Original Article

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Physical Medicine and Rehabilitation Section

Carpal Tunnel Syndrome and Associated Factors among Healthcare Practitioners at Vaccine Centres in Saudi Arabia: A Cross-sectional Study

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ABSTRACT

Introduction: Carpal Tunnel Syndrome (CTS) presents with symptoms like numbness, tingling, and weakness along the median nerve pathway. Risk factors include prolonged wrist positions, repetitive muscle contractions, and exposure to vibrations.

Aim: To determine the prevalence of CTS among healthcare practitioners at vaccine facilities in Saudi Arabia.

Materials and Methods: A cross-sectional study on a total of 150 healthcare practitioners (aged 25-30 years) working in vaccination centres in Riyadh, Saudi Arabia were recruited. The study was conducted from November 2021 to March 2022. The authors collected demographic data, Body Mass Index (BMI) and work shift information, and administered two validated questionnaires, the Boston Carpal Tunnel Syndrome Questionnaire (BCTSQ) and the Duruoz Hand Index (DHI). CTS symptoms were diagnosed using Phalen's and Arm Raising Test (ART).

Results: Of the 150 practitioners (aged 25-45 years), predominantly in the 25-30 age group, n=65 (44.0%) tested positive on the Phalen's test, and n=65 (43.5%) on the ART. Females had higher BCTSQ scores, while DHI scores were similar across genders. Spearman's correlation analysis showed positive correlations between BCTSQ and DHI, and a moderate negative correlation between ART and DHI. Logistic regression analysed factors affecting the likelihood of CTS diagnosed by ART and Phalen's Test. Higher BCTSQ and DHI scores increased the likelihood of CTS (ART: BCTSQ OR=0.843, DHI OR=1.064; Phalen's Test: BCTSQ OR=0.830, DHI OR=1.069).

Conclusion: During the Coronavirus Disease-2019 (COVID-19) pandemic, the prevalence of CTS among healthcare practitioners at vaccine centres in Riyadh, Saudi Arabia reached up to 43-44%. The present study highlights that day shift workers face a higher risk of CTS compared to night shift workers, likely due to heavier daytime workloads. This underscores the need for ergonomic interventions and workload management, especially during high-demand periods like the vaccination campaign, to safeguard healthcare workers' health and productivity.

Keywords: Boston carpal tunnel syndrome questionnaire, Duruöz hand index, Median nerve, Occupational injury

INTRODUCTION

The CTS is diagnosed clinically, primarily based on a symptom complex that encompasses numbness, tingling, and weakness of the thenar muscles, along with a burning sensation within the median nerve distribution [1,2]. These symptoms are often more prevalent at night though they may also manifest during repetitive hand tasks, particularly for individuals engaged in busy, demanding occupations. Numerous risk factors contribute to the prevalence of CTS. Various medical factors can exacerbate CTS. These include conditions like diabetes [3], obesity, rheumatoid arthritis [4], metabolic syndrome, pregnancy, thyroid diseases, trauma, renal failure, mass lesions, leukaemia, and multiple myeloma. These medical factors may further compound the systems and severity of CTS [5,6]. Additionally, environmental factors play a significant role, including prolonged positions involving excessive wrist flexion or extension, repetitive movements of wrist flexor muscles, and exposure to excessive vibration [7]. Among these factors, repetitive movements are significant risk factors for the development of CTS [8].

Healthcare practitioners often engage in highly repetitive movements, which include dynamic actions such as using syringe plungers, operating blood pressure bulbs, typing on keyboards, and performing various work-related tasks [9]. These repeated movements can contribute to an increased incidence of CTS among this group of healthcare professionals.

Healthcare practitioners exhibit the highest incidence of overexertion injuries, prompting workplace health experts to seek methods to alleviate this risk. Furthermore, healthcare practitioners, particularly in busy settings such as vaccine centres in Riyadh, Saudi Arabia where they routinely administer numerous vaccination doses during one-day clinics, are susceptible to the development of finger, wrist, or forearm pain. As an illustrative example of such a busy setting, after the Saudi Pharmaceutical Industries and Medical Appliances Corporation (SPIMACO) in Saudi Arabia signed agreements approving the usage of the Pfizer-BioNTech vaccine and the AstraZeneca vaccine with associated side-effects [10], and the Moderna vaccine [11], the Saudi coronavirus vaccination campaign commenced in December 2020. Across the kingdom, almost 587 vaccine centres in Saudi Arabia were established, including 12 in Riyadh. From December 2020 to March 2022, these centres in Riyadh, Saudi Arabia administered approximately 10 million vaccine doses, involving about three million working hours and 144 million appointments. In addition, the operation can handle up to 500 thousand appointments per day, and more than 12 million text messages were sent for reservations, motivation, and reminders about the importance of receiving the vaccines [12]. The unique occupational environment of vaccine centres in Riyadh, Saudi Arabia , characterised by repetitive hand movements, prolonged equipment use, and ergonomic challenges, presents a fertile ground for the development of CTS [13].

Numerous studies have investigated the prevalence and risk factors of CTS among healthcare practitioners, including nurses, physicians, and allied health professionals [9,14-17]. However, limited attention has been given to healthcare practitioners specifically those working in vaccine centres in Riyadh, Saudi Arabia, where the demands and stressors of administering vaccinations may exacerbate ergonomic risk factors associated with CTS development. This may be due to their engagement in several mechanical and environmental stressors that workers in other fields do not commonly experience. Despite the growing importance of vaccination efforts, there remains a notable gap in the available literature regarding the prevalence, risk factors, and impact of CTS on the healthcare workforce in these settings. While CTS can affect individuals across various occupations [18-20], emerging evidence suggests that healthcare practitioners working in vaccine centres in Riyadh, Saudi Arabia may be at a heightened risk of developing this condition. Understanding the factors contributing to the increased prevalence of CTS in this population is crucial for implementing effective prevention and management strategies.

The present study aimed to address the gap by investigating the prevalence and risk factors of CTS among healthcare practitioners working in COVID-19 vaccine centres in Riyadh, Saudi Arabia. By examining the association between occupational factors, such as repetitive hand movements and ergonomic conditions, and the development of CTS symptoms, the present research seeks to provide valuable insights into the occupational health concerns of frontline healthcare workers during the COVID-19 pandemic.

MATERIALS AND METHODS

A cross-sectional study was conducted at the vaccine centres in Riyadh, Saudi Arabia, from November 2021 to March 2022. The Majmaah University Research Ethics Committee (MUREC) in Saudi Arabia reviewed and approved the present study under ethics project # (HA-01-R-088). Also, approval from the Saudi Ministry of Health (MOH) was obtained under project # (21-117E).

Inclusion criteria: The inclusion criteria for the present study comprised healthcare practitioners who worked at the vaccine centres in Riyadh, Saudi Arabia and experienced one or more of the following: numbness and tingling sensation in the median nerve territory of the hand, with or without pain, symptoms induced by repetitive hand movements or malposition, symptoms relieved by resting, rubbing, or shaking the hand, nighttime awakening and sleep disturbance, and weakness in thumb abduction.

Exclusion criteria: The present study excluded participants who presented with sensory or motor complaints in the upper extremities, upper extremity deformities, Parkinson's disease, peripheral neuropathies, the presence of predisposing factors for peripheral neuropathies (such as hypothyroidism and diabetes), arthritic diseases, other neurologic conditions, a history of wrist or arm trauma, peripheral nerve repair, or pregnancy.

Sample size calculation:

Formula to calculate sample size: $$n=\frac{Z^2 \times p \times (1-p)}{E^2 + \frac{Z^2 \times p \times (1-p)}{N}}$$

n=sample size needed

Z=Z-score corresponding to the desired level of confidence (e.g., 1.96 for a 95% confidence level)

p=estimated population proportion (the proportion of healthcare practitioners experiencing a certain outcome)

E=margin of error (the desired precision or level of accuracy)

N=population size

Assuming a conservative estimated population proportion of 0.5 (to maximise the sample size) and a finite population size of, for instance, 10,000 healthcare practitioners in the Riyadh region, a sample size of approximately 150 was needed to estimate the prevalence of burnout among healthcare practitioners during the COVID-19 pandemic with a 95% confidence level and a margin of error of 5%.

Study Procedure

The participants were interviewed face-to-face. After signing the informed consent, questions on demographic data, including age, height (cm), weight (kg), Body Mass Index (BMI; kg/m^2), dominant hand (right, left, or both), and work shift (day, night, or both) were collected. The BCTSQ was used to measure the intensity of symptoms and functional status in CTS [21]. The BCTSQ contains two scales: the Symptom Severity Scale (SSS) and the Functional Status Scale (FSS). The SSS comprises 11 items rated on a Likert scale ranging from 1 (normal) to 5 (very serious). Meanwhile, the FSS encompasses eight items, similarly rated on a Likert scale from one (no difficulty) to five (inability to perform the activity). Higher scores on both scales indicate greater impairment in functional abilities [22,23]. Subsequently, the participants were requested to be seated in chairs in a relaxed and comfortable position, with their elbows flexed to allow maximal wrist flexion. Then, the DHI was utilised to assess activity limitations and hand-related impairment. The DHI, a self-report questionnaire consisting of 18 items, yields higher scores indicative of greater hand-related disability [24]. Following the questionnaire administration, Phalen's test was conducted, wherein participants were instructed to hold their hands at the wrist in extreme flexion for one minute. This manoeuvre is considered positive often when it reproduces painful symptoms, including nocturnal pain and paresthesia, typically localised to the thumb, index, and middle fingers but occasionally extending to the entire hand [25]. Finally, ART was administered by instructing participants to elevate both hands above their heads for one minute. The test result was considered positive if paresthesia, numbness, or dull pain occurred [24]. ART is the most sensitive and specific test for diagnosing CTS, with a reported positive predictive value of 98.3%, a negative predictive value of 81.9%, and an accuracy of 91.4% [26].

STATISTICAL ANALYSIS

The data were analysed using Statistical Package for Social Sciences (SPSS) version 19.0 Descriptive statistics were utilised to summarise the demographic data. The correlation between tests and questionnaires was determined using the Spearman's correlation coefficient. Additionally, a binary logistic regression analysis was conducted to assess the predictive strength of demographic variables and workplace factors on the occurrence of CTS, as diagnosed by the ART and Phalen's Test. All assumptions necessary for conducting binary logistic regression analysis were satisfied by the data. The significance level was set at 0.05.

RESULTS

Participant characteristics: The study involved 150 healthcare practitioners at different vaccination centres in Riyadh, Saudi Arabia in the Riyadh region during the COVID-19 pandemic. Most participants 79 (52.7%), belonged to the age group between 25 and 30 years, while only a small number of participants 7 (4.7%), belonged to the age group between 46 and 50 years. Most participants in the study were female (n=94), 62.6%. The mean score of female participants on the BCTSQ was higher (mean=30.3.1, SD=12.5) than that of male participants (mean=25.1, SD=7.0). However, no statistically significant difference was found for DHI between genders, p=0.373 [Table/Fig-1].

The demographic distinctions among participants diagnosed with CTS classified as positive or negative, all of whom were employed at a vaccination centre during the COVID-19 pandemic is presented in [Table/Fig-2,3]. Individuals with positive CTS 65 (43.33%),

Variables	Male (n=56) n (%)[a] M(SD)[b]	Female (n=94) n (%)[a] M(SD)[b]	All (N=150) n (%)[a] M(SD)[b]	p-value
Age (years)				
25-30 (years)	27 (48.2)[a]	52 (55.3)[a]	79 (52.7)[a]	0.780*
31-35 (years)	16 (28.6)[a]	19 (20.2)[a]	35 (23.3)[a]	
36-40 (years)	6 (10.7)[a]	13 (13.8)[a]	19 (12.7)[a]	
41-45 (years)	4 (7.1)[a]	6 (6.4)[a]	10 (6.7)[a]	
46-50 (years)	3 (5.4)[a]	4 (4.3)[a]	7 (4.7)[a]	
Working shift				
Day shift	32 (57.1)[a]	49 (52.1)[a]	81 (54.0)[a]	0.229**
Night shift	14 (25.0)[a]	17 (18.1)[a]	31 (20.7)[a]	
Both	10 (17.9)[a]	28 (29.8)[a]	38 (25.3)[a]	
Hand dominance				
Right	50 (89.3)[a]	76 (80.9)[a]	126 (84.0)[a]	0.336*
Left	4 (7.1)[a]	10 (10.6)[a]	14 (9.3)[a]	
Both	2 (3.6)[a]	8 (8.5)[a]	10 (6.7)[a]	
Body mass index				
Height (cm)	172.6 (6.6)[b]	158.1 (5.3)[b]	68.3 (16.2)[b]	0.001*
Weight (kg)	79.2 (16.0)[b]	61.8 (12.5)[b]	163.6 (9.1)[b]	0.111*
BMI (kg/m²)	26.5 (5.2)[b]	24.7 (4.8)[b]	25.4 (5.0)[b]	0.001*
Questionnaire scores				
Boston Self-assessment questionnaire	25.1 (7.0)	30.3 (12.5)	28.3 (11.1)	0.134*
Duruoz Hand Index (DHI) questionnaire	24.0 (11.9)	24.4 (10.3)	24.3 (10.9)	0.373*

[Table/Fig-1]: Participants' characteristics.
M: Mean; SD: Standard deviation; N: frequency, %: Percentage
*Likelihood Ratio, **Pearson Chi-square, BMI: Body mass index

as determined by the Phalen's test, exhibited higher weight (mean=68.3, SD=15.6), BMI, and scored higher on the Boston Self-assessment Questionnaire and the DHI Questionnaire compared to those with negative CTS. Conversely, participants with positive CTS identified through the ART (n=46, 44%) did not display differences in weight (mean) or BMI but demonstrated higher scores on both questionnaires in comparison to individuals with negative CTS diagnosed via the ART.

Assessment of binary logistic regression: Logistic regression was performed to determine the effects of age, height, weight, BMI, gender, hand dominance, work shift, and BCTSQ and DHI scores on the likelihood that participants had CTS as diagnosed by ART [Table/Fig-4]. The logistic regression model was statistically significant {χ^2 (14)=44.326, p<0.001}. The model explained 34.3% (Nagelkerke R^2) of the variance in CTS and correctly classified 75.3% of cases. A significant difference (p=0.021) was observed in the likelihood of developing CTS between shift workers, with day shift workers being 4.244 times more likely to develop CTS than those on other shifts. In addition, increasing scores on the BCTSQ and DHI were associated with an increased likelihood of exhibiting CTS, by 0.843 and 1.064 times, respectively. Similarly, for Phalen's Test [Table/Fig-5], the logistic regression model was statistically significant {χ^2 (14)=59.737, p<0.001}. The model explained 44.1% (Nagelkerke R^2) of the variance in CTS and correctly classified 74.7% of cases. Increasing scores on the BCTSQ and DHI were associated with an increased likelihood of exhibiting CTS by 0.830 and 1.069 times, respectively [Table/Fig-5].

Spearman's correlation analysis indicated that there was a strong, significant positive correlation between scores on the BCTSQ and the DHI (r=0.764, n=150, p<0.01), and a moderate, significant negative correlation between the DHI and ART (r=-0.308, n=150, p<0.01). Other significant correlations are shown in [Table/Fig-6].

Phalen's test		Weight (kg)	Height (cm)	BMI (kg/m²)	Boston self-assessment questionnaire	Duruoz Hand Index (DHI) questionnaire
Positive (Male=20, Female=45)	Mean (SD)	71.7 (16.6)	162.3 (8.3)	27.14 (5.5)	34.2 (12.6)	27.0 (11.8)
	Variance	276.4	70.1	30.7	160.1	139.4
	Range	48-110	145-182	18.3-41.8	19-66	18-68
Negative (Male 36, Female=49)	Mean	65.6 (15.5)	164.4 (9.5)	24.0 (4.2)	23.9 (7.1)	22.2 (9.7)
	Variance	240.7	91.9	18.2	51.0	95.3
	Range	40-115	146-184	16.1-35.5	18-58	17-78

[Table/Fig-2]: Characteristics of participants with positive and negative test results from Phalen's Test (Positive=65, Negative=85).

Arm raising test		Weight (kg)	Height (cm)	BMI (kg/m²)	Boston self-assessment questionnaire	Duruoz Hand Index (DHI) questionnaire
Positive (Male=19, Female=47)	Mean (SD)	68.3 (15.6)	162.45 (8.51)	25.7 (5.1)	33.6 (12.1)	26.7 (11.1)
	Variance	243.5	72.4	26.3	148.7	123.5
	Range	40-108	145-184	16.6-41.7	19-66	18-68
Negative (Male=37, Female 47)	Mean (SD)	68.3 (16.8)	164.4 (9.5)	25.1 (5.0)	24.2 (8.1)	22.3 (10.4)
	Variance	282.7	90.7	25.5	66.2	109.2
	Range	44-115	146-183	16.4-41.8	18-59	17-78

[Table/Fig-3]: Characteristics of participants with positive and negative test results from Arm Raising Test (ART) (Positive=66, Negative=84).

Model Summary-ART

Model	Deviance	AIC	BIC	df	χ^2	p-value	McFadden R^2	Nagelkerke R^2	Tjur R^2	Cox and Snell R^2
H_0	205.779	207.779	210.790	149						
H_1	161.453	191.453	236.613	135	44.326	<0.001	0.215	0.343	0.264	0.256

Coefficients

	Estimate	Standard error	Odds ratio	z	Wald test: Wald statistic	Wald test: df	Wald test: p-value
(Intercept)	-1.346	19.642	0.260	-0.069	0.005	1	0.945
Gender (Female)	-0.584	0.673	0.558	-0.867	0.752	1	0.386

Age (31-35) (in years)	-0.452	0.537	0.636	-0.841	0.708	1	0.400
Age (36-40) (in years)	0.617	0.694	1.852	0.888	0.788	1	0.375
Age (41-45) (in years)	-1.332	0.993	0.264	-1.342	1.800	1	0.180
Age (46-50) (in years)	0.865	1.370	2.375	0.631	0.399	1	0.528
Working Shift (Nightshift)	0.235	0.527	1.265	0.447	0.200	1	0.655
Working Shift (day)	1.446	0.624	4.244	2.315	5.360	1	0.021
Dominant Hand (Left)	-0.787	0.701	0.455	-1.123	1.260	1	0.262
Dominant Hand (right)	-0.303	0.861	0.739	-0.352	0.124	1	0.725
Duruoz Hand Index (DHI) questionnaire	0.062	0.031	1.064	2.008	4.032	1	0.045
Weight	-0.065	0.134	0.937	-0.488	0.238	1	0.626
Height	0.033	0.119	1.034	0.279	0.078	1	0.781
BMI	0.160	0.364	1.173	0.438	0.192	1	0.661
Boston self-assessment questionnaire	-0.171	0.038	0.843	-4.486	20.125	1	<0.001

[Table/Fig-4]: Logistic Regression Model of Arm Raising Test (ART).
ART level 'Negative' coded as class 1

Model Summary-Phalen's test

Model	Deviance	AIC	BIC	df	χ^2	p-value	McFadden R^2	Nagelkerke R^2	Tjur R^2	Cox and Snell R^2
H_0	205.270	207.270	210.280	149						
H_1	145.532	175.532	220.692	135	59.737	<0.001	0.291	0.441	0.344	0.329

Coefficients

					Wald test		
	Estimate	Standard error	Odds ratio	z	Wald statistic	df	p-value
(Intercept)	19.290	22.539	$2.385\times10^{+8}$	0.856	0.732	1	0.392
Gender (Female)	-0.551	0.715	0.576	-0.771	0.595	1	0.441
Age (31-35)	-0.098	0.573	0.906	-0.171	0.029	1	0.864
Age (36-40)	1.202	0.769	3.327	1.563	2.444	1	0.118
Age (41-45)	0.187	1.165	1.205	0.160	0.026	1	0.873
Age (46-50)	-1.379	1.467	0.252	-0.940	0.884	1	0.347
Working shift (Nightshift)	-0.049	0.554	0.952	-0.088	0.008	1	0.930
Working shift (day)	1.045	0.663	2.843	1.575	2.480	1	0.115
Dominant hand (Left)	-0.251	0.793	0.778	-0.317	0.100	1	0.751
Dominant hand (right)	-0.389	0.925	0.678	-0.420	0.177	1	0.674
Duruoz and Index (DHI) questionnaire	0.066	0.033	1.069	2.013	4.052	1	0.044
Weight	0.067	0.154	1.069	0.433	0.187	1	0.665
Height	-0.070	0.136	0.932	-0.516	0.266	1	0.606
BMI (kg/m²)	-0.333	0.423	0.717	-0.786	0.618	1	0.432
Boston self-assessment questionnaire	-0.186	0.042	0.830	-4.390	19.276	1	<0.001

[Table/Fig-5]: Logistic Regression Model of Phalen's Test.
Phalen's Test level 'Negative' coded as class 1

	Arm raising test	Phalen's test	Boston self-assessment questionnaire
Phalen's test	0.580**		
Boston self-assessment questionnaire	-0.470**	-0.485**	
Duruoz Hand Index (DHI) questionnaire	-0.308**	-0.325**	0.764**

[Table/Fig-6]: Spearman's rho Correlations Matrix between Test and Questionnaires.
**Correlation is significant at the 0.01 level (2-tailed)

DISCUSSION

The present study aimed to determine the prevalence of CTS among Saudi vaccination practitioners during the COVID-19 pandemic, with the participation of 150 healthcare professionals. Phalen's test, the BCTSQ, and the Disabilities of the Arm, Shoulder, and Hand (DHI) were utilised to evaluate CTS prevalence among the participants.

The findings revealed a high prevalence of CTS among participants, with 43.5% (n=65) exhibiting classical symptoms of CTS according to Phalen's Test and 44.0% (n=66) according to the Arm Raise Test (ART). A summary of the table is provided indicating a prevalence ranging from 4.5 to 26.7% [Table/Fig-7] [27-39].

Females scored higher on the BCTSQ than males, indicating a higher likelihood of developing CTS. These findings align with Schulze DG and Nilsen KB (2021), who evaluated the clinical utility of the CTS-6 and BCTSQ for assessing disease intensity in a Norwegian population [40]. Similarly, a study in Saudi Arabia demonstrated that females experience higher rates of CTS compared to males [19], with female

Study/Source	Prevalence of CTS (%)	Sample size	Year	Population	Country
Aghilinejad M et al., [27]	26.7	300	2017	Steel workers	Iran
Harris-Adamson C et al., [28]	8.7	1,107	2015	Healthcare workers	United States
Hegmann KT et al., [29]	5.1	4,143	2003	Healthcare workers	United States

Trinkoff AM et al., [30]	11.3	6,151	2003	Nurses	United States
Smith DR et al., [31]	9.8	570	2004	Computer users	United States
Bonfiglioli R et al., [32]	18.5	1,161	2006	Hospital workers	Italy
Roquelaure Y et al., [33]	12.7	3,215	2009	Healthcare workers	France
Burt S et al., [34]	4.5	1,000	2003	Healthcare workers	United States
Violante FS et al., [35]	14.3	1,500	2003	Healthcare workers	Italy
Gerr F et al., [36]	10.2	1,200	2001	Dental hygienists	United States
Franzblau A et al., [37]	8.9	1,500	2005	Automotive assembly workers, and healthcare workers	United States
Nordander C et al., [38]	13.5	1,200	2013	Laboratory technicians	Sweden
Roquelaure Y et al., [39]	16.8	1,800	2001	Supermarket cashiers	France
Present study	44	150	2022	Vaccination centre worker	Saudi Arabia

[Table/Fig-7]: Summary of the prevalence of CTS in the previous studies [27-39].

Saudi dentists being over twice as likely as their male counterparts to develop CTS symptoms. However, McDiarmid M et al., (2000) found no correlation between gender and CTS [41]. Furthermore, evaluations of symptom severity using the BCTSQ and diagnostic screening with hand diagrams also yielded higher scores for females [42], while it appears that CTS incidence in males rises with age [43]. The highest incidence of CTS occurs among the working population aged 25 to 45 years, with similar risk levels between males and females [18]. Compared to the non working population, individuals engaged in employment exhibit a significantly elevated risk of developing CTS [44]. Healthcare practitioners are particularly susceptible to CTS in their occupational settings compared to those in other professions [45]. Gender differences play a significant role in CTS prevalence, with approximately 4-5% of the global population affected, showing a prevalence of 6% in males and 9.2% in females [46]. Multiple studies consistently report that females are more prone to CTS than males [41,43,47-50], possibly due to the inherently smaller cross-sectional space of the carpal tunnel in females compared to males, as observed in Magnetic Resonance Imaging (MRI) scans [48]. The increased risk of CTS in pregnant and nursing females, as well as those in the first year of menopause, individuals using oral contraceptives, or undergoing hormone replacement therapy, suggests that hormonal factors may contribute to these gender disparities [51]. Conversely, CTS prevalence in males tends to rise with age [43].

The prevalence of CTS was higher in ART when compared to Phalen's test. This finding aligns with Ahn DS (2001), who found ART to be more sensitive and specific for identifying CTS than Phalen's and Tinel's tests [52]. Additionally, Amirfeyz R et al., reported ART's superiority over questionnaires and other clinical tests [53]. Arab AA et al., (2018) concluded that ART as the most accurate test for CTS after studying 123 patients [26]. In the present study, day shift workers were more prone to CTS due to heavier workloads, especially during the increased work hours of the COVID-19 vaccination period in Saudi Arabia. Shift and long-hour workers tested positive on ART for CTS, while night shift workers showed lower susceptibility. Similarly, in a study by Alhusain FA et al., experienced dentists experienced more CTS symptoms than younger ones [19].

Although there is a correlation between years of service and CTS incidence, no relationship was found between workload and the occurrence of CTS [54]. Recent cases of CTS have shown an increase in Work-related Musculoskeletal Disorders (WMSDs), attributed to heightened strain and repetitive movements among individuals. Many healthcare professionals have reported WMSDs in atleast one body region [14]. Working in the same position for prolonged periods and handling an excessive number of patients or samples per day were the most frequently reported work risk factors contributing to the development of WMSDs.

There was no statistically significant difference in the occurrence of CTS with hand dominance. This disagrees with a previous study on Saudi dentists, which reported that left-handedness was strongly associated with CTS symptoms, with an estimated Odds Ratio (OR) of 6.28 (95% CI 1.24-31.90) [19]. Right-handed female nurse anaesthetists were more likely to have left-hand and bilateral CTS than operating room nurses, with an odds ratio of 3.85 (CI, 1.05-12.16) [15]. The disparity may be attributable to the difference in physical work between the two occupations and the repetitive nature of the job performed in vaccination facilities. Furthermore, it's worth noting that the sample distribution in this study was uneven, with the majority of the population being right-handed.

Limitation(s)

The present study is subject to certain limitations. Firstly, the absence of Nerve Conduction Velocity (NCV) testing, which is widely recognised for its superior sensitivity and specificity in diagnosing CTS [55,56]. Secondly, a previous study has reported a correlation between work-related pain and specific healthcare professions, such as Nurses, Dentists, and Physiotherapists [14]. However, the present study did not document the specific occupations of the healthcare professionals participating in the research.

This gap in information limits our ability to explore potential associations between occupation and the prevalence of CTS. Future investigations should consider including this critical occupational data to gain deeper insights into this relationship. It's worth noting that employing objective tools, like Electromyography (EMG) and NCV, is essential for confirming CTS diagnosis without introducing bias.

To address these limitations, future studies should incorporate these objective diagnostic tools to enhance the reliability of their findings. To introduce the incidence of work-related musculoskeletal pains in healthcare professionals, particularly those at high-risk, it is imperative to develop an awareness and education program aimed at prevention and effective management. Such a program is essential not only for the well-being of the healthcare workforce but also to enhance patient care efficiency.

CONCLUSION(S)

Throughout the COVID-19 pandemic, a notable prevalence of CTS was observed, reaching as high as 43-44% among healthcare practitioners at vaccine centres in Riyadh, Saudi Arabia. The present study in Saudi Arabia revealed that day shift workers are at a higher risk of developing CTS compared to those on night shifts, potentially due to heavier workloads during daytime hours. This emphasises the importance of implementing measures to alleviate strain and promote ergonomic practices, especially during periods of increased workload such as the COVID-19 vaccination campaign. Healthcare organisations should prioritise strategies to mitigate the risk of CTS among their staff, including regular assessments, ergonomic interventions, and workload management, to ensure a healthy and productive workforce.

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Authors' contribution: RaA, RyA, and BA conceived of the idea. AA, RaA, RyA, and BA planned the experiments and developed the theory. RaA, RyA, BA, and SA collected the data. AA and Faizan Kashoo verified the analytical methods and performed the computations. AA supervised the findings of the present work. RaA, RyA, and BA wrote the manuscript with support from AA. AA finalise the writing. All authors discussed the results and contributed to the final manuscript.

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