

Decreases in Occupational Exposure to Ionizing Radiation among Canadian Dental Workers

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A b s t r a c t

Objective: To describe doses of ionizing radiation and their possible associations with mortality rates and cancer incidence among Canadian dental workers.

Methods: The National Dose Registry (NDR) of Canada was used to assess occupational dose of ionizing radiation received by dental workers. The NDR cohort includes 42,175 people classified as dental workers. Subjects in the NDR were linked to both the Canadian Mortality Database and the Canadian Cancer Database to ascertain cause of death and cancer incidence, respectively.

Results: The cohort consisted of 9,051 male and 33,124 female dental workers. A total of 656 incident cases of cancer and 558 deaths were observed. The standardized mortality ratio associated with all-cause mortality was 0.53 (90% confidence interval [CI] 0.49–0.57). The incidence of cancer among dental workers was lower than that for the Canadian population for all cancers except melanoma of the skin (for melanoma, the standardized incidence ratio was 1.46 [90% CI 1.14–1.85]). Occupational doses of ionizing radiation among dentists and dental workers have decreased markedly since the 1950s.

Conclusions: Dental workers receive very low doses of ionizing radiation, and these doses do not appear to be associated with any increase in cancer incidence; the increased incidence of melanoma is more likely related to other risk factors such as exposure to ultraviolet radiation from sunlight.

MeSH Key Words: cancer; dental staff; dentist; occupational exposure; radiation

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Ionizing radiation is a well-established risk factor for cancer.^{1–7} However, despite the fact that most dental offices and clinics have x-ray machines that are in frequent use,⁸ the exposure of dental workers to ionizing radiation and the associated potential cancer risk have been assessed in only a few studies. It appears that there has been a downward trend in the occupational dose of ionizing radiation received by dental workers, which provides evidence

of the efficacy of radiation protection measures.^{9,10} Nonetheless, concerns remain about total-body radiation dose and the risk of cancer^{11,12}; for example, one study suggested that dentists and dental assistants were at increased risk of papillary thyroid cancer.¹³

The purpose of this study was to determine the occupational doses of ionizing radiation and to examine possible associations with mortality rates and cancer incidence in a

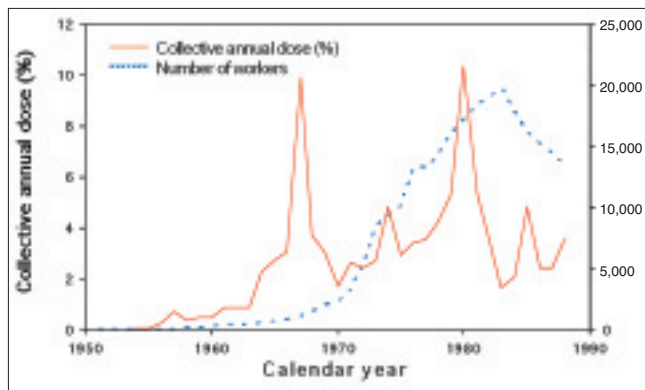


Figure 1: Number of dental workers in the National Dose Registry cohort and their collective annual dose (as a percentage of total collective dose of 13.07 Sv) between 1951 and 1987.

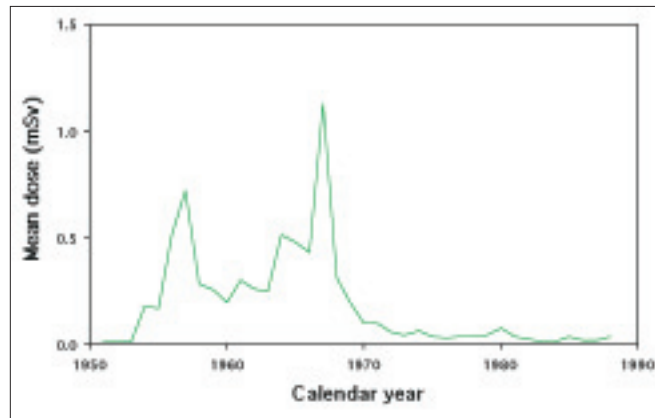


Figure 2: Mean annual radiation dose received by dental workers in the National Dose Registry between 1951 and 1987.

cohort of dental workers listed in the National Dose Registry (NDR) of Canada.

Materials and Methods

National Dose Registry of Canada

The NDR, a database maintained by the Radiation Protection Bureau of Health Canada since 1950, contains records of occupational doses of ionizing radiation for over 500,000 individuals from about 24,000 organizations. The NDR, a major part of Health Canada's population health surveillance program, accounts for virtually all monitored radiation workers in Canada. Further details on the NDR are provided elsewhere.¹⁴

Cohort Definition

The study cohort was derived from all 191,042 individuals in the NDR database whose sex, year of birth and dose information spanning the period 1951–1987 were recorded; of these, 42,175 were classified as dental workers, including dentists, dental assistants and hygienists. A retrospective dose history for each individual in the cohort was previously constructed by combining dose records for individuals over the entire study period.^{14–16} Vital status and cause of death were determined by record linkage to the Canadian Mortality Database for the years 1951 to 1987.¹⁵ Incident cases of cancer were identified by linkage to the Canadian Cancer Database,⁴ derived from the National Cancer Incidence Reporting System for the years 1969 to 1987. Cases of non-melanoma skin cancer were excluded from the cohort because reporting procedures for this type of cancer have varied widely among provinces.⁴ Disease and death codes were reconciled to the ninth revision of the *International Classification of Diseases*.¹⁷

Dosimetry

Dosimetry information was obtained from the National Dosimetry Services of the Radiation Protection Bureau of Health Canada. External radiation dose, expressed in millisieverts (mSv), represents the amount of energy

absorbed per gram of tissue.⁴ Individual doses recorded at frequencies ranging from biweekly to annually were combined to obtain annual doses for each member of the cohort. In cases where the recorded dose was below the detection limit of the radiation dosimeter used (generally < 0.20 mSv), the value was recorded as zero.^{4,15} The collective dose received by the cohort was the sum of all individual doses throughout the study period. Similarly, the collective annual dose was the sum of all individual doses recorded in a given year.

Statistical Methods

Mortality rates and cancer incidence for dental workers were compared with those for the general Canadian population using standardized mortality ratios (SMRs) and standardized incidence ratios (SIRs). Associated confidence intervals were calculated under the assumption that numbers of deaths and incident cases of cancer follow a Poisson distribution.¹⁸

Results

The cohort consisted of 9,051 men and 33,124 women. The number of dental workers in the NDR cohort peaked in the early 1980s and subsequently declined (Fig. 1). The collective annual dose reflects the percentage of the total collective dose of 13.07 Sv received by cohort members in any given year (Fig. 1). The mean annual dose received by dental workers reached a maximum around 1963 and then declined, reaching very low levels by 1975 and remaining at those low levels thereafter (Fig. 2). The mean lifetime cumulative dose among Canadian dental workers in the NDR cohort was 0.31 mSv. The mean annual dose for the period 1970–1987 was 0.045 mSv, which is over 50-fold less than the annual background radiation dose of 2.4 mSv.⁸

A total of 656 incident cases of cancer and 558 deaths were observed. The mortality rate among dental workers was lower than that for the general Canadian population, and the SMR was estimated at 0.53 (90% CI 0.49–0.57) (Table 1). The overall incidence of cancer within the cohort

Table 1 Standardized mortality ratios (SMRs) for dental workers in the National Dose Registry cohort (1951–1987)

Cause of death	No. of deaths		SMR (90% CI)
	Observed	Expected ^a	
Cancer			
Tongue and mouth	2	2.8	0.71 (0.12–2.23)
Pharynx	1	3.2	0.31 (0.01–1.47)
Esophagus	2	4.9	0.41 (0.07–1.28)
Stomach	8	13.2	0.61 (0.30–1.09)
Colon	30	23.4	1.28 (0.92–1.74)
Rectum	3	8.1	0.37 (0.10–0.96)
Liver, primary	4	2.8	1.44 (0.49–3.29)
Liver, not specified	1	1.2	0.85 (0.03–4.01)
Gallbladder	1	2.5	0.40 (0.02–1.89)
Pancreas	13	13.1	0.99 (0.59–1.58)
Lung	29	69.8	0.42 (0.30–0.57)
Bone	2	1.6	1.28 (0.22–4.04)
Connective tissue	1	2.2	0.46 (0.02–2.18)
Melanoma	7	5.8	1.21 (0.57–2.28)
Female breast	39	36.2	1.08 (0.81–1.41)
Ovary	6	9.0	0.67 (0.29–1.32)
Uterus, including cervix	6	9.7	0.62 (0.27–1.22)
Prostate	7	8.6	0.82 (0.38–1.53)
Bladder	4	4.4	0.90 (0.31–2.07)
Kidney	2	6.1	0.33 (0.06–1.04)
Brain, nervous system	9	13.2	0.68 (0.36–1.19)
Thyroid	1	0.6	1.60 (0.06–7.58)
Non-Hodgkin's lymphoma	7	9.8	0.72 (0.34–1.35)
Hodgkin's disease	6	3.8	1.60 (0.70–3.15)
Multiple myeloma	4	3.6	1.12 (0.38–2.55)
Leukemia	17	13.5	1.26 (0.80–1.89)
Leukemia, excluding chronic lymphatic leukemia	15	11.8	1.27 (0.78–1.95)
Myeloid leukemia	7	6.7	1.05 (0.49–1.97)
Acute myeloid or monocytic leukemia	5	4.3	1.15 (0.45–2.43)
All cancers	224	296.5	0.76 (0.67–0.84)
Noncancer			
Accidents	101	222.4	0.45 (0.38–0.54)
Circulatory	165	339.7	0.49 (0.43–0.55)
Endocrine and metabolic	8	21.6	0.37 (0.18–0.67)
Genitourinary	2	9.7	0.21 (0.04–0.65)
Infective and parasitic	2	7.9	0.25 (0.04–0.79)
Respiratory	13	48.6	0.27 (0.16–0.43)
All causes	558^b	1,059.1	0.53 (0.49–0.57)

^aThe expected numbers of deaths were calculated on the basis of the mortality rates in the Canadian population.

^bTotal number of deaths includes 43 deaths in the noncancer category that were not analyzed.

was also lower than that in the Canadian population; the SIR was 0.87 (90% CI 0.82–0.93) (Table 2). For the majority of specific cancers, the SIR was less than 1.0 among dental workers; however, the incidence of melanoma was greater among dental workers (SIR 1.46, 90% CI 1.14–1.85).

Discussion

Although several studies of dental workers have focused on exposure to mercury, anesthetic gases and infectious diseases, as well as on stress and allergic reactions to latex,^{9,11,19,20} few studies have examined the potential risks

of occupational exposure to radiation. Direct radiation injury has been virtually eliminated by improvements in radiologic equipment and methods and radioprotection measures.⁹ However, the potential effects of whole-body doses remain of concern,¹¹ with secondary radiation scattered from bones in the patient's head now representing the greatest source of radiation received by dentists and dental workers.¹⁰

Other than an increased SIR for melanoma, mortality rates and cancer incidence among dental workers were no greater than within the general Canadian population. To our knowledge, a greater incidence of melanoma among

Table 2 Standardized incidence ratios (SIRs) for dental workers in the National Dose Registry cohort (1969–1987)

Type of cancer	No. of cancers		SMR (90% CI)
	Observed	Expected ^a	
Tongue and mouth	6	8.9	0.67 (0.29–1.33)
Salivary gland	5	3.0	1.65 (0.65–3.46)
Pharynx	1	7.3	0.14 (0.01–0.65)
Esophagus	2	5.3	0.38 (0.07–1.19)
Stomach	14	19.6	0.71 (0.43–1.11)
Colon	57	51.5	1.11 (0.88–1.38)
Rectum	30	27.8	1.08 (0.78–1.47)
Liver, primary	3	3.5	0.87 (0.23–2.24)
Pancreas	16	14.0	1.15 (0.72–1.74)
Nose	1	1.6	0.63 (0.02–2.96)
Lung	44	93.0	0.47 (0.36–0.61)
Bone	5	3.9	1.27 (0.50–2.67)
Connective tissue	11	7.6	1.44 (0.81–2.38)
Melanoma	50	34.2	1.46 (1.14–1.85)
Female breast	126	129.7	0.97 (0.83–1.13)
Ovary	22	24.0	0.92 (0.62–1.31)
Uterus and cervix	42	66.4	0.63 (0.48–0.82)
Prostate	30	34.7	0.86 (0.62–1.17)
Testis	10	6.3	1.58 (0.86–2.68)
Bladder	25	27.4	0.91 (0.63–1.27)
Kidney	14	15.5	0.90 (0.55–1.41)
Brain, nervous system	20	20.5	0.98 (0.65–1.42)
Thyroid	25	20.9	1.20 (0.83–1.67)
Non-Hodgkin's lymphoma	22	27.2	0.81 (0.55–1.15)
Hodgkin's disease	15	16.5	0.91 (0.56–1.40)
Multiple myeloma	6	6.0	1.01 (0.44–1.99)
Leukemia	26	21.0	1.24 (0.87–1.72)
Leukemia, excluding chronic lymphatic leukemia ^b	18	15.9	1.13 (0.73–1.68)
Myeloid leukemia ^b	12	11.0	1.10 (0.63–1.78)
Acute myeloid or monocytic leukemia ^b	7	6.7	1.05 (0.49–1.96)
Other cancers	28	39.4	0.71 (0.51–0.98)
All cancers	656	750.8	0.87 (0.82–0.93)

^aThe expected numbers of deaths were calculated on the basis of the mortality rates in the Canadian population.

^bThe individual numbers of observed cancers sum to more than the total of 656 observed cancers because the counts for chronic lymphatic leukemia, myeloid leukemia, and acute myeloid or monocytic leukemia were also included in the overall count for leukemia.

dental workers has not been previously observed, although medical workers exposed to x-rays have been reported to be at higher risk.^{5,21} The elevated risk of melanoma observed in the present study is more likely related to ultraviolet sunlight exposure than to occupational exposure to ionizing radiation.⁴ Because of the large number of cancer types examined in the present study, it is also possible that the elevated SIR for melanoma was due to chance.

The current study summarizes actual dose measurements for dental workers in Canada over a 40-year period. This study was limited by the fact that monitoring of dental workers was not compulsory throughout the entire study period and varied from province to province. As such, an unknown number of dental workers are missing from the cohort, and some dose records may be incomplete.¹⁵ However, there is no reason to assume that the radiation dose received by monitored dental workers was systematically different from that for workers who were not monitored.

The dose of ionizing radiation received by Canadian

dentists and other dental workers has declined to very low levels. Continued adherence to established guidelines for occupational radiation exposure²² is recommended as a means of protecting dental workers from the harmful effects of ionizing radiation. ♦

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