

## Characterization of Chilean Firefighters in terms of cancer risk factors: a pilot study

### Caracterización de bomberos chilenos en términos de factores de riesgo de cáncer: un estudio piloto

### Caracterização dos bombeiros chilenos quanto aos fatores de risco de câncer: um estudo piloto

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#### Abstract

Firefighters (FF) are exposed to chemicals, some of them carcinogens. Recently, the International Agency for Research on Cancer has classified the FF occupation on Group 1, known to be carcinogenic to humans. In Chile, FF activity is mostly a volunteer-based occupation. The objective of this study was to characterize FFs from the Fire Department of Talcahuano, Chile in regards with cancer risk factors. A descriptive observational study was performed. Characterization of cancer risk factors (modifiable and non-modifiable) was determined by applying to participants an on-line self-administered survey that included demographics, occupational and safety health, and FF work-related questions. Descriptive statistics parameters and associations were established. A total of 364 FFs (33 women and 330 men) participated of the study. FF age range and mean were 18-72, and 36.3 years old, respectively. 30 % of FFs were smokers, 56 % drinkers, and 36.5 % sedentary. Also, 2.7 % of participants had been diagnosed with cancer. 31.5 % of formally employed FFs declared to be exposed to chemicals at the workplace. Of these, 26 % have also experienced exposures to at least one carcinogen agent. Additionally, 51.1 % of FFs experienced at least one acute symptom associated with fire-controlling activities. 87.1 % of FFs adhered to established gear decontamination and cleaning protocols. This pilot study characterized FFs in terms of modifiable and non-modifiable cancer risk factors, along with occupational exposures to chemicals in their formal employments. Finally, more research is needed in order to assess multiple cancer risk factors, including combined occupational exposures among volunteer FFs.

**Keywords:** firefighter; cancer risk; occupational exposure; Chile.

#### Resumen

Los bomberos se exponen constantemente a sustancias químicas dentro de las cuales algunas son carcinogénicas. Recientemente la Agencia Internacional para la Investigación sobre el Cáncer ha clasificado la ocupación bomberil en el grupo 1, actividad carcinogénica para los humanos. En Chile, la actividad bomberil es mayoritariamente voluntaria. El objetivo de este estudio fue caracterizar a los bomberos del Cuerpo de Bomberos de Talcahuano de Chile con relación a los factores de riesgo para cáncer. Se realizó un estudio observacional descriptivo. La caracterización de los factores de riesgo modificables y no modificables

para cáncer fue determinada mediante una encuesta auto aplicada a los participantes del estudio. La encuesta incluyó aspectos demográficos, de salud y seguridad ocupacional y de actividades propias de la ocupación bomberil. Se establecieron parámetros estadísticos descriptivos y asociaciones entre variables. Un total de 364 bomberos (33 mujeres y 330 hombres) participaron del estudio. El rango de edad y el promedio fue de 18-72 y 36,3 años respectivamente. Un 30 % de los bomberos resultaron ser fumadores, un 56 % bebedores y un 36,5 % sedentarios. Un 2,7 % de los participantes había sido diagnosticado con cáncer al momento del estudio. El 31,5 % de los bomberos con trabajo formal declaró exponerse a sustancias químicas en el lugar de trabajo. Dentro de este grupo, un 26 % ha experimentado exposiciones ocupacionales a al menos un agente carcinogénico. El 51,1 % de los bomberos indicó haber desarrollado síntomas agudos asociados a la extinción de incendios. El 87,1 % de los participantes reconoció adherirse a los protocolos de descontaminación y limpieza de la vestimenta de trabajo. Este estudio piloto caracterizó a los bomberos participantes en relación con los factores de riesgo modificables y no modificables para cáncer en conjunto con la exposición ocupacional a sustancias químicas en los trabajos formales. Bajo este escenario, se hace necesario contar con más estudios que evalúen los múltiples factores de riesgo para cáncer, incluyendo las exposiciones ocupacionales combinadas en los bomberos voluntarios.

**Palabras clave:** bombero; factor de riesgo para cáncer; exposición ocupacional; Chile.

### Resumo

Os bombeiros estão expostos a produtos químicos, alguns deles cancerígenos. Recentemente, a International Agency for Research on Cancer classificou a profissão de bombeiro no Grupo 1, reconhecidamente carcinogênica para humanos. No Chile, a atividade de bombeiro é principalmente uma ocupação voluntária. O objetivo deste estudo foi caracterizar os bombeiros do Corpo de Bombeiros de Talcahuano, Chile, em relação aos fatores de risco de câncer. Foi realizado um estudo observacional descritivo. A caracterização dos fatores de risco de câncer (modificáveis e não modificáveis) foi determinada pela aplicação aos participantes de uma pesquisa auto-administrada on-line que incluiu dados demográficos, saúde ocupacional e segurança e questões relacionadas ao trabalho do bombeiro. Parâmetros estatísticos descriptivos e associações foram estabelecidos. Participaram do estudo 364 bombeiros (33 mulheres e 330 homens). A faixa etária e a média de idade dos bombeiros foram de 18 a 72 anos e 36,3 anos, respectivamente. 30 % dos bombeiros eram fumantes, 56 % etilistas e 36,5 % sedentários. Além disso, 2,7 % dos participantes foram diagnosticados com câncer. 31,5 % dos bombeiros com carteira assinada declararam estar expostos a produtos químicos no local de trabalho. Destes, 26 % também foram expostos a pelo menos um agente cancerígeno. Além disso, 51,1 % dos bombeiros experimentaram pelo menos um sintoma agudo associado às atividades de controle de incêndio. 87,1 % dos bombeiros aderiram aos protocolos estabelecidos de descontaminação e limpeza de equipamentos. Este estudo piloto caracterizou bombeiros em termos de fatores de risco de câncer modificáveis e não modificáveis, juntamente com exposições ocupacionais a produtos químicos em seus empregos formais. Finalmente, mais pesquisas são necessárias para avaliar múltiplos fatores de risco de câncer, incluindo exposições ocupacionais combinadas entre bombeiros voluntários.

**Palavras-chave:** bombeiro; risco de câncer; exposição profissional; Chile.

## INTRODUCTION

Many concerns exist about firefighter (FF) cancer risk<sup>1</sup>. FFs are exposed to carcinogens while on-scene, as well as at the fire station from both diesel exhaust and contaminated Personal Protective Equipment (PPE) or gear<sup>2</sup>. FF PPE provides protection during fire incident responses, however the same PPE can serve as potential contaminated material after fire suppressing activities (i.e. off-gassing stage)<sup>3,4</sup>. It is known that inhalation and skin absorption are the two main routes of exposure<sup>5</sup>.

Carcinogens present at fire scenes are linked to high cancer rates and mainly include volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs)<sup>6-8</sup>. Increased and repeated exposure to these compounds contributes to overall cancer risk among FFs<sup>9</sup>. Recently the International Agency for Research on Cancer (IARC) has classified FF occupation in Group 1,

known to be carcinogenic to humans, finding sufficient evidence for developing mesothelioma and bladder cancer<sup>10</sup>. Furthermore, FFs are 14 % more likely to be diagnosed with cancer (e.g. digestive, oral, respiratory, and genitourinary system) compared to the general population<sup>2,4,7,11</sup>.

In Chile, FF activity is mostly a volunteer-based occupation. Some examples of common FF activities are attending general emergencies, which includes fires extinction (e.g. wild and structural fires), rescue maneuvers, and hazardous material emergencies<sup>12</sup>.

According to the Chilean Ministry of State' 1 757 law act published in 2018, FFs have the right of being economically compensated in case of injuries during performing FF-related activities. However, chronic (non-communicable) diseases, such as cancer are yet not considered. Also, data regarding occupational cancer

among Chilean FFs are scarce except for local letter to the editor-like publications where concerns about long exposure to carcinogens among FFs is raised<sup>13</sup>.

The objective of this study was to characterize firefighters from the Fire Department of Talcahuano, Chile in regards with cancer risk factors.

## MATERIALS AND METHODS

A descriptive observational study was performed among FFs from the Fire Department of Talcahuano (FDT) between November 2019 and January 2020. Characterization of FFs in regards with cancer risk factors was determined by surveying participants by means of a validated self-administered online survey (SAOS).

### 1. VALIDATION OF THE SAOS

The SAOS was validated by using the Delphi method<sup>14</sup>. Firstly, a group of experts composed of 2 experienced FFs (i.e. more than 10 years of service), 1 Occupational Safety and Health officer, and 1 Occupational toxicologist analyzed the original questions and provided researchers with feedback in order to clarify some doubts and also to dispose of an objective instrument to survey participating FFs.

Secondly, the SAOS was completed by 10 FFs, one representative of each fire station from the FDT. At this stage, female and male, experienced (i.e. more than 10 years of service) and non-experienced (i.e. less than a year of service) FFs were recruited.

### 2. ETHICAL CONSIDERATIONS

This study was approved by the University of Concepcion's Review Board (CEEB 561-2019). Informed consent was obtained from the participants of the study.

### 3. SAOS AVAILABILITY

The SAOS was built through Google Forms® and it was available from January 2<sup>nd</sup> - 31<sup>st</sup> 2020. FDT Chief commanders distributed the SAOS via email among FFs of all ten fire stations.

### 4. INCLUSION AND EXCLUSION CRITERIA

FFs from FDT older than 18 years old were invited to participate, including all FF ranks (i.e. volunteers, professionals, officers).

As to exclusion criteria, administrative staff and mechanic-related personnel were excluded from the

study since they did not participate of fire-controlling activities.

### 5. COMPONENTS OF THE SAOS AND VARIABLES OF THE STUDY

The SAOS incorporated sections associated with demographic, occupational and safety health, and FF work-related activity information. Age of participants was classified in intervals:  $18 \leq 24$ ,  $25 \leq 44$ ,  $45 \leq 64$ , and  $\geq 65$  years old. Marital status was considered as single, married, divorced/separated, and widow/er. Number of children (1, 2,  $\geq 3$ ), educational level as school, high school, college, and graduate studies. Ethnicity was classified as Hispanic, Caucasian, Chilean indigenous, Saxon, and African American.

In regards with cancer risk factors, these were classified as modifiable and non-modifiable<sup>15</sup>. Modifiable cancer risk factors were the following: tobacco and alcohol consumption; and sedentarism. Non-modifiable cancer risk factors were associated with exposure to chemicals (carcinogen and non-carcinogen agents) at formal and informal employments. Also, diagnosis of cancer prior to or during the study period was registered in the SAOS.

Additionally, variables related to occupational and safety health, such as employment status (i.e. formal, informal, unemployed, retired), time of employment, exposure to chemicals in their workplace, and time dedicated to FF service were included. Similarly, development of acute symptoms associated with fire-controlling activities; and use, maintenance and storage of FF PPE/gear were assessed.

### 6. STATISTICAL ANALYSIS

Statistical analysis was performed by using Infostat® software<sup>16</sup>. Categorical data are presented as frequency, percentage, mean, range, and median. Associations between categorical variables were made by employing the Spearman's Rank correlation coefficient in order to assess correlations between time of employment in formal work and hours per week of FF service as an indicator of frequency exposures to chemicals, and the Mann-Whitney U-test was used to compare female and male FF age medians. A p-value  $< 0.05$  was considered as statistically significant.

## RESULTS

### 1. DEMOGRAPHICS AND CANCER DIAGNOSIS

A total of 364 (50.4 %) out of 722 (total number of FFs from the FDT) FFs participated of the study and fulfilled the inclusion criteria. Tables 1 and 2 show information

Table 1. Demographic information of participating firefighters

	Women age (years)					Men age (years)				
	18 ≤ 24	25 ≤ 44	45 ≤ 64	≥ 65	Total	18 ≤ 24	25 ≤ 44	45 ≤ 64	≥ 65	Total
Number (%)	8 (2.2)	24 (6.6)	2 (0.5)	0 (0.0)	34* (9.3)	65 (17.9)	173 (47.5)	81 (22.3)	11 (3.0)	330** (90.7)
<b>Marital status</b>										
Single (%)	5 (1.4)	3 (0.8)	2 (0.5)	0 (0.0)	10 (2.7)	38 (10.4)	99 (27.2)	42 (11.5)	2 (0.5)	181 (49.7)
Married (%)	3 (0.8)	21 (5.8)	0 (0.0)	0 (0.0)	24 (6.6)	23 (6.3)	62 (17.0)	31 (8.5)	7 (1.9)	123 (33.8)
Divorced/separated (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.5)	9 (2.5)	9 (2.5)	1 (0.3)	21 (5.8)
Widow/er (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.3)	2 (0.5)	2 (0.5)	0 (0.0)	5 (1.4)
<b>Number of children</b>										
0 (%)	4 (1.1)	16 (4.4)	0 (0.0)	0 (0.0)	20 (5.5)	32 (8.8)	67 (18.4)	37 (10.2)	1 (0.3)	137 (37.6)
1 (%)	3 (0.8)	4 (1.1)	1 (0.3)	0 (0.0)	8 (2.2)	10 (2.7)	37 (10.2)	14 (3.8)	5 (1.4)	66 (18.1)
2 (%)	1 (0.3)	4 (1.1)	1 (0.3)	0 (0.0)	6 (1.6)	13 (3.6)	39 (10.7)	24 (6.6)	0 (0.0)	76 (20.9)
≥ 3 (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	10 (2.7)	30 (8.2)	7 (1.9)	4 (1.1)	51 (14.0)
<b>Education level</b>										
School (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.5)	1 (0.3)	1 (0.3)	0 (0.0)	4 (1.1)
High school (%)	2 (0.5)	7 (1.9)	0 (0.0)	0 (0.0)	9 (2.5)	18 (4.9)	56 (15.4)	21 (5.8)	0 (0.0)	95 (26.1)
College (%)	4 (1.1)	12 (3.3)	2 (0.5)	0 (0.0)	18 (4.9)	38 (10.4)	102 (28.0)	48 (13.2)	4 (1.1)	192 (52.7)
Graduate studies (%)	2 (0.5)	5 (1.4)	0 (0.0)	0 (0.0)	7 (1.9)	7 (1.9)	14 (3.8)	12 (3.3)	6 (1.6)	39 (10.7)
<b>Ethnicity</b>										
Hispanic (%)	6 (1.6)	23 (6.3)	2 (0.5)	0 (0.0)	31 (8.5)	51 (14.0)	149 (40.9)	66 (18.1)	6 (1.6)	272 (74.7)
Caucasian (%)	2 (0.5)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.5)	7 (1.9)	13 (3.6)	6 (1.6)	1 (0.3)	27 (7.4)
Chilean indigenous (%)	0 (0.0)	1 (0.3)	0 (0.0)	0 (0.0)	1 (0.3)	4 (1.1)	8 (2.2)	6 (1.6)	3 (0.8)	21 (5.8)
Saxon (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (0.8)	2 (0.5)	4 (1.1)	0 (0.0)	9 (2.5)
African American (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.3)	0 (0.0)	0 (0.0)	1 (0.3)

N = 364 \*Range=18-54, mean=30.2, SD=8.4, median=29 years old

\*\*Range=18-72, mean=37, SD=13.4, median=35 years old

Ratio Men/women = 9.7 Mann-Whitney U-test: p = 0.0068

Table 2. Modifiable cancer risk factors, exposure to chemicals in workplace, and diagnosis of cancer

	Women age (years)					Men age (years)				
	18 ≤ 24	25 ≤ 44	45 ≤ 64	≥ 65	Total	18 ≤ 24	25 ≤ 44	45 ≤ 64	≥ 65	Total
<b>Modifiable cancer risk factor*</b>										
<b>Tobacco (%)</b>	1 (0.3)	4 (1.1)	0 (0.0)	0 (0.0)	5 (1.4)	17 (4.7)	65 (17.9)	20 (5.5)	2 (0.5)	104 (28.6)
<b>Alcohol (%)</b>	7 (1.9)	12 (3.3)	0 (0.0)	0 (0.0)	19 (5.2)	44 (12.1)	101 (27.7)	40 (11.0)	0 (0.0)	185 (50.8)
<b>Sedentarism (%)</b>	6 (1.6)	9 (2.5)	1 (0.3)	0 (0.0)	16 (4.4)	17 (4.7)	58 (15.9)	35 (9.6)	7 (1.9)	117 (32.1)
<b>Non- Modifiable cancer risk factors</b>										
<b>Exposure to chemicals in workplace</b>	0 (0.0)	5 (1.3)	1 (0.3)	0 (0.0)	6 (1.6)	16 (4.4)	63 (17.3)	29 (8.0)	1 (0.3)	109 (30.0)
<b>Diagnosis of cancer</b>	0 (0.0)	1 (0.3)	0 (0.0)	0 (0.0)	1 (0.3)	2 (0.5)	2 (0.5)	4 (1.0)	1 (0.3)	9 (2.5)

N=364 (33 women, 330 men)

\*Participants who presented at least one modifiable cancer risk factor.

related to demographics, and cancer risk factors among participating FFs.

Among smoker participants, 63.7 % were regular smokers (e.g. 5-10 cigarettes 3-7 days/week), and 36.3 % were occasional smokers (e.g. 5-10 cigarettes 1-2 days/week). Men presented higher relative frequencies of tobacco consumption when compared with women (31.5 % vs 14.7 %).

As for drinkers, 98 % were social drinkers (e.g. beer, wine or spirits 2-4 times per month), while 2 % were regular drinkers (e.g. beer, wine or spirits 3-4 days/week). Relative frequencies of alcohol consumption among women and men were 55.9 % and 56.1 % respectively.

Also, 36.5 % of FFs did not perform any physical activity. In contrast, within the group of those who performed physical activity, 91.4 % and 8.6 % of participants declared to exercise 1-2 and 4-7 days/week, respectively. Women resulted to have higher relative frequencies of sedentarism than men (47.1 % vs 35.4 %).

At the time of the study, 2.7 % (10) of FFs had been diagnosed with cancer. The types of cancer reported by the participants were: colon cancer (1 female FF, 32 years old, and 1 male FF, 71 years old); kidney cancer (2 male FFs, 19 and 53 years old); testicular cancer (3 male FFs, 18, 32, and 48 years old); Hodgkin lymphoma (2 male FFs, 28 and 53 years old); skin cancer (1 male FF, 48 years old).

Additionally, 20.8 % (76) of FFs had been diagnosed with some chronic disease such as hypertension, Type 2 Diabetes Mellitus, and Asthma. Of these, 15.8 % (12) were related to either obesity or overweight.

## 2. EMPLOYMENT OF FFs

As for FFs employment, 75.4 % of participants declared to be formally employed, while 16.1 % had an informal employment. Formal employment was considered according to the International Labour Organization definition, which basically comprises persons who are employed and protected by a national labour legislation<sup>17</sup>.

Also, 4.9 % were unemployed, and 3.6 % were retired. Among those who had a formal employment, 115 FFs (31.5 %) declared to be exposed to chemicals at the workplace. Men had larger relative percentages of occupational exposures to chemicals (33 %) when compared with women (4.7 %).

Table 3 shows periods of exposure to chemicals among participants in their formal employments and dedication time of FF service.

FFs formally employed with stable job for more than 10 years and more than 45 hours per week of FF service resulted in the highest proportion (19.1 %) of participants been exposed to some chemical at the workplace. Also, we found that there is no correlation between the variables time of employment and hours per week of FF service in the last year (Spearman's Rank correlation coefficient).

Additionally, 30 (26 %) out of 115 FFs exposed to chemicals in their formal employment have also experienced exposures to at least one carcinogen agent, classified on IARC's group 1, group 2A, or group 2B.

The most frequent carcinogen agents found as IARC's group 1 were arsenic, asbestos, chromium VI, formaldehyde, coke production, radioactive isotopes, x rays, benzene, and silica; while those in IARC's groups 2A and 2B were lead, and petroleum derivatives respectively.

## 3. TIME DEDICATED TO FF SERVICE, FIRE-CONTROLLING ACTIVITIES AND ACUTE SYMPTOMS

FFs who have been on active service between 6 and 11 years presented the highest proportion of participants (29.4 %) followed by those between 0 and 5 years (27.5 %). Regardless the time of active service, most FFs dedicated more than 10 hours per week to FF-related activities during the last year.

Table 4 shows engagement of FFs in fire-controlling activities, including times spent in controlling fires and number of attended fire events during December of 2019.

Most of participating FFs (63.2 %) attended either one or two fire events during December 2019. Among this group, 45.1 % of participants spent less than an hour in the fire-controlling process. On the other hand, a small percentage (1.7 %) of FFs attended more than 8 fire events, spending more than 6 hours to control fire at scene.

Furthermore, 20.9 % and 30.2 % of FFs experienced, at least, one acute symptom during and 1 hour after performing fire-controlling activities, respectively. The main symptoms experienced during fire-controlling activities were headache (65 %), respiratory difficulty (15 %), and dizziness (5 %). Instead, main symptoms 1 hour after fire-controlling activities were fatigue (35.2 %), respiratory and heart rate increase with 15.7 %, and 23.1 % respectively. Other minor acute symptoms experienced by FFs were blurred vision, skin irritation, and disorientation.

Table 3. FF exposure to chemicals in formal employments

Hours per week of FF service in the last year	Time of employment (years)				Spearman's Rank correlation coefficient
	≤ 1 N (%)	2 ≤ 5 N (%)	6 ≤ 10 N (%)	> 10 N (%)	
1 ≤ 11	7 (6.1)	3 (2.6)	2 (1.7)	3 (2.6)	
12 ≤ 33	2 (1.7)	3 (2.6)	0 (0.0)	3 (2.6)	
34 ≤ 44	5 (4.3)	14 (12.2)	4 (3.5)	6 (5.2)	
≥ 45	14 (12.2)	17 (14.8)	10 (8.7)	22 (19.1)	
Total	28 (24.3)	37 (32.2)	16 (13.9)	34 (29.6)	$\rho = 0.6839$

N= 115 (7 women, 108 men)

Table 4. Participation in fire-controlling activities

Fire-controlling time (hours)	Number of Fire events attended (December 2019)			
	1 ≤ 2 N (%)	3 ≤ 5 N (%)	6 ≤ 8 N (%)	> 8 N (%)
≤ 1	164 (45.1)	28 (7.7)	2 (0.5)	4 (1.1)
2 ≤ 4	55 (15.1)	42 (11.5)	7 (1.9)	2 (0.5)
5 ≤ 6	5 (1.4)	16 (4.4)	3 (0.8)	5 (1.4)
≥ 6	6 (1.6)	14 (3.8)	5 (1.4)	6 (1.7)
Total	230 (63.2)	97 (27.5)	17 (4.7)	17 (4.7)

N = 364

#### 4. FF PPE/GEAR USAGE, MAINTENANCE, AND STORAGE

Eighty three percent of participants declared to be capacitated for wearing and using FF PPE/gear adequately. In regards with frequency of PPE cleaning, this was as follows: 44 % weekly, 34 % monthly, 13 % every 6 months, and 9 % yearly.

As for respiratory protection gear (i.e. breathing apparatus), 87.1 % of FFs adhered to established decontamination and cleaning protocols after attending or participating of fire-controlling activities. In contrast, 12.9 % of participants did not follow protocols appropriately.

Also, periodic visual inspection of FF PPE/gear for identifying damages is one strategy to reduce chemical exposures among FFs. 87.5 % of participants performed periodic visual inspection while 12.5 % did not.

Additionally, 56 % of FFs stored their PPE/gear following the local guidelines (e.g. inside fire stations) while 44 % of participants did not. It is remarkable that some areas or places where FFs used to store their PPE/gear were the trunk of the car, somewhere at home (e.g. living room, laundry room, bedroom, bathroom), and the office.

#### DISCUSSION

Of all participants, 90.7 % were men. As it has published in other works the proportion of male FFs is larger than that of female FFs. This is especially relevant since the majority of studies related to Occupational Safety and Health of FFs focus on male FFs<sup>18-20</sup>.

Also, more than 50 % of FFs were 25-44 years old, and only 3 % of participants were older than 65 years old. Additionally, 52.4 % and 43.1 % of participants were single and had no children, respectively. These data show that most of participants were relatively young people and had no family-related duties. In regards with participants' education level, 57.6 % completed college. Similar findings have been reported in the work of Martinez-Fiestas et al.,<sup>21</sup> where a group of Chilean FFs participated of a multinational risk perception study.

Also, 83.2 % of FFs were Hispanic, this feature turns relevant when considering race and ethnicity as a condition for developing certain types of chronic diseases, including cancer<sup>5,22,23</sup>.

Considerable proportions of FFs, including women and men were related to alcohol consumption and sedentarism. Particularly, proportions of alcohol drinkers

of both genders, when considering relative frequencies, resulted similar. However, for tobacco consumption and exposure to chemicals at workplace (formal employment), men nearly doubled women. Additionally, participating FFs had much lower percentages of sedentarism when compared to Chilean general population where sedentary women and men corresponded to 90 % and 83 % respectively<sup>24</sup>. However, prevalence of modifiable cancer risk factors among FFs (i.e. tobacco and alcohol consumption) promotes cumulative health risks, including those related to cancer<sup>15,25</sup>.

Several studies have demonstrated that FFs are more susceptible to develop specific types of cancer<sup>6,26</sup>. Testicular and colon cancer among FFs has been studied for more than 30 years<sup>27,28</sup>. In our study, 3 male FFs had been diagnosed with testicular cancer. Also, 1 female and 1 male FF reported to have colon cancer.

As for kidney cancer, female FFs are more frequently diagnosed with this type of disease<sup>1</sup> along with those FFs who have served for more than 30 years<sup>26</sup>. According to our results, 2 male FFs had been diagnosed with this type of cancer. These participants had been active as FF for 8 and 12 years respectively.

In regards with non-melanoma skin cancer, this is commonly diagnosed among FFs who have served between 10 and 20 years<sup>26</sup>. In this study, 1 male FF, who has been in active service for 15 years, was diagnosed with skin cancer.

Some of the formally employed participants declared to be exposed to chemicals at the workplace, and within these chemicals some carcinogens were identified. Despite, there were no correlations (Spearman's Rank Correlation coefficient) between time of employment in formal work and hours per week of FF service, it is important to consider for Chilean FFs and also for other FFs who based their occupation on a volunteer basis that multiple occupational exposures to carcinogens may exist (FF-related and non-FF-related activities). In the work of Latinen et al.,<sup>29</sup> is described the importance of assessing these scenarios in order to predict potential health risks and protect FFs. More specifically, some of the FFs resulted exposed to mixtures of carcinogens classified on the same and on different IARC's groups. It is known that occupational exposures to carcinogen mixtures increase the potential of developing cancer<sup>30-32</sup>.

In regards with acute symptoms that may present after fire-controlling activities, Miranda et al., mentioned that these could be caused by the presence of chemicals that may be passively released from FFs gear and equipment<sup>33</sup>. It is important to consider that cooling and hydration are two main components of structured-FF recovery procedure after performing fire-controlling

activities<sup>34</sup>. In our study, some participants indicated that there is no structured-FF recovery protocol in place. This may jeopardize subsequent FF performances.

As previously discussed, Chilean FFs are volunteers and they have to take care of all issues concerning acquisition, maintenance and care of FF PPE/gear. According to our findings, most of FFs do not perform regular decontamination and cleaning of their PPE despite local and international recommendations<sup>35</sup>. There is evidence suggesting that FF structural suits tend to accumulate HAPs over the time, especially if PPE is not frequently decontaminated and cleaned after participation in fire-controlling activities<sup>36</sup>. Also, storing FF PPE/gear in places other than that recommended by international safety guidelines, increases the chances of facilitating secondary residual contamination with HAPs. This scenario may affect not only to FFs, but their families<sup>37,38</sup>. Therefore, regular cleaning, along with storage in proper places contribute to decrease passive exposure among FFs<sup>39</sup>.

#### **LIMITATIONS OF THE STUDY**

This study only included volunteers FFs from one city of Chile. Also, some information related to FFs formal employment is missing, such as in-place safety protocols, and intensity of exposure to chemicals in the workplace. Similarly, there is lack of information associated with those informally employed FFs. In regards with those volunteers diagnosed with some type of cancer, it is important to consider that there was no access to medical records to verify such medical condition, then only perception of participants themselves were taken into account for the study. These missing data may contribute to underestimate the population actually exposed to chemicals and carcinogens in non-FF-related activities.

#### **CONCLUSIONS**

Firefighters are constantly at risk of developing cancer associated with exposures to combustion-based compounds generated in fires. This pilot study allowed researchers to characterize FFs of the FDT in terms of modifiable and non-modifiable cancer risk factors, along with occupational exposures to chemicals in their formal employments. Tobacco and alcohol consumption, and sedentarism resulted in a major concern within the studied population. This turns even more relevant when adding multiple sources of exposure to carcinogens, including those from FF-related activities and non-FF-related activities (formal employment). Under these circumstances, urgent interventions including adoption of occupational cancer prevention strategies is strongly recommended, such as "the U.S. National Firefighter Registry understanding and reducing cancer program". Finally, more research is needed in order to assess multiple

cancer risk factors, including combined occupational exposures among volunteer FFs.

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