

Association between Abnormal Sleep Duration and Sleepiness and Road Traffic Crashes in Urban Taxi Drivers

Rami Azmi Elshatarat^{1,*}, Barbara J. Burgel²

¹Department of Medical and Surgical Nursing, College of Nursing, Taibah University, Kingdom of Saudi Arabia

²Department of Community Health Systems, School of Nursing, University of California, USA

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Abstract Introduction: Road traffic crashes (RTC) and road traffic injuries (RTI) are major health problems facing taxi drivers. Shorter sleep duration (≤ 7 hours/day) and sleepiness during driving are two risk factors for RTC and RTI. **Aims:** Identify the associations between shorter sleep duration and sleepiness during driving a taxi and RTC in taxi drivers. **Methods:** A cross-sectional design and convenience sampling method were used to recruit a total of 130 taxi drivers in San Francisco (California, United States). Data was collected from taxi drivers via interview, using a structured questionnaire. **Results:** Based on the Epworth Sleepiness Scale (ESS) total score, 14% of the subjects had abnormal sleepiness (ESS > 10). On average, the subjects slept 7 hours daily, with 64% reporting sleeping ≤ 7 hours/day. About 22% of participants (n=29) reported at least one crash in the prior 12 months while driving their cab, totaling 45 crashes. Factors associated with abnormal sleep (≤ 7 hours/day) included not taking pain medication ≥ 1 time/week, not attending a health and safety training session for taxi driving, and not eating five cups of fruits and vegetables each day. Shorter sleep duration, overall fatigue and higher ESS scores were not significantly associated with RTC. **Conclusion:** Drivers reported abnormal sleep duration. Twenty-two percent of taxi drivers reported at least one crash in the prior 12-months; 11.5% RTI were reported in the prior 12-months. There were no significant bivariate associations between

RTC and ESS, and abnormal sleep. There are opportunities to further explore interventions to enhance sleep hygiene in professional drivers. **Clinical Relevance:** Recognition of sleepiness in professional drivers is an important public health measure. The most important countermeasure to mitigate drowsy driving is to begin a work shift after sleeping more than 7 hours. Frequent rest breaks, drinking coffee, chewing gum, and opening a car window to refresh air are additional evidence-based countermeasures.

Keywords Abnormal Sleep, Sleepiness, Epworth Sleepiness Scale, Urban Taxi Drivers, Road Traffic Crashes

1. Introduction

Globally, death for all persons from road traffic injuries (RTI) ranks eighth as a leading cause of death globally, and if current trends continue, RTI are estimated to become the fifth leading cause of death by 2030 [1, 2]. Annually, 1.35 million people die as a result of road traffic crashes (RTC), and millions suffer non-fatal injuries, with many cases of disability as a result of RTI. Road traffic deaths and injuries are preventable [1]. In the U.S., there were 36,096 deaths due to fatal RTC in 2019, 11 deaths per 100,000 people, representing a 2% decrease from 2018 [3]. The literature

on road traffic accidents in California, USA, consistently highlights the high prevalence of accidents and identifies various associated factors. These include high traffic volume, driver behavior (such as distracted and impaired driving), drug-related incidents, road infrastructure, weather conditions, and the increased risk for teenage drivers. Efforts to address these factors and improve road safety are crucial for reducing the prevalence of accidents in California [3].

The economic losses related to RTI affect the individuals, their families, and extend to nations as a whole. These economic losses result from the cost of treatment, lost productivity of disabled individuals, and the adverse impact on family income due to such factors as new caregiving roles and loss of work. Unsafe driving behaviors (e.g. high speed driving), distracted driving, poor quality of sleep and sleepiness while driving, high level fatigue, and mental exertion are the major risks for RTI and related death worldwide [1, 4, 5]. One U.S. study of crash fatality data from 1999-2008 estimated that 16.5% of traffic fatalities involved a drowsy driver [6].

In one large prospective population study in Boston (n=3201 adults enrolled in the Sleep Heart Health Study), sleep duration and obstructive sleep apnea were documented to pose a risk for RTC [7]. About 7% reported an RTC during the prior year. A higher apnea-hypopnea index, fewer hours of sleep, and self-reported excessive sleepiness were significantly associated with RTC. Sleeping only 6 hours a night increased the RTC risk by 33% (when compared to sleeping 7-8 hours/night); for every hour decrease in usual sleep duration, the adjusted odds ratio for any RTC increased by 13% in the overall population.

Globally, RTI are a major health problem facing taxi drivers, and involve many work-related factors, including abnormal sleep duration and driving when drowsy. For example, in a recent study of 300 drivers in Morocco, taxi drivers self-reported an RTC career prevalence of 47.5%, averaging 2.78 crashes per year [8]. The Epworth Sleepiness Scale (ESS) was used to measure a person's general level of daytime sleepiness; the authors didn't find a statistically significant association between ESS score and RTC, although there was a positive correlation (mean ESS score=13.23 \pm 5.59) [8]. Moreover, one large study of 2,391 taxi drivers from 4 cities in China found about 17% (n=400) drivers self-reported 4 or more property damage crashes, with 7.74% (n=185) of the total sample self-reporting 1 personal injury crash; 1.51% (n=36) self-reported 2 personal injury crashes. Sleeping problems over the prior 2 years was associated only with personal injury crash rates. This large study documented a high prevalence of sleeping problems, and the contribution of drowsy driving to both property damage and personal injury crashes [9].

1.1. Study Objectives

This study aims to: 1) Describe participants' sleep and work factors, current workload, and 12-month prevalence and situations of work-related crashes, 2) Determine self-care techniques used by drivers to relax after work, and 3) Determine the associations between abnormal sleeping (\leq 7 hours/day) with demographical data, current workload, RTCs, and nutrition habits.

2. Methodology

2.1. Design

A descriptive, cross-sectional design was used to explore sleeping \leq 7 hours/night, and its association with demographic data, selected work factors, and RTCs.

2.2. Sample and Setting

A convenience sample of 130 taxi drivers was recruited to address the objectives of the current study. Taxi drivers who were working in San Francisco (California, USA), 21 years old or above, driving 20 hours weekly or more, and English speakers were able to participate in the study. Recruitment was conducted by sending recruitment letters to all 34 taxi companies in San Francisco Bay area, requesting them to post notices. Additionally, taxi drivers were recruited through personal outreach at dispatch lots, and the airport holding lot.

2.3. Ethical Considerations and Data Collection Procedure

Institutional Review Board (IRB) approval was obtained from the Committee on Human Research at University of California, San Francisco. The eligible taxi drivers were recruited from 34 taxi companies in San Francisco. All who decided to participate in the study signed a written consent form. Personal interviews with eligible participants were conducted using a structured questionnaire.

2.4. Instrument

A structured questionnaire was used to collect the data via person-to-person interview. This questionnaire included demographical data and work factors. Two nutrition items were included: drinking 3 or more caffeinated drinks (yes/no), and if the driver ate 5 servings of fruits/vegetables per day (yes/no). Sleep patterns were assessed by asking the participants: the number of hours of sleep per day, and the number of days in the past 30 days the driver did not get enough rest/sleep. Sleep duration is coded as \leq 7 hours/day, indicating abnormal sleep, and $>$ 7 hours/day, indicating normal sleep [10]. Moreover, ESS is a validated 8-item scale, which assesses the likelihood of

the individual dozing or sleeping in the daytime under a variety of situations, for example, while watching TV, or when stopped for a few minutes while driving. The response on this 4-point Likert scale ranged from 0 points (would never doze or sleep) to 3 points (a high chance of dozing or sleeping). The 8 items of ESS are summed, with a maximum score of 24, with higher scores representing greater levels of sleepiness. The score of ESS >10 is generally considered as the cut-off point for clinically significant abnormal sleepiness [11].

RTC data included a self-report of any accident while driving a taxi in the prior 12 months, and to identify the number of accidents. If yes, they were asked to report if they were at fault. Any injuries while driving a taxi in the prior 12 months were also described (data not shown). Attendance at health and safety training for taxi driving was assessed.

An open-ended question was included for drivers to identify what strategies they used to relax after driving. Answer responses were qualitatively analyzed and categorized into 10 self-care strategies, including sleeping/resting, exercise/walking, watching television, praying, reading, drinking an alcoholic beverage, listening to music, talking with friends/family, taking a bath, and drinking herb tea.

2.5. Data Analysis

The Statistical Package for the Social Sciences ([SPSS], version 23) software program was used for data management. Frequencies and descriptive statistics were used to describe the taxi drivers' socio-demographic data and work characteristics. Chi square test was used to investigate the bivariate associations between abnormal sleep and demographic and work characteristics, nutrition habits and RTC. The results of the chi-square test would provide valuable insights into the potential links between abnormal sleep patterns and the variables studied, shedding light on the associations between sleep duration, driver characteristics, habits, and the occurrence of road traffic crashes among urban taxi drivers. A *p* value of < 0.05 was used to determine a statistically significant difference.

3. Results

The majority of the taxi drivers were male (93.8%), married (53.8%), had some college or less (61.5%), middle

aged (45.3 ±10.75 years), born outside of the USA (55.4%), night shift drivers (50.8%), and drove on average 9.7 years and 41 hours per week (Table 1).

Table 1. Demographical data and work factors N=130

Variables		Total n (%)
Gender (Male)		122 (93.8%)
Marital status (Married or partnered)		70 (53.8%)
Education (< Some college (not graduated))		80 (61.5%)
Place of birth (United States of America)		58 (44.6%)
Work shift (Night driver)		66 (50.8%)
Work Mixed Shift (Day and Night)		9 (6.9%)
Have other paid job		25 (19.3%)
Variables	Mean (±SD)	(Minimum - Maximum)
Age (years)	45.3 (±10.75)	(25-71)
Worked as a taxi driver (year)	9.73 (±8.39)	(2 – 40)
Number of hours worked prior week	40.94 (± 12.96)	(15.5 – 70)
Number of hours worked in other paid job per week	17.12 (± 11.57)	(2 – 40)

Based on the ESS total score, 14.3% of the subjects had abnormal sleepiness (ESS > 10). The participants' mean of ESS was 6.39 (±3.8) and ranged between 0 and 18 (out of 24). On average, the participants were sleeping about 7 hours daily. About 64% of participants (n= 83) reported sleeping ≤ 7 hours/day (abnormal sleeping). The participants reported not getting enough rest or sleep on average of 7 days in the prior 30 days (Table 2).

About 22% of drivers (n= 29) reported at least one RTC while driving their taxi in the past year (29 drivers had a total of 45 RTC [some of drivers had more than one RTC]). Resulting from 45 RTC were 15 RTI (33.3%). This reflects an overall sample, about 11.5% (n=15/130) had RTI during the past 12-months. Of the 45 RTC, 6 (13.3%) drivers reported they were at fault. Only 34.6% of participants attended a health and safety training session for taxi driving. Watching television (55.6%) and/or sleep or resting (46.5%) were the most frequent techniques used by drivers to relax after driving a taxi (Table 2).

Table 2. Sleepiness characteristics, sleeping pattern, RTCs, and relaxation methods after driving a tax

Chance of dozing or sleeping in the following situations*	Would never doze or sleep	Slight chance of dozing or sleeping	Moderate chance of dozing or sleeping	High chance of dozing or sleeping	
	0	1	2	3	
Sitting and reading	38 (29.2%)	47 (36.2%)	29 (22.3%)	16 (12.3%)	
Watching TV	31 (24.2%)	32 (25.0%)	47 (36.2%)	18 (14.1%)	
Sitting inactive in a public place	91 (70.0%)	29 (22.3%)	7 (5.4%)	3 (2.3%)	
Being a passenger in a motor vehicle for an hour or more	73 (56.2%)	31 (24.2%)	17 (13.1%)	9 (6.9%)	
Lying down in the afternoon	27 (20.9%)	30 (23.3%)	38 (29.5%)	34 (26.4%)	
Sitting and talking to someone	117 (90.0%)	8 (6.2%)	3 (2.3%)	2 (1.5%)	
Sitting quietly after lunch (no alcohol)	52 (40.3%)	52 (40.3%)	20 (15.5%)	5 (3.9%)	
Stopped for a few minutes in traffic while driving	113 (86.9%)	12 (9.2%)	4 (3.1%)	1 (0.8%)	
Total Epworth Sleepiness Scale (ESS) Score	Mean (SD)	Median	Minimum	Maximum	
	6.40 (3.8)	2	0	18	
Classification of Sleepiness Score*		Score of Epworth Sleepiness (ESS) Scale		n (%)	
Normal range in healthy adults		0–10		108 (85.7%)	
Mild sleepiness		11–14		15 (11.9%)	
Moderate sleepiness		15–17		2 (1.6%)	
Severe sleepiness		18–24		1 (0.8%)	
Sleeping Pattern	Mean (SD)	Mode (n [%])	Minimum (n [%])	Maximum (n [%])	
Hours of sleep per day	6.96 (1.04) hours	7–7.30 hours (51 [39.3%])	4 hours (1 [0.8%])	10 hours (1 [0.8%])	
During the past 30 days, number of days did not get enough rest or sleep	7.11 (\pm 8.21) days	3 days (16 [12.3%])	0 day (15 [11.5%])	30 days (7 [5.4%])	
Sleeping duration per day				n (%)	
Sleeping duration \leq 7 hours/day				83 (63.8%)	
Exhausted when working hard at driving taxi	Strongly agree		agree	Disagree	Strongly disagree
	12 (9.4%)		53 (41.4%)	48 (37.5%)	15 (11.7%)
In the past 12 months, number of accidents while driving taxi	No accident	1 time	2 times	3 times	4–5 times
	101 (77.7%)	18 (13.8%)	9 (6.9%)	1 (0.8%)	0
Road traffic accidents and injuries					n (%)
Total of road traffic accidents during the past 12 months (N= 29 drivers)					45 (34.6%)
During the past 12 months, have been injured (RTI) while driving a taxi cab (N=45 accidents)					15 (33.3%)
For any accident, it was the taxi drivers' fault (N=45 accidents)					6 (13.3%)
Attended a health and safety training session for taxi driving					45 (34.6%)
Relaxation method after driving a taxi**					
Watch television (TV)					70 (55.6%)
Sleep/rest					59 (46.5%)
Exercise/walk					27 (21.1%)
Reading (e.g. book, magazine)					21 (16.5%)
Drink an alcoholic beverage					19 (15.1%)
Talk/visit with friends/family					16 (12.8%)
Take a bath					13 (10.3%)
Pray					9 (7.1%)
Drink herb tea					8 (6.4%)
Listen to music					4 (3.2%)

* Participants' sleepiness: measured by using Epworth Sleepiness Scale

** The participants may select more than one method

Table 3. Bivariate associations between participants' abnormal sleep and their demographical data, work factors and RTCs

Variables	Total score n (%)	Abnormal sleep (≤ 7 hours daily) (N=83)		
		n (%)	Chi Square X ²	p value*
Demographic characteristics				
Marital status (Married or partnered)	70 (53.8%)	46 (55.4%)	0.23	0.72
Education (< Some college (not graduated))	80 (61.5%)	46 (61.4%)	0.01	0.99
Place of birth (Outside of the USA)	72 (55.4%)	46 (55.4%)	0.01	0.99
Work factors				
Work shift (night driver)	66 (50.8%)	38 (45.8%)	2.28	0.15
Have other paid job	25 (19.3%)	15 (18.3%)	0.17	0.82
Worked as a taxi driver (>9.7 year)	57 (43.8%)	35 (42.2%)	0.26	0.71
Number of hours worked prior week (>41 hours)	62 (47.6 %)	39 (47.6%)	1.04	0.36
Miles driven per week (>539 miles)	57 (44.2%)	23 (50.0%)	0.98	0.36
Driving safety and crashes				
Driver reports an accident while driving cab in prior 12 months	29 (22.3%)	19 (22.9%)	0.05	0.99
Not attending a health and safety training session for taxi driving	85 (65.4%)	61 (73.5%)	6.67	0.01
Nutrition habits				
Not eating five cups of fruits and vegetables each day (a cup is equal to one small apple or 16 grapes)	93 (71.5%)	65 (78.3%)	5.18	0.03
Drink more than 3 caffeinated beverages each day (coffee, tea, cola, and/or energy drinks)	52 (40.3%)	35 (42.2%)	0.33	0.58

* Significant value ($p < 0.05$) is in bold print

The chi square analyses (Table 3) show there are significant bivariate associations between having abnormal sleep (≤ 7 hours daily) and not attending a health and safety training session for taxi driving ($X^2 = 6.67, p = 0.01$), and not eating five cups of fruits and vegetables each day ($X^2 = 5.18, p = 0.03$). Moreover, a logistic regression analysis was done to identify if any of the factors in Table 3 were associated with abnormal sleep (≤ 7 hours daily). This regression analysis showed one significant association between abnormal sleep (≤ 7 hours daily) and not attending a health and safety training session (OR=2.51, $p = 0.02$) (data not shown in tables). Furthermore, the ESS scores over 10 were not significantly associated with RTC (data not shown in tables). A positive correlation existed between the two factors; however, the numbers were small (there were 7 drivers with high ESS scores who reported at least one RTC, [$X^2 = 3.375, p = 0.06$]).

4. Discussion

Our study sampled an ethnically diverse group of middle-aged taxi drivers, primarily male, driving a taxi an average of 10 years, and working on average 41 hours/week. Eighteen drivers (14.3%) had ESS scores higher than 10.

For work-related crashes, 22.3% of drivers (n=29) in our study reported at least one RTC in the prior 12 months, ranging from 1-6 accidents, totaling 45 RTC. Of drivers involved in the 45 RTC, 15 (33.3%) reported injuries. Our findings of RTC are similar to a previous study [12], where their taxi drivers reported about 20% prevalence of at least one RTC, and lower than the other previous study [9] of drivers from 4 cities in China, where 40.8% of drivers reported RTC with physical damage to their vehicles in the prior two years [9].

Overall sleeping 7 or fewer hours/night wasn't significantly associated with a self-report of RTC, although there was a positive correlation. Similarly, an ESS score > 10 was positively correlated with RTC, with small numbers, but not statistically significant. We found that 64% of drivers slept 7 or fewer hours a night, a much higher proportion when compared to a U.S. telephone sample of adults in 2009, where 29% reported 7 or fewer hours of sleep/night [13]; likewise, our findings were higher when compared to the most recent U.S. Behavioral Risk Factor Surveillance System (BRFSS) national survey [14], where only 34.8% of adults reported ≤ 7 hours of sleep/night [10]. Our sample had a higher proportion of abnormal sleep when compared to a New York City taxi driver study, where 48.5% of their sample reported 7 hours or fewer of sleep/night [15].

Regarding numbers of participants who reported insufficient rest or sleep in the prior 30 days, the most recent BRFSS survey (in 2009) of over 400,000 adults across the USA showed that 30.7% of adults reported 0 of 30 days of insufficient rest [13], as compared to our finding of 11.5% (n=15) reporting 0 of 30 days of insufficient rest/sleep, demonstrating that our study sample had a higher proportion of taxi drivers not feeling rested. On the other extreme, insufficient rest/sleep was reported for 30 of 30 days in 11.1% of adults across the U.S. [13], as compared to 5.4% (n=7) in our study reporting 30 of 30 days of insufficient rest/sleep, a smaller number than population data [13].

ESS results showed that 14% of our sample had scores over 10, with a mean of 6.39. These are lower numbers than two other taxi driver studies, where Benaicha et al. [8] reported a mean score of 13 in their study of Moroccan taxi drivers, and Lim & Chia [16] found that 33% of their sample of taxi drivers in Singapore had ESS scores greater than 10.

Regarding factors associated with abnormal sleep duration, surprisingly, the majority of work factors (hours worked/day, miles driven/week, night shift, second job, etc.) were not associated with sleeping ≤ 7 hours of sleep/night. The only work factor that was associated with shorter sleep duration was not attending a health and safety training in the prior year, which was reported by 65% of the participants; we have no knowledge of the driver health and safety training curriculum, and if it included any sleep hygiene information. Health and safety training may be a proxy variable for other unmeasured health and safety factors. Not eating 5 servings fruits or vegetables/day was reported by 71.5% of the sample and was associated with shorter sleep duration. Surprisingly, caffeine intake was not significantly associated with shorter sleep duration. Apantaku-Onayemi et al. [17] found in their study of Chicago taxi drivers that only 4.5% of their sample ate 5 servings of fruits/vegetables. Unhealthy food choices may be a proxy variable representing overall workload, i.e. drivers with limited time to shop, prepare and/or seek healthy food choices.

Drivers reported many strategies to relax after driving, including watching TV, and, more importantly resting/sleeping. The focus of this item in the questionnaire was how drivers chose to relax after driving. Further study is needed to identify specific strategies drivers use to mitigate drowsy driving.

In summary, the literature on taxi driver health and safety has consistently identified several common challenges faced by this occupational group. The findings of the study align with existing research in this field. High workloads, characterized by long working hours and demanding schedules, are frequently reported among taxi drivers. Similarly, shorter sleep duration is a common issue experienced by taxi drivers due to their irregular working hours and the need to meet passenger demand at various times of the day. The study's finding of a high 12-month

prevalence of self-reported RTCs among taxi drivers is in line with previous research. The nature of taxi drivers work, including exposure to traffic and the pressures of time constraints, can contribute to an increased risk of accidents on the road. Although the study did not identify significant associations between sleep duration, ESS scores (a measure of daytime sleepiness), and RTC, the authors acknowledge that this could be attributed to the smaller sample size and limited study power. Therefore, it highlights the importance of conducting larger studies with more statistical power to comprehensively explore the relationships between sleep-related factors, daytime sleepiness, and road traffic accidents among taxi drivers. Overall, the study adds valuable insights to the existing literature on taxi driver health and safety. It reinforces the challenges faced by taxi drivers and emphasizes the need for further research to better understand the complex interplay between sleep, fatigue, and road safety in this profession. Such knowledge can inform the development of interventions and policies aimed at improving the health and safety outcomes for taxi drivers.

5. Research Recommendation and Nursing Implication

To mitigate drowsy driving, taxi drivers and other professional drivers can use several evidence-based countermeasures when they feel sleepy at the wheel. The most important countermeasure is to begin a work shift after sleeping more than 7 hours [4]. Nurse educators and community health nurses have important roles in providing health education for community members to promote their health and prevent sleep disturbance and any health complications including RTCs [18, 19]. Focusing on the population of this study (taxi drivers), health and safety training programs need to include sleep hygiene content, including countermeasures (i.e. taking frequent rest breaks, drinking coffee, chewing gum, and opening a car window to refresh air) to prevent drowsy driving [18, 19]. In addition, talking with passengers, taking a short nap, and listening to the radio were the less frequent measures that have been used to reduce sleepiness during driving [20-22]. Unfortunately, professional drivers often do not take the time to rest nor to nap as a preventive approach until they have experienced a sleep-related RTC. Therefore, it is very important to conduct health and safety educational programs for taxi drivers about the mechanism of drowsy driving RTC and the essential need to use effective strategies to manage driving fatigue and improve coping with sleepiness during driving. Policy changes that modify long driving schedules from 12 hours/shift to 8 hours/shift for professional drivers may be an effective measure to prevent drowsy driving, deserving of future research. Also, there is an opportunity to educate and encourage professional drivers to sleep > 7 hours daily [16, 20, 22-23]. To prevent insomnia and to maintain nocturnal sleep

quality and get adequate amount of sleep, the professional drivers who are working night shift should be encouraged to take naps at daytime and drink caffeinated drinks at evening or night. Similarly, encouraging day shift drivers to sleep more than 7 hours/night is advised, and to avoid caffeinated drinks before sleeping [21, 22].

6. Study Limitations

The study limitations are related to this study's design and sampling method. Using cross-sectional design impairs our ability to determine the cause and effect relationship between variables. Also, using convenience sampling methods and recruiting the drivers from one city (San Francisco) limited generalization of the findings to all drivers in California or other cities in the United States.

7. Conclusions

Drivers reported abnormal sleep duration and sleepiness. About 22% of taxi drivers reported at least one crash in the prior 12-months; 11.5% RTI were reported in the prior 12-months. There were no significant associations between RTC and ESS and abnormal sleep. Factors associated with abnormal sleep include not attending a health and safety training, and not eating at least five servings of fruits and vegetables/day. Prevention of RTC in taxi drivers remains an important public health concern. There are opportunities for sleep hygiene education for taxi drivers regarding the importance of sleeping 7 or more hours/day, and policy interventions to explore, for example, incentivizing drivers to take rest breaks throughout their shift, limiting driving to 8 hours (instead of 12 hours), and incentivizing access to healthier food choices.

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Declaration of Conflicting Interest

The authors have disclosed no potential conflicts of interest, financial or otherwise. Also, the funding body had

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Data Availability Statement

This study's data will be available and submitted upon journal's request.

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