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Evaluating Some Immunological and Inflammatory Parameters Among Radiology Staff and Technicians in Kirkuk City Hospitals

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Abstract: Introduction and Objective: X-rays have been widely used in medical imaging since their discovery, but chronic occupational exposure may induce immune and inflammatory alterations. This study aimed to evaluate selected biochemical and immunological parameters in X-ray technicians to assess potential effects of chronic exposure. **Materials and Methods:** The study included 50 X-ray technicians and 35 healthy controls from Al-Kirkuk and Azadi Teaching Hospitals, conducted between June 2024 and November 2024. Participants' age, gender, and years of occupational exposure were recorded. Serum levels of TNF-α, IL-1α, IL-6, IL-8, IL-17, CRP, sCD3, and sCD10 were measured using ELISA kits. Participants were stratified by years of work (0–5, 6–10, 11–15, 16–20 years) and analyzed according to age and gender. **Results:** A significant increasing in TNF-α, IL-1α, IL-6, IL-8 and IL-17 serum levels at $p<0.05$ (20.1 ± 4.2 pg/mL), (13.2 ± 3.0 vs 8.7 ± 2.2), (9.3 ±2.2 vs 5.5±1.6), (9-8± 23 vs 61±18), and (62±16vs38±12) respectively in compared with control group (12.4 ± 3.1 pg/mL and also in sCD3(7.8 ± 1.8 ng/mL)vs control group 5.2 ± 1.4 ng/mL, sCD107.0 ± 1.6 vs 4.8 ± 1.2 ng/mL, CRP 4.4 ± 1.2 vs 2.1 ± 0.8 clearly appeared in technicians staff with 16-20. No significant differences were found for any parameter between genders ($p>0.05$). **Conclusions:** Chronic occupational exposure to X-rays is associated with elevated serum cytokines, CD markers, and CRP, reflecting subclinical inflammatory and immune alterations. These findings highlight the need for ongoing monitoring and protective strategies for X-ray personnel.

Keywords: cytokines; x-ray; tumor necrosis factor alpha, Interleukins, CD markers.

Introduction

X-rays were discovered in 1895 by Wilhelm Conrad Roentgen, and the first X-ray image was made in February 1896 [1]. With extremely short wavelength (sub-nanometer), X-rays offer novel theoretical resolution and extraordinary capacity to penetrate into the biological tissues [2]. X-radiation is an electromagnetic radiation with wavelengths from 0.01 to 10 nm, frequencies from 3×10^{16} Hz to 3×10^{19} and energies between 100 eV and 100 keV [3,4]. Whilst X-rays are crucial for diagnostic and therapeutic intervention, there is the potential of biological harm from their ionizing properties. Several epidemiological studies have already shown the association between occupational X-ray exposure and cancer, and other health risks The adverse effects of chronic low-dose exposure (<50–100 mSv) on a long-term basis is still no conclusive [5–7]. Therefore, the International Agency for Research on Cancer (IARC) regards X-rays as a carcinogen [8]. Pregnant women are particularly sensitive to them since there are fetal risks from radiation (advantages of diagnosis versus risk should be evaluated) [9]. Cytokines, a family of low molecular weight proteins, mediate immune and inflammatory responses.

They are regulating communication between hematopoietic and lymphoid cells, as well as other inflammatory and anti-inflammatory cells such as interleukins, tumor necrosis factor and chemokines [10]. New findings show changes in the levels of cytokines and oxidative stress biomarkers even after a prolonged period of chronic low dose occupational exposure to ionizing radiation in workers in a radiology department. For instance, higher levels of IL-6, IL-1α and MIP-1α in radiology employees along with markers for increased oxidative stress have been reported compared to unexposed referents [11,12]. These results suggest that x-ray exposure may cause subclinical immune and biochemical changes. Nevertheless, such studies are scarce especially at study populations that have implemented both cytokine profiles as well as standard biochemical parameters for radiology technicians, thereby representing an unmet research need. Thus, the current study is to evaluate some inflammatory cytokines and biochemical markers in workers and technicians at X-ray departments for early indicators of radiation-induced health outcomes.

Materials and Methods

Study Subjects

The present cross-sectional study included a total of 85 participants: 50 technicians working in the X-ray field and 35 healthy controls. Participants were recruited from Kirkuk Hospital and Azadi Teaching Hospital. The study was conducted between June 2024 and November 2024, with participants' ages ranging from 21 to over 60 years. Socio-demographic data, including age, sex, smoking status, and work history, were collected for all participants to describe the baseline characteristics of the study population. Additional information on clinical history and occupational exposure was also obtained.

Biochemical and Immunological Measurements

Blood samples were collected from all participants, and serum was separated and stored at -80°C until analysis.

Cytokine measurements: Serum levels of TNF-α, IL-1α, IL-6, IL-8, and IL-17 were measured using commercially available ELISA kits (DRG, USA) according to the manufacturer's instructions. Briefly, standards and serum samples were added to 96-well microtiter plates pre-coated with monoclonal antibodies against each cytokine. After incubation, 100 µL of 3,3',5,5'-tetramethylbenzidine (TMB) substrate was added, and plates were incubated for 30 minutes. The reaction was stopped, and absorbance was measured at 450 nm using an ELISA reader (BioTek, USA).

CRP measurement: Serum C-reactive protein (CRP) was determined using an ELISA-based immunoturbidimetric assay (DRG, USA) following standard procedures.

Lymphocyte markers: Serum CD3 and CD10 levels were detected by commercially available ELISA kits for human soluble sCD3 (sCD3) and soluble sCD10 (sCD10), as instructed by the manufacturer (DRG, USA). In short, standards and serum samples were applied to 96-well plates precoated with a monoclonal antibodies specific for sCD3 and sCD10. Upon incubation, the reaction was developed The color was developed using the provided substrate, and absorbance at 450 nm was measured with an ELISA reader (BioTek, USA).

Exclusion Criteria

Individuals with chronic inflammatory or autoimmune diseases, recent infections or vaccinations, pregnancy, use of immunosuppressive drugs, or significant non-occupational radiation exposure were excluded. All eligible participants provided informed consent.

Socio-Demographic and Clinical Data

Participants' socio-demographic characteristics, including age, sex, smoking status, body mass index (BMI), duration of occupational exposure, and protective measures used (e.g., lead aprons, shielding), were recorded. This information was used to evaluate potential correlations between exposure levels, biochemical markers, and immunological parameters.

Statistical Analysis

Data were analyzed using SPSS version 20 (IBM, USA). Continuous variables are presented as mean ± standard deviation (SD), while categorical variables are expressed as frequencies and percentages. Comparisons between exposed and control groups were performed using the chi-square test for categorical variables and independent t-tests or ANOVA for continuous variables, as appropriate. A p-value ≤0.05 was considered statistically significant [13,14].

Results

Baseline characteristics of the participants are presented in Table 1. There were no significant differences in the age and gender distributions of the X-ray technicians and controls (p>0.05). The mean duration of occupational exposure was 9.6 ± 5.2 in the Technicians and 0 in the Controls group.

Table 1. Socio-demographic characteristics of study participants

Characteristic	Control (n=35)	Technicians (n=50)	Total (n=85)
Age (years, mean ± SD)	35.2 ± 9.1	39.8 ± 10.5	37.8 ± 10.2
Gender (M/F)	18/17	30/20	48/37
Years of Work (mean ± SD)	0	9.6 ± 5.2	5.6 ± 5.4

Occupational exposure time increased TNF-α, IL-1α, IL-6, IL-8 and IL-17 serum levels

The TNF-α, IL-1α, IL-6, IL-8 and IL-17 serum levels were assessed for all technicians staff and control groups ,the results showed significantly increasing in all serum levels in technicians staff with 16-20 years service group at p<005 (20.1 ± 4.2 pg/mL), (13.2 ± 3.0 vs 8.7 ± 2.2), (9.3 ±2.2 vs 5.5±1.6), (9-8± 23 vs 61±18), and (62±16vs38±12) respectively in compared with control group (12.4 ± 3.1 pg/mL. It showed an increasing tendency in inflammatory cytokine levels as occupational exposure time increased, and the difference was statistically significant Fig 1.

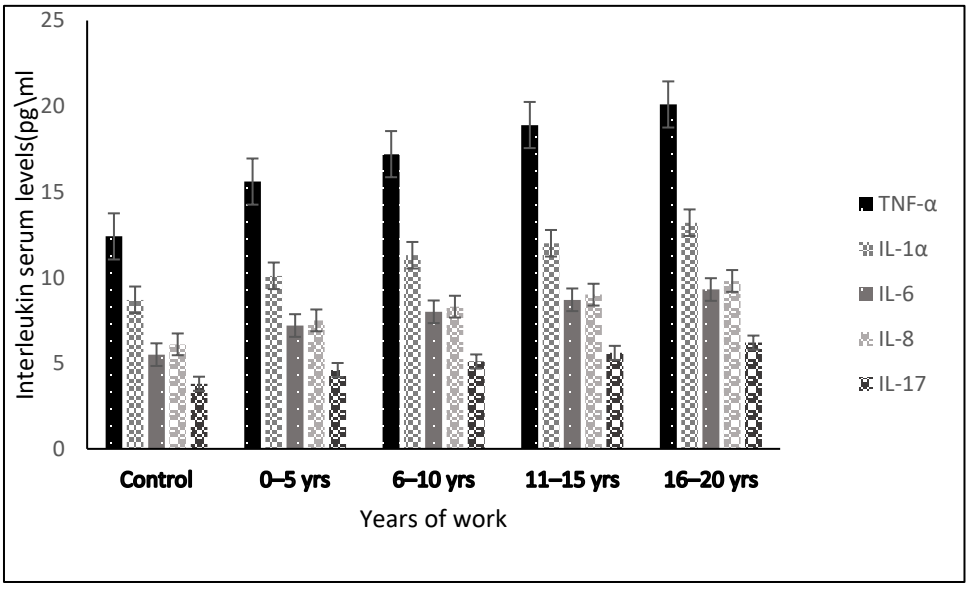

Figure 1. Serum interleukin levels (pg/mL) stratified by the duration of occupational exposure. ***P < 0.05

Occupational exposure time increased sCD3, sCD10, and CRP serum levels

The levels of sCD3, sCD10, and CRP serum were measured using commercially available ELISA kits (DRG, USA), the results observed highest levels of sCD3(7.8 ± 1.8 ng/mL) in 16-20 years service group in compared with other groups particularly with control group(5.2 ± 1.4 ng/mL, $p<0.05$). sCD10 and CRP also peaked in this group: sCD10 7.0 ± 1.6 vs 4.8 ± 1.2 ng/mL, CRP 4.4 ± 1.2 vs 2.1 ± 0.8 mg/L ($p<0.05$). These results indicate a cumulative effect of occupational X-ray exposure on immune activation and systemic inflammation Fig 2.

Figure 2. Serum sCD3, sCD10, and CRP levels stratified by the duration of occupational exposure. ***P < 0.05

Serum cytokines and markers by gender

In comparing serum cytokine and biomarker levels between males and females. No significant differences were found for any parameter between genders ($p>0.05$). The highest TNF-α, IL-6, IL-17, CRP, sCD3, and sCD10 values were observed in males (16.7 ± 4.2 pg/mL, 7.1 ± 2.1 pg/mL, 4.9 ± 1.4 pg/mL, 3.1 ± 1.1 mg/L, 6.3 ± 1.6 ng/mL, and 5.6 ± 1.4 ng/mL respectively) compared with females, but these differences were not statistically significant Fig 3.

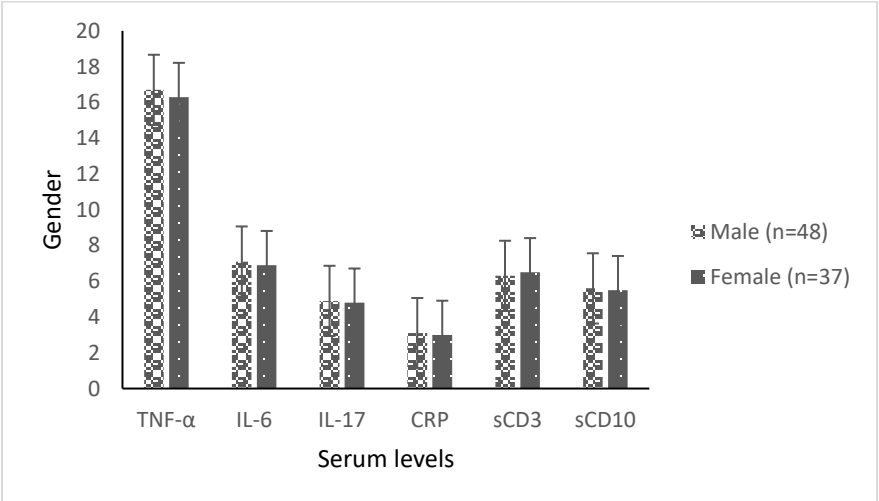

Figure 3. Serum cytokines and markers by gender.

Effect of age on biomarker levels

Figure4 shows the effect of age on biomarker levels. Participants >50 years had the highest values for all parameters compared with younger groups and controls.The TNF-α 18.5 ± 4.2 pg/mL vs control 12.4 ± 3.1, IL-6 8.5 ± 2.1 vs 5.5 ± 1.6, IL-17 5.7 ± 1.5 vs 3.8 ± 1.2, CRP 4.0 ± 1.2 vs 2.1 ± 0.8, sCD3 7.2 ± 1.7 vs 5.2 ± 1.4, sCD10 6.5 ± 1.5 vs 4.8 ± 1.2 (all $p<0.05$). These results suggest age-related increases in inflammatory and immune markers independent of occupational exposure.

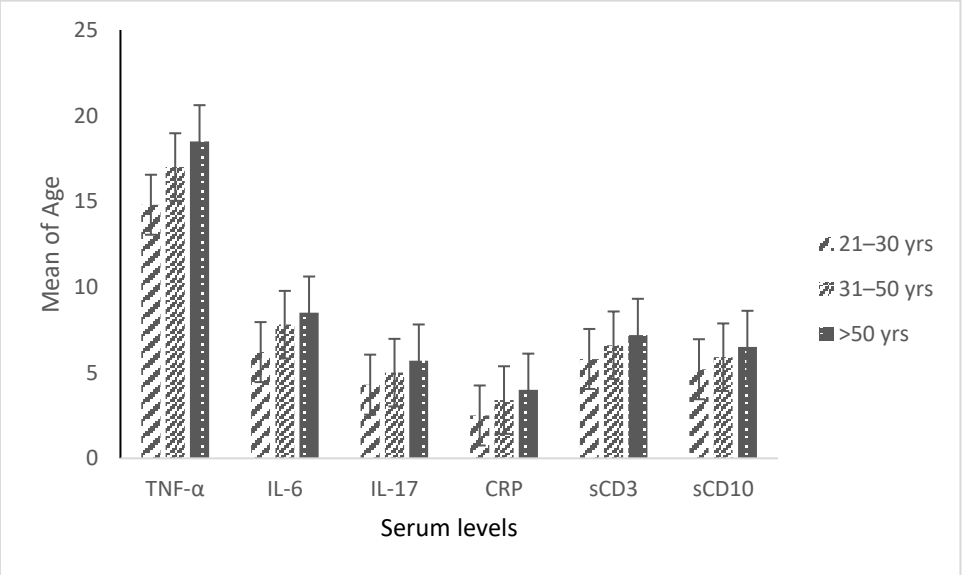

Figure 4. The effect of age on biomarker levels

Discussion

Despite their adherence to the occupation dose limits, we have found that low-level chronic exposure to X-rays in working conditions is accompanied by significant increase of serum pro-inflammatory cytokines (TNF-α, IL-6, IL-1α, IL-8 and IL-17), CRP level and markers of soluble immunity (sCD3 and sCD10) among this category of workers; especially in those with longer duration at work (16–20 years) along with elder age – indicating the possible existence of a radiation-inducing mechanisms even at "low-dose" occupational levels may enhance persistent subclinical immune activation or systemic inflammation. These findings are in agreement with reports of increased IL-6 and IL-1α levels in plasma of healthcare workers exposed to ionizing radiation compared with non-exposed controls, while also displaying augmented reactive oxygen species (ROS) production, indicativeof oxidative and inflammatory effects even under low dose conditions [15,16,17,26]. In addition, long-term occupational radiation exposure — even in compliance with safety limits — was associated to significantly higher levels of IL-6 and eosinophils compared with controls among an Iranian cohort of radiology workers [16,21], strengthening the hypothesis that it may be chronic accumulation rather than acute high-dose being responsible for subtle gradual changes in the immune system over time. Correspondingly, analyses of TNF-α and other pro-inflammatory cytokines in plasma as well as redox imbalance revealed upregulation in plasma from nuclear-industry workers [17] and hospital staff occupationally exposed to low-dose radiation [18], further indicating that chronic ionizing radiation exposure may maintain a significant pro-inflammatory milieu which may contribute to long-term deleterious health effects.

Consistently, meta-analyses and reviews of health personnel for chronic exposure to low-dose ionizing radiation have shown similar changes in oxidative stress biomarkers and immune parameters [18,22,23], indicating that this kind of stress can be considered a common mediator through which ionizing radiations can cause immune/inflammatory dysregulation. These consistent data appear to be both of biological interest and supported on a coherent physical scenario: chronic sub-lethal doses of ionizing radiation would generate oxidative stress and cellular lesions (by generation of ROS, DNA lesions), which would in turn activate immune cells producing pro-inflammatory cytokines. Other experimental data have also demonstrated that a low dose of irradiation (e.g., 0.1–1 Gy) would also upregulate circulating DAMPs in association with the pro-inflammatory cytokines TNF-α, IL-6 and IL-1α, indicating a pathway from radiation-induced cellular stress to systemic inflammation [19]. The increased sCD3 and sCD10 levels found in our study may be indicative of increased lymphocyte activation or a variation of the immune cell turnover / shedding dynamics under chronic cellular stress — an aspect that is not well studied in radiation-exposed medical staff. The dose–response trend seen (higher biomarker levels with longer years of exposure) supports the cumulative effect hypothesis and is also consistent with those observed in other cohorts [20,25]. However, the present pattern of alterations in cytokines was not consistently described across all publications; some reported only limited or lack of significant changes outside a few cytokines (e.g., IL-6), potentially being related to differences in radiation dose, work practices, use of protective equipment, dosimetry techniques, time point after irradiation or genetic / environmental determinants between exposed populations [16]20]. Furthermore, measurement of these soluble CD markers in serum is seldomly described in the literature, again (temporarily) cautioning against overt interpretation of these markers as proof positive of lymphocyte activation; shedding, cell turnover or non-specific inflammatory responses may influence them more than true activation [21,23].

Conclusion

Pro-inflammatory cytokines (TNF-α, IL-6, IL-1α, IL-8 and IL-17), CRP and soluble immune markers (sCD3 and sCD10) are increased in relation to chronic occupational exposure to X-rays in radiology technicians, especially regarding workers with longer work duration or older age. These results suggest that subclinical immune activation and inflammation are accumulative even at low-dose exposure. It underlines the importance of continuous biomonitoring and stringent radiation protection in order to reduce long-term health hazards on personnel working in radiology.

References

1. Röentgen W. C. (1896). Nature London 53, 274.
2. Fouras, A.; Kitchen, M. J.; Dubsky S.; Lewis R. A.; Hooper S. B. and Hourigan K. (2009). The past, present, and future of x-ray technology for in vivo imaging of function and form. J. APP. PHY. 105: 1-14.
3. USF Radiation safety research x-ray safety fundamentals by Adam weaver in University of south Florida. (2003).
4. Vermaa M.; Sonam B. and Shahanaz A. (2016). Biological Effects of X-rays on X-ray Technicians. Int. J. Inn. Res. Sci. Eng. Tech. 5(10): 18512-18516.
5. Cameron J. (2005). Moderate dose rate ionising radiation increases longevity. Br J Radiol. 78:11–3.
6. Feinendegen L. (2005). Evidence for beneficial low level radiation effects and radiation hormesis. Br J Radiol. 78:3–7.

7. Wall, B F.; Kendall, G M.; Edwards A A.; Bouffler S.; Muirhead C R. and Meara J R. (2006). What are the risks from medical X-rays and other low dose radiation?. Br J Radiol. 79: 285–294.

8. Roobottom CA.; Mitchell G. and Morgan-Hughes G. (2010). Radiation-reduction strategies in cardiac computed tomographic angiography. Clin Radiol. 65 (11): 859–67.

9. Giles D.; Hewitt D.; Stewart A. and Webb J (1956). Preliminary Communication: Malignant Disease in Childhood and Diagnostic Irradiation In-Utero. Lancet. 271 (6940): 447.

10. Ray A. and Jagdish J. (2016). Cytokines and their Role in Health and Disease: A Brief Overview. MOJ Immunol. 4(2): 00121.

11. Abbas AK, Lichtman AH, Pillai S. Cellular and Molecular Immunology. 9th ed. Philadelphia: Elsevier; 2017. Healthcare workers occupationally exposed to ionizing radiation exhibit altered levels of inflammatory cytokines and redox parameters. Antioxidants (Basel). 2019;8(1):12.

12. Bahrami Asl F, Islami-seginsara M, Ebrahimi Kalan M, Hemmatjo R, Hesam M, Shafiei-Irannejad V. Exposure to ionizing radiations and changes in blood cells and interleukin-6 in radiation workers. Environ Sci Pollut Res. 2022;30(13):35757–35768.

13. Ahmad M.A., Agha B.S., Alabade A.I.Y., Abd-Alhuseein Jasim E., Meftahizade H. Synergistic effects of boron and zinc foliar applications on growth and post-harvest storage attributes of potato (Solanum tuberosum L.) cultivar Argana. BMC Plant Biology. 2025; 25(1), 1623.

14. Almaghrebi E., Alabbas E.A.K., Vatansev H., Akat F., Vatansev H. Comparative Profiling of Organic Acids, Phenolics, and Tocopherols in Freshwater and Marine Crabs: Effects of Solvent Systems and Habitat. Thalassas, 2025; 41(4), 201.

15. Ahmad IM, Abdalla MY, Moore T, Bartenhagen L, Zimmerman MC. Healthcare workers occupationally exposed to ionizing radiation exhibit altered levels of inflammatory cytokines and redox parameters. Antioxidants (Basel). 2019;8(1):12.

16. Bahrami Asl F, Islami-seginsara M, Ebrahimi Kalan M, Hemmatjo R, Hesam M, Shafiei-Irannejad V. Exposure to ionizing radiations and changes in blood cells and interleukin-6 in radiation workers. Environ Sci Pollut Res. 2022;30(13):35757–35768.

17. Aneva N, Zaharieva E, Katsarska O, et al. Inflammatory profile dysregulation in nuclear workers occupationally exposed to low-dose gamma radiation. J Radiat Res. 2019;60(6):768–779.

18. Al-Ali SH, Ibrahem KA, Salah OE, et al. Blood oxidative stress parameters in hospital workers occupationally exposed to low doses of ionizing radiation: A systematic review and meta-analysis. Heliyon. 2024;10(22):e39989.

19. Xhaier L, McCorkle S, Park G, et al. Comprehensive analysis of gene expression profiles to radiation exposure reveals molecular signatures of low-dose radiation response. preprint. 2023.

20. Mahmood SQ, Talabany BK, Hama-Soor TA. Effects of long-term X-ray exposure on CBC among radiological department staff in Sulaimani city. J Taibah Univ Med Sci. 2024;19(3):524–533.

21. Abeer MM, Sarmad MZ, Muhammad MA, Faiq IC, Adnan AR. Diagnostic and predictive values of IL-6 in a group of Iraqi patients with rheumatoid arthritis. J Fac Med Baghdad. 2021;63(2):48–57.

22. Ali HJ, Salman SA. Oxidative stress and inflammatory biomarkers among radiology technicians exposed to low-dose ionizing radiation in Iraq. Iraqi J Med Sci. 2022;20(4):112–120.

23. Saghir F, Al-Hakeem K, Al-Anbari F. Cytokine profile alterations in hospital workers occupationally exposed to X-rays. Arab J Health Sci. 2023;6(1):33–41.

24. Tang H, Zhao Y, Li P, et al. Chronic low-dose radiation exposure induces inflammation and immune system modulation in medical radiology workers. J Occup Health. 2020;62(1):e12110.

25. Lee Y, Kim S, Choi W, et al. Biomarkers of oxidative stress and immune activation in hospital staff exposed to low-dose X-ray radiation. Radiat Prot Dosimetry. 2021;195(4):412–420.

26. EFFECTS OF DIFFERENT DOSES OF GAMMA RAYS AND ASCORBIC ACID CONCENTRATION ON HUMAN RBCS FOR CONSERVATION PURPOSE. IRAQI JMS 2019, 17 (1)