Health effects of the 2012 Valencia (Spain) wildfires on children in a cohort study

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Abstract

In July 2012, two simultaneous wildfires burnt a big area in Valencia (Spain), where a birth cohort study (INMA) is being developed. The heavy smoke covered the whole INMA study area for several days. We aimed at evaluating the 2012 Valencia wildfire effects on the health of children enrolled in the INMA-Valencia cohort. Two weeks after the extinction of the wildfires, a phone survey was conducted and finally 460 individuals were enrolled. We considered a wildfire period (12-day interval when they were active) and a control period (12-day interval just before wildfires). Parents were asked about respiratory symptoms experienced during both periods, and during wildfires only about the preventive measures adopted and the perception of exposure, along with individual data collected through the different follow-up surveys of the cohort. Conditional logistic regression models were applied, and we

included interaction terms for asthma/rhinitis and level of perception of exposure; 82.4 % perceived smoke smell outdoors, 40 % indoors and more than 90 % of the families observed the presence of ash. An adjusted odds ratio of 3.11 [95 % confidence interval 1.62–5.97] for itchy/watery eyes and 3.02 [1.41–6.44] for sore throat was obtained. Significant interaction terms for rhinitis and asthma in itchy/watery eyes and sneezing, and only asthma for sore throat were obtained. Exposure to wildfire smoke was associated with increased respiratory symptoms in this child population, particularly affecting susceptible individuals with asthma or rhinitis.

Keywords

Wildfire Children Allergy Air pollution Cohort Asthma Rhinitis

Electronic supplementary material

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Notes

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Compliance with ethical standards

Conflict of interest

The authors declare that they have no actual or potential competing financial interests.

Supplementary material

10653_2015_9753_MOESM1_ESM.doc (52 kb)
Supplementary material 1 (DOC 52 kb)

References

Amster, E. D., Fertig, S. S., Baharal, U., Linn, S., Green, M. S., Lencovsky, Z., & Carel, R. S. (2013). Occupational exposures and symptoms among firefighters and police during the Carmel forest fire: The Carmel cohort study. *The Israel Medical Association Journal: IMAJ, 15*(6), 288–292.
Google Scholar (http://scholar.google.com/scholar_lookup?title=Occupational%20exposures%20and%20symptoms%20among%20firefighters%20and%20police%20during%20the%20Carmel%20forest%20fire%3A%20The%20Carmel%20cohort%20study&author=ED.%20Amster&author=SS.%20Fertig&author=U.%20Baharal&author=S.%20Linn&author=MS.%20Green&author=Z.%20Lencovsky&author=RS.%20Carel&journal=The%20Israel%20Medical%20Association%20Journal%3A%20IMAJ&volume=15&issue=6&pages=288-292&publication_year=2013)

Analitis, A., Georgiadis, I., & Katsouyanni, K. (2012). Forest fires are associated with elevated mortality in a dense urban setting. *Occupational and Environmental Medicine, 69*(3), 158–162. doi: 10.1136/oem.2010.064238 (https://doi.org/10.1136/oem.2010.064238).
CrossRef (https://doi.org/10.1136/oem.2010.064238)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Forest%20fires%20are%20associated%20with%20elevated%20mortality%20in%20a%20dense%20urban%20setting&author=A.%20Analitis&author=I.%20Georgiadis&author=K.%20Katsouyanni&journal=Occupational%20and%20Environmental%20Medicine&volume=69&issue=3&pages=158-162&publication_year=2012&doi=10.1136%2Foem.2010.064238)

Anderson, J. O., Thundiyil, J. G., & Stolbach, A. (2012). Clearing the air: A review of the effects of particulate matter air pollution on human health. *Journal of Medical Toxicology, 8*(2), 166–175. doi: 10.1007/s13181-011-0203-1 (https://doi.org/10.1007/s13181-011-0203-1).
CrossRef (https://doi.org/10.1007/s13181-011-0203-1)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Clearing%20the%20air%3A%20A%20review%20of%20the%20effects%20of%20particulate%20matter%20air%20pollution%20on%20human%20health&author=JO.%20Anderson&author=JG.%20Thundiyil&author=A.%20Stolbach&journal=Journal%20of%20Medical%20Toxicology&volume=8&issue=2&pages=166-175&publication_year=2012&doi=10.1007%2Fs13181-011-0203-1)

Betha, R., Behera, S. N., & Balasubramanian, R. (2014). 2013 Southeast Asian smoke haze: Fractionation of particulate-bound elements and associated health risk. *Environmental Science and Technology, 48*(8), 4327–4335.
doi: 10.1021/es405533d (https://doi.org/10.1021/es405533d).
CrossRef (https://doi.org/10.1021/es405533d)
Google Scholar (http://scholar.google.com/scholar_lookup?

title=2013%20Southeast%20Asian%20smoke%20haze%3A%20Fractionation%20of%20particulate-bound%20elements%20and%20associated%20health%20risk&author=R.%20Betha&author=SN.%20Behera&author=R.%20Balasubramanian&journal=Environmental%20Science%20and%20Technology&volume=48&issue=8&pages=4327-4335&publication_year=2014&doi=10.1021%2Fes405533d)

Caamano-Isorna, F., Figueiras, A., Sastre, I., Montes-Martínez, A., Taracido, M., & Piñeiro-Lamas, M. (2011). Respiratory and mental health effects of wildfires: An ecological study in Galician municipalities (north–west Spain). *Environmental Health: A Global Access Science Source, 10*, 48. doi: 10.1186/1476-069X-10-48 (https://doi.org/10.1186/1476-069X-10-48).
CrossRef (https://doi.org/10.1186/1476-069X-10-48)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Respiratory%20and%20mental%20health%20effects%20of%20wildfires%3A%20An%20ecological%20study%20in%20Galician%20municipalities%20%28north%E2%80%93west%20Spain%29&author=F.%20Caamano-Isorna&author=A.%20Figueiras&author=I.%20Sastre&author=A.%20Montes-Mart%C3%ADnez&author=M.%20Taracido&author=M.%20Pi%C3%B1eiro-Lamas&journal=Environmental%20Health%3A%20A%20Global%20Access%20Science%20Source&volume=10&pages=48&publication_year=2011&doi=10.1186%2F1476-069X-10-48)

Crabbe, H. (2012). Risk of respiratory and cardiovascular hospitalisation with exposure to bushfire particulates: New evidence from Darwin, Australia. *Environmental Geochemistry and Health, 34*(6), 697–709. doi: 10.1007/s10653-012-9489-4 (https://doi.org/10.1007/s10653-012-9489-4).
CrossRef (https://doi.org/10.1007/s10653-012-9489-4)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Risk%20of%20respiratory%20and%20cardiovascular%20hospitalisation%20with%20exposure%20to%20bushfire%20particulates%3A%20New%20evidence%20from%20Darwin%2C%20Australia&author=H.%20Crabbe&journal=Environmental%20Geochemistry%20and%20Health&volume=34&issue=6&pages=697-709&publication_year=2012&doi=10.1007%2Fs10653-012-9489-4)

Delfino, R. J., Brummel, S., Wu, J., Stern, H., Ostro, B., Lipsett, M., et al. (2009). The relationship of respiratory and cardiovascular hospital admissions to the southern California wildfires of 2003. *Occupational and Environmental Medicine, 66*(3), 189–197. doi: 10.1136/oem.2008.041376 (https://doi.org/10.1136/oem.2008.041376).
CrossRef (https://doi.org/10.1136/oem.2008.041376)
Google Scholar (http://scholar.google.com/scholar_lookup?title=The%20relationship%20of%20respiratory%20and%20cardiovascular%20hospital%20admissions%20to%20the%20southern%20California%20wildfires%20of%202003&author=RJ.%20Delfino&author=S.%20Brummel&author=J.%20Wu&author=H.%20Stern&author=B.%20Ostro&author=M.%20Lipsett&journal=Occupational%20and%20Environmental%20Medicine&volume=66&issue=3&pages=189-197&publication_year=2009&doi=10.1136%2Foem.2008.041376)

Domingo-Salvany, A., Regidor, E., Alonso, J., & Alvarez-Dardet, C. (2000). Proposal

for a social class measure. Working Group of the Spanish Society of Epidemiology and the Spanish Society of Family and Community Medicine. *Atencion primaria/Sociedad Española de Medicina de Familia y Comunitaria, 25*(5), 350–363.
CrossRef (https://doi.org/10.1016/S0212-6567(00)78518-0)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Proposal%20for%20a%20social%20class%20measure.%20Working%20Group%20of%20the%20Spanish%20Society%20of%20Epidemiology%20and%20the%20Spanish%20Society%20of%20Family%20and%20Community%20Medicine&author=A.%20Domingo-Salvany&author=E.%20Regidor&author=J.%20Alonso&author=C.%20Alvarez-Dardet&journal=Atencion%20primaria%2FSociedad%20Espa%C3%B1ola%20de%20Medicina%20de%20Familia%20y%20Comunitaria&volume=25&issue=5&pages=350-363&publication_year=2000)

Elliott, C. T., Henderson, S. B., & Wan, V. (2013). Time series analysis of fine particulate matter and asthma reliever dispensations in populations affected by forest fires. *Environmental Health: A Global Access Science Source, 12*(1), 11. doi: 10.1186/1476-069X-12-11 (https://doi.org/10.1186/1476-069X-12-11).
CrossRef (https://doi.org/10.1186/1476-069X-12-11)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Time%20series%20analysis%20of%20fine%20particulate%20matter%20and%20asthma%20reliever%20dispensations%20in%20populations%20affected%20by%20forest%20fires&author=CT.%20Elliott&author=SB.%20Henderson&author=V.%20Wan&journal=Environmental%20Health%3A%20A%20Global%20Access%20Science%20Source&volume=12&issue=1&pages=11&publication_year=2013&doi=10.1186%2F1476-069X-12-11)

Emmanuel, S. C. (2000). Impact to lung health of haze from forest fires: The Singapore experience. *Respirology (Carlton, Vic.), 5*(2), 175–182.
CrossRef (https://doi.org/10.1046/j.1440-1843.2000.00247.x)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Impact%20to%20lung%20health%20of%20haze%20from%20forest%20fires%3A%20The%20Singapore%20experience&author=SC.%20Emmanuel&journal=Respirology%20%28Carlton%2C%20Vic.%29&volume=5&issue=2&pages=175-182&publication_year=2000)

Gao, Y., Chan, E. Y. Y., Li, L. P., He, Q. Q., & Wong, T. W. (2013). Chronic effects of ambient air pollution on lung function among Chinese children. *Archives of Disease in Childhood, 98*(2), 128–135. doi: 10.1136/archdischild-2011-301541 (https://doi.org/10.1136/archdischild-2011-301541).
CrossRef (https://doi.org/10.1136/archdischild-2011-301541)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Chronic%20effects%20of%20ambient%20air%20pollution%20on%20lung%20function%20among%20Chinese%20children&author=Y.%20Gao&author=EYY.%20Chan&author=LP.%20Li&author=QQ.%20He&author=TW.%20Wong&journal=Archives%20of%20Disease%20in%20Childhood&volume=98&issue=2&pages=128-135&publication_year=2013&doi=10.1136%2Farchdischild-2011-301541)

Gauderman, W. J., Avol, E., Gilliland, F., Vora, H., Thomas, D., Berhane, K., et al.

(2004). The effect of air pollution on lung development from 10 to 18 years of age. *The New England Journal of Medicine, 351*(11), 1057–1067. doi: 10.1056/NEJMoa040610 (https://doi.org/10.1056/NEJMoa040610).
CrossRef (https://doi.org/10.1056/NEJMoa040610)
Google Scholar (http://scholar.google.com/scholar_lookup?title=The%20effect%20of%20air%20pollution%20on%20lung%20development%20from%2010%20to%2018%C2%A0years%20of%20age&author=WJ.%20Gauderman&author=E.%20Avol&author=F.%20Gilliland&author=H.%20Vora&author=D.%20Thomas&author=K.%20Berhane&journal=The%20New%20England%20Journal%20of%20Medicine&volume=351&issue=11&pages=1057-1067&publication_year=2004&doi=10.1056%2FNEJMoa040610)

Gruzieva, O., Bergström, A., Hulchiy, O., Kull, I., Lind, T., Melén, E., et al. (2013). Exposure to air pollution from traffic and childhood asthma until 12 years of age. *Epidemiology (Cambridge, Mass.), 24*(1), 54–61. doi: 10.1097/EDE.0b013e318276c1ea (https://doi.org/10.1097/EDE.0b013e318276c1ea).
CrossRef (https://doi.org/10.1097/EDE.0b013e318276c1ea)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Exposure%20to%20air%20pollution%20from%20traffic%20and%20childhood%20asthma%20until%2012%C2%A0years%20of%20age&author=O.%20Gruzieva&author=A.%20Bergstr%C3%B6m&author=O.%20Hulchiy&author=I.%20Kull&author=T.%20Lind&author=E.%20Mel%C3%A9n&journal=Epidemiology%20%28Cambridge%2C%20Mass.%29&volume=24&issue=1&pages=54-61&publication_year=2013&doi=10.1097%2FEDE.0b013e318276c1ea)

Guxens, M., Ballester, F., Espada, M., Fernández, M. F., Grimalt, J. O., Ibarluzea, J., et al. (2012). Cohort profile: The INMA–INfancia y Medio Ambiente–(Environment and Childhood) project. *International Journal of Epidemiology, 41*(4), 930–940. doi: 10.1093/ije/dyr054 (https://doi.org/10.1093/ije/dyr054).
CrossRef (https://doi.org/10.1093/ije/dyr054)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Cohort%20profile%3A%20The%20INMA%E2%80%93INfancia%20y%20Medio%20Ambiente%E2%80%93%28Environment%20and%20Childhood%29%20project&author=M.%20Guxens&author=F.%20Ballester&author=M.%20Espada&author=MF.%20Fern%C3%A1ndez&author=JO.%20Grimalt&author=J.%20Ibarluzea&journal=International%20Journal%20of%20Epidemiology&volume=41&issue=4&pages=930-940&publication_year=2012&doi=10.1093%2Fije%2Fdyr054)

Hanigan, I. C., Johnston, F. H., & Morgan, G. G. (2008). Vegetation fire smoke, indigenous status and cardio-respiratory hospital admissions in Darwin, Australia, 1996-2005: A time-series study. *Environmental Health: A Global Access Science Source, 7*, 42. doi: 10.1186/1476-069X-7-42 (https://doi.org/10.1186/1476-069X-7-42).
CrossRef (https://doi.org/10.1186/1476-069X-7-42)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Vegetation%20fire%20smoke%2C%20indigenous%20status%20and%20cardio-respiratory%20hospital%20admissions%20in%20Darwin%2C%20Australia%2C%2

01996-2005%3A%20A%20time-series%20study&author=IC.%20Hanigan&author=FH.%20Johnston&author=GG.%20Morgan&journal=Environmental%20Health%3A%20A%20Global%20Access%20Science%20Source&volume=7&pages=42&publication_year=2008&doi=10.1186%2F1476-069X-7-42)

Iskandar, A., Andersen, Z. J., Bønnelykke, K., Ellermann, T., Andersen, K. K., & Bisgaard, H. (2012). Coarse and fine particles but not ultrafine particles in urban air trigger hospital admission for asthma in children. *Thorax, 67*(3), 252–257. doi: 10.1136/thoraxjnl-2011-200324 (https://doi.org/10.1136/thoraxjnl-2011-200324).
CrossRef (https://doi.org/10.1136/thoraxjnl-2011-200324)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Coarse%20and%20fine%20particles%20but%20not%20ultrafine%20particles%20in%20urban%20air%20trigger%20hospital%20admission%20for%20asthma%20in%20children&author=A.%20Iskandar&author=ZJ.%20Andersen&author=K.%20B%C3%B8nnelykke&author=T.%20Ellermann&author=KK.%20Andersen&author=H.%20Bisgaard&journal=Thorax&volume=67&issue=3&pages=252-257&publication_year=2012&doi=10.1136%2Fthoraxjnl-2011-200324)

Jalaludin, B., Smith, M., O'Toole, B., & Leeder, S. (2000). Acute effects of bushfires on peak expiratory flow rates in children with wheeze: A time series analysis. *Australian and New Zealand Journal of Public Health, 24*(2), 174–177.
CrossRef (https://doi.org/10.1111/j.1467-842X.2000.tb00138.x)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Acute%20effects%20of%20bushfires%20on%20peak%20expiratory%20flow%20rates%20in%20children%20with%20wheeze%3A%20A%20time%20series%20analysis&author=B.%20Jalaludin&author=M.%20Smith&author=B.%20O%E2%80%99Toole&author=S.%20Leeder&journal=Australian%20and%20New%20Zealand%20Journal%20of%20Public%20Health&volume=24&issue=2&pages=174-177&publication_year=2000)

Johnston, F. H., Bailie, R. S., Pilotto, L. S., & Hanigan, I. C. (2007). Ambient biomass smoke and cardio-respiratory hospital admissions in Darwin, Australia. *BMC Public Health, 7*, 240. doi: 10.1186/1471-2458-7-240 (https://doi.org/10.1186/1471-2458-7-240).
CrossRef (https://doi.org/10.1186/1471-2458-7-240)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Ambient%20biomass%20smoke%20and%20cardio-respiratory%20hospital%20admissions%20in%20Darwin%2C%20Australia&author=FH.%20Johnston&author=RS.%20Bailie&author=LS.%20Pilotto&author=IC.%20Hanigan&journal=BMC%20Public%20Health&volume=7&pages=240&publication_year=2007&doi=10.1186%2F1471-2458-7-240)

Johnston, F. H., Henderson, S. B., Chen, Y., Randerson, J. T., Marlier, M., Defries, R. S., et al. (2012). Estimated global mortality attributable to smoke from landscape fires. *Environmental Health Perspectives, 120*(5), 695–701. doi: 10.1289/ehp.1104422 (https://doi.org/10.1289/ehp.1104422).
CrossRef (https://doi.org/10.1289/ehp.1104422)
Google Scholar (http://scholar.google.com/scholar_lookup?

title=Estimated%20global%20mortality%20attributable%20to%20smoke%20from%20landscape%20fires&author=FH.%20Johnston&author=SB.%20Henderson&author=Y.%20Chen&author=JT.%20Randerson&author=M.%20Marlier&author=RS.%20Defries&journal=Environmental%20Health%20Perspectives&volume=120&issue=5&pages=695-701&publication_year=2012&doi=10.1289%2Fehp.1104422)

Johnston, F. H., Kavanagh, A. M., Bowman, D. M. J. S., & Scott, R. K. (2002). Exposure to bushfire smoke and asthma: An ecological study. *The Medical Journal of Australia, 176*(11), 535–538.
Google Scholar (http://scholar.google.com/scholar_lookup?title=Exposure%20to%20bushfire%20smoke%20and%20asthma%3A%20An%20ecological%20study&author=FH.%20Johnston&author=AM.%20Kavanagh&author=DMJS.%20Bowman&author=RK.%20Scott&journal=The%20Medical%20Journal%20of%20Australia&volume=176&issue=11&pages=535-538&publication_year=2002)

Kuehni, C. E., Strippoli, M.-P. F., Zwahlen, M., & Silverman, M. (2006). Association between reported exposure to road traffic and respiratory symptoms in children: Evidence of bias. *International Journal of Epidemiology, 35*(3), 779–786. doi: 10.1093/ije/dyl022 (https://doi.org/10.1093/ije/dyl022).
CrossRef (https://doi.org/10.1093/ije/dyl022)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Association%20between%20reported%20exposure%20to%20road%20traffic%20and%20respiratory%20symptoms%20in%20children%3A%20Evidence%20of%20bias&author=CE.%20Kuehni&author=M-PF.%20Strippoli&author=M.%20Zwahlen&author=M.%20Silverman&journal=International%20Journal%20of%20Epidemiology&volume=35&issue=3&pages=779-786&publication_year=2006&doi=10.1093%2Fije%2Fdyl022)

Künzli, N., Avol, E., Wu, J., Gauderman, W. J., Rappaport, E., Millstein, J., et al. (2006). Health effects of the 2003 Southern California wildfires on children. *American Journal of Respiratory and Critical Care Medicine, 174*(11), 1221–1228. doi: 10.1164/rccm.200604-519OC (https://doi.org/10.1164/rccm.200604-519OC).
CrossRef (https://doi.org/10.1164/rccm.200604-519OC)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Health%20effects%20of%20the%202003%20Southern%20California%20wildfires%20on%20children&author=N.%20K%C3%BCnzli&author=E.%20Avol&author=J.%20Wu&author=WJ.%20Gauderman&author=E.%20Rappaport&author=J.%20Millstein&journal=American%20Journal%20of%20Respiratory%20and%20Critical%20Care%20Medicine&volume=174&issue=11&pages=1221-1228&publication_year=2006&doi=10.1164%2Frccm.200604-519OC)

MacNee, W., & Donaldson, K. (2003). Mechanism of lung injury caused by PM10 and ultrafine particles with special reference to COPD. *The European Respiratory Journal. Supplement, 40*, 47s–51s.
CrossRef (https://doi.org/10.1183/09031936.03.00403203)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Mechanism%20of%20lung%20injury%20caused%20by%20PM10%20and%20ultrafine%20particles%20with%20special%20reference%20to%20COPD&author=W.%20MacNee&author=K.%20Donaldson&journal=The%20European%20Respirat

ory%20Journal.%20Supplement&volume=40&pages=47s-51s&publication_year=2003)

Makino, K. (2000). Association of school absence with air pollution in areas around arterial roads. *Journal of Epidemiology/Japan Epidemiological Association, 10*(5), 292–299.
CrossRef (https://doi.org/10.2188/jea.10.292)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Association%20of%20school%20absence%20with%20air%20pollution%20in%20areas%20around%20arterial%20roads&author=K.%20Makino&journal=Journal%20of%20Epidemiology%2FJapan%20Epidemiological%20Association&volume=10&issue=5&pages=292-299&publication_year=2000)

Mirabelli, M. C., Künzli, N., Avol, E., Gilliland, F. D., Gauderman, W. J., McConnell, R., & Peters, J. M. (2009). Respiratory symptoms following wildfire smoke exposure: Airway size as a susceptibility factor. *Epidemiology (Cambridge, Mass.), 20*(3), 451–459. doi: 10.1097/EDE.0b013e31819d128d (https://doi.org/10.1097/EDE.0b013e31819d128d).
CrossRef (https://doi.org/10.1097/EDE.0b013e31819d128d)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Respiratory%20symptoms%20following%20wildfire%20smoke%20exposure%3A%20Airway%20size%20as%20a%20susceptibility%20factor&author=MC.%20Mirabelli&author=N.%20K%C3%BCnzli&author=E.%20Avol&author=FD.%20Gilliland&author=WJ.%20Gauderman&author=R.%20McConnell&author=JM.%20Peters&journal=Epidemiology%20%28Cambridge%2C%20Mass.%29&volume=20&issue=3&pages=451-459&publication_year=2009&doi=10.1097%2FEDE.0b013e31819d128d)

Miranda, A. I., Martins, V., Cascão, P., Amorim, J. H., Valente, J., Borrego, C., et al. (2012). Wildland smoke exposure values and exhaled breath indicators in firefighters. *Journal of Toxicology and Environmental Health. Part A, 75*(13–15), 831–843. doi: 10.1080/15287394.2012.690686 (https://doi.org/10.1080/15287394.2012.690686).
CrossRef (https://doi.org/10.1080/15287394.2012.690686)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Wildland%20smoke%20exposure%20values%20and%20exhaled%20breath%20indicators%20in%20firefighters&author=AI.%20Miranda&author=V.%20Martins&author=P.%20Casc%C3%A3o&author=JH.%20Amorim&author=J.%20Valente&author=C.%20Borrego&journal=Journal%20of%20Toxicology%20and%20Environmental%20Health.%20Part%20A&volume=75&issue=13%E2%80%9315&pages=831-843&publication_year=2012&doi=10.1080%2F15287394.2012.690686)

Ostro, B., Roth, L., Malig, B., & Marty, M. (2009). The effects of fine particle components on respiratory hospital admissions in children. *Environmental Health Perspectives, 117*(3), 475–480. doi: 10.1289/ehp.11848 (https://doi.org/10.1289/ehp.11848).
CrossRef (https://doi.org/10.1289/ehp.11848)
Google Scholar (http://scholar.google.com/scholar_lookup?title=The%20effects%20of%20fine%20particle%20components%20on%20respiratory%20hospital%20admissions%20in%20children&author=B.%20Ostro&author=L.

%20Roth&author=B.%20Malig&author=M.%20Marty&journal=Environmental%20Health%20Perspectives&volume=117&issue=3&pages=475-480&publication_year=2009&doi=10.1289%2Fehp.11848)

Pavagadhi, S., Betha, R., Venkatesan, S., Balasubramanian, R., & Hande, M. P. (2013). Physicochemical and toxicological characteristics of urban aerosols during a recent Indonesian biomass burning episode. *Environmental Science and Pollution Research International, 20*(4), 2569–2578. doi: 10.1007/s11356-012-1157-9 (https://doi.org/10.1007/s11356-012-1157-9).
CrossRef (https://doi.org/10.1007/s11356-012-1157-9)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Physicochemical%20and%20toxicological%20characteristics%20of%20urban%20aerosols%20during%20a%20recent%20Indonesian%20biomass%20burning%20episode&author=S.%20Pavagadhi&author=R.%20Betha&author=S.%20Venkatesan&author=R.%20Balasubramanian&author=MP.%20Hande&journal=Environmental%20Science%20and%20Pollution%20Research%20International&volume=20&issue=4&pages=2569-2578&publication_year=2013&doi=10.1007%2Fs11356-012-1157-9)

Peters, A., Dockery, D. W., Heinrich, J., & Wichmann, H. E. (1997). Short-term effects of particulate air pollution on respiratory morbidity in asthmatic children. *The European Respiratory Journal, 10*(4), 872–879.
Google Scholar (http://scholar.google.com/scholar_lookup?title=Short-term%20effects%20of%20particulate%20air%20pollution%20on%20respiratory%20morbidity%20in%20asthmatic%20children&author=A.%20Peters&author=DW.%20Dockery&author=J.%20Heinrich&author=HE.%20Wichmann&journal=The%20European%20Respiratory%20Journal&volume=10&issue=4&pages=872-879&publication_year=1997)

Pope, C. A, 3rd, & Dockery, D. W. (2006). Health effects of fine particulate air pollution: Lines that connect. *Journal of the Air & Waste Management Association (1995), 56*(6), 709–742.
CrossRef (https://doi.org/10.1080/10473289.2006.10464485)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Health%20effects%20of%20fine%20particulate%20air%20pollution%3A%20Lines%20that%20connect&author=CA.%20Pope&author=DW.%20Dockery&journal=Journal%20of%20the%20Air%20%26%20Waste%20Management%20Association%20%281995%29&volume=56&issue=6&pages=709-742&publication_year=2006)

Ribeiro, M., de Paula Santos, U., Bussacos, M. A., & Terra-Filho, M. (2009). Prevalence and risk of asthma symptoms among firefighters in São Paulo, Brazil: A population-based study. *American Journal of Industrial Medicine, 52*(3), 261–269. doi: 10.1002/ajim.20669 (https://doi.org/10.1002/ajim.20669).
CrossRef (https://doi.org/10.1002/ajim.20669)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Prevalence%20and%20risk%20of%20asthma%20symptoms%20among%20firefighters%20in%20S%C3%A3o%20Paulo%2C%20Brazil%3A%20A%20population-based%20study&author=M.%20Ribeiro&author=U.%20Paula%20Santos&author=MA.%20Bussacos&author=M.%20Terra-

Filho&journal=American%20Journal%20of%20Industrial%20Medicine&volume=52&issue=3&pages=261-269&publication_year=2009&doi=10.1002%2Fajim.20669)

Vora, C., Renvall, M. J., Chao, P., Ferguson, P., & Ramsdell, J. W. (2011). 2007 San Diego wildfires and asthmatics. *The Journal of Asthma, 48*(1), 75–78. doi: 10.3109/02770903.2010.535885 (https://doi.org/10.3109/02770903.2010.535885).
CrossRef (https://doi.org/10.3109/02770903.2010.535885)
Google Scholar (http://scholar.google.com/scholar_lookup?title=2007%20San%20Diego%20wildfires%20and%20asthmatics&author=C.%20Vora&author=MJ.%20Renvall&author=P.%20Chao&author=P.%20Ferguson&author=JW.%20Ramsdell&journal=The%20Journal%20of%20Asthma&volume=48&issue=1&pages=75-78&publication_year=2011&doi=10.3109%2F02770903.2010.535885)

Woodruff, T. J., Parker, J. D., & Schoendorf, K. C. (2006). Fine particulate matter (PM2.5) air pollution and selected causes of postneonatal infant mortality in California. *Environmental Health Perspectives, 114*(5), 786–790.
CrossRef (https://doi.org/10.1289/ehp.8484)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Fine%20particulate%20matter%20%28PM2.5%29%20air%20pollution%20and%20selected%20causes%20of%20postneonatal%20infant%20mortality%20in%20California&author=TJ.%20Woodruff&author=JD.%20Parker&author=KC.%20Schoendorf&journal=Environmental%20Health%20Perspectives&volume=114&issue=5&pages=786-790&publication_year=2006)

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