Is Testicular Cancer an Occupational Disease of Fire Fighters?

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Background *A previous investigation showed an increased risk of testicular cancer among fire fighters in Wellington City, New Zealand, during the 1980s. Other studies of fire fighters had not identified testicular cancer as an occupational disease.*
Methods *This was an historical cohort study of mortality and cancer incidence in all paid New Zealand fire fighters, from 1977 to 1995.*
Results *The only cancer for which this study provided evidence of an increased risk was testicular cancer, even after excluding cases from the previous investigation. The standardized incidence ratio for 1990–96 was 3.0 (95% confidence interval: 1.3–5.90). There was no evidence that fire fighters were at increased risk from any particular cause of death.*
Conclusions *This study confirmed that New Zealand fire fighters are at increased risk of testicular cancer, although the reason is unknown. Other incidence studies of cancer in fire fighters are needed to confirm this finding.* Am. J. Ind. Med. 40:263–270, 2001.
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INTRODUCTION

Increased cancer or mortality risks for fire fighters are of concern because of the carcinogens in smoke to which fire fighters may be exposed. A cluster of testicular cancer cases occurred in fire fighters in the city of Wellington in the 1980s. The cluster was identified when the Wellington fire fighters were used as a referent group in another study [Bandaranayake et al., 1993]. A more detailed investigation of the Wellington cluster confirmed an increased risk of testicular cancer between 1980 and 1991 (relative risk [RR] = 8.2, 95% confidence interval [CI]: 2.2–21.0, based on four cases) [Bates and Lane, 1995]. No obvious explanation was found, and it was not possible to rule out the possibility that the risk was more widespread or continuing.

An earlier cancer registry-based case-control study of occupational associations with testicular cancer, during the period 1958–79, had found no evidence of an increased risk for New Zealand fire fighters [Pearce et al., 1987]. However, as all the cases in the Wellington investigation were diagnosed after 1983, it is possible that work-related risk factors for testicular cancer may not have been apparent before that year. There have been a number of studies of health risks in fire fighters, particularly for cancer, both in New Zealand and elsewhere. The outcomes of most of these studies have been well summarized in three recent reviews [Howe and Burch, 1990; Golden et al., 1995; Guidotti, 1995]. Although study results have been far from consistent,

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some evidence exists for elevated risks from cancers of the lung, brain, colon, rectum, the genitourinary tract, and lymphatic and haematopoietic systems, as well as melanoma. None of the reviews suggested that testicular cancer was associated with fire fighting.

The objectives of this study, which had an historical cohort design, were: (1) specifically to determine whether there is an elevated risk for testicular cancer in New Zealand fire fighters overall and (2) generally, to determine whether there was evidence of other cancer or mortality risks for New Zealand fire fighters.

MATERIALS AND METHODS

Identification and Definition of the Cohort

Data were obtained from a registry of all paid and volunteer fire fighters maintained by the United Fire Brigades Association of New Zealand (UFBA). The register is maintained mainly for the purpose of confirming eligibility for length-of-service awards. For each fire fighter, the register contains full name, date of birth, sex, the fire brigades that each person belonged to, their joining and retiring dates from each brigade, and whether they were paid or volunteer fire-fighters. UFBA data available for this study were current to mid 1995.

The study cohort was defined as every person in the UFBA database who (1) had worked in New Zealand as a paid fire fighter for a total period of at least one year and (2) also worked as a paid fire fighter for at least one day during the period 1 January 1977 to 30 June 1995, inclusive. The beginning date was the earliest date at which computerised cancer and mortality data were available through the New Zealand Health Information Service (NZHIS).

Confirmation of Vital Status

The list of cohort members (names, dates of birth, and sex) was matched by the NZHIS with corresponding information on the New Zealand national mortality index. For cohort members not recorded by the NZHIS as having died, a variety of methods were used to confirm that they were alive as close as possible to the final date(s) of follow-up—December 31, 1995 for the mortality analysis and December 31, 1996 for the cancer analysis. These were the final dates for which national mortality and cancer registration data were complete at time of analysis.

Sources of information and methods used to confirm cohort members as alive and living in New Zealand were: (1) period of service with the Fire Service (from the UFBA database), (2) the last recorded date of contact with the New Zealand public health system, for whatever reason, (3) matching with Work and Income New Zealand (WINZ) records of pension and benefit payments, (4) matching with New Zealand Defence Force personnel records (some fire fighters were employed in the New Zealand Defence Force as fire fighters), (5) matching with electronic electoral rolls for 1997 and 1999, and (6) printed electoral rolls.

Rates for Calculation of Expected Numbers

Statistics for the total population of New Zealand, by age and sex, were obtained from Statistics New Zealand for the census years between 1971 and 1996 (every five years). Age- and sex-specific inter-censal populations were estimated by straight-line interpolation.

Anonymized data for incident cancer cases and deaths were obtained from the NZHIS. For deaths these covered the period from 1977 to 1995 inclusive, and for cancers from 1977 to 1996. Data were coded according to the Australasian Version of ICD-9-CM. Cancer and cause of death rates were calculated for strata designated by 5-year calendar period, 5-year age-bands, and separately by sex. These rates were used in the calculation of the expected numbers of cases.

Calculation of SIRs and SMRs

Standardized mortality ratios (SMRs) and standardized incidence ratios (SIRs) were obtained by dividing observed by expected numbers. Ninety-five percent confidence intervals were calculated using standard methods [Breslow and Day, 1987].

RESULTS

Follow-Up of the Cohort

From the UFBA database, 4,359 fire fighters would potentially have been eligible for the cohort. However, 53 were excluded because their sex was unclear, or their birth date was missing or uncertain. The final cohort contained 4,305 firefighters (4,221 males and 84 females). The outcome of follow-up of the cohort is shown in Table I, and demographic details of the cohort in Table II.

To the end of 1995, the total follow-up time for the cohort was 59,322 person-years, comprising 58,709 for males and 613 for females. For the cancer analysis, which included the year 1996, there was additional follow-up time of 3,735 person-years, comprising 3,657 for males and 78 for females. The theoretically possible follow-up time (if all fire fighters had been traced until either death or the end of 1995) would have been 63,437 person-years. Therefore, the follow-up was successful in tracing 93.5% of the total. The fire fighters excluded from the cohort because of incomplete or inadequate identifier details could have supplied a

TABLE I. Outcome of Follow-Up, to December 31, 1995

	Number of fire fighters		
Outcome	**Male**	**Female**	**Total (%)**
Deceased	117	0	117 (2.7)
Lost to follow-up†	436	15	451 (10.4)
Followed to end	3,668	69	3,737 (86.8)
Total	4,221	84	4,305 (100)

†Mean years lost to follow-up: males, 7.4; females, 5.6, assuming no deaths.

maximum (assuming no deaths) of 687 person-years of follow-up.

There was a total for the cohort of 67,503 person-years of service as either a paid or volunteer fire fighter, of which 67,039 years were by males. Eighty-four percent of the years of service by the cohort were as full-time fire fighters.

TABLE II. Demographic Details for the Cohort

Characteristic	**Males**	**Females**	**Total**
Age at start of follow–up (Means: males, 30.2 yrs; females, 28.9 yrs)			
< 20	158	4	162
20–24	1,092	21	1,113
25–29	1,325	29	1,354
30–34	710	16	726
35–39	392	6	398
40–44	232	6	238
45–49	150	2	152
50–54	111	0	111
55–59	43	0	43
≥60	8	0	8
Years of entry into cohort			
1977–81	2,770	19	2,789
1982–86	591	12	603
1987–91	650	29	679
1992–95	210	24	234
Years of follow–up to 31 December 1995: (Means: males, 13.9 yrs; females, 7.3 yrs)			
< 5	397	34	431
5–9	745	25	770
10–14	641	11	652
15–19	2,438	14	2,452
Years as a firefighter (full–time and volunteer): (Means: males, 15.9 yrs; females, 5.5 yrs)			
0–10	1,433	74	1,507
11–20	1,406	10	1,416
21–30	1,098	0	1,098
31–40	254	0	254
> 41	30	0	30

Twenty-eight percent of these years occurred before the beginning of 1977 (the beginning date of follow-up for the cohort).

Cancer Incidence

Because of the small number of females in the cohort, computation of SIRs was limited to male fire fighters. However, three cancers, all at different sites, had been recorded as occurring in female fire fighters.

Results for 1977–96 (Table III) show that cancer rates overall, and at most individual sites, are close to what would be expected. Eleven testicular cancers occurred in the cohort, but 7.1 were expected. Although they were part of the cohort, two of the four fire fighters with testicular cancer that comprised the cluster occurring in Wellington in the 1980s [Bates and Lane, 1995] were not recorded in the Cancer Registry, and do not appear in Table III.

The variation in the overall cancer rates across the time period of follow-up was also investigated. Results of this analysis are shown in Table IV. This shows that the SIR has generally remained at around 1.0.

A concern about matching with the NZHIS databases on mortality and cancer is the possibility of incomplete registrations. However, our experience is that the NZHIS databases are most complete from about 1990. Therefore, we carried out an analysis of cancer rates in the cohort, limited to cancers occurring in the years 1990–96. Results of this analysis are shown in Table V. This analysis is also important in that it excludes the testicular cases in the original cluster that generated the key hypothesis that this study was intended to investigate. In so doing, it examines whether the high testicular cancer rate in Wellington fire fighters during the 1980s was part of a phenomenon that continued into the 1990s.

For the 1990–96 period, the observed numbers of cancers for most sites were close to the expected. The exception was testicular cancer, which had a three-fold elevated rate. Of the eight testicular cancer cases diagnosed in the 1990–96 period, three had worked in the Wellington area.

For the exposure analysis the cohort was stratified according to the number of years of work as a paid fire fighter, or as either a paid or a volunteer fire fighter. SIRs were calculated for each of three exposure categories, for all cancers and for individual cancer sites with reasonable numbers of observed cases. Results are shown in Table VI. The period to which this analysis applies ends at 30 June 1995, as that is the final date for which Fire Service employment information was regarded as complete.

The results for paid fire fighters only show an exposure–response relationship for testicular cancer (although the trend test was not statistically significant), and some evidence for such relationships for lung and rectal cancers. Such relationships are less clear when exposure is

TABLE III. Cancer Incidence in New Zealand Male Fire Fighters, 1977–96

Site†	ICD-9	Expected	Observed	SIR	95% CI
All cancers	140–208	123.8	118	0.95	0.8–1.1
Esophagus	150	1.8	3	1.67	0.3–4.9
Stomach	151	3.9	3	0.76	0.2–2.2
Colon	153	11.8	7	0.60	0.2–1.2
Rectum	154	7.8	9	1.15	0.5–2.2
Pancreas	157	2.3	3	1.28	0.3–3.7
Lung	162	15	17	1.14	0.7–1.8
Melanoma	172	18.3	23	1.26	0.8–1.9
Prostate	185	10.2	11	1.08	0.5–1.9
Testis	186	7.1	11	1.55	0.8–2.8
Bladder	188	4.4	5	1.14	0.4–2.7
Kidney	189	3.5	2	0.57	0.1–2.1
Brain	191	3.9	5	1.27	0.4–3.0
Myeloleukemia	205	2.2	4	1.81	0.5–4.6

†Sites with at least two cases.

treated as the sum of years of paid and volunteer exposure. However, caution is necessary, as in both the tables, the number of cancers at any one site is small.

There were no deaths of female members of the cohort, and the following analysis is for males only. Table VII shows the results for the entire period of the cohort follow-up. The observed numbers of deaths, overall and for specific causes, are appreciably below what would be expected.

When total deaths were stratified in terms of five calendar-year blocks, a tendency for the all-cause mortality SMR to increase over time was evident (Table VIII).

We also examined the period 1990–95 separately, on the assumption that mortality data for these years were likely to be the most complete (results not shown). The SMR for all deaths was higher than the corresponding figure for the entire period of follow-up for the cohort, but the number of deaths was smaller and the SMRs for individual ICD-codes correspondingly imprecise.

Exposure–response analysis was limited by the small number of deaths in most categories. However, SMRs were calculated for each of the three exposure categories, for all deaths, and for deaths caused by circulatory diseases (ICD codes 390–459), for which there is a reasonable number of cases. No clear exposure–response relationships were apparent (data not shown).

TABLE IV. Variation Over Time of Rates for All Cancers (ICD-Codes 140–208)

Registration years	Expected	Observed	SIR	95% CI
1977–96	123.8	118	0.95	0.8–1.1
1977–81	12.8	8	0.62	0.3–1.2
1982–86	20.8	20	0.96	0.6–1.5
1987–91	33.1	35	1.06	0.7–1.5
1992–96	57.1	55	0.96	0.7–1.3

DISCUSSION

A primary motivation for this study was to investigate whether the high rate of testicular cancer that occurred in Wellington fire fighters in the 1980s [Bates and Lane, 1995] was more widespread, and whether it continued into the 1990s. Given the prior hypothesis, it is striking that testicular cancer was the only cancer for which the cohort produced convincing evidence of an elevated incidence rate, even when the original Wellington cluster was excluded from the analysis. The elevated risk seems unlikely to have been due to chance. That there may be an association with occupation was supported by evidence of an exposure–response relationship, particularly when the exposure was limited to service as a paid fire fighter (Table VI).

Other studies have produced evidence of laryngeal cancer and kidney cancer risks elevated in New Zealand fire fighters [Delahunt et al., 1995; Firth et al., 1996]. Our study produced no evidence that New Zealand fire fighters are at particular risk for either of these cancers. The cases for these other studies were probably registered prior to the period of follow-up for the present study. With the possible exception of melanoma, the present study supplies little support for any of the associations with other cancers identified by previous studies [Howe and Burch, 1990; Golden et al., 1995; Guidotti, 1995].

The question arises whether the elevated risk of testicular cancer found in this study could be due to

TABLE V. Cancer Incidence in New Zealand Male Fire Fighters, 1990–96

Site†	ICD-9	Expected	Observed	SIR	95% CI
All cancers	140–208	71.2	72	1.01	0.8–1.3
Esophagus	150	1.1	2	1.80	0.2–6.5
Stomach	151	2.2	2	0.89	0.1–3.2
Colon	153	6.9	4	0.58	0.2–1.5
Rectum	154	4.6	5	1.08	0.3–2.5
Pancreas	157	1.4	3	2.17	0.4–6.4
Lung	162	8.6	7	0.82	0.3–1.7
Melanoma	172	10.1	15	1.49	0.8–2.5
Prostate	185	8.2	9	1.09	0.5–2.1
Testis	186	2.7	8	2.97	1.3–5.9
Bladder	188	2.7	2	0.74	0.1–2.7
Brain	191	1.9	3	1.59	0.3–4.6

†Sites with at least two cases.

selection bias, information bias, or confounding. Since the cohort involved all paid New Zealand fire fighters, and the follow-up rate was good for cohorts of this type, it seems improbable that we could, somehow, have selected fire fighters more likely to be affected by testicular cancer. However, other possibilities need to be considered. These are related to the high level of awareness of testicular cancer within the New Zealand Fire Service, engendered by the previous testicular cancer cluster investigation. First, fire fighters may be self-examining themselves more regularly

TABLE VI. Cancer by Years of Service as a Fire Fighter (1 Jan 1977 to 30 June 1995)

Cancer (ICD-9)	Exposure length (year)	Paid service only				Paid and volunteer service			
		O/E†	SIR	95% CI	*P* for trend	O/E	SIR	95% CI	*P* for trend
All cancers (140–208)	0–10	28/27.2	1.03	0.7–1.5	0.68	14/15.1	0.93	0.5–1.6	0.60
	11–20	31/22.5	1.38	0.9–2.0		33/18.8	1.75	1.2–2.5	
	>20	39/32.7	1.19	0.9–1.6		51/49.2	1.04	0.8–1.4	
Colon (153)	0–10	1/2.4	0.41	0.0–2.3	0.18	1/1.2	0.82	0.0–4.6	0.81
	11–20	1/2.2	0.46	0.0–2.6		1/1.7	0.58	0.0–3.3	
	>20	5/3.6	1.37	0.4–3.2		5/5.5	0.92	0.3–2.1	
Rectum (154)	0–10	2/1.6	1.22	0.1–4.4	0.74	1/0.8	1.23	0.0–6.8	0.97
	11–20	2/1.5	1.38	0.2–5.0		2/1.1	1.75	0.2–6.3	
	>20	4/2.5	1.61	0.4–4.1		5/3.7	1.35	0.4–3.1	
Lung (162)	0–10	3/3.2	0.93	0.2–2.7	0.48	1/1.5	0.66	0.0–3.7	0.85
	11–20	4/2.8	1.45	0.4–3.7		4/2.0	2.04	0.6–5.2	
	>20	8/5.2	1.52	0.7–3.0		10/8.0	1.25	0.6–2.3	
Melanoma (172)	0–10	7/4.1	1.72	0.7–3.5	0.97	4/2.5	1.58	0.4–4.0	0.93
	11–20	6/3.4	1.75	0.6–3.8		6/3.3	1.83	0.7–4.0	
	>20	6/3.6	1.67	0.6–3.6		9/5.3	1.70	0.8–3.2	
Prostate (185)	0–10	3/2.1	1.46	0.3–4.3	0.12	1/0.9	1.09	0.0–6.1	0.21
	11–20	1/1.7	0.60	0.0–3.3		2/1.1	1.9	0.2–6.9	
	>20	1/3.4	0.29	0.0–1.6		2/5.2	0.38	0.0–1.4	
Testis (186)	0–10	3/1.9	1.55	0.3–4.5	0.21	2/1.4	1.39	0.2–5.0	0.44
	11–20	4/1.1	3.51	1.0–9.0		5/1.2	4.03	1.3–9.4	
	>20	2/0.5	4.14	0.5–14.9		2/0.8	2.65	0.3–9.6	

†O/E: observed/expected mortality.

TABLE VII. Mortality in New Zealand Male Fire Fighters, 1977–95

Cause of death†	ICD-9 code	Exp	Obs	SMR	95% CI
All causes	0–999	201	117	0.58	0.5–0.7
Malignant tumors	140–208	51.9	42	0.81	0.6–1.1
Stomach cancer	151	2.6	3	1.16	0.2–3.4
Colon cancer	153	5.0	6	1.19	0.4–2.6
Rectal cancer	154	3.3	4	1.21	0.3–3.1
Lung cancer	162	11.7	10	0.86	0.4–1.6
Melanoma	172	3.1	2	0.65	0.1–2.4
Bladder cancer	188	0.7	2	2.73	0.3–9.8
Brain cancer	191	3.0	2	0.68	0.1–2.4
Hematopoietic cancer	200–208	5.6	4	0.72	0.2–1.8
Circulatory diseases	390–459	70.4	38	0.54	0.4–0.7
Ischemic heart disease	410–414	49.8	29	0.58	0.4–0.8
Cerebrovascular disease	430–438	8.5	5	0.59	0.2–1.4
Respiratory diseases	460–519	9.5	4	0.42	0.1–1.1
Asthma, bronchitis, emphysema	490–493	3.9	2	0.51	0.1–1.8
Digestive system diseases	520–579	4.5	4	0.89	0.2–2.3
External causes	E800–999	47.4	24	0.51	0.3–0.8
Motor vehicle accidents	E810–825	17.3	12	0.69	0.4–1.2
Suicide	E950–959	14.0	8	0.57	0.2–1.1

†Causes with at least two deaths.

and testicular cancers may be detected at an earlier stage than would otherwise be the case. This could raise the SIR for this cancer. However, such an effect would be transitory, as the cancers would all eventually be diagnosed anyway. Secondly, it could be that the publicity has led to more complete notification to the Cancer Registry of incident testicular cancers in fire fighters than of testicular cancer cases diagnosed in the general male population. To account for the elevated risk in the 1990–96 period, testicular cancer cases in fire fighters would need to be three times as likely to be notified as cases in the general population. This seems unlikely.

Information bias would be possible if, for some reason, fire fighters were more likely to be erroneously diagnosed as having testicular cancer than were other males in the New Zealand population. All the fire fighters with testicular cancer in this study had histological classifications consistent with testicular cancer. Irrespective of this, it seems unlikely that fire fighters would be three-fold overdiagnosed relative to all other males.

TABLE VIII. Variation Over Time of All-Cause Mortality (ICD-Codes 000–999)

Registration years	Expected	Observed	SMR	95% CI
1977–95	201.0	117	0.58	0.5–0.7
1977–81	30.4	10	0.33	0.2–0.6
1982–86	43.0	23	0.54	0.3–0.8
1987–91	62.9	39	0.62	0.4–0.8
1992–95	64.8	45	0.69	0.5–0.9

Confounding would be possible if there were a risk factor for testicular cancer that was correlated with employment as a fire fighter, but not incurred as a consequence of being a fire fighter. If such a risk factor exists, it is not clear what it could be.

In contrast to the cancer incidence data, the mortality analysis was reassuring. The overall mortality rate was lower than expected and individual cause of death risks were not elevated. A low mortality rate, due to the so-called "healthy worker effect", is to be expected in occupations, such as fire fighting, that require fitness and good health.

The healthy worker effect has been a consistent finding in virtually all mortality studies of fire fighters [Musk et al., 1978; Eliopoulos et al., 1984; Feuer and Rosenman, 1986; Vena and Fiedler, 1987; Hansen, 1990; Heyer et al., 1990; Beaumont et al., 1991; Grimes et al., 1991; Demers et al., 1992; Guidotti, 1993; Aronson et al., 1994; Burnett et al., 1994]. In most cases, the effect has been less than that found in the present study. Relative risk estimates (such as SMRs) for all cause mortality have generally been in the region 0.80–0.95, whereas this study produced estimates ranging from 0.33 to 0.69 (Table VIII). However, a recent study of Paris fire fighters obtained an SMR for all cause mortality of 0.52 (95% CI: 0.35–0.75) [Deschamps et al., 1995]. There are at least two possible reasons why the mortality rate that we measured might be low relative to most other studies. Firstly, it may be that people applying to join the New Zealand Fire Service have to meet more stringent health and fitness entry criteria than is the case in other countries where fire fighter mortality studies have been carried out (mainly the United States, Canada, Australia, and Scandinavia). Secondly, there is the possibility that errors in recording of key identifier data may be such that matching of our cohort database with the mortality database may be incomplete. This could occur if there are errors in the recording of names and birth dates in either database, or in both. If so, some deaths recorded by the NZHIS would contribute to the calculation of the expected number of deaths, but not be recognized as contributing to the observed number of deaths. This would lead to underestimation of relative risks. SMRs for consecutive five-year periods steadily increase (Table VIII). This could be due to the healthy worker effect wearing off as the average age of the cohort increases, or it could be due to a greater frequency of errors in the earlier recorded data.

These two possibilities cannot be discounted. However, a number of deaths were recorded in the UFBA fire fighter database, and others in the WINZ data as the reason why payment of some benefits was terminated. Of 33 deaths recorded in the UFBA database, NZHIS mortality data were not found for four. It is possible that these four deaths occurred overseas. WINZ advised us of 43 deaths, all of which were found on the NZHIS mortality database. This information suggests that identification of deaths in the cohort was fairly complete and the low SMR may have been due to a strong healthy worker effect. Whatever the case, it is probable that the fire fighter cohort did not have a high mortality rate. For the cohort to have had an actual mortality rate that corresponded to the rate of the general male population, there would need to have been an extra 84 deaths not detected by the follow-up. This seems unlikely.

The reason for the excess risk of testicular cancer remain obscure. The possibility that it is a chance occurrence cannot be totally discounted, but is unlikely. There is no obvious explanation from bias or confounding in the study, although such possibilities also cannot be completely dismissed. The question arises as to why, if the finding of testicular cancer is a real occupational risk of fire fighting, it has not been detected in studies elsewhere. A possible reason is the type and timing of most of the other studies of cancer in fire fighters. Firstly, of the studies done elsewhere, most have investigated mortality only [Musk et al., 1978; Feuer and Rosenman, 1986; Vena and Fiedler, 1987; Hansen, 1990; Heyer et al., 1990; Beaumont et al., 1991; Grimes et al., 1991; Demers et al., 1992; Guidotti, 1993; Aronson et al., 1994; Burnett et al., 1994; Deschamps et al., 1995]. As testicular cancer can be very successfully treated, there are few fatal cases (only one occurred in this cohort). Therefore, unless mortality studies are very large, they are unlikely to detect an elevated risk of testicular cancer. A study involving fire fighters in the Toronto Metropolitan Fire Brigade, from 1950–89, reported an SMR for testicular cancer of 2.52 (95% CI: 0.52–7.37), based on three deaths [Aronson et al., 1994].

Some studies have examined cancer incidence in fire fighters and it is important to consider possible reasons why these did not detect a raised incidence of testicular cancer [Sama et al., 1990; Giles et al., 1993; Demers et al., 1994; Tornling et al., 1994]. The timing of the period of follow-up for these studies may be important. Of the thirteen testicular cancers known to have occurred in New Zealand fire fighters during our follow-up (including the two in the Wellington cluster not recorded by the Cancer Registry), twelve were registered in the years 1988 to 1996. Of the studies of cancer incidence in fire fighters carried out elsewhere, the two with the most recent periods of follow-up concluded in 1989 [Giles et al., 1993; Demers et al., 1994]. It is conceivable, for example, that there could be a relatively new building material that produces a combustion product that is a testicular carcinogen, and only recently has begun to manifest its effect. Alternatively, there could be new fire fighting work practices or fire suppressant materials that carry an increased testicular cancer risk. It is beyond the scope of this study to investigate such possibilities. A nested case-control study would be appropriate for that purpose. An update of this cohort after, for example, ten years, would be useful to investigate whether the elevated testicular cancer risk continues. More current cohort studies of cancer incidence in fire fighters from other countries would determine whether the findings in this study have more widespread applicability.

In conclusion, the raised incidence of testicular cancer that occurred in Wellington fire fighters during the 1980s, continued into the 1990s, but was more widespread among New Zealand fire fighters. There are no indications of what could be causing it. There was no evidence that paid fire fighters in New Zealand are at particular risk for other types of cancer, and they generally had a low risk of premature mortality compared with the general New Zealand population. Further studies, both in New Zealand and elsewhere, are needed to confirm our testicular cancer result, and to identify possible causal factors.

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