Knowledge deficiency of work-related radiation hazards associated with psychological distress among orthopedic surgeons
A cross-sectional study

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Abstract

Knowledge and concern degree about work-related radiation hazards remained unknown among orthopedic surgeons. The aim of the cross-sectional study is to investigate whether the knowledge degree of work-related radiation is associated with psychological distress among orthopedic surgeons. This cross-sectional study sent electronic questionnaire via WeChat to orthopedic surgeons nationwide. Concern and knowing degree over radiation exposure was evaluated by a single self-reported question. Professional evaluation of concern degree was reflected by general psychological distress, which was assessed with the Kessler 10 scale (K10) and depressive symptoms with the Center for Epidemiologic Studies Depression Scale (CES-D). Only 43.23% (115/266) respondents knew well about radiation and a total of 78.20% (208/266) respondents considered radiation exposure as a great concern. Among those who reported concerns about radiation exposure, a total of 57.69% (120/208) respondents reported knowing little about radiation. Respondents who reported concerns over radiation exposure were significantly associated with higher scores on CES-D and K10 (P < .05). Among respondents who reported concerns over radiation exposure, those who have fewer knowledge about radiation, had higher CES-D and K10 scores than those who knew well about radiation (P < .05). Among respondents who reported no concerns over radiation exposure, those who knew little about radiation still had higher CES-D and K10 scores (P < .05). Fewer radiation knowledge tends to induce more radiation concerns associated with higher psychological distress in orthopedic surgeons. Radiation knowledge should be enhanced for surgeons who daily work with radiation-related fluoroscopy.

Abbreviations: ANOVA = analysis of variance, CES-D = Epidemiologic Studies Depression Scale, GDP = gross domestic product, ICRP = International Commission of Radiation Protection, K10 = Kessler 10 scale.

Keywords: bibliometric analysis, orthopedic surgeons, psychological distress, radiation concerns, radiation exposure, work health

1. Introduction

The fluoroscopically guided technique has provided effective assistance for orthopedic surgery, whose drawback appears to dramatically increase radiation exposure to surgeons as well as other medical staff.[1] Orthopedic surgeons can be exposed to primary radiation and secondary radiation from iatrogenic X-ray. Primary radiation refers to direct radiation exposure while a surgeon enters the space between X-ray generator and receptor, and secondary radiation mainly refers to scattered radiation.[2] In general, radiation exposure is accused for causing a series of physical and mental illness, with stochastic and deterministic effect.[3] The accumulated radiation exposure over time has been reported to be associated with cancer, cataracts and other diseases,[4] especially the organs sensitive to radiation (eg, gonads, bone marrow, breast, cornea).[5] Thus, radiation exposure is a great concern for orthopedic surgeons as a special group routinely applying radiation-related fluoroscopy.

Occupational health problem in hospital is came up with lately and valued as both physical and mental obstacles for all healthcare workers.[6] In an attempt to minimize sequela of occupational exposure to ionizing radiation, the International Commission of Radiation Protection (ICRP) has published the maximum, yearly, occupational exposure limit for all sensitive organs or tissues.[7] Occupational exposure limit for eye has been already updated from 130 to 20mSv per year recommended by ICRP.[8] These recommended limits should raise the attention of all orthopedic surgeons, because they routinely used radiation-related fluoroscopy to conduct surgeries. However, knowledge and concern degree about work-related radiation hazards remained unknown among orthopedic surgeons, although many studies have indicated relatively safe radiation dosage accumulated per year in various surgeries.[9–11] Therefore, the aim of the cross-sectional study is to investigate whether the knowledge degree of work-related radiation is associated with psychological distress among orthopedic surgeons.
2. Methods

2.1. General information

The cross-sectional study was reviewed and approved by the Ethical Commission of Shanghai Tenth People’s Hospital. We provided a complete description of this study to all the participants whose consent were obtained prior to the survey. The procedures of the research were approved by the Ethical Commission of Shanghai Tenth People’s Hospital. We recruited orthopedic surgeons nationwide via WeChat as well as paper questionnaires during national conference from May 2015 to Dec 2015. We recruited orthopedic surgeons include chief physicians, associate chief physicians, attending physicians, resident doctors, and graduates of orthopedics.

The inclusion criteria were (1) aged 18 years or older; (2) orthopedic surgeons including various subspecialties such as spine, traumatic orthopedics, foot and ankle, as well as joint who routinely employing radiation-related fluoroscopy; (3) physically and psychologically capable of understanding and providing consent for study participation. We excluded invalid paper questionnaires: (1) incomplete responses to required question; (2) unidentified answers to required questions; (3) evident mistakes of the replied answers; (4) others that we researchers independently confirmed invalid.

2.2. Measures

Participants were surveyed via a self-reported questionnaire which we settled with mainly a series of multiple choice questions and part fill in the blanks for this study. Demographic characteristics including gender, age, height, weight, occupation, physical activity level, period of employment and subspecialty (repeatable) were obtained with questions. To evaluate knowledge and concern over radiation exposure, the participants answered the questions, “Do you concern and know about radiation exposure?” and chose the most appropriate one from the following answers “know little and not concern,” “know little but concern,” “know well but not concern,” “know well but concern,” and “know well and concern.”

To further evaluate radiation concerns, participants needed to provide informations of their protection strategies (eg, leaded glasses, real-time monitor, thyroid gland shield, leaded apron, and leaded hat). General psychological distress was assessed with the Kessler 10 scale (K10), and depressive symptoms with the Center for Epidemiologic Studies Depression Scale (CES-D). K10 was presented with priority in detecting depressive disorders which also worked on anxiety. CES-D is one of the most widely used self-administered instruments for depression screening. Reliability and validity of all those scales have been proved and confirmed in prior studies.

2.3. Statistical analysis

Inter-group comparisons of the dependent variables, including K10 and CES-D scores, were performed using an analysis of variance (ANOVA). Pearson correlations test was conducted to investigate the potential relationship between employment period and psychological assessment (K10 and CES-D). A P < .05 indicated statistical significance and all statistical analysis was performed via SPSS version 20.0 (SPSS, Inc., Chicago, IL). We also conducted a bibliometric analysis via GoPubMed to provide a macroscopic view of global publications concerning orthopedic radiation. Pearson correlation test was used to investigate the potential correlation between knowledge contributions over orthopedic radiation and gross domestic product (GDP) of a country.

3. Results

A total of 500 questionnaires were sent, and we received 277 responses but excluded 11 invalid questionnaires. There were 266 orthopedic surgeons who enrolled in this study as participants and completed the questionnaire, all of whom were males. Informations of demographic characteristics were listed in Table 1. The average age was 36.80 ± 8.12 years old, and the average employment period was 12.11 ± 8.05 years. Chief physician accounted 18.8% for the sample, whereas associate chief doctor 20.7%, attending physician 25.9%, resident doctor accounted for 9.8% and graduate students for 22.6%. Only 43.23% (115/266) respondents knew well about radiation and a total of 78.20% (208/266) respondents considered radiation exposure was a great concern. Among those who concerned about radiation exposure, a total of 57.69% (120/208) respondents reported knowing little about radiation.

ANOVA results demonstrated no significant differences in CES-D or K10 between different subspecialties and work degree (P > .05). However, concern over radiation exposure significantly associated with higher scores on CES-D as well as K10 (P < .05) (Table 2). Respondents who reported knowing little about radiation also presented higher scores on CES-D and K10 (P < .05). Multiple comparisons demonstrated that among those who concerned radiation, fewer knowledge about radiation led to more radiation concern associated with higher CES-D (P = 0.049) and K10 scores (P < .001). Among respondents who reported no concerns over radiation exposure, those who knew little about radiation still had higher CES-D and K10 scores (P < .05). However, there were no correlations between employment period and psychological assessment, either K10 or CES-D (P > .05). Most participants (89.10%) took various protection strategies to minimize the radiation hazards (Fig. 1), but only 4.51% participants (12/266) wore leaded glasses to protect their eyes. Respondents who reported concerns over radiation tended to take protection strategies (P < .05).

4. Discussion

Orthopedic surgeons are routinely exposed with fluoroscopic radiation but radiation knowledge varies. This was the first study to demonstrate that knowledge deficiency might lead to more radiation concerns associated with higher psychological distress...
in orthopedic surgeons. We also confirmed the protection
deficiency of radiation hazards among orthopedic surgeons over
the nation, which further confirmed their reported concerns over
radiation. Thus, it is essential to enhance protection management
for minimizing radiation exposure as well as providing more
relevant knowledge to comfort surgeons.

As a kind of mental health problem, psychological distress is a
ubiquitous phenomenon among current social life. Psychological
distress is an umbrella term that encompasses stress, burnout,
depression, anxiety, and other related mental health problems.[17]
Inducements of psychological distress are complicate and
interactive, stress is usually associated with the development of
mental health problems, in which concern over a physical
condition may also play a role.[18] Scholars have indicated long-
term, low-dose rate radiation exposure would cause psychologi-
cal stress and an increased risk of depression decades later.[19]

| Scores | Not concerned with radiation knowledge (n = 27) | Not concerned without radiation knowledge (n = 31) | Concerned with radiation knowledge (n = 88) | Concerned without radiation knowledge (n = 120) | P |
|--------|-----------------------------------------------|-------------------------------------------------|------------------------------------------|-----------------------------------------------|---|
| K10    | 13.26 ± 4.96                                  | 17.19 ± 5.15                                   | 16.86 ± 6.53                             | 19.99 ± 8.09                               | <.001 |
| CES-D  | 11.19 ± 9.42                                  | 19.32 ± 22.60                                  | 22.47 ± 16.36                            | 29.90 ± 18.30                              | <.001 |

CES-D = Epidemiologic Studies Depression Scale; K10 = Kessler 10 scale.

Figure 1. Proportional map of different radiation protection strategies in participants.

Figure 2. Publications concerning orthopedic radiation over the past five decades.
Review to Chernobyl accident and Japan’s nuclear disaster also presented significant association of radiation exposure and subsequent psychological distress. The current study further confirmed the association of concern over radiation exposure with psychological distress. Cause of psychological distress among subjects could both be concern over radiation exposure and the radiation effect itself, which is difficult to accurately distinguish.

Protection strategies of radiation exposure to orthopedic surgeons were gradually widespread and published since Barry reported in 1984. Multiple studies have introduced more advanced fluoroscopy devices to assist an orthopedic surgery, and numerous strategies protection has been proposed to minimize the radiation exposure. Lee et al indicated that following factors could reduce radiation exposure during intraoperative use of C-arm, which included distance from the patient, C-arm configuration, radio-protective equipment, rotating the surgeons’ eyes away from the patient, and avoiding direct exposure to the patient.

### Table 3

| Countries             | Publications | GDP ($) | Population | GDP per capital ($) | Publications/population | Publications/GDP | GDP per capital |
|-----------------------|--------------|---------|------------|---------------------|-------------------------|-----------------|-----------------|
| USA                   | 631          | 17,460,000,000,000 | 318,892,103 | 54,800 | 1.98E-06 | 1.9787E-06 | 0.011514599 |
| Germany               | 124          | 3,621,000,000,000  | 80,996,685  | 44,700  | 1.53E-06 | 1.5309E-06 | 0.002774049 |
| South Korea           | 46           | 1,786,000,000,000  | 49,039,986  | 35,400  | 9.38E-07 | 9.3801E-07 | 0.001299435 |
| Peoples R China       | 129          | 17,630,000,000,000 | 1,355,692,576 | 12,900  | 9.52E-08 | 9.5154E-08 | 0.004497354 |
| Japan                 | 170          | 4,807,000,000,000  | 127,103,388 | 37,800  | 1.34E-06 | 1.3374E-06 | 0.000497354 |
| Italy                 | 64           | 2,066,000,000,000  | 61,680,122  | 34,500  | 1.04E-06 | 1.0376E-06 | 0.001855072 |
| France                | 32           | 2,587,000,000,000  | 66,259,012  | 40,400  | 4.83E-07 | 4.8295E-07 | 0.000792079 |
| Canada                | 63           | 1,579,000,000,000  | 54,854,841  | 44,500  | 1.81E-06 | 1.8085E-06 | 0.00141573 |
| Switzerland           | 28           | 444,700,000,000    | 8,061,516   | 52,200  | 3.47E-07 | 3.4729E-07 | 0.00057246 |
| United Kingdom        | 101          | 2,435,000,000,000  | 63,742,977  | 37,700  | 1.58E-06 | 1.5849E-06 | 0.002679045 |
| Turkey                | 31           | 1,512,000,000,000  | 81,619,392  | 19,600  | 3.80E-07 | 3.7912E-07 | 0.001581633 |
| Australia             | 33           | 1,100,000,000,000  | 22,507,617  | 46,600  | 1.47E-06 | 1.4661E-06 | 0.000708155 |
| Netherlands           | 38           | 798,100,000,000    | 16,877,351  | 47,400  | 2.25E-06 | 2.2514E-06 | 0.000801688 |
| Taiwan                | 40           | 1,022,000,000,000  | 23,359,928  | 43,600  | 1.71E-06 | 1.7123E-06 | 0.00087431 |
| Austria               | 13           | 386,600,000,000    | 8,223,062   | 45,400  | 1.58E-06 | 1.5802E-06 | 0.000296344 |
| Spain                 | 28           | 3,073,000,000,000  | 202,656,788 | 15,200  | 3.47E-07 | 3.4729E-07 | 0.00057246 |
| India                 | 36           | 7,277,000,000,000  | 1,236,344,631 | 5,800  | 2.91E-08 | 2.9118E-08 | 0.00620897 |
| Israel                | 22           | 268,300,000,000    | 7,821,850   | 33,400  | 2.81E-06 | 2.8126E-06 | 0.00058683 |
| Brazil                | 11           | 3,073,000,000,000  | 202,656,788 | 15,200  | 5.43E-08 | 5.4279E-08 | 0.000723684 |
| Czech Republic        | 9            | 299,700,000,000    | 10,627,448  | 28,400  | 8.47E-07 | 8.4686E-07 | 0.000316901 |
| Belgium               | 13           | 467,100,000,000    | 10,449,361  | 41,700  | 1.24E-06 | 1.2441E-06 | 0.00031751 |
| Greece                | 15           | 284,300,000,000    | 10,775,557  | 25,800  | 1.39E-06 | 1.3902E-06 | 0.000381296 |
| Norway                | 11           | 339,500,000,000    | 5,147,792   | 65,900  | 2.14E-06 | 2.1384E-06 | 0.00016692 |
| Hungary               | 6            | 239,900,000,000    | 9,919,128   | 24,300  | 6.05E-07 | 6.0492E-07 | 0.000249614 |
| Singapore             | 10           | 445,200,000,000    | 5,567,301   | 81,300  | 1.80E-06 | 1.7962E-06 | 0.000123001 |
| Finland               | 6            | 221,500,000,000    | 5,268,799   | 40,500  | 1.14E-06 | 1.1387E-06 | 0.000148148 |

GDP = gross domestic product.
exposure of surgeons’ hands. Yu and Khan[31] found that orthopedic surgeons can decline potential radiation risks by optimizing variables such as the use of barriers, knowledge of position, distance from the radiation source, and use of advanced image guidance navigation-assisted technology. However, the inconvenient truths were that only 4.51% participants wore leaded glasses to protect their eyes, although the eye was one of the most sensitive organs to radiation exposure[34]. Only 19.17% wore thyroid gland shield, although radiation-induced thyroid cancer has been well documented.[136]

Even among orthopedic surgeons, who should be more knowledgeable about radiation exposure than other public workers, uncertainty about radiation exposure still existed and created a significant negative effect on their mental health.[134] Indeed, we did observe a rapid increase of publication productivity concerning orthopedic radiation over the last decades, which meant more and more surgeons conducted the related research and increase their knowledge in a way. Bibliometric analysis demonstrated that only 3631 publications concerning orthopedic radiation were obtained over 5 decades, although we could observe a nearly triple increase over the last 2 decades (Fig. 2). However, the global map demonstrated that the scientific productivity of orthopedic radiation concentrated in western countries (Fig. 3). As demonstrated in Table 3, strong correlation between knowledge contributions over orthopedic radiation were strongly correlated with GDP ($r^2 = 0.762$, $P < 0.0001$). However, we should also realize that most research activities over orthopedic radiation concentrated in developed countries. These knowledge deficiency of radiation might play a role in radiation concerns, because people tend to be afraid something they did not know well. As we observed in the current study, knowledge deficiency over radiation might contribute to the radiation concern associated with higher CES-D and K10 scores. The cumulative exposure doses to the surgeon can be maintained well within annual permissible limits.[133] Nevertheless, this cross-sectional study is not without limitations. First of all, a presented correlation is not the cause-and-effect relationship. We could not identify whether long-term radiation exposure might induce psychological distress. Secondly, we did not investigate radiation knowledge of patients and subspecialty analysis, which we will disclose in the near future study. We need a larger sample to participate in the future study, although we have adequate data to clarify the issue we aimed to discuss in the current study.

5. Conclusions
This was the first study to demonstrate that knowledge deficiency might contribute to the radiation concerns associated with higher psychological distress in orthopedic surgeons. Radiation knowledge should be enhanced with more education and research activities for surgeons who daily work with radiation-related fluoroscopy, especially in developing countries. However, when interpreting these data, we should realize that this cross-sectional study could not define a cause-and-effect relationship for any potential associations identified in the study.

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