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Self-reported diabetes mellitus among seafarers: occupational and sociodemographic predictors

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ABSTRACT

Background: *Seafarers are at increased risk of diabetes due to their lifestyle and working conditions on board ships. There is, however, limited evidence regarding the magnitude of diabetes and its risk factors. In this study, we aimed to assess the prevalence of self-reported diabetes among seafarers on board ships and identify risk factors associated with it.*

Materials and methods: *A cross-sectional epidemiological survey was conducted among seafarers aboard ships between November and December 2022. The study enrolled a total of 4,500 seafarers aged 18 and older. Data were collected using anonymous, standardized questionnaires. The association between the outcome variable and the independent variables was assessed using binary logistic regression models.*

Results: *In total, 2,986 participants were included in the study. The prevalence of self-reported diabetes among seafarers was found to be 8.2% (95% CI: 7.2–9.2). Self-reported diabetes prevalence among officers and non-officers was 7% and 9%, respectively. The mean age of study participants was 37.96 ± 10.22, while the mean age of participants with diabetes was 47.5 ± 9.46. Independent predictors of self-reported diabetes mellitus were age (51+ years) [adjusted odds ratio (AOR): 3.52, 95% confidence interval (CI): 1.46–8.95], rank (non-officer) [AOR: 1.65; 95% CI: 1.14–2.40], worksites (engine) (AOR: 2.08, 95% CI: 1.19–3.77), work experience (10–20 years) (AOR: 4.66, 95% CI: 2.33–10.05), work experience (21+ years) (AOR: 5.01, 95% CI: 2.32–11.55), working hours per week (57–70 hours) (AOR: 1.57, 95% CI: 1.08–2.31), working hours per week (71+ hours) (AOR: 1.80, 95% CI: 1.17–2.80), self-reported hypertension (AOR: 1.44, 95% CI: 1.03–1.99), overweight (AOR: 1.74; 95% CI: 1.24–2.47), and obesity (AOR: 2.93; 95% CI: 1.84–4.65).*

Conclusions: *This study revealed that one in twelve seafarers between the ages of 19 and 70 have self-reported diabetes. The present study identified significant risk factors associated with diabetes. Risk factor mitigation strategies aimed at high-risk groups should be implemented on board ships.*

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Keywords: diabetes, hypertension, overweight, obesity, smoking, seafarers, working hours

INTRODUCTION

Diabetes mellitus is a chronic, metabolic disease characterized by high levels of blood glucose or blood sugar which, over time, can adversely affect cardiovascular health. Type 2 diabetes is the most prevalent type of diabetes, usually occurring in adults, and it occurs when the body no longer

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produces enough insulin or becomes resistant to it [1]. In 2021, there were estimated to be 537 million people living with diabetes worldwide, and this number is expected to rise to 643 million by 2030 and 783 million by 2045 [2]. Diabetes is directly responsible for approximately 1.5 million deaths per year [1]. It is important to understand that there are several factors that can increase the risk of diabetes, including a high body mass index, a family history of diabetes, an unhealthy diet, physical inactivity, elevated blood pressure, and other factors [3].

Seafarers are individuals who work on vessels that travel through the oceans, seas, and other navigable waterways. They are responsible for navigating the vessel, operating machinery, and maintaining crew and passenger safety. Compared with land workers, seafarers are exposed to more psychological and physical stress because of the intrinsic nature of their work [4]. Seafarers may have limited access to fresh fruits, vegetables, and other healthy food options while at sea, which can lead to a diet high in processed and fast foods [5]. In other words, seafarers are more likely to live unhealthy lifestyles that can lead to increased body mass index and insulin resistance, which could increase the risk of developing diabetes. Seafarers smoke more and exercise less. Regarding physical activity, 58% of seafarers exercise less than once a week, whereas 31% of the general population exercise less than once a week [6]. In terms of smoking, it is estimated that 60% of seafarers are active smokers, compared to 22% of the general population [6]. In studies conducted on ships, modifiable risk factors such as high body mass index (both overweight and obesity) and tobacco smoking were found to be more prevalent among seafarers than those in the general population [7, 8]. These risk factors are also well-known as risk factors for diabetes. Many factors may explain why seafarers are more at risk of developing diabetes than the general population. Due to the nature of their work, seafarers are required to work long hours, for long periods of time away from their families, experience work-related stress, and live a sedentary lifestyle. There is substantial evidence that work-related stress contributes to chronic diseases such as diabetes mellitus and other cardiovascular diseases [7, 9]. As a result of their particularly hazardous work environment, which is marked by physical and psychological strain, sudden climate change, vibration and sound radiation, seafarers are more likely to suffer fatalities, injuries, and illnesses than workers ashore [10]. In general, seafarers are at an increased risk of developing type 2 diabetes as a result of their lifestyle and working conditions on board ships [6].

Different studies have documented that the prevalence of diabetes mellitus among seafarers ranges from 3.30% to 22.04% [11–15]. However, most of the studies conducted on board vessels [16–20] were based on those seafarers who contacted telemedical maritime assistance services (TMAS) centres for medical advice during emergency situations, rather than conducting surveys on board ships by considering a representative sample of seafarers. Evidence-based information pertaining to the prevalence of diabetes on board ships among seafarers is limited, although seafarers are exposed to different factors which increase their risk for chronic diseases such as diabetes.

It is important to understand the current prevalence of self-reported diabetes mellitus on board ships to reduce the burden of this disease among seafarers. Self-reporting is a widely used technique in research settings to evaluate the burden of health conditions, including high blood pressure (hypertension), despite several drawbacks such as low sensitivity [21]. However, Najafi et al. (2019) have provided strong evidence about the comparability of self-reports and objective assessments of hypertension [22]. The research found that self-reported hypertension had a sensitivity of 75.5% and specificity of 96.4% [22], which supports the acceptability of self-reports as a method of evaluating the burden of the health condition. The self-reporting approach is a cost-effective strategy that relies on people voluntarily disclosing their attitudes, habits, beliefs, or plans regarding health issues [23]. Self-reported histories of heart disease, diabetes, and hypertension are valid and reliable when compared to direct measurements [24]. Therefore, the primary objective of this study was to estimate the prevalence of self-reported diabetes mellitus among seafarers. In addition, the study aimed to identify potential risk factors associated with this condition. Finding the sociodemographic and occupational traits linked to a higher risk of diabetes could result in practical diabetes preventive and management plans for sailors.

MATERIALS AND METHODS

We used a cross-sectional epidemiological study design. This study was conducted on board ships between November and December 2022 among seafarers. We recruited participants for the study through the Italian Telemedical Maritime Assistance Service (TMAS). The Centro Internazionale Radio Medical (C.I.R.M.) centre, an Italian TMAS, provides teleconsultations and medical advice to seafarers and passengers regardless of their nationality. A simple random sample technique was used to choose 210 ships out of a list of more than 5,000 ship contacts. To get authorization to submit an anonymous questionnaire and get seafarer lists, the second stage involved presenting the protocol and goal of the study to all captains of the chosen vessels. Captains who consented to participate in the study provided us with the active seafarer lists for 210 ships. On 210 ships, we counted 4,500 sailors. Individuals who signed an informed consent form and were older than 18 were eligible. Based

on our qualifying requirements, we subsequently chose potential participants.

The study team conducted a one-day videoconference training on survey administration for one crew member and telemedicine case manager (TCM) per ship in cooperation with the C.I.R.M. doctors. TCMs are crew members with specific responsibilities related to seafarers' healthcare. In addition to being trained as medical first responders, TCMs possess valuable experience and skills gained from working on board ships and contacting the TMAS centre during emergencies on board ships. They are also familiar with the procedures and protocols established by the maritime industries. Therefore, the C.I.R.M. emailed the questionnaire to telemedicine case managers along with an invitation letter and informed consent form. The survey was then administrated by each vessel's telemedicine case manager and a trained crew member. Participants received a brief overview of the study's goals, methods, confidentiality statement, and voluntary participation in the invitation letter. The participants received assurances regarding the confidentiality of their answers. Prior to taking part in the study, the individual gave written informed consent.

Data were collected using a standardized and anonymous questionnaire that consists of four main components. The first part of the questionnaire consists of socio-demographic questions (age, gender, educational level, nationality, and marital status). In the second section of the questionnaire, occupational characteristics were addressed (rank, work site, work experience, and work hours), and in the third part, health-related characteristics were included (hypertension, smoking status, snoring, and body mass index). Hypertension was determined by asking the following questions: "Have you ever been told by a physician or other health professional that you have hypertension?" There are only two possible answers, "Yes" or "No". For those who answered "Yes", the next question was, "Are you currently receiving medication for your hypertension?". The answer to this question has two options: "Yes" or "No". Participants who answered "yes" to the above medicine question were also asked to show any antihypertensive medication they were taking. Self-reported hypertension (HTN) is defined in this study as having previously been diagnosed with hypertension and currently taking medication to treat it. The self-reported diabetes was assessed by asking, "Have you ever been told by a doctor that you have high blood sugar or diabetes?". Subjects who answered "Yes" to the above question were then asked if they were taking medication for high blood sugar levels at present. In addition, those subjects who were taking medication due to diabetes were asked to provide evidence of the medication they were receiving. Self-reported diabetes mellitus (DM) is defined as having a past diagnosis of diabetes mellitus and being treated currently for diabetes mellitus. Smoking habits were assessed by asking, "Do you currently smoke tobacco products?" There are two responses to the above question, "Yes", and "No". Those who answered "Yes" were further asked if they smoked tobacco products on a regular basis. Those who answered "Yes" to the above question were also asked how long they had smoked cigarettes continuously. We considered participants who had not ceased smoking tobacco products for at least six months as current smokers. Snoring was assessed by asking the question, "Do you snore when you sleep?" Those who answered "Yes" were further asked how frequently they snore per week. The body weight and height of study participants were measured. Body mass index (BMI) was calculated by dividing the weight in kilograms (Kg) by the height in meters (m) squared. In accordance with the World Health Organization (WHO) guidelines [25], BMI was classified into four categories: underweight (< 18.5 kg/m^2), normal (18.5 to 24.99 kg/m^2), overweight (25 to 29.99 kg/m^2), and obesity (30 kg/m^2 and higher).

DATA ANALYSIS

Descriptive statistics included frequency and percentages, were determined for categorical variables to understand the distribution of socio-demographic and occupational characteristics of study participants. For each independent variable, we assigned categorical codes prior to conducting the analysis. A dependent variable in this study was self-reported diabetes, which was coded 0 for no diabetes and 1 for diabetes. To compare prevalence based on sociodemographic, occupational, and other health-related characteristics, the Chi-squared test was used. Bivariate and multivariable logistic regression models were used to identify socio-demographic and occupational variables associated with diabetes. The variables from the bivariate analysis with a P value of less than 0.25 were included in the multivariable logistic regression to identify the predictor variables. To assess the model's fitness, the Hosmer-Lemeshow goodness of fit test was used. Finally, the adjusted Odds Ratio (OR) and 95% Confidence Interval (CI) were reported. Statistical analyses were performed using R-software [26], version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

CHARACTERISTICS OF THE STUDY PARTICIPANTS

The study enrolled a total of 4,500 subjects aged 18 and older. The survey was completed by 3,250 seafarers with a response rate of 72.2%. Of the 3,250 respondents, 264 were excluded from the analysis due to missing data. In total, 2986 participants were included in the study. Diabetes mellitus is described in Table 1 based on the characteris-

tics of the study participants. In the study, the mean (SD) age of the participants was 37.96 ± 10.22 (ranging from 19 to 70 years). Among study participants with self-reported DM, the average age was 47.5 ± 9.46, while among those without DM, the average age was 37.1 ± 9.85. Among the study participants, 54.3% (1,621) were non-officers and 26.9% (803) were between the ages of 41 and 50. More than two-thirds (70.3%) of the study subjects were married, and over fifty percent (55.7%) were deck workers. 23.8% (712) of the study participants worked 71 hours or more per week, and 45.8% of study subjects had work experience at sea between 10 and 20 years. Only 18.5% of the study participants had sailed at sea for 21 years or more. 49.7% and 9.5% of the study participants were overweight and obese, respectively (Table 1).

PREVALENCE OF SELF-REPORTED DIABETES

The overall prevalence of self-reported DM was found to be 8.2% (95% CI: 7.2–9.2). Among non-officers, 9.0% (95% CI: 7.8–10.7), and among officers, 7.0% (95% CI: 5.8–8.6) reported DM. Self-reported DM prevalence increased significantly with working hours per week, from 5.6% (95% CI: 4.2–7.6) among those who worked less than or equal to 56 hours per week to 10.0% (95% CI: 8.0–12.6) among those who worked 71 or more hours per week ($p = 0.006$). Similarly, the magnitude of reported DM significantly increased with work experience at sea, ranging from 1.3% (95% CI: 0.8–2.3) among those with less than 10 years of seafaring experience to 17.9% (95% CI: 14.9–21.5) among those with 21 years and more of seafaring experience ($p < 0.001$). In addition, the prevalence of diabetes mellitus significantly increased with age (1.4% in 19–30 years vs. 24.2% in 51 or older). In seafarers with self-reported hypertension (HTN), current smokers, and snorers, the prevalence of self-reported DM was 15.9% (95% CI: 13.2–19.0), 9.6% (95% CI: 7.9–11.7), and 9.9% (95% CI: 8.0–12.0), respectively. There was a significant increase in the magnitude of reported diabetes with an increased body mass index ($p < 0.001$). Consequently, 15.5% and 9.9% of obese and overweight seafarers reported diabetes, respectively. Table 1 shows the prevalence of self-reported diabetes with 95% confidence intervals (CIs) (Table 1).

PREDICTORS OF SELF-REPORTED DIABETES MELLITUS

A bivariate analysis of socio-demographic factors found that age, marital status, and educational level were significantly associated with a self-reported diagnosis of diabetes mellitus. Among occupational factors and other health-related factors, our unadjusted analysis revealed that rank, work sites, work experience, working hours per week, current smokers, and self-reported hypertension were significant-

Table 1. Characteristics of study participants and prevalence (%) of self-reported diabetes among seafarers (n = 2,986)

	Overall, n	Self-reported DM	p-value
Study participants	2,986	8.2 (7.2–9.2)	
Age (years)			< 0.001
19–30	833	1.4 (0.8–2.6)	
31–40	999	4.7 (3.5–6.3)	
41–50	803	12.5 (10.3–14.9)	
51+	351	24.2 (19.9–29.1)	
Marital status			< 0.001
Single	887	2.5 (1.6–3.8)	
Married	2099	10.6 (9.3–11.9)	
Educational level			0.030
Low	533	10.3 (7.9–13.3)	
Middle	1249	8.6 (7.2–10.4)	
Higher	1204	6.7 (5.4–8.3)	
Nationality			0.704
EU-countries	839	7.9 (6.2–9.9)	
Non-EU countries	2147	8.3 (7.2–9.6)	
Rank of seafarers			0.037
Officer	1365	7.0 (5.8–8.6)	
Non-officer	1621	9.0 (7.8–10.7)	
Work site			0.142
Galley	321	5.9 (3.7–9.2)	
Deck	1662	7.9 (6.7–9.4)	
Engine	1003	9.3 (7.6–11.3)	
Work experience			< 0.001
< 10 years	1065	1.3 (0.7–2.3)	
10–20 years	1369	9.6 (8.0–11.3)	
21+ years	552	17.9 (14.9–21.5)	
Working hours per week			0.006
≤ 56 hours	762	5.6 (4.2–7.6)	
57–70 hours	1512	8.5 (7.2–10.0)	
71+ hours	712	10.0 (8.0–12.6)	
Body mass index			< 0.001
Normal	1218	4.4 (3.3–5.7)	
Overweight	1484	9.9 (8.5–11.6)	
Obesity	284	15.5 (11.6–20.4)	

Table 1 cont. Characteristics of study participants and prevalence (%) of self-reported diabetes among seafarers (n= = 2,986)

	Overall, n	Self-reported DM	p-value
Current smoking			0.049
No	2017	7.5 (6.4–8.7)	
Yes	969	9.6 (7.9–11.7)	
Snoring			0.023
No	2099	7.4 (6.4–8.7)	
Yes	887	9.9 (8.0–12.0)	
Self-reported hypertension			< 0.001
No	2351	6.1 (5.2–7.2)	
Yes	635	15.9 (13.2–19.0)	

ly associated with the outcome variable. Among the variables, only nationality did not meet the criteria for inclusion in multivariable analyses (p = 0.704) (Table 2).

Multivariable analysis was performed in order to control the effects of confounders and to estimate the independent effects of the sociodemographic, occupational, and health-related factors on the self-reported diagnosis of diabetes mellitus. Accordingly, age from sociodemographic factors, work sites, rank, work experience, and working hours per week among occupational factors, and self-reported hypertension and body mass index (BMI) among other health-related factors were found to be independent predictors of self-reported diabetes mellitus (Table 2).

The odds of developing diabetes mellitus was more than three times higher among those aged 51+ years and older than among those aged between 19 and 30 years old [AOR = 3.52, 95% CI: 1.46–8.95]. Non-officers had 1.65 times the odds of self-reported diabetes as officers (AOR = 1.65; 95% CI: 1.14–2.40). Engine room workers were two times more likely to have self-reported diabetes than galley staff (AOR = 2.08; 95% CI: 1.19–3.77). A self-report of diabetes was 4.7 times more likely among seafarers with 10 to 21 years of seafaring experience compared to those with less than ten years (AOR = 4.66; 95% CI: 2.33–10.05). Furthermore, self-reported diabetes was five times more likely to occur in seafarers with 21 years or more of seafaring experience than in those with less than 10 years (AOR = 5.01; 95% CI: 2.32–11.55). Seafarers working 71 hours or more per week were nearly twice as likely to develop self-reported diabetes as those working less than or equal to 56 hours per week (AOR = 1.80; 95% CI: 1.17–2.80). Seafarers with hypertension were 1.44 times more likely to report diabetes than those without hypertension (AOR = 1.44; 95% CI: 1.03–1.99). The odds of developing diabetes mellitus for obese seafarers were nearly three times higher

Table 2. Bivariate and multivariable analysis of predictors of self-reported diabetes mellitus among seafarers

Characteristic	Self-reported DM		Unadjusted*			Adjusted		
	Yes, n (%)	No, n (%)	OR	95% CI	p-value	OR	95% CI	p-value
Age (years)								
19–30	12 (4.9)	821 (29.9)	–	–		–	–	
31–40	47 (19.3)	952 (34.7)	3.38	1.84–6.71	< 0.001	0.87	0.39–2.03	0.73
41–50	100 (41.0)	703 (25.6)	9.73	5.52–18.81	< 0.001	1.74	0.75–4.25	0.21
51+	85 (34.8)	266 (9.7)	21.86	12.22–42.70	< 0.001	3.52	1.46–8.95	0.006
Marital status								
Single	22 (9.0)	865 (31.5)	–	–		–	–	
Married	222 (91.0)	1,877 (68.5)	4.65	3.05–7.46	< 0.001	1.52	0.91–2.64	0.12
Educational level								
Low	55 (22.5)	478 (17.4)	–	–		–	–	
Middle	108 (44.3)	1,141 (41.6)	0.82	0.59–1.16	0.263	0.95	0.65–1.39	0.78
Higher	81 (33.2)	1,123 (41.0)	0.63	0.44–0.90	0.011	0.98	0.61–1.58	0.92
Nationality								
EU countries	66 (27.0)	773 (28.2)	–	–				
Non-EU countries	178 (73.0)	1,969 (71.8)	1.06	0.79–1.43	0.704			

Table 2 cont. Bivariate and multivariable analysis of predictors of self-reported diabetes mellitus among seafarers

Characteristic	Self-reported DM		Unadjusted*			Adjusted		
	Yes, n (%)	No, n (%)	OR	95% CI	p-value	OR	95% CI	p-value
Rank of seafarers								
Officer	96 (39.3)	1,269 (46.3)	–	–		–	–	
Non-officer	148 (60.7)	1,473 (53.7)	1.33	1.02–1.74	0.038	1.65	1.14–2.40	0.009
Work site								
Galley	19 (7.8)	302 (11.0)		–		–	–	
Deck	132 (54.1)	1,530 (55.8)	1.37	0.86–2.32	0.213	1.43	0.83–2.56	0.210
Engine	93 (38.1)	910 (33.2)	1.62	1.00–2.78	0.062	2.08	1.19–3.77	0.012
Work experience								
< 10 years	14 (5.7)	1,051 (38.3)	–	–		–	–	
10–20 years	131 (53.7)	1,238 (45.1)	7.94	4.72–14.50	< 0.001	4.66	2.33–10.05	< 0.001
21+ years	99 (40.6)	453 (16.5)	16.41	9.59–30.28	< 0.001	5.01	2.32–11.55	< 0.001
Working hours per week								
≤ 56 hours	43 (17.6)	719 (26.2)	–	–		–	–	
57–70 hours	129 (52.9)	1,383 (50.4)	1.56	1.10–2.25	0.015	1.57	1.08–2.31	0.022
71+ hours	72 (29.5)	640 (23.3)	1.88	1.28–2.80	0.002	1.80	1.17–2.80	0.008
Body mass index								
Normal	53 (21.7)	1,165 (42.5)	–	–		–	–	
Overweight	147 (60.2)	1,337 (48.8)	2.42	1.76–3.37	< 0.001	1.74	1.24–2.47	0.002
Obesity	44 (18.0)	240 (8.8)	4.03	2.63–6.15	< 0.001	2.93	1.84–4.65	< 0.001
Current smoking								
No	151 (61.9)	1,866 (68.1)	–	–		–	–	
Yes	93 (38.1)	876 (31.9)	1.31	1.05–1.72	0.049	1.30	0.96–1.75	0.082
Snoring status								
No	156 (63.9)	1,943 (70.9)	–	–		–	–	
Yes	88 (36.1)	799 (29.1)	1.37	1.04–1.80	0.024	0.74	0.53–1.02	0.066
Self-reported hypertension								
No	143 (58.6)	2,208 (80.5)	–	–		–	–	
Yes	101 (41.4)	534 (19.5)	2.92	2.22–3.83	< 0.001	1.44	1.03–1.99	0.030

*Common confounders adjusted for in the multivariable logistic regression model include age, marital status, educational level, rank, worksite, work experience, working hours per week, body mass index (BMI), smoking, snoring status, and hypertension.

than for those with normal body weights (AOR = 2.93; 95% CI: 1.84–4.65). Moreover, overweight seafarers were nearly two times more likely to develop diabetes than those with normal body weights (AOR = 1.74; 95% CI: 1.24–2.47).

DISCUSSION

In this cross-sectional epidemiological study, we assessed the magnitude of self-reported diabetes among seafarers and identified the sociodemographic, occupational, and other health related factors associated with it. In the present study, the prevalence of self-reported diabetes was 8.2% (95% CI: 7.2–9.2). Our finding was lower than some studies conducted in seafarers on board ships, which reported 23.8% [15], 22.04% [13] and 17.94% [14]. In contrast, the prevalence of diabetes mellitus in this study was greater than the prevalence reported in previous studies,

which was 3.30% [12] and 5.0% [11]. The difference might be attributed to variation in study design, the study tools they used to measures and other differences like study setting. For example, studies conducted on German-flagged ships [11] and in Indonesia [12] analysed data from routine medical fitness examinations of seafarers. Similarly, the studies conducted among seafarers in Iran [15] and the United States of America (USA) [13] were based on the results of annual health examinations. Due to the fact that our study was a questionnaire-based survey, there are many reasons why the prevalence of diabetes mellitus in our study might be lower than in other previously conducted studies. We assessed self-reported diabetes in our study and excluded participants who were not taking diabetes medication during the study period, even if they had high blood glucose levels. Thus, this may have contributed to an underestimation of diabetes prevalence in this study.

We found that seafarers aged 51 years and older were 3.5 times more likely to have diabetes than those aged 19–30 (AOR = 3.52, 95% CI: 1.46–8.95). According to a study conducted in the USA among seafarers, the prevalence of diabetes increases with age significantly [13]. The study conducted among the general population also indicated that advanced age is a risk factor for both prediabetes and diabetes [27]. Increasing age has been proven to have a major impact on the increased risk of diabetes. The reason for this might be because of aging effects, which are frequently accompanied by body fat accumulation that may contribute to insulin resistance. In addition, in this study we found that the prevalence of diabetes significantly increased with age (1.4% in 19–30 years vs. 24.2% in 51 years and older). As people age, insulin resistance increases, and this can cause a shift in β-cell functional mass. This alteration can lead to inadequate compensation, which has a significant effect on the body's ability to produce insulin [28]. The aging process is also associated with a decrease in β-cell proliferative capacity and an increase in sensitivity to apoptosis, further contributing to the decline in insulin production [28].

The results of our study showed that non-officers were 1.65 times more likely to develop diabetes than officers, while controlling for age, work site, working hours per week, work experience, educational level, marital status, snoring status, smoking status, body mass index, and self-reported hypertension. The reason for this might be work-related stress because non-officers handle tasks that arise during a voyage, which are physically more demanding [29]. Work-related stress is higher for non-officers because of sleep interruptions, high job demands, nightshift work, and intense activity [29]. In addition, metabolic disorders, including diabetes, are stress related [30]. This study also identified that engine room workers were two times more likely to develop diabetes than galley workers (AOR = 2.08, 95% CI: 1.19–3.77). The reason for this could be a work-related stressor in the engine room, as various studies have reported that workers in the engine room are exposed to noise, vibration, heat, or pollution daily [31, 32]. Because of the heat in their workplaces and the physically demanding nature of their jobs, engine room workers reported higher levels of work-related stress [31]. Different studies have reported that long-term noise was independently associated with an increased risk of developing diabetes, especially type 2 diabetes [33, 34]. According to a study conducted among the general population, participants with high job strain had a 45% higher fully adjusted risk of developing type 2 diabetes mellitus than those with low job strain [hazard ratios (HR) =1.45, 95% CI: 1.00–2.10] [35]. In addition, a meta-analysis showed that individuals with high job strain were 29% more likely to develop diabetes than those with low job strain [odds ratio (OR) = 1.29, 95% CI: 1.11–1.51] [36]. In general, seafarers have higher mental, psychological, and physical stressors than jobs ashore [37–39]. Furthermore, in terms of worksites on board ships, engine rooms have more work-related stress than deck and galley due to their work nature [31]. This could explain why engine room workers in this study are more likely to develop diabetes than catering staff.

The present study found that seafarers working 57–70 hours per week were 57% more likely to develop diabetes than those working less than or equal to 56 hours per week (AOR = 1.57, 95% CI: 1.08–2.31). Furthermore, this study demonstrated that seafarers working 71 hours or more per week were 80% more likely to have self-reported diabetes than those working less than or equal to 56 hours (AOR = 1.80, 95% CI: 1.17–2.80). We reported in our previous study that long working hours per week (57–70 hours per week and 71+ hours per week) were significantly associated with at least two modifiable cardiovascular risk factors [40]. According to a study conducted among seafarers, 49.3% of deck workers, 37.5% of engine room workers, and 64.7% of catering staff reported higher stress levels due to long working hours [31]. Working long hours can lead to a range of health problems, including an increased risk of diabetes. This is largely due to a chronic stress response mechanism, which activates the hypothalamic-pituitary-adrenal axis. This leads to an increase in cortisol and glucocorticoid levels, as well as insulin resistance, glucose intolerance, and obesity [41–43]. It is important to take measures to ensure that working hours are managed appropriately to avoid adverse health effects, including diabetes. This includes taking regular breaks, avoiding stressful situations, having a balanced diet, and exercising regularly.

The present study also revealed that seafarers with 10–20 years of seafaring experience were 4.66 times more likely to have self-reported diabetes than those with less

than 10 years of seafaring experience (AOR = 4.66, 95% CI: 2.33–10.05). We also found that after adjusting for factors such as age, educational level, BMI, working hours per week, marital status, rank, worksite, smoking, snoring, and self-reported hypertension, seafarers who had served at sea 21 years and more years were five times more likely to develop diabetes than seafarers who had served at sea for less than 10 years (AOR = 5.01, 95% CI: 2.32–11.55). A study conducted on German-flagged ships revealed that job duration at sea was significantly associated with at least three established coronary risk factors (AOR = 1.08, 95% CI: 1.02–1.14) after adjusting for age [44]. Compared to those without self-reported hypertension, participants with self-reported hypertension were 44% more likely to have diabetes mellitus in the current study (AOR = 1.44; 95% CI: 1.03–1.99). Insulin resistance is a condition in which the body's cells are resistant to insulin effects. It can be caused by several different factors, including high blood pressure, which is known to alter the delivery of insulin and glucose to the skeletal muscle cells. This alteration can lead to impaired glucose metabolism, which can cause the body to be unable to process blood sugar effectively [45]. As a result, individuals with high blood pressure frequently experience insulin resistance and are more likely to develop diabetes than those without high blood pressure [46]. Therefore, it is imperative to maintain healthy blood pressure levels in order to reduce the risk of developing insulin resistance.

Our study found that overweight seafarers were 74% more likely to develop diabetes than seafarers with normal body weights (AOR = 1.74; 95% CI: 1.24–2.47). The current study also identified that obese seafarers were almost three times more likely to have diabetes mellitus than their normal-weight counterparts (AOR = 2.93; 95% CI: 1.84–4.65). Obesity contributes to insulin resistance and decreases insulin-stimulated glucose disposal, leading to diabetes [47, 48]. High body mass index (BMI) can cause insulin resistance and impair the body's ability to process and dispose of glucose. This reduction in insulin-stimulated glucose disposal is a major factor in the development of diabetes. Therefore, reducing BMI is a crucial factor in reducing diabetes risk. Furthermore, Obesity is a serious health concern that has far-reaching implications. Not only does it increase the risk of diabetes mellitus, but it can also render seafarers unfit for employment on board ships [49–51]. As obesity can lead to physical limitations, it can prevent seafarers from successfully performing their tasks. This could include rigorous manual labour, emergency drills, and other safety-related activities. In addition, obesity can affect seafarers' overall health. This could include issues such as increased fatigue, difficulty breathing, and a weakened immune system. All these factors could cause seafarers to be unable to meet the physical requirements of the job. For these reasons, seafarers should take steps to prevent obesity and maintain a healthy lifestyle. This includes eating a balanced diet, engaging in regular physical activity, and getting rest. Doing so can help ensure their health and fitness for employment on board ships.

In general, chronic diseases, such as diabetes and other cardiovascular diseases, have received less attention on board ships than in the general population or among land workers, even though the risks are increasing. As a result, shipping companies, IMO, and other responsible bodies should work on strategies to mitigate diabetes risk factors to improve the health of seafarers. For TMAS centres as well as shipping companies to take action on diabetes on board ships, the results of our study will serve as a reference for the magnitude of diabetes among seafarers. Telemedicine would be the most effective approach at sea for reducing this disease burden and identifying high-risk groups of seafarers. Using telemedicine regularly, TMAS doctors can monitor and plan actions to assist sailors in managing their high blood pressure, blood sugar levels, and other lipid profiles. For example, on the part of the TMAS doctor, remote monitoring of treatment adherence, regular monitoring of patients with hypertension and diabetes, an antihypertensive or antidiabetic treatment plan, and health education regarding the prevention of their complications should be communicated to users through various telemedicine modalities or interactive communication. Advanced telemedicine technologies should be available on board ships via wireless communication technologies in order to provide users with advice on high blood glucose level management on a regular basis and to be able to communicate directly with TMAS doctors.

Limitation of this study: this study was a cross-sectional study, and the study design prevents us from determining the causality or temporal relationship between diabetes and associated factors. In the present study, we did not include participants who were not on treatment despite having high blood sugar levels. Therefore, it may have resulted in an underestimation of diabetes prevalence. Another limitation of this study is the possibility of nondisclosure of diabetes status during survey administration. This may also have led to underestimation of the actual prevalence of self-reported diabetes.

CONCLUSION

A total of 8.2% of seafarers aged 19 to 70 had diabetes. In our study, we observed a high prevalence of diabetes among non-officers. Diabetes prevalence was significantly higher among participants with more than 21 seafaring experiences at sea, those who worked long hours per week (71 or more hours), and obese seafarers. Age (51+ years), rank (non-officers), work site, working long hours per week, work experience, overweight, obesity, and self-reported

hypertension were the associated risk factors for self-reported diabetes. Therefore, a specific intervention should be designed and implemented on board ships to target the high-risk groups. Future longitudinal studies are required to investigate the causal or temporal relationship between diabetes and its associated risk factors and to recommend further intervention strategies on board ships.

ARTICLE INFORMATION AND DECLARATIONS

Author contributions: G.G.S.: conceived and designed the study, performed analysis, interpreted the data and results, and drafted the initial manuscript. G.B., G.R., and M.D.: contributed to data collection and drafting manuscript. F.A. reviewed, guided, and approved the study. The final version of the manuscript has been read and approved by all authors.

Ethics approval and consent to participate: The study was conducted in accordance with the Declaration of Helsinki's ethical principles for medical research involving human subjects and approved by the C.I.R.M. ethics, scientific, and medical committee. Each participant included in the study provided written informed consent.

Availability of data and materials: The datasets used and/or analysed during this study are available upon reasonable request from the corresponding author.

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