Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Knowledge, practice and emotional status related to COVID-19 pandemic among radiology technicians working at pandemic hospitals

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ABSTRACT

Purpose: This study aimed to evaluate knowledge, attitude, practice and emotional and psychological concerns related to COVID-19 pandemic among radiology technicians working at pandemic hospitals across Turkey

Methods: A total of 228 radiology technicians working at pandemic hospitals across Turkey were included on a voluntary basis in this questionnaire-based online survey The questionnaire form elicited items on socio-demographic and occupational characteristics and personal opinions and experience on COVID-19 outbreak and related protective strategies, along with survey scales including Knowledge on COVID-19 Outbreak Scale (KCS), Knowledge on Protective Strategies for COVID-19 Scale (KPSCS), General Preventive Practices for COVID-19 Scale (GPPCS), Emotional State Scale (ESS) and Fear of COVID-19 Scale (FCS).

Results: Males had lower ESS ($p = 0.004$) scores and higher FCS ($p = 0.026$) scores than females. Having a COVID-19 training (63.4 %) was associated with higher KCS ($p = 0.006$) and PSCS ($p < 0.001$) scores, while higher KCS was also related with higher PSCS ($p < 0.001$) and GPPCS ($p < 0.0001$) and lower ESS ($p = 0.004$) scores. Those who had knowledge on the facility safety (56.6 %) and risk management (59.2 %) plans had higher scores on KCS, PSCS, GPPCS and FCS, while had lower scores on ESS ($p < 0.05$ for each).

Conclusions: Our findings revealed association of female gender, co-morbid psychiatric disease, lack of training unawareness of safety and risk management plans, lack of experience in COVID-19 imaging and high workload with higher risk of poor emotional state and/or intense fear of the disease among radiology technicians during pandemic.

1. Introduction

Coronavirus disease 2019 (COVID-19) is a novel coronavirus-induced pneumonia caused by severe acute respiratory syndrome coronavirus (SARS-CoV-2), first recognized on December 30, 2019, in Wuhan, China; and labeled as a global pandemic by the World Health Organization on March 12, 2020 [1,2].

Imaging, especially CT and x-ray, plays a critical role in the diagnosis of COVID-19 pneumonia and triage of patients for appropriate management [3,4], rendering certain subspecialties like interventional radiology to entail a greater risk of acquiring and transmitting infection due to the close patient contact and invasive nature of interventions [5]. Accordingly, working in close proximity with patients every day for performing medical imaging procedures, radiology technicians are at high risk of acquiring the COVID-19 virus [6]. This seems notable given that combined with excessive workload and related pressures, COVID-19 outbreak is considered to induce great challenges to healthcare professionals and thus emergence of psychological distress (i.e. fear and anxiety) [6–10].

Hence, given their vital role in COVID-19 pandemic serving as frontline professionals who are in physical contact with the patient during the COVID-19 pandemic, the knowledge and practice of radiology technicians regarding COVID-19 disease and protective measures is critical to ensure that suspected or confirmed COVID-19 patients are scanned safely [3]. In addition, by virtue of their profession, they are faced with the problems of high workload and psychological pressure and thus risk of psychological distress-mediated problems including anxiety, depression and burnout [3,10].

Notably, the nature and predictors of the potential impact of COVID-19 pandemic on healthcare professionals is suggested to vary in different countries, depending on healthcare policies, availability of personal protective equipment (PPE), labor and employment conditions and the policies of lockdown, indicating value of local data [11].

This cross-sectional questionnaire-based survey was therefore

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Table 1
Participant characteristics and Scale score comparisons.

	Total n(%)	KCS Median(IQR)	KPSC Median(IQR)	GPPCS Median(IQR)	ESS Mean(SD)	FCS Median(IQR)
Sociodemographic characteristics						
Gender						
Male	122(53.5)	3.3(3.0−3.8)	4.0(3.5−5.0)	4.7(4.4−5.0)	3.2(0.8)	2.9(2.0−3.6)
Female	106(46.5)	3.5(2.9−3.8)[2]	4.0(3.5−3.8)[2]	4.7(4.4−4.9)[2]	3.5(0.8)[1a]	3.0(2.3−4.0)[2b]
Age (year)						
18 – 25	75(32.9)	3.3(3.0−3.8)	4.3(3.8−4.8)	4.7(4.4−4.9)	3.2(0.9)	2.7(2.1−3.4)
26 - 30	57(25.0)	3.5(3.1−3.8)	4.3(3.5−5.0)	4.8(4.5−5.0)	3.3(0.8)	3.0(2.1−4.0)
31 - 40	54(23.7)	3.4(2.8−3.7)	3.9(3.5−4.8)	4.7(4.4−5.0)	3.4(0.9)	3.2(2.1−4.7)[4e]
>40	42(18.4)	3.2(2.8−3.7)[4]	4.0(3.5−4.5)[4]	4.6(4.3−4.8)[4]	3.4(0.7)[3]	3.1(2.7−4.1)
Academic education						
Medical vocational high school	16(7.0)	3.5(3.0−3.7)	3.8(3.5−4.8)	4.7(4.4−5.0)	3.0(0.8)	2.6(1.9−4.1)
Associate degree	154(67.5)	3.3(3.0−3.8)	4.3(3.5−5.0)	4.7(4.4−4.9)	3.3(0.8)	2.9(1.1−3.9)
Graduate or postgraduate	58(25.4)	3.4(2.8−3.7)[4]	4.0(3.5−4.5)[4]	4.6(4.3−4.9)[4]	3.4(0.8)[3]	3.1(2.3−4.0)[4]
Marital status						
Single	115(50.4)	3.3(3.1−3.8)	4.3(3.8−5.0)	4.7(4.5−4.9)	3.3(0.8)	2.9(2.1−3.6)
Married	113(49.6)	3.4(2.8−3.8)[2]	4.0(3.5−4.8)[2b]	4.7(4.4−5.0)[2]	3.3(0.9)[1]	3.0(2.3−4.1)[2]
Place of residence						
Metropolitan city	111(74.0)	3.3(3.0−3.8)	4.0(3.3−5.0)	4.7(4.4−4.9)	3.3(0.9)	2.7(2.1−4.0)
Small city	39(26.0)	3.6(3.0−4.2)[2]	4.0(3.3−4.5)[2]	4.8(4.4−4.9)[2]	3.1(0.8) [1]	3.0(2.1−4.0)[2]
Medical background						
Chronic comorbidity						
Yes	35(15.4)	3.4(3.0−3.8)	4.0(3.8−4.5)	4.7(4.4−5.0)	3.2(0.9)	3.0(2.3−4.0)
No	193(84.7)	3.4(3.0−3.8)[2]	4.0(3.5−5.0)[2]	4.7(4.4−4.9)[2]	3.3(0.8)[1]	3.0(2.1−3.9)[2]
Previous flu vaccine						
Yes	25(11.0)	3.5(3.1−3.8)	4.5(3.8−5.0)	4.8(4.4−5.0)	3.3(1.0)	2.9(1.7−4.1)
No	203(89.0)	3.4(3.0−3.8)[2]	4.0(3.5−4.8)[2]	4.7(4.4−4.9)[2]	3.3(0.8)[1]	3.0(2.1−3.7)[2]
Psychiatric illness						
Yes	18(7.9)	3.0(1.4−3.5)	4.0(1.5−4.5)	4.4(3.8−4.9)	4.1(0.7)	4.1(3.1−5.0)
No	210(92.1)	3.4(3.0−3.8)[2a]	4.0(3.5−5.0)[2]	4.7(4.4−4.9)[2]	3.2(0.8)[1a]	2.9(2.1−3.7)[2a]
Occupational characteristics						
Hospital type						
Public	152(66.7)	3.4(3.0−3.8)	4.0(3.5−4.8)	4.7(4.4−4.9)	3.3(0.9)	3.0(2.1−3.9)
Private	76(33.3)	3.4(3.0−3.9)[2]	4.3(3.5−5.0)[2]	4.8(4.5−5.0)[2]	3.3(0.8)[1]	2.9(2.1−4.0)[2]
Radiology subunit						
Computerized Tomography	109(47.8)	3.3(2.9−3.8)	4.3(3.5−5.0)	4.7(4.4−4.9)	3.4(0.9)	3.0(2.1−4.0)
ER radiology	62(27.2)	3.3(3.0−3.8)	4.0(3.5−4.5)	4.5(4.3−4.8)	3.5(0.8)	3.0(2.3−4.0)
Other	57(25.0)	3.5(3.2−3.9)[4]	4.0(3.5−5.0)[4]	4.8(4.5−4.9)[4]	3.0 (0.7)[6 d]	2.9 (2.1−3.3)[4]
Years in practice						
0 - 5	94(41.2)	3.3(3.0−3.8)	4.3(3.8−5.0)	4.7(4.5−4.9)	3.2(0.9)	2.7(2.0−3.6)
6 -10	44(19.3)	3.5(3.2−4.0)	4.0(3.6−4.9)	4.7(4.5−4.9)	3.3(0.8)	2.9(2.1−3.6)
11 - 15	36(15.8)	3.5(2.7−3.9)	3.8(3.3−5.0)	4.8(4.2−5.0)	3.5(0.8)	3.5(2.1−4.4)
16 - 20	23(10.1)	2.9(2.6−3.7)	4.0(3.0−5.0)	4.5(4.2−4.8)	3.7(0.9)	3.4(2.4−5.0)[4f]
>20	31(13.6)	3.4(2.9−3.7)[4]	4.0(3.5−4.5)[4]	4.6(4.4−4.9)[4]	3.3(0.7)[3]	3.1(2.7−3.7)
# of standard dose CT films processed per day						
1 - 50	87(38.8)	3.4(2.9−3.8)	4.3(3.8−5.0)	4.7(4.5−4.9)	3.4(0.8)	3.0(2.1−4.0)
51 - 99	36(16.1)	3.4(3.2−3.8)	4.5(3.8−5.0)	4.8(4.4−5.0)	3.2(0.7)	3.0(2.1−3.9)
>100	101(45.1)	3.3(2.9−3.7)[4]	4.0(3.3−4.5)[4c]	4.6(4.3−4.9)[4]	3.3(0.9)[3]	2.9(2.1−4.9)[4]

KCS: Knowledge on COVID-19 Outbreak Scale; KPSC: Knowledge on Protective Strategies for COVID-19; GPPCS: General Preventive Practices for COVID-19 Scale; ESS: Emotional State Scale, FCS: Fear of COVID-19 Scale; IQR: Interquartile range (25th – 75th percentile).
[1]T-test; [2] Mann-Whitney U test; [3]One-way ANOVA; [4] Kruskal-Wallis test; [5] One-way ANOVA Bonferroni comparison; [6] One-way ANOVA Tamhane T2 comparison; [a]$p<0.01$; [b]$p<0.05$; [c] $p<0.05$ compared to lower number of CT films per day; [d] $p<0.01$ compared to CT and ER subdivisions; [e]$p<0.05$ compared to 18−25 year age group; [f]$p<0.01$ compared to 0–5 years in practice.

designed to evaluate knowledge, attitude, practice and psychosocial concerns related to COVID-19 pandemic among radiology technicians working at pandemic hospitals across Turkey.

2. Materials and methods

2.1. Study population

A total of 228 radiology technicians working at pandemic hospitals across Turkey and who were members of Turkish Medical Radiotechnology Association (TMRA) were included on a voluntary basis in this cross-sectional questionnaire-based online survey conducted between April 6th and April 13th, 2020. The online survey link including the questionnaire form was sent to the 312 radiology technicians' phone through TMRA, while 228 radiology technicians who agreed to participate in the study and completed the online questionnaire form comprised the study population with a response rate of 73 %. The study was conducted in accordance with the ethical principles stated in the "Declaration of Helsinki", and participant's informed consent was obtained electronically in advance of the data collection through the informed consent page presented two options (yes/ no).

2.2. The questionnaire

The questionnaire form elicited items on a) socio-demographic characteristics (age, gender, educational level, marital status, medical background), b) occupational characteristics (hospital type, radiology unit, years in practice, number of daily standard CT films processed, self-rated health status) and c) personal opinions and experience on COVID-19 outbreak and related protective strategies, and d) survey instruments including Knowledge on COVID-19 Outbreak Scale (KCS), Knowledge on Protective Strategies for COVID-19 Scale (KPSCS), General Preventive

Practices for COVID-19 Scale (GPPCS), Emotional State Scale (ESS) and Fear of COVID-19 Scale (FCS).

2.3. Survey instruments

In addition to 32-items related to socio-demographic and occupational characteristics and personal opinions and experience on COVID-19 outbreak and related protective strategies, the participants responded five scales, including four scales developed by the researcher to measure knowledge on COVID-19 (KCS, 10 items), knowledge on protective strategies for COVID-19 (KPSCS, 4 items), general preventive practices for COVID-19 (GPPC, 10 items), and emotional state (ESS, 19 items), and the Turkish translation of an existing scale on Fear of COVID-19A (FCS, 7 items) [12]. For the development of the scales, the literature review was carried out to evaluate the scales on knowledge and attitudes towards COVID-19, anxiety, and depression [8,9,12–28]. The items suitable for medical staff were selected from the studiesin accordance with the local practice conditions. The all measurement instruments had 5-point Likert scale, and the scores were computed as mean item score.

For KCS, the items are related to epidemiological and clinical aspects of the disease (1= not clear, 2= not very clear, 3=neutral, 4=clear, and 5= very clear), and the total score ranges from with higher score indicating the better epidemiological and clinical knowledge on COVID-19 pandemic.

For KPCS, items are related to healthcare professional's knowledge on protection of themselves and the patients against the disease (1=strongly disagree, and 5=strongly agree), and the higher score indicates better knowledge.

For GPPCS, items are related to frequency of practice measures implemented by the radiology technicians for the prevention of the disease (1=never, and 5=always), and the higher score indicates that the person is more involved in preventive practices.

For ESS, items are related the concerns of radiology technicians regarding emotional and behavioral change, compared to days before the pandemic (1= less, 2= much less, 3=same, 4=more, and 5=much more). This scale includes 3 reverse items indicating being happy, cheerful, and excited (items 9–11). The higher the score the poorer the one's emotional state. For FCS, items are related to fear about the disease (1=strongly disagree, and 5=strongly agree) and the total higher score indicates more intense fear of disease (12).

Overall, the scale score higher than 3 were considered as having sufficient self-perceived knowledge on the outbreak and protective strategies, frequent implementation of preventive practices, poorer emotional state and more fearful of COVID-19, regarding the KCS, KPSC, GPPC, ES and FC scales, respectively

2.4. Study parameters

Participant characteristics and personal opinion and experience on COVID-19 outbreak and related protective strategies were evaluated with respect to scores on survey scales (KCS, KPSCS, GPPCS, ESS and FCS). Inter-scale correlations, internal consistency and descriptive statistics as well as exploratory factor analysis and factor loadings for each scale in the study population were also defined.

2.5. Statistical analysis

The analyses were performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). The normal distribution assumption was examined with Kolmogorov-Smirnov test. The participant characteristics related to the scale scores. The parametric data comparisons between two groups were analyzed with t-test, while One-way ANOVA was performed for comparisons of more than two groups. The pairwise comparisons were examined using Bonferroni, when groups have equal variances, and with Tamhane T2 when groups have unequal variances. The nonparametric data comparisons between two groups examined with Mann-Whitney U test, and Kruskal-Wallis test performed for comparisons of more than two groups. The association between the scales examined with Spearman's rank correlation. Median item score was imputed for 4 missing data in FC for the comparisons and correlation analysis. The scale validity assessed with exploratory factor analysis (EFA), and sample adequacy for performing EFA examined with Kaiser-Meyer-Olkin test and Bartlett's test of sphericity. Principal component analysis and Varimax rotation method were performed. The internal reliability assessed with Cronbach's alpha. Data were expressed as mean ± standard deviation (SD)" and percent (%) where appropriate. $p < 0.05$ was considered statistically significant.

3. Results

3.1. Participant characteristics overall and according to scale scores

Participant characteristics are summarized in Table 1.

When compared to males, female radiology technicians had higher ES (3.5(0.8) vs. 3.2(0.8), $p = 0.004$) and FS (3.0(2.3−4.0) vs. 2.9 (2.0−3.6), $p = 0.026$). The participants aged 31–40 years had higher FS scores than those aged 18−25 years (3.2(2.1−4.7) vs. 2.7(2.1−3.4), $p = 0.032$). The married vs. single participants had lower KPSC scores (4.0(3.5−4.8) vs. 4.3(3.8−5.0), $p = 0.014$), while those with vs. without psychiatric illness had lower KCS (3.0(1.4−3.5) vs. 3.4(3.0−3.8), $p = 0.002$) and higher ESS (4.1(3.1−5.0) vs. 3.2(0.8), $p = 0.001$) and higher FSS (4.1(0.7) vs. 2.9(2.1−3.7), $p = 0.001$) scores (Table 1)

The ESS scores of participants working in other units was lower than those working in CT and ER units (3.0 (0.7) vs. 3.4(0.9) and 3.5(0.8), $p = 0.009$), while FSS scores were lower in participants with 0–5 years vs. 16–20 years in practice (2.7(2.0−3.6) vs. 3.4(2.4−5.0), $p = 0.008$). The radiology technicians who process >100 standard dose CT films per day had lower KPSC scores than those process lower number of CT films per day (4.0(3.3−4.5) vs. 4.3(3.8−5.0) and 4.5(3.8−5.0), $p = 0.005$) (Table 1).

3.2. COVID-19 outbreak and related protective strategies according to scale scores

Overall, 21(9.2 %) radiology technicians had a COVID-19 positive relative and 17(7.5 %) technicians were themselves tested for COVID-19, and 5(29.4 %) of those who tested were diagnosed positively. In addition, 142(63.4 %) participants had a COVID-19 training provided by the institutional infection control committee, and majority reported that they use all the protective equipment in the radiological unit (Table 2).

The radiology technicians with vs. without a COVID-19 positive relative (3.7(0.8) vs. 3.3(0.8), $p = 0.036$) or those themselves tested vs. not-tested for COVID-19 (3.9(0.8) vs.

3.3(0.8) $p = 0.002$.) had higher ESS scores. Self-rated very good vs. poor health status was associated with higher KCS (3.5(3.1−3.9) vs. 3.0 (2.7−3.3), $p < 0.001$), KPSC (4.3(3.8−5.0) vs. 4.0(3.3−4.5, $p = 0.028$) and GPPCS (4.8(4.5−5.0) vs. 4.5(4.3−4.7), $p < 0.001$) scores, whereas with lower ESS (3.0(0.8) vs. 4.0(0.7), $p < 0.001$) and FSS scores (2.4 (1.9−3.1) vs. 4.0(3.0−4.9), $p < 0.001$) (Table 2).

The participants who examined intubated COVID-19 patients had higher ESS scores (3.2(0.8) vs 3.4(0.9), $p = 0.030$), while those performed unenhanced CT vs. standard dose CT had higher KPSCS (4.5 (4.0−5.0) vs. 4.0(3.3−4.8), $p = 0.003$) scores.. The source of information significantly impacted scale scores; scientific sources was associated with higher GPPCS scores (vs. internet $p = 0.045$), TV sources with lower KPPCS scores (vs. others $p = 0.024$) and internet sources with higher ESS scores (vs. others $p < 0.05$). The radiology technicians who consider Turkey as the most successful country in coping with the pandemic had lower FSS scores than who consider other countries more successful (median 2.6 vs. > 2.9, $p = 0.025$) (Table 2).

The radiology technicians who had COVID-19 training provided by the institutional infection control committee had higher KCS and KPPCS

Table 2
Opinion and experience on COVID-19 and related protective strategies and Scale score comparisons.

		Total n(%)	KCS Median(IQR)	KPSC Median(IQR)	GPPCS Median(IQR)	ESS Mean (SD)	FCS Median(IQR)
Having a relative with COVID-19	Yes	21(9.2)	3.3(2.9−3.8)	4.3(3.5−5.0)	4.6(4.2−4.9)	3.7(0.8)	3.0(2.3−4.3)
	No	207 (90.8)	3.4(3.0−3.8)[2]	4.0(3.5−5.0)[2]	4.7(4.4−4.9)[2]	3.3 (0.8)[1a]	3.0(2.1−3.9)[2]
COVID-19 test performed for the radiology technician	Yes	17(7.5)	2.9(1.8−4.1)	3.3(1.5−5.0)	4.6(4.2−4.9)	3.9(0.8)	3.0(2.1−5.0)
	No	211 (92.5)	3.4(3.0−3.8)[2]	4.0 (3.5−5.0)[2a]	4.7 (4.4−4.9)[2a]	3.3 (0.8)[1a]	3.0(2.1−3.7)[2]
COVID-19 test result	Positive	5(29.4)	2.5(1.0−4.1)	1.0(1.0−2.0)	3.8(3.5−4.8)	4.5(0.4)	5.0(5.0−5.0)
	Negative	12(70.6)	3.0(2.2−4.0)[2]	3.9(2.4−5.0)[2]	4.6(3.7−4.9)[2]	3.7 (0.8)[1a]	2.4 (1.7−4.8)[2a]
Self-rated health status	Very good	121 (53.3)	3.5 (3.1−3.9)[4b]	4.3 (3.8−5.0)[4c]	4.8 (4.5−5.0)[4b]	3.0 (0.8)[5b]	2.4 (1.9−3.1)[4b]
	Good	77(33.9)	3.2(2.9−3.8)	4.0(3.5−4.8)	4.6(4.2−4.8)	3.6(0.7)	3.3(2.7−4.1)
	Poor	29(12.8)	3.0(2.7−3.3)	4.0(3.3−4.5)	4.5(4.3−4.7)	4.0(0.7)	4.0(3.0−4.9)
Daily working hours after pandemic	Flexible (8 h)	76(33.9)	3.4(2.9−3.8)	4.0(3.5−5.0)	4.7(4.3−4.9)	3.3(1.0)	2.9(1.9−4.1)
	Normal (12 h)	27(12.1)	3.6(3.0−4.0)	4.5(3.8−5.0)	4.7(4.5−5.0)	3.1(0.8)	2.9(2.1−3.3)
	ER radiology (24 h)	68(30.4)	3.3(3.0−3.8)	4.0(3.5−4.5)	4.6(4.3−4.9)	3.3(0.7)	3.1(2.2−3.9)
	Other	53(23.7)	3.4(3.0−3.8)[4]	4.3(3.5−5.0)[4]	4.8(4.5−5.0)[4]	3.4(0.8)[3]	3.0 (2.3−3.7)[4]
Experience on radiological imaging methods in COVID-19 patients	Yes	180 (78.9)	3.4(3.0−3.8)	4.3(3.8−5.0)	4.7(4.4−5.0)	3.3(0.8)	3.0(2.1−3.9)
	No	48(21.1)	3.3(3.0−3.8)[2]	3.5 (3.3−4.3)[2d]	4.6 (4.2−4.8)[2a]	3.2(0.9)[1]	2.9(2.3−3.9)[2]
Type of radiography performed for COVID-19 patients	Chest XR at PU	27(11.8)	3.3(3.0−3.8)	4.0(3.3−4.8)	4.5(4.4−4.9)	3.0(0.8)	2.7(1.7−3.3)
	Chest XR at DR	47(20.6)	3.3(3.0−3.8)	4.0 (3.5−4.5)[4e]	4.5(4.3−4.8)	3.4(0.7)	3.0(2.9−3.6)
	Low dose CT	24(10.5)	3.8(3.2−4.1)	4.1(3.8−5.0)	4.7(4.5−5.0)	3.2(0.8)	2.6(1.9−4.2)
	Unenhanced CT	55(24.1)	3.3(3.0−3.8)	4.5(4.0−5.0)	4.8(4.5−5.0)	3.2(0.8)	3.1(2.1−3.6)
	Standard dose CT	75(32.9)	3.4(2.9−3.8)[4]	4.0 (3.3−4.8)[4e]	4.7(4.3−4.9)[4]	3.4(0.9)[3]	3.0(2.1−4.1)[4]
Examination of intubated COVID-19 patient	Yes	99(44.2)	3.2(2.8−3.8)	4.3(3.5−5.0)	4.7(4.3−4.9)	3.4(0.9)	3.1(2.1−4.1)
	No	125 (55.8)	3.5(3.1−3.8)[2]	4.0(3.5−4.8)[2]	4.7(4.4−4.9)[2]	3.2 (0.8)[1a]	2.9(2.1−3.6)[2]
Source of information on COVID-19 news	TV	38(16.7)	3.5(3.0−3.9)	3.8 (3.3−4.5)[4f]	4.7(4.5−4.9)	3.2(0.9)	3.0(2.1−3.9)
	Internet	132 (57.9)	3.3(3.0−3.8)	4.0(3.5−4.8)	4.6 (4.3−4.9)[4f]	3.5(0.8)	3.0(2.3−4.0)
	Scientists	29(12.7)	3.5(3.1−3.8)	4.5(3.8−5.0)	4.9(4.6−4.9)	3.2(0.8)	3.0(2.0−3.4)
	Other	29(12.7)	3.5(2.9−3.9)[4]	4.5(4.0−5.0)	4.8(4.4−5.0)	3.0(0.9)[3]	2.7(2.1−3.4)[4]
Opinion on most successful country in COVID19 pandemic[5]	China	91(40.6)	3.3(2.9−3.8)	4.0(3.5−4.8)	4.7(4.3−4.9)	3.4(0.9)	3.0(2.3−4.0)
	Turkey	53(23.7)	3.7(3.0−4.1)	4.3(3.5−5.0)	4.8(4.5−5.0)	3.1(0.8)	2.6 (1.9−3.3)[4g]
	South Korea	37(16.5)	3.6(3.1−3.8)	4.0(3.8−5.0)	4.8(4.5−4.9)	3.2(0.9)	3.1(2.3−4.1)
	Other	43(19.2)	3.2(2.9−3.8)[4]	4.0(3.5−5.0)[4]	4.6(4.2−4.9)[4]	3.6(0.7)[3]	2.9(1.8−3.6)
Opinion on least successful country in COVID19 pandemic[6]	Italy	132 (57.9)	3.4(2.9−3.8)	4.0(3.5−3.8)	4.7(4.4−4.9)	3.4(0.8)	2.9(2.3−3.6)
	United States	66(28.9)	3.4(3.0−3.8)	4.1(3.5−5.0)	4.8(4.4−5.0)	3.1(0.8)	3.0(2.0−4.0)
	Turkey	10(4.4)	3.1(2.7−3.4)	4.0(3.8−4.5)	4.4(3.9−4.8)	3.5(1.0)	4.4(2.3−4.7)
	Other	20(8.8)	3.5(3.0−3.8)[4]	4.4(3.8−5.0)[4]	4.6(4.4−4.8)[4]	3.4(3.7)[3]	3.0(2.1−3.4)[4]
COVID-19 training organized by IICC	Yes	142 (63.4)	3.5(3.1−3.8)	4.5(3.8−6.0)	4.7(4.4−4.9)	3.3(0.8)	2.9(2.1−3.6)
	No	82(36.6)	3.2(2.83.7)[2a]	3.8 (3.3−4.5)[2d]	4.7(4.3−4.9)[2]	3.4(0.9)[1]	3.0(2.1−4.3)[2]
Presence of facility safety plan	Yes	129 (56.6)	3.6(3.1−3.9)	4.5(3.8−5.0)	4.8(4.5−5.0)	3.1(0.8)	2.7(2.0−3.4)
	No	99(43.4)	3.2 (2.8−3.7)[2d]	3.8 (3.3−4.5)[2d]	4.5 (4.2−4.8)[2d]	3.6 (0.9)[1d]	3.1 (2.4−4.4)[2a]
Presence of facility risk management plan	Yes	135 (59.2)	3.5(3.1−3.8)	4.5(3.8−5.0)	4.8(4.5−5.0)	3.1(0.8)	2.7(2.1−3.3)
	No	93(40.8)	3.2 (2.8−3.7)[2a]	3.8 (3.3−4.3)[2d]	4.5 (4.3−4.8)[2d]	3.6 (0.9)[1d]	3.4 (2.4−4.6)[2a]
Knowledge on management of contaminated/dangerous substances	Yes	178 (78.1)	3.5(3.1−3.8)	4.5(3.8−5.0)	4.8(4.5−5.0)	3.2(0.8)	2.9(2.1−3.6)
	No	50(21.9)	3.0 (2.6−3.5)[2d]	3.4 (2.8−3.8)[2d]	4.4 (3.8−4.6)[2d]	3.8 (0.8)[1d]	4.0 (2.3−4.7)[2d]
Duration of standard dose thorax CT	Maximum 4−5 min	64(28.6)	3.3(3.0−3.9)	4.3(3.5−3.8)	4.7(4.4−4.9)	3.5(0.9)	3.1(2.1−4.4)
	Minimum 30−35 sec	83(37.1)	3.4(3.0−3.8)	3.5(4.5−5.0)	4.7(4.4−4.9)	3.4(0.8)	3.0(2.1−3.7)
	Other	77(34.4)	3.3(3.0−3.7)[4]	4.0(3.5−4.8)[4]	4.7(4.4−4.9)[4]	3.1(0.8) [sh]	2.7(1.3−3.6)[4]
Protective equipment used in radiology unit	Only one equipment	34 (14.9)	3.5(3.0−3.8)	4.0(3.5−4.5)	4.7(4.1−4.9)	3.5(0.9)	3.1(2.4−4.7)

(*continued on next page*)

Table 2 (*continued*)

		Total n(%)	KCS Median(IQR)	KPSC Median(IQR)	GPPCS Median(IQR)	ESS Mean (SD)	FCS Median(IQR)
Type of mask used in filming, including probable COVID-19 patients	All equipment	194 (85.1)	3.4(3.0−3.8)[2]	4.3(3.5−5.0)[2]	4.7(4.4−4.9)[2]	3.3(0.8)[1]	2.9(2.1−3.7)[2]
	N95	142 (63.4)	3.5(3.0−3.9)	4.3(3.5−5.0)	4.8(4.4−5.0)	3.2(0.8)	2.9(2.1−3.7)
	Surgical mask	54(24.1)	3.2(2.9−3.7)	4.0(3.5−4.8)	4.7(4.4−4.9)	3.5(0.9)	3.3(2.3−4.0)
	Other	28(12.5)	3.3(2.9−3.8)[4]	3.5(3.5−4.5)[4]	4.5 (4.2−4.8)[ai]	3.4(0.8)[3]	2.9(2.4−3.6)[4]
Opinion on use of heat to disinfect the masks	Agree	35(15.4)	3.6(2.8−4.3)	4.0(3.3−5.0)	4.7(3.9−5.0)	3.6(1.0)	3.0(2.3−4.7)
	Disagree	90(39.5)	3.5(3.0−3.9)	4.3(3.8−5.0)	4.7(4.4−4.9)	3.3(0.8)	2.9(2.1−4.0)
	Indecisive	103 (45.2)	3.2(3.0−3.7)[4]	4.0(3.5−4.8)[4]	4.7(4.3−4.9)[4]	3.2(0.8)[3]	3.0(2.1−3.7)[4]

KCS: Knowledge on COVID-19 Outbreak Scale; KPSC: Knowledge on Protective Strategies for COVID-19; GPPC: General Preventive Practices for COVID-19; ESS: Emotional State Scale, FCS: Fear of COVID-19 Scale; IQR, Interquartile range (25th – 75th percentile); IICC, Institutional infection control committee.
[1]T-test; [2] Mann-Whitney U test; [3]One-way ANOVA; [4] Kruskal-Wallis test; [s]One-way ANOVA Bonferroni comparison; [a]$p < 0.05$ and [d]$p < 0.001$ compared to Yes, [b]$p < 0.001$ and.
$p < 0.05$ compared to good and poor, [e]$p < 0.01$ compared to unenhanced CT, [f]$p < 0.05$ compared to other and scientists, respectively, [g]$p < 0.05$ compared to China, [h]$p < 0.05$ compared to maximum 4−5 min, [i]$p < 0.05$ compared to N95.

scores ($p < 0.01$ for each). The technicians who know the facility safety plan, facility risk management plan, and management of contaminated substances had higher KCS, KPPCS and GPPCS scores, as well as lower ESS and FCS scores ($p < 0.001$ for each) (Table 2).

3.3. Mean scale scores and correlation analysis

Mean(SD) scale and subscale scores are provided in Table 3. The KCS scores were positively correlated with KPSC ($r = 0.34$) and GPPCS ($r = 0.39$) scores, whereas negatively correlated with ESS scores($r= -0.19$) scores ($p < 0.01$). The KPSCS was positively correlated with GPPCS scores ($r = 0.45$), while both were negatively correlated with FSS scores ($r= -0.16$ and $r= -0.21$, respectively) ($p < 0.05$) (Table 3).

3.4. EFA and factor loadings of the survey scales

The scales were adequate for performing EFA. The variation explained was higher than 55 %, and the internal reliability was higher than 0.7 for the five scales. The EFA produced two subscales for KCO and GPPC, while ES had 4 subscales (Table 4). The factor loadings were presented in Table 5.

4. Discussion

In the current study, mean KCS scores indicated that radiology technicians have a relatively clear knowledge on the cause, transmission, infectious rate, symptoms and diagnosis of coronavirus-19, rather than treatment, healing, contagion after recovery, and mortality of the disease. Mean KPPCS and GPPCS scores indicated that the radiology technicians have sufficient knowledge and practice on the preventive practices for COVID-19. ESS scores indicated that the radiology technicians had relatively poor emotional state, similar social relationships, poor morale, similar sleeping behaviors, and poor happiness level compared to days before outbreak, while mean FSS scores were consistent with a neutral attitude towards fear of COVID-19.

Our findings indicate favorable conditions to be reported by most of radiology technicians such as very low rates of COVID-19 positivity among themselves or relatives, good self-rated health status, daily working hours, experience in radiological imaging method for a COVID-19 patient, previous training provided by the institutional infection control committee, awareness of facility safety and risk management plans, and knowledge on management of the contaminated or dangerous substances as well as use of PPE. This seems in accordance with consideration of the delayed entrance of the disease in Turkey and immediate implementation of preventive measures with sufficient hospital beds and ICU capacities for nearly all provinces and no shortage of PPE to be important advantages of Turkey in terms of being well prepared [29,30]. It should also be noted that the psychological impacts of infectious agents on healthcare staff is considered to differ according to department and occupation with better degree of control over situations by health care workers with professional knowledge and experience on exposure patterns and transmission of different infectious diseases [31,32]. Hence, working in the field of radiation technologies, radiology technicians are already at risk of occupational hazards related to exposure to radiation and thus are well aware of special work responsibilities regarding radiation protection and safety measures to ensure the implementation of radiological imaging within standards for the safety of radiology employees and patients [33–36].

Nonetheless, due to features of infectivity of coronavirus (i.e. contagious asymptomatic state), the contact with asymptomatic carriers during their visits for different hospital departments indiscriminately affects medical workers, regardless of their hospital department or job title [7,37]. Moreover, the current study took place on April 6–13, 2020, consistent with the time period with peak of total active COVID-19 cases in Turkey, emphasizing the likelihood of heavy healthcare demand and increased workload among radiology technicians during our survey period.

Nonetheless, albeit reported by 20–30% of participants in the current study, no experience in radiological imaging methods used in a COVID-19 patient, working in ER radiology with 24-h shift, lack of training on COVID-19, lack of awareness about facility safety and risk management plans or ways to manage the contaminated or dangerous substances and long duration of standard dose thorax CT intervention were correlated significantly with poorer scale scores and thus increased risk of poor knowledge and practice regarding COVID-19 disease as well as emotional concerns and fear of disease.

Specifically, being tested for COVID-19 or having a COVID-19 positive relative along with examination of intubated COVID-19 patients and use of maximum duration thorax CT filming strategy was associated with poorer emotional state, while higher awareness on risk plans, considering Turkey as a successful country in coping with the pandemic, male gender, younger age, good self-rated health status and lack of any psychiatric disease were all associated with better emotional state and much less fear of the disease.

These findings seem to be in accordance with the proposed sources of distress related to psychological response of health care workers to an epidemic of infectious diseases that include feelings of vulnerability or loss of control and concerns and perception of danger about health of self, spread of virus, health of family and others, changes in work, and being isolated [6,38]. The association of being personally tested for

Table 3
Descriptives and Correlation Analysis of Scales.

Scale or Subscale	Median(IQR)	1	1.1	1.2	2	3	3.1	3.2	4	4.1	4.2	4.3	4.4
1.KCO	3.4(3.0−3.8)												
1.1Factor1	3.0(2.4−3.4)	0.86[b]											
1.2.Factor 2	4.0(3.4−4.4)	0.86[b]	0.52[b]										
2.KPSC	4.0(3.5−5.0)	0.34[b]	0.28[b]	0.29[b]									
3.GPPC	4.7(4.4−4.9)	0.39[b]	0.38[b]	0.30[b]	0.45[b]								
3.1.Factor1	4.7(4.3−5.0)	0.29[b]	0.26[b]	0.27[b]	0.44[b]	0.87[b]							
3.2.Factor2	4.7(4.0−5.0)	0.36[b]	0.39[b]	0.24[b]	0.32[b]	0.80[b]	0.45[b]						
4.ES, Mean(SD)	3.3(0.8)	−0.19[b]	−0.17[a]	−0.13[a]	−0.10	−0.25[b]	−0.15[a]	−0.28[b]					
4.1.Factor1	2.9(2.1−3.6)	−0.22[b]	−0.18[b]	−0.17[b]	−0.13	−0.24[b]	−.017[a]	−0.24[b]	0.90[b]				
4.2.Factor2	3.8(3.0−4.6)	−0.09	−0.09	−0.04	−0.10	−0.12	−0.01	−0.22[b]	0.86[b]	0.72[b]			
4.3.Factor3	3.0(2.0−4.0)	−0.14[a]	−0.12	−0.09	−0.01	−0.24[b]	−0.18[b]	−0.24[b]	0.79[b]	0.64[b]	0.53[b]		
4.4.Factor4	4.3(3.3−5.0)	−0.19[b]	−0.18[b]	−0.14[a]	−0.10	−0.20[b]	−0.10	−0.23[b]	0.37[b]	0.15[a]	0.28[b]	0.12	
5.FC	3.0(2.1−3.9)	−0.09	−0.10	−0.03	−0.16[a]	−0.21[b]	−0.13[a]	−0.23[b]	0.72[b]	0.64[b]	0.76[b]	0.49[b]	0.25[b]

KCO, Knowledge on COVID-19 Outbreak; KPSC, Knowledge on Protective Strategies for COVID-19; GPPC, General Preventive Practices for COVID-19; ES, Emotional State; FC, Fear of COVID-19.
Spearman's Rank Correlation coefficient is significant at [a] 0.05 level, and [b] 0.01 level.

COVID-19, poor self-rated health status, female gender, older age and co-morbid psychiatric disease with poorer emotional state and intense fear of COVID-19 in our study support data from a past study among 906 healthcare workers which indicated higher likelihood of experiencing physical symptoms in older age persons with pre-existing comorbidities and a positive screen for depression, anxiety, stress, and PTSD [39].

Similarly, in a sample of 304 healthcare staff (doctors, nurses, radiologists, technicians, etc.) from Iran, authors reported high prevalence of anxiety (28.0 %), depression (30.6 %), and distress (20.1 %) and poorer physical health among older workers, more distress and depression among female staff, and poorer physical and mental health in lower educated staff as well as higher depression, anxiety and distress, and lower job satisfaction in case of unknown COVID-19 status and poor PPE access [11]. In addition, in a past study of 1257 health care workers in 34 hospitals from China, a considerable proportion of health care workers reported experiencing symptoms of depression, anxiety, insomnia, and distress, particularly the female healthcare workers and front-line health care workers directly engaged in diagnosing, treating, or providing nursing care to patients with suspected or confirmed COVID-19 [6]. In another study on anxiety and depression symptoms in first-line anti-epidemic medical staff (79 doctors and 86 nurses) from China, authors reported high the prevalence rates of anxiety and depression symptoms among doctors (11.4 % and 45.6 %), and nurses (27.9 % and 43.0 %) and considered being a female doctor and history of depression or anxiety in both doctors and nurses as a risk factor for anxiety symptoms [40]. Likewise, in a past study on resilience and perceived stress of 600 medical staff members from the radiology departments in 32 public hospitals in China, authors reported high perceived stress, female gender, lack of understanding of COVID-19 and protective measures, and lack of protective materials to be to be independent risk factors for low resilience [41].

Accordingly, our findings emphasize the higher vulnerability to psychosocial distress in certain socio-demographic groups of healthcare professionals working frontline with COVID-19 patients, and thus need for focused mental health work particularly in these groups.

In the current study, lower level of knowledge on protective strategies and less frequent implementation of preventive practices were noted among radiology technicians who were tested for COVID-19 and who had self-rated poor health status. In addition, experience on radiological imaging methods used in COVID-19 patients, previous training on COVID-19 disease, awareness of facility safety and risk management plans and management of contaminated substances were associated with better knowledge on COVID-19 outbreak and protective strategies and also with more frequent implementation of preventive practices. These findings support a strong and direct relation reported between knowledge and awareness levels of radiology technicians and their protection from the harmful effects of radiation [35]. Accordingly, our findings support the previously reported vital role of provision of training by hospitals and related organizations in the prevention of infectious diseases and in improving the willingness to work by staff members through supporting their ability to acquire and use evidence-based information [42–44]. Notably, implementation of appropriate education and protective measures and thus advanced training of psychiatrists was reported to be an independent predictor of a

Table 4
Validity and Reliability of the Scales.

	No. of Items	KMO	Bartlett's test	% of Variation	Cronbach's alpha
Knowledge on COVID-19 Scale[1,2]	10	0.84	811.21	55.31	0.84
Factor1	5			42.09	0.78
Factor 2	5			13.22	0.77
Knowledge on Protective Strategies for COVID-19 Scale[1]	4	0.75	277.09	60.92	0.75
General Preventive Practices for COVID-19 Scale[1,2]	10	0.85	1013.97	58.54	0.83
Factor1	7			47.00	0.80
Factor 2	3			11.53	0.68
Emotional State Scale[1,2]	19	0.88	3684.48	72.09	0.92
Factor1	7			43.02	0.87
Factor 2	5			14.43	0.90
Factor3	4			8.12	0.90
Factor 4	3			6.53	0.86
Fear of COVID-19 Scale[a,1]	7	0.89	1063.20	65.11	0.91

KMO: Kaiser-Meyer-Olkin test;
[a] analysis performed for n=224 participants.
[1] Extraction Method: Principal Component Analysis.
[2] Rotation method: Varimax with Kaiser Normalization.

Table 5
Factor Loadings of Survey Scales.

Knowledge on COVID-19 Scale Items	Factor 1		Factor 2	
1. Cause			0.64	
2. Transmission of disease			0.83	
3. Infectious rate			0.72	
4. Symptoms			0.54	
5. Diagnosis criteria			0.59	
6. Treatment	0.83			
7. Healing criteria	0.83			
8. Healing rate	0.74			
9. Disease contagion after recovery	0.68			
10. Mortality	0.32			
Knowledge on Protective Strategies for COVID-19 Scale Items	**Factor**			
1. I know how to protect myself, and the patients I'm going to examine	0.88			
2. I have experience of how COVID-19 patients are examined, and which device to use in examinations.	0.76			
3. I have completed the training program provided by my institution.	0.64			
4. I know COVID-19 pandemic's risk for the patients and healthcare professionals	0.83			
General Preventive Practices for COVID-19 Scale Items	**Factor 1**		**Factor 2**	
1. I avoided going to the affected areas.	0.37			
2. I wore mask			0.64	
3. I changed the mask regularly.			0.83	
4. I have properly removed the mask.			0.77	
5. I avoided gatherings.	0.64			
6. I washed my hands.	0.82			
7. I used disinfectants.	0.75			
8. I was attentive to personal hygiene.	0.82			
9. I avoided contact with certain groups of people (those come from abroad, over the age of 65 etc.).	0.81			
10. I tried to have a balanced diet.	0.65			
Emotional State Scale Items	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**
1. I feel anxious.		0.90		
2. I feel worried.		0.90		
3. I feel depressed.		0.67		
4. I feel alarmed.		0.64		
5. I feel all alone.	0.64			
6. I feel nervous.	0.57			
7. I feel sad.		0.70		
8. I feel angry.	0.65			
9. I feel happy. (RV)				0.89
10. I feel cheerful. (RV)				0.90
11. I feel excited. (RV)				0.82
12. I have Insomnia.			0.88	
13. I a unable to fall asleep.			0.85	
14. I see nightmare.			0.56	
15. I'm not having enough sleep.			0.85	
16. I argue with others (family, friends, colleagues, foreigners, etc.)	0.86			
17. I fight with others (family, friends, colleagues, foreigners, etc.)	0.88			
18. I drink alcohol.	0.54			
19. I use cell phone.	0.32			
Fear of COVID-19 Scale Items	**Factor**			
1.I'm most afraid of the coronavirus-19.	0.72			
2.It makes me uncomfortable to think about coronavirus-19.	0.70			
3.My hands become clammy when I think about coronavirus-19.	0.84			
4.I am afraid of losing my life because of coronavirus-19.	0.82			
5.When watching news and stories about coronavirus-19 on social media, I become nervous or anxious.	0.83			
6.I cannot sleep because I'm worrying about getting coronavirus-19.	0.88			
7.My heart races or palpitates when I think about getting coronavirus-19.	0.83			

greater likelihood of them to be willing to care for psychiatric patients suffering from the COVID-19 [42]. Professional knowledge, appropriate safety measures and mental well-being of every radiology staff has been suggested to affect personal and patient protection positively in the fight against COVID-19 [3]. Hence, in addition to advanced COVID-19 training organized by institutional infection control committee, health organizations should also have clear and regularly updated policies for imaging staff in relation to techniques for imaging and safe application and removal of PPE relevant to the level of potential exposure for dealing with suspected or confirmed COVID-19 patients [13].

In fact, the source of information significantly impacted scale scores in our study with higher likelihood of implementing preventive practices in case of use of scientific sources, whereas poorer knowledge on protective strategies and poorer emotional state in case of using TV and internet sources, respectively. Accordingly, our findings emphasize the provision of accurate health information by government and health authorities during the epidemic to reduce the impact of rumors [45], given the association of higher satisfaction with the health information received with a lower psychological impact of the outbreak and lower levels of stress, anxiety, and depression [46].

The qualitative cross-sectional study design of the study seems to be the major limitation preventing us to make causal inferences. Nevertheless, providing data on pandemic hospitals practice across Turkey, our findings seem to be generalizable and to represent a valuable contribution to the literature given the restricted amount of data available on this subject area.

5. Conclusion

In conclusion, our findings revealed favorable status in most of radiology technicians working at pandemic hospitals across Turkey in terms of knowledge, attitude and practice regarding COVID-19 outbreak and related preventive measures, whereas association of certain factors (being tested for COVID-19 positivity or positive relatives, poor self-rated health status, female gender, older age, co-morbid psychiatric disease, lack of training and thus low level of knowledge on outbreak and preventive measures, unawareness of safety and risk management plans, lack of experience in COVID-19 related imaging methods, heavy working hours and use of internet sources for information on disease) with higher risk of poor emotional state and/or intense fear of the disease. Accordingly, our findings emphasize the crucial role of advanced training on COVID-19 outbreak and related protective measures among radiology technicians and the need for a focused social support and provision of specialized mental health care to radiology technicians working frontline with COVID-19 patients, tailored to highly vulnerable groups to improve their health, safety and job-satisfaction during the COVID-19 pandemic.

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CRediT authorship contribution statement

Nuran Akyurt: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

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