

OCCUPATIONAL EXPOSURE AS A FIREFIGHTER

VOLUME 132

This publication represents the views and expert opinions of an IARC Working Group on the Identification of Carcinogenic Hazards to Humans, which met in Lyon, France, 7–14 June 2022

LYON, FRANCE - 2023

IARC MONOGRAPHS
ON THE IDENTIFICATION
OF CARCINOGENIC HAZARDS
TO HUMANS

Table S1.13 Levels of carbon monoxide, polycyclic aromatic hydrocarbons, particulate matter, and volatile and semi-volatile organic compounds measured at wildland fires

Sample type	Type of fire (n, no. of firefighters)	Sampling period	No. of fires (sampling duration)	Units	Mean concentration; SD ^a (range)	Location	Reference
<i>Carbon monoxide (CO)</i>							
Personal air	Wildfires – prescribed burns (n = 35)	March to April, 2016–2019	8 events	mg/m ³	10.79; 7.80 ^a (1.26–27.76)	Ohio, USA	Wu et al. (2021)^b
Personal air	Wildfires – prescribed burns (n = 122)	2005–2016	31 events	mg/m ³	10.58 (0.34–931)	Australia	MacSween et al. (2020)^b
Personal air	Wildfires and prescribed burns (n = 585)	Fire season 2009–2012	57 events (~11 h)	mg/m ³	2.76 (0.80–57.6)	USA	Henn et al. (2019)^b
Personal air	Wildfires – prescribed burns (n = 20)	2009–2011	4 events	mg/m ³	4.02; 5.63; 5.75; 11.96	USA	Reinhardt & Broyles (2019)^b
Personal air	Wildfires – prescribed burns (n = 12)	January to July 2015	NR	mg/m ³	0.92 (0.46–2.07) ^c	South Carolina, USA	Adetona et al. (2019)^b
Personal air	Wildfires – prescribed burns (n = 12)	January to July 2015	7 burn days	mg/m ³	2.3; 0.80 (0.345–5.86) ^c	South Carolina, USA	Adetona et al. (2017)^b
Personal air	Wildfires – simulated wildland firefighting (n = 10)	NR	(1.5 h/shift)	mg/m ³	(0.003–2.15)	USA	Ferguson et al. (2017)^b
Personal air	Wildfires – live fire (n = 17)	NR	4 days, (12 h/shift)	mg/m ³	2.22; 4.42 ^a 1.43; 3.52 ^a (0.575–19.0)	Colorado, USA	Gaughan et al. (2014c)^b
Personal air	Wildfires – prescribed burns (n = 19)	January to March 2014	NR	mg/m ³	1.15 (0.008–14.9)	South Carolina, USA	Adetona et al. (2013b)^b
Personal air	Wildfires – prescribed burns (n = 19)	January to March 2008, 2009	30 burn days	mg/m ³	1.72 (1.49–1.95) ^c 9.43 ^d	South Carolina, USA	Adetona et al. (2013a)^b
Personal air	Wildfires – prescribed burns	February to March 2011 (n = 12)	4 events	mg/m ³	4.14 (1.77–22.8)	Savanah River site, South Carolina, USA	Hejl et al. (2013)^b
Personal air	Wildfires – prescribed burns (n = 20)	Burn season 2004–2005	(6.7 h/shift)	mg/m ³	Fire period 1.54 (ND–20.7) Overall shift 1.22 (ND–16.1)	Savanah River site, USA	Dunn et al. (2013)^b
Personal air	Wildfires – live fire (n = 10)	May to October, 2008–2010 (< 8 h)	52 fire operations	mg/m ³	(1.61–61.4) 1150 ^d	Leiria, Coimbra, Aveiro, Portugal	Miranda et al. (2012)^b
Personal air	Wildfires – prescribed burns (n = 28)	January to March, 2003–2005	30 burn days	mg/m ³	1.15 (0.103–13.3) ^c	South Carolina, USA	Adetona et al. (2011)^b

Table S1.13 (continued)

Sample type	Type of fire (n, no. of firefighters)	Sampling period	No. of fires (sampling duration)	Units	Mean concentration; SD ^a (range)	Location	Reference
Personal air	Wildfires – experimental fire	2008	1 event	mg/m ³	(ND–73.03)	Gestosa, Portugal	Miranda et al. (2011)
Personal air	Wildfires – prescribed burns Wildfires – live fires	2005–2008	NR	mg/m ³	(3.33–14.0) 5.17 (0.11–10.8)	Victoria, Tasmania, Queensland, southern, western, and northern territory, Australia	Reisen et al. (2011)^b
Personal air	Wildfires – experimental fire (n = 10)	2008–2009 (10–15 min)	11 events	mg/m ³	(1.49–22.8) 706.1 ^d	Gestosa, Lousã, Portugal	Miranda et al. (2010)^b
Personal air	Wildfires – live fires (n = 44)	Summer 2007–2009	58 events	mg/m ³	21.16; 1.95 ^a (0.80–66.5)	Leon, Caceres, Zaragoza, Avila, Spain	Carballo-Leyenda et al. (2010)^b
Personal air	Wildfires – prescribed burns (n = 10)	February to March 2004	10 burn days (4.5 h/shift)	mg/m ³	2.15; 2.66 ^a (0.01–16.2)	USA	Dunn et al. (2009)^b
Personal air	Wildfires – prescribed and experimental burns	April to June 2005, 2006 (n = 50)	12 events (0.5–16 h)	mg/m ³	8.51 (0.23–55.2) 197.8 ^d	Victoria, Tasmania, south and northern areas, Australia	Reisen & Brown (2009)^b
Personal air	Wildfires – prescribed burns (n = 13)	February to March 2004	20 shifts (< 12 h)	mg/m ³	4.25; 3.22 ^a (0.23–11.15)	Savannah River Site, USA	Neitzel et al. (2009)^b
Personal air	Wildfires – prescribed burns and simulated experiments	October and November 2005	4 days (15 min to 2 h)	mg/m ³	(31.0–295.5) 1072 ^d	Western Australia	De Vos et al. (2009b)^b
Personal air	Wildfires – training camps (n = 34)	May to August 2004–2005	NR	mg/m ³	(5.75–23.0)	British Columbia, Canada	Swiston et al. (2008)^b
Personal air	Wildfires – prescribed and experimental burns	April to June 2005 (n = 25)	6 events	mg/m ³	12.6 (0.23–55.2) 356.5 ^d	Victoria, Tasmania, Australia	Reisen et al. (2006)^b
Personal air	Wildfires – prescribed burns (n = 12)	January to February 2005	5 weeks	mg/m ³	(0.16–0.67)	Savannah River site, USA	Edwards et al. (2005)
Ambient air	Wildfires – training exercises (n = 64)	NR	4 events	mg/m ³	Fire attack (86.2–1483) Overhaul (ND–149)	Brandford, Killingworth, Madison, New Haven, Connecticut, USA	Cone et al. (2005)^b
Personal air	Wildfires – prescribed burns (n = 65)	1991–1994	1 shift (7–8 h)	mg/m ³	8.27; 7.89 ^a (0.316–31.4)	USA	Slaughter et al. (2004)^b

Table S1.13 (continued)

Sample type	Type of fire (n, no. of firefighters)	Sampling period	No. of fires (sampling duration)	Units	Mean concentration; SD ^a (range)	Location	Reference
Personal air	Wildfires – prescribed burns (n = 129)	August 1992 to August 1995 (< 24 h)	30 days	mg/m ³	At fires (4.60–8.51) 66.7 ^d Overall shift (1.84–4.71) 43.7 ^d	California, Washington, Idaho, Oregon, Montana, USA	Reinhardt & Ottmar (2004) ^b
Personal air	Wildfires – live fires (n = 129)	1992–1995	30 events	mg/m ³	4.60; 44.85 ^d	California, Idaho, Montana, Washington	Reinhardt & Ottmar (2004)
Personal air	Wildfires – prescribed burns				7.93; 66.7 ^d	USA	Reinhardt & Ottmar (2000) ^b
Personal air	Wildfires – live fires (n = 21)	August 1990	1 event	mg/m ³	(1.38–27.8)	California, USA	NIOSH (1994) ^b
Personal air	Wildfires and prescribed burns	Fire seasons 1986–1989	NR	mg/m ³	(1.61–345)	Northern California, USA	Materna et al. (1992) ^b
Personal air	Wildfires – prescribed burns	Summer and early autumn 1988	14 events (1.2–6.3 h/shift)	mg/m ³	(< 6.9–34.5)	Georgia, USA	McMahon & Bush (1992) ^b
Personal air	Wildfires – live fires	July 1991	3 days	mg/m ³	(ND–19.55)	Montana, USA	NIOSH (1991) ^b
Personal air	Wildfires – live fires (n = 20)	November 1991	2 days	mg/m ³	4.6	Gauley Mountain, USA	NIOSH (1992a) ^b
Personal air	Wildfires – live fires (n = 22)	August 1988	3 events	mg/m ³	(1.84–26.8)	USA	NIOSH (1992b) ^b
<i>Polycyclic aromatic hydrocarbons (PAHs)</i>							
Personal air	Wildfires – live fires (n = 86)	April to August 2019	NR	µg/m ³	Benzo[<i>b,j,k</i>]fluoranthene: 0.073; 0.051 ^a Phenanthrene: 0.132; 0.120 ^a	Alberta, British Columbia, Canada	Cherry et al. (2021a)
Ambient air	Wildfires – live fires	July to August, 2015	12 days	ng/m ³	Acenaphthene: 3; 4 ^a (< 1–19) Acenaphthylene: 1; 1 ^a (< 1–4) Anthracene: 1 (< 1–2) Benz[<i>a</i>]anthracene: 3; 2 ^a (< 4–2) Benzo[<i>a</i>]pyrene: 3; 2 ^a (< 3–23) Benzo[<i>b</i>]fluoranthene: 3; 2 ^a (< 3–8)	California, USA	Navarro et al. (2019)

Table S1.13 (continued)

Sample type	Type of fire (n, no. of firefighters)	Sampling period	No. of fires (sampling duration)	Units	Mean concentration; SD ^a (range)	Location	Reference
Ambient air (cont.)					Benzo[<i>g,h,i</i>]perylene: 1 (< 1–29) Benzo[<i>k</i>]fluoranthene: 4; 4 ^a (< 3–10) Chrysene: 4; 1 ^a (< 4–11) Dibenz[<i>a,h</i>]anthracene: 4; 6 ^a (< 3–11) Fluoranthene: 2; 3 ^a (< 1–13) Fluorene: 14; 34 ^a (< 1–120) Indeno[1,2,3- <i>c,d</i>]pyrene: 2; 2 ^a (< 1–12) Naphthalene: 467; 579 ^a (80–2515) Phenanthrene: 10; 15 ^a (< 1–70) Pyrene: 1 (< 1–3) Retene: 37; 66 ^a (< 3–268) Total PAHs: 56; 55 ^a (> 29–236)		Navarro et al. (2019) (cont.)
Personal air	Wildfires – live fires (n = 21)	July to August 2015	2 events	ng/m ³	Acenaphthene: 21; 4 ^a (2–1094) Acenaphthylene: 72; 4 ^a (6–992) Anthracene: 16; 5 ^a (< 1–550) Benz[<i>a</i>]anthracene: 10; 4 ^a (< 3–192) Benzo[<i>a</i>]pyrene: 7; 4 ^a (< 3–140) Benzo[<i>b</i>]fluoranthene: 7; 3 ^a (< 3–87) Benzo[<i>g,h,i</i>]perylene: 5; 4 ^a (< 1–68) Benzo[<i>k</i>]fluoranthene: 7; 3 ^a (< 3–79) Chrysene: 16; 3 ^a (< 4–250)	California, USA	Navarro et al. (2017)

Table S1.13 (continued)

Sample type	Type of fire (n, no. of firefighters)	Sampling period	No. of fires (sampling duration)	Units	Mean concentration; SD ^a (range)	Location	Reference
Personal air (cont.)					Dibenz[<i>a,h</i>]anthracene: 4; 2 ^a (< 3–50)		Navarro et al. (2017) (cont.)
					Fluoranthene: 33; 3 ^a (5–248) Fluorene: 77; 4 ^a (9–1383) Indeno[1,2,3- <i>c,d</i>]pyrene: 6; 5 ^a (< 1–103) Naphthalene: 3189; 3 ^a (319–21 439) Phenanthrene: 210; 3 ^a (13–2867) Pyrene: 22; 5 ^a (< 1–2375) Retene: 1254; 6 ^a (36–24 562) Total PAHs: 586; 3 ^a (88–7935)		
	Prescribed burns (n = 4)	October 2014, 2015	2 events	ng/m ³	Acenaphthene: 6; 4 ^a (< 1–31) Acenaphthylene: 34; 9 ^a (< 1–489) Anthracene: 4; 6 ^a (< 1–106) Benz[<i>a</i>]anthracene: 8; 4 ^a (< 3–84) Benzo[<i>a</i>]pyrene: 5; 4 ^a (< 3–66) Benzo[<i>b</i>]fluoranthene: 5; 3 ^a (< 3–45) Benzo[<i>g,h,i</i>]perylene: 3; 4 ^a (< 1–45) Benzo[<i>k</i>]fluoranthene: 5; 3 ^a (< 3–59) Chrysene: 11; 4 ^a (< 4–97) Dibenz[<i>a,h</i>]anthracene: 4; 2 ^a (< 3–23) Fluoranthene: 8; 6 ^a (< 1–306) Fluorene: 13; 6 ^a (< 1–232)		

Table S1.13 (continued)

Sample type	Type of fire (n, no. of firefighters)	Sampling period	No. of fires (sampling duration)	Units	Mean concentration; SD ^a (range)	Location	Reference
Personal air (cont.)					Indeno[1,2,3- <i>c,d</i>]pyrene: 3; 5 ^a (< 1-75) Naphthalene: 699; 7 ^a (< 4-5073) Phenanthrene: 50; 7 ^a (< 1-761) Pyrene: 9; 6 ^a (< 1-270) Retene: 76; 15 ^a (< 4-4020) Total PAHs: 265; 3 ^a (< 39-9103)		Navarro et al. (2017) (cont.)
Personal air	Wildfires – prescribed burns (n = 21)	November to December, 2006	5 events	µg/m ³	Fluorene: 0.83 (< 0.97-1.5) Phenanthrene: 0.64 (< 0.44-1.18) Naphthalene: 6.17 (3.2-8.1)	Arizona, USA	Robinson et al. (2008)
Ambient air	Wildfires – prescribed burns (n = 21)	November to December, 2006	5 events	µg/m ³	Acephenanthrylene: (0.013-0.216) Anthracene: (0.009-0.182) Benz[<i>a</i>]anthracene: (0.066-0.376) Benzo[<i>a</i>]pyrene: (0.003-0.185) Benzo[<i>b</i>]fluoranthene: (0.015-0.121) Benzo[<i>c</i>]phenanthrene: (0.001-0.017) Benzo[<i>e</i>]pyrene: (0.022-0.115) Benzo[<i>j</i>]fluoranthene: (0.006-0.056) Benzo[<i>k</i>]fluoranthene: (0.015-0.116) Benzo[<i>g,h,i</i>]fluoranthene: (0.027-0.110) Benzo[<i>g,h,i</i>]perylene: (0.014-0.084)		Robinson et al. (2008)

Table S1.13 (continued)

Sample type	Type of fire (n, no. of firefighters)	Sampling period	No. of fires (sampling duration)	Units	Mean concentration; SD ^a (range)	Location	Reference
Ambient air (cont.)					Chrysene + triphenylene: (0.072–0.339) Cyclopenta[<i>c,d</i>]pyrene: (0.002–0.153) Dibenz[<i>a,h</i>]anthracene: (ND–0.015) Fluoranthene: (0.087–0.453) Fluorene (ND–0.422) Indeno[1,2,3- <i>c,d</i>]pyrene: (0.011–0.081) Perylene: (0.007–0.073) Phenanthrene: (0.103–0.938) Pyrene: (0.090–0.463) Total PAHs: (0.606–3.647)		Robinson et al. (2008) (cont.)
Personal air	Wildfires – live fires (n = 21)	August 1990	1 event	µg/m ³	Acenaphthene: (ND–1.7) Anthracene: (ND–26.5) Benzo[<i>b</i>]fluoranthene: (ND–1.7) Fluoranthene: (ND–9.3) Naphthalene: (11.6–35.9)	California, USA	NIOSH (1994)
Personal air	Wildfires and prescribed burns	Fire seasons 1986–1989	NR	µg/m ³	Anthracene: 0.076 (0.005–0.152) Benz[<i>a</i>]anthracene: 0.018 (ND–0.034) Benzo[<i>a</i>]pyrene: 0.015 (ND–0.034) Benzo[<i>b</i>]fluoranthene: 0.028 (ND–0.120) Benzo[<i>k</i>]fluoranthene: 0.006 (ND–0.014) Benzo[<i>g,h,i</i>]perylene: 0.023 (ND–0.032) Chrysene: 0.031 (ND–0.080) Dibenz[<i>a,h</i>]anthracene: 0.010 (ND–0.021)	Northern California, USA	Materna et al. (1992)

Table S1.13 (continued)

Sample type	Type of fire (n, no. of firefighters)	Sampling period	No. of fires (sampling duration)	Units	Mean concentration; SD ^a (range)	Location	Reference
Personal air (cont.)					Fluoranthene: 0.101 (ND–0.781) Indeno[1,2,3- <i>c,d</i>]pyrene: 0.021 (ND–0.042) Phenanthrene: 0.380 (0.013–0.869) Pyrene: 0.099 (ND–0.110)		Materna et al. (1992) (cont.)
Personal air	Wildfires – live fires (n = 20)	November 1991	2 days	µg/m ³	Naphthalene: (ND–6.1)	Gauley Mountain, USA	NIOSH (1992a)
Personal air	Wildfires – live fires (n = 22)	August 1988	3 events	µg/m ³	Acenaphthene: (0.57–1.53) Fluorene: (ND–1.04) Naphthalene: (ND–3.53)	USA	NIOSH (1992b)
<i>Particulate matter (PM)</i>							
Personal air	Wildfires – prescribed burns (n = 35)	March to April, 2016–2019	8 events	mg/m ³	PM _{2.5} 1.75; 1.20 ^a (0.35–5.25)	Ohio, USA	Wu et al. (2021)
Personal air	Wildfires – suppression tasks	2015–2017	NR	mg/m ³	PM ₄ 0.32 ± 2.06 (0.11–2.56)	USA	Navarro et al. (2021)
Personal air	Wildfires – prescribed burns (n = 20)	2009–2011	4 events	mg/m ³	PM ₄ 0.21; 0.49	USA	Reinhardt & Broyles (2019)
Personal air	Wildfires – prescribed burns (n = 12)	January to July 2015	NR	mg/m ³	PM _{2.5} 0.259 (0.156–0.431) ^c	South Carolina, USA	Adetona et al. (2019)
Ambient air	Wildfires – live fire (n = 158)	May to June 2016	NR	mg/m ³	PM _{2.5} 0.0456; 0.0347 ^a (0.0137–0.0772)	Edmonton, Alberta, Canada	Cherry et al. (2019)
Ambient air	Wildfires – live fires	July to August 2015	12 days	mg/m ³	PM _{2.5} 0.029 (0.007–0.105)	California, USA	Navarro et al. (2019)
Personal air	Wildfires – prescribed burns (n = 12)	January to July 2015	7 burn days	mg/m ³	PM _{2.5} 0.338; 0.240 (0.134–0.654) ^c	South Carolina, USA	Adetona et al. (2017)
Personal air	Wildfires – simulated firefighting (n = 10)	NR	(1.5 h/shift)	mg/m ³	PM _{2.5} (0.0052–0.5062)	Western USA	Ferguson et al. (2017)
Personal air	Wildfires – live fire (n = 17)	NR	4 days (12 h/shift)	mg/m ³	Total PM 2.28; 1.43 ^a (1.16–3.93) 1.86; 1.88 ^a (0.92–3.12)	Colorado, USA	Gaughan et al. (2014c)

Table S1.13 (continued)

Sample type	Type of fire (n, no. of firefighters)	Sampling period	No. of fires (sampling duration)	Units	Mean concentration; SD ^a (range)	Location	Reference
Personal air					Respirable PM 0.45; 1.62 ^a (0.24–0.88) 0.38; 1.92 ^a (0.20–0.72)		Gaughan et al. (2014c) (cont.)
Personal air	Wildfires – prescribed burns (n = 19)	January to March 2014	NR	mg/m ³	PM _{2.5} 0.248 (0.184–0.333) ^c	South Carolina, USA	Adetona et al. (2013b)
Personal air	Wildfires – prescribed burns (n = 19)	January to March 2008, 2009	30 burn days	mg/m ³	PM _{2.5} 0.525 (0.466–0.590) ^c 2.456 ^d	South Carolina, USA	Adetona et al. (2013a)
Personal air	Wildfires – prescribed burns (n = 12)	February to March 2011	4 events	mg/m ³	PM _{2.5} 0.650 (0.288–1.306)	Savanah River Site, South Carolina, USA	Hejl et al. (2013)
Personal air	Wildfires – prescribed burns (n = 19)	January to March 2004	10 events (10 h/shift)	mg/m ³	PM _{2.5} 0.354 (0.313–0.400) ^c	South Carolina, USA	Naeher et al. (2013)
Personal air	Wildfires – live fires (n = 1050)	August 2009 (~48 h)	9 days	mg/m ³	PM _{2.5} Day: (0.005–0.037) Night: (0.011–0.044)	Washington, Oregon, California, USA	McNamara et al. (2012)
				number/cm ³	PM _{0.3} to PM _{0.5} (9.24–82.75) PM _{0.5} to PM _{1.0} (0.57–10.34) PM _{1.0} to PM _{2.5} (0.08–1.85)		
Personal air	Wildfires – prescribed burns Wildfires	2005–2008	NR	mg/m ³	Respirable PM >1.2 (0.02–16) 154 ^d Respirable PM 0.39 (0.02–1.46) 119 ^d	Victoria, Tasmania, Queensland, Southern, western, and northern territory, Australia	Reisen et al. (2011)^a
Personal air	Wildfires – prescribed burns (n = 28)	January to March, 2003–2005	30 burn days	mg/m ³	PM _{2.5} 0.264 (0.221–0.316) ^c	South Carolina, USA	Adetona et al. (2011)
Personal air	Wildfires – experimental fire	2008	1 event	mg/m ³	PM _{2.5} 0.738 (0.18–0.74)	Gestosa, Portugal	Miranda et al. (2011)
Personal air	Wildfires – experimental fire (n = 10)	2008–2009 (10–15 min)	11 events	mg/m ³	PM _{2.5} (0.12–2.2) 19.95 ^d	Gestosa, Lousã, Portugal	Miranda et al. (2010)
Personal air	Wildfires –prescribed burns and simulated experiments	October and November 2005	4 days (15 min to 2 h)	mg/m ³	Total PM 10.0; 4.10 ^a	Western Australia	De Vos et al. (2009b)

Table S1.13 (continued)

Sample type	Type of fire (n, no. of firefighters)	Sampling period	No. of fires (sampling duration)	Units	Mean concentration; SD ^a (range)	Location	Reference
Personal air	Wildfires – prescribed burns (n = 13)	February to March 2004	20 work-shifts (< 12 h/shift)	mg/m ³	PM _{2.5} 1.20; 0.61 ^a (0.63–2.67)	Savannah River site, USA	Neitzel et al. (2009)
Personal air	Wildfires – prescribed and experimental burns	April to June 2005, 2006 (n = 50)	12 events (0.5–16 h)	mg/m ³	PM ₄ (0.09–4) 110 ^d	Victoria, southern and northern areas, Australia	Reisen & Brown (2009)
Personal air	Wildfires – prescribed burns (n = 21)	November to December, 2006	5 events	mg/m ³	Total PM 1.01; 1.37 ^a PM _{2.5} 0.73	Arizona, USA	Robinson et al. (2008)
Ambient air	Wildfires – prescribed burns (n = 21)	November to December, 2006	5 events	mg/m ³	PM _{2.5} (0.90–6.98)	Arizona, USA	Robinson et al. (2008)
Personal air	Wildfires – prescribed and experimental burns	April to June 2005 (n = 25)	6 events	mg/m ³	Respirable PM > 3 (0.2 to > 9.0) PM ₄ (2.6–5)	Victoria, Tasmania, Australia	Reisen et al. (2006)
Personal air	Wildfires – prescribed burns	February 2003	12 h	mg/m ³	PM _{2.5} 0.520; 0.239 ^a 0.773; 0.322 ^a	South Carolina, USA	Naeher et al. (2006)
Personal air	Wildfires – controlled simulated bushfires (n = 64)	NR	(15 min)	mg/m ³	Total PM Particulate mask: (0.1–5.1) Particulate/organic vapour mask: (0.7–2.2)	Western Australia	De Vos et al. (2006)
Personal air	Wildfires – prescribed burns (n = 12)	January to February 2005	5 weeks	mg/m ³	PM _{2.5} 435; 418 ^a	Savannah River site, USA	Edwards et al. (2005)
Personal air	Wildfires – prescribed burns (n = 65)	1991–1994	1 shift (7–8 h)	mg/m ³	PM _{3.5} 0.88; 0.90 ^a (0.051–3.96)	USA	Slaughter et al. (2004)
Personal air	Wildfires – prescribed burns (n = 129)	August 1992 to August 1995 (< 24 h)	30 days	mg/m ³	PM _{3.5} At fires: (0.72–1.11) 10.5 ^d Overall shift: (0.022–0.63) 6.90 ^d Total suspended particles At fires: (1.72–5.32) 8.64 ^d Overall shift: (1.39–1.47) 4.17 ^d	California, Washington, Idaho, Oregon, Montana, USA	Reinhardt & Ottmar (2004)

Table S1.13 (continued)

Sample type	Type of fire (n, no. of firefighters)	Sampling period	No. of fires (sampling duration)	Units	Mean concentration; SD ^a (range)	Location	Reference
Personal air	Wildfires – live fires (n = 129)	1992–1995	30 events	mg/m ³	Total suspended PM Fire lines: 1.72; 4.17 ^d Work shift: 1.47; 4.38 ^d	California, Idaho, Montana, Washington, USA	Reinhardt & Ottmar (2000)
	Wildfires – prescribed burns				PM _{3,5} Fire lines: 0.72; 2.3 ^d Work shift: 0.50; 2.93 ^d		
Personal air	Wildfires – live fires (n = 21)	August 1990	1 event	mg/m ³	PM ₁₀ (0.6–1.7)	California, USA	NIOSH (1994)
Personal air	Wildfires and prescribed burns	Fire seasons 1986–1989	NR	mg/m ³	Total PM 9.46 (2.70–37.4) Respirable PM (1.15–1.75) 5.14 ^d	Northern California, USA	Materna et al. (1992)
Personal air	Wildfires – prescribed burns	Summer and early autumn 1988	14 events (1.2–6.3 h/shift)	mg/m ³	Total PM 2.0 ^e (2.0–45) Respirable PM 1.3 ^e (0.2–3.7)	Georgia, USA	McMahon & Bush (1992)
Personal air	Wildfires – live fires (n = 20)	November 1991	2 days	mg/m ³	Respirable PM 0.49; 1.5 ^d	Gauley Mountain, Virginia, USA	NIOSH (1992a)
Ambient air	Wildfires – live fires (n = 22)	August 1988	3 events	mg/m ³	Total PM (0.1–47.6)	USA	NIOSH (1992b)
Personal air	Wildfires	July 1991	3 days	mg/m ³	Respirable PM 0.37; 4.3 ^d	Montana, USA	NIOSH (1991)
<i>Volatile and semi-volatile organic compounds (VOCs and sVOCs)</i>							
Personal air	Wildfires – suppression tasks	2015–2017	NR	ppb	Acrolein 1.7 ± 2.1 (0.6–13.8) Benzene 3.0 ± 2.1 (1.0–23.6) Formaldehyde 31.2 ± 2.1 (10.7–247.9)	USA	Navarro et al. (2021)
Personal air	Wildfires – live fires (n = 10)	May to October, 2008–2010 (< 8h)	52 fire operations	ppm	Total VOCs (0.1–2.3) 64 ^d	Leiria, Coimbra, Aveiro, Portugal	Miranda et al. (2012)

Table S1.13 (continued)

Sample type	Type of fire (n, no. of firefighters)	Sampling period	No. of fires (sampling duration)	Units	Mean concentration; SD ^a (range)	Location	Reference
Personal air	Wildfires – prescribed burns	2005–2008	-	mg/m ³	Formaldehyde (< 0.052–0.212) 0.818 ^d	Victoria, Tasmania, Queensland, southern, western, and northern territory, Australia	Reisen et al. (2011)^b
	Wildfires – live fires				Formaldehyde 0.052 (0.029–0.134)		
Personal air	Wildfires – experimental fire	2008	1 event	mg/m ³	(0.415–5.302)	Gestosa, Portugal	Miranda et al. (2011)
Personal air	Wildfires – experimental fire (n = 10)	2008–2009 (10–15 min)	11 events	ppm	Total VOCs (ND–0.86) 88 ^d	Gestosa, Lousã, Portugal	Miranda et al. (2010)
Ambient air	Wildfires – prescribed fires	NR	5 events	mg/m ³	Benzene: (12–54) Ethylbenzene: (2–62) Toluene: (6–78) Xylene: (1–54)	Island of Corsica, France	Barboni et al. (2010)
Personal air	Wildfires –prescribed burns and simulated experiments	October and November 2005	4 days (15 min to 2 h)	ppm	Total VOCs (2.1–4) 22 ^d	Western Australia	De Vos et al. (2009b)
				mg/m ³	Acrolein: (0.08–0.58) Formaldehyde: (1.53–2.25)		
Personal air	Wildfires – prescribed and experimental burns	April to June 2005, 2006 (n = 50)	12 events (0.5–16 h)	mg/m ³	Total VOCs: 1.83 (0.01–7.50) Acetaldehyde: < 0.09 (ND–0.468) Acrolein: (ND–0.046) Benzene: 0.06 (0.002–0.26) Formaldehyde: < 0.172 (ND–0.701) Phenol: (ND–0.35) Toluene: 0.17 (0.002–0.95) Xylenes: (ND–0.5)	Victoria, Tasmania, south and northern areas, Australia	Reisen & Brown (2009)^b
Personal air	Wildfires – prescribed burns (n = 67)	NR	(1–2 h)	mg/m ³	Particulate mask Formaldehyde: (0.23–0.44) Particulate/organic vapour mask Formaldehyde: (0.01–0.08) Particulate/organic vapour/formaldehyde mask Formaldehyde: (0.01–0.05)	Western Australia	De Vos et al. (2009a)

Table S1.13 (continued)

Sample type	Type of fire (n, no. of firefighters)	Sampling period	No. of fires (sampling duration)	Units	Mean concentration; SD ^a (range)	Location	Reference
Personal air	Wildfires – prescribed and experimental burns	April to June 2005 (n = 25)	6 events	mg/m ³	Total VOCs 2.50 (0.013–7.50) Acetaldehyde: < 0.144 (ND–0.468) Acrolein: < 0.069 (ND–0.046) Benzene: 0.120 (0.002–0.260) Formaldehyde: 0.283 (0.049–0.972) 2-Furaldehyde: < 0.070 (ND–0.150) Phenol: < 0.130 (ND–0.350) Toluene: < 0.170 (0.002–0.550)	Victoria, Tasmania, Australia	Reisen et al. (2006)^b
Personal air	Wildfires – controlled simulated bushfires (n = 64)	NR	(15 min)	mg/m ³	Particulate mask Acrolein: (0.001–0.350) Formaldehyde: (0.017–1.73) Particulate/organic vapour mask Acrolein: (ND–0.010) Formaldehyde: (0.033–0.104) Particulate/organic: vapour/formaldehyde mask Acrolein: (0.001–0.010) Formaldehyde: (0.053–0.160)	Western Australia	De Vos et al. (2006)
Personal air	Wildfires – prescribed burns (n = 65)	1991–1994	1 shift (7–8 h)	mg/m ³	Acrolein: 0.023 (ND–0.094) Formaldehyde: 0.066 ± 0.074 ^a (ND–0.258)	USA	Slaughter et al. (2004)^b
Personal air	Wildfires – live fires (n = 129)	1992–1995	30 events	mg/m ³	Acrolein: 0.0046; 0.037 ^d Benzene: 0.019; 1.22 ^d Formaldehyde: 0.022; 0.114 ^d	California, Idaho, Montana,	Reinhardt & Ottmar (2004)
Personal air	Wildfires – prescribed burns				Acrolein: 0.034; 0.224 ^d Benzene: 0.089; 0.281 ^d Formaldehyde: 0.092; 0.738 ^d	Washington, USA	Reinhardt & Ottmar (2000)^b

Table S1.13 (continued)

Sample type	Type of fire (n, no. of firefighters)	Sampling period	No. of fires (sampling duration)	Units	Mean concentration; SD ^a (range)	Location	Reference
Personal air	Wildfires – live fires (n = 21)	August 1990	1 event	mg/m ³	Acetaldehyde: (0.018–0.072) Acrolein: (ND–0.023) Formaldehyde: (0.025–0.086) Furfural: (0.008–0.031)	California, USA	NIOSH (1994)^b
Personal air	Wildfires and prescribed burns	Fire seasons 1986–1989	NR	mg/m ³	Acetaldehyde: 0.078 (ND–0.15) Acrolein: 0.052 Formaldehyde: 0.16 (0.048–0.42) Furfural: 0.13 (ND–0.23)	Northern California, USA	Materna et al. (1992)
Personal air	Wildfires – live fires (n = 20)	November 1991	2 days	mg/m ³	Formaldehyde: 0.086; 12.3 ^d Furfural: (ND–0.118)	Gauley Mountain, Virginia, USA	NIOSH (1992a)
Personal air	Wildfires – live fires (n = 22)	August 1988	3 events	mg/m ³	Benzene: (ND–0.096) Formaldehyde: (0.025–0.037) Furfural: (ND–0.196) Methyl acetate: (ND–0.06) 2-Methylfuran: (0.03–0.13) Terpenes: (ND–1.16) Toluene: (ND–0.038)	USA	NIOSH (1992b)^b
Personal air	Wildfires – live fires	July 1991	3 days	mg/m ³	Acetaldehyde (ND–0.10) Formaldehyde: (ND–10) Furfural: (ND–0.04)	Montana, USA	NIOSH (1991)

CO, carbon monoxide; ND, not detected; NR, not reported; PAH, polycyclic aromatic hydrocarbon; PM, particulate matter; ppm, parts per million; SD, standard deviation; sVOC, semi-volatile organic compound; VOC, volatile organic compound.

^a Standard deviation (SD) of the mean.

^b Data was converted from ppm to mg/m³.

^c Range is expressed as 95% confidence limits.

^d Maximum peak value.

^e Represents median.

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