariates	All the study population (ESS ≥ 11, No.= 41; ESS ≤ 10, No.=129) OR (95% CI)		Only non-frontline UK nurses (ESS ≥ 11, No.= 27; ESS ≤ 10, No.= 97) OR (95% CI)		Only frontline UK nurses (ESS ≥ 11, No.= 24; ESS ≤ 10, No.= 76) OR (95% CI)	
Age (per 10-year age-group)	1.3	0.94 - 1.90	1.2	0.76 - 1.79	1.2	0.76 - 1.99
Female Sex	1.8	0.54 - 6.04	1.8	0.42 - 7.74	2.6	0.67 - 10.3
Parenting children Aged ≤ 4 years	2.1	0.90 - 4.75	2.7	0.98 - 7.35	1.5	0.39 - 5.72
12-hour (UK) *vs.* 8-hour (Italy) nightshift	1.2	0.50 - 2.97	0.9	0.32 - 2.59	1.5	0.56 - 4.06

include forward or backward rotation shift schedules, rotation speed, number of consecutive night shifts, and shift duration [20-22]. In this paper, we explored whether; after adjusting for age, sex, and parenting children < 4 years old, a longer nightshift duration might affect the risk of daytime sleepiness as an indicator of fatigue. Our results suggest that 12-hour forward rotating shifts, including night shifts, do not increase the frequency of self-reported daytime sleepiness compared to 8-hour rotating shift schedules.

If longitudinal trials supported by adequate statistical power confirm them, prolonging night shifts up to 12 hours and allowing additional rest days would not affect daytime sleepiness, fatigue, and, possibly, other adverse health outcomes related to shift work more than a rotating 8-hour shift schedule. Other shift work schedules or individual covariates might be more important risk factors. Although with insufficient statistical power, our results confirm previous reports about the association between parenting children aged ≤ 4 with shorter sleep duration and lower sleep quality, two determinants of daytime sleepiness [23, 24]. Our finding of an increased risk of daytime sleepiness among female nurses is also consistent with previous reports of a higher frequency of insomnia, daytime sleepiness, and poor sleep quality among women in general and particularly among female night shift workers [15, 25].

Previous reports evaluated job satisfaction [10, 20], the shift rotation speed [20], patients' outcomes [11], and perceived patients' safety and quality of care [13] or described sleep, sleepiness, fatigue, and performance in 12-hour nightshift vs. daytime nurses [12] but not the direct effects of prolonged nightshift hours on daytime sleepiness. Various drivers might orientate the nurses' preference about hours and type of shift schedule: an older age was a factor for preferring shorter shifts. At the same time, marital status and parenting children were associated with a preference for longer shifts [26]. Other factors, such as the chronotype, the commuting time, and the physical strain associated with the job, might contribute. Overall, when staff were involved in decision-making and personal preferences were taken into account, both acceptance of shifts and job satisfaction were higher [26]. In New York state, compared to nurses working 8-hour shifts, 12-hour shift workers were more frequently happy with their jobs, more likely to be satisfied with their shift schedule, less emotionally exhausted, and less likely to report missing shifts. Besides, units with 12-hour shifts had lower vacancy rates and weeks required to fill the vacant positions. Patient outcomes did not differ [27]. It is quite possible that the additional days of rest per week, the saving of weekly time and money for commuting, and the extra time available for family or leisure activities might compensate for the increased fatigue at the end of the work shift; still, longer working hours imply more fatigue, the risk of burnout, and a higher frequency of intention to leave [28]. A European survey showed that nurses from 12 countries perceived the 12-hour shift and working overtime as causes of lower quality and safety at work; compared to nurses on 8-hour shifts, those engaged in 12-hour shifts rated 30% more frequently as poor the quality of nursing and the patient's safety, and 13% more frequently the care left undone at the end of the work shift [13].

Indeed, fatigue increases from the beginning to the end of a 12-hour shift, as suggested by a decrease in the work pace and no change in energy expenditure and heart rate [29]. However, in the study of U.K. nurses, the number of consecutive night shifts worked at the time of data collection was not a predictor of daytime sleepiness in the univariable analysis and was not explored further [14]. Currently, the U.K. Health and Safety Executive guidance recommends a shift duration not exceeding 12 hours, no more than 2-3 consecutive night shifts, and a minimum rest time between shifts of 11 hours [30]. 8-hour shifts are recommended when work is monotonous and physically demanding, concentration is required, is conducted in isolation, presents safety issues, or implies exposure to physical or chemical hazards. 12-hour shifts require frequent breaks to reduce fatigue, adequate recovery time between shifts, and consideration of the contribution to fatigue by commuting time and availability of public transport [30]. In Italy, the nurses' working time is regulated through the national collective contract: the regular weekly working hours are 36, and work shifts may last from 6 to 7 hours and 12 minutes but can extend up to eight hours with one extra paid hour. The maximum consecutive hours allowed is 12 hours and 50 minutes, and the minimum resting time between shifts is 11 hours. A 12-hour shift is considered a double shift [31].

Several weaknesses limit the interpretation of our results. First, both original studies used a cross-sectional study design, which raises doubts about the link between symptoms and the current engagement in night shift work. The most resilient nurses might have been selected for shift work, while that incapable of adapting moved to a more tolerable work schedule. However, we compared two populations of night shift workers, both presumably selected for their resilience.

The small size and non-random selection criteria of the study population contributing to our pooled analysis may but allow tentative remarks as none of our results could exclude chance as the determinant. Because of the exploratory nature of our study, we pooled the data sets of two published reports without conducting prior statistical power calculations. A *posterior* calculation indicates that, with our study size, we might have estimated a 4-fold risk of daytime sleepiness associated with a 12-hour night shift schedule, with 80% statistical power ($\beta = 0.20$) and an α-error of 5%. We did not detect an excess risk, but we can only exclude a greater than 4-fold risk, which indicates that a substantial risk increase might still occur. Therefore, we interpret our findings as preliminary and hope they might stimulate further research on the most appropriate work organization to reduce fatigue and prevent fatigue and the other adverse health outcomes associated with night shift work.

A further major limitation of our study is that it addresses daytime sleepiness as an indicator of sleep loss, fatigue, and circadian disruption, the condition leading to oxidative stress, immune suppression, and the pro-inflammatory status responsible for the excess risk of cancer and other health outcomes reported in the majority of shift work studies [1]. We used the ESS tool, which is popular among sleep scientists worldwide. We are confident that minor language changes to adapt it to country-specific cultural issues did not impair the international comparability of the resulting scores. However, although a standardized questionnaire was used, socio-cultural differences between the two countries might have influenced the frequency of reporting symptoms and, therefore, the ESS score. Nevertheless, the ESS is a subjective report of symptoms and, thus, subject to error depending on the level of job satisfaction, as previously mentioned. We aimed to compare daytime sleepiness in nurses working 12-hour vs. 8-hour shifts. Due to the lack of a wider within-country variation, we had to compare nurses from two countries by excluding nurses working only daytime shifts from both datasets and, from the U.K. dataset, nurses who worked three or more consecutive nights before the interview and those working permanently on night shifts. Poor job satisfaction might have occurred in both study populations, attenuating the bias on the risk estimate. However, we cannot exclude that, among the U.K. nurses, a greater acceptance because of more free time might have resulted in fewer sleepiness symptoms, thus reducing their ESS score and biasing towards the null their hypothetic greater risk compared with the briefer 8-hour shift.

The two studies contributing to this pooled analysis were separated two years, and the U.K. study recruited participants during the exponential growth of the COVID-19 epidemic. To preserve the comparability between the two study populations, we first excluded those who had worked more than two-night shifts at the time of the interview; then, we conducted a secondary analysis after excluding nurses from critical care units. Although the results were substantially confirmed, this procedure further reduced the study population size and the statistical power of the analysis.

Besides, the two-year lag between the recruitment of the two study populations, socio-economic differences between the two countries, and, most of all, the incumbent COVID-19 pandemic at the time of recruiting for study the U.K. nurses might have introduced important, uncontrolled sources of bias making it more difficult to interpret our findings. We are also aware of being unable to exclude chance as a determinant of our observation. Still, some published reports agree with our findings, and we thought that, although statistically weak, they might foster interest in conducting further research with larger data sets.

5. Conclusion

Further research with a prospective study design and adequate statistical power is warranted to confirm or reject whether adopting a 12-hour instead of an 8-hour nightshift schedule might increase daytime sleepiness, fatigue, and metabolic changes typical of circadian disruption.

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Institutional Review Board Statement: The two studies were conducted following the Declaration of Helsinki and approved by the local Ethics Committees, the Comitato Etico Indipendente of the Cagliari University Hospital (Protocol No. PG/2018/17165) and the University of Manchester Research Ethics Committee (2020-8652-12800). The UK study also received approval from the Health Research Authority (HRA) - Research and Development (R&D) for NHS research through the Integrated Research Application System (IRAS) (268824) in 2020 animals.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Declaration of Interest: The Authors declare no conflict of interest.

Author Contribution Statement: LR and AW wrote the original manuscript; MP, MvT, and PC and BC contributed to the design and implementation of the research; MF and EM contributed to the analysis of the results, and PC contributed to the writing of the manuscript. All coauthors reviewed and approved the final manuscript.

Declaration on the use of AI: None.

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