# Identified Conflicts of Interest, Faulty Test Methods and Further Recommendations for EPA's "Tire Crumb and Synthetic Turf Field Literature and Report List as of Nov. 2015"

Please see table below referencing EPA's "Tire Crumb and Synthetic Turf Field Literature and Report List as of Nov. 2015" posted at https://www.epa.gov/chemical-research/tire-crumb-and-synthetic-turf-field-literature-and-report-list-nov-2015. Conflicts of interest are identified in the studies conducted on shredded waste tire crumb infill and tire playground surfaces. Because conflicts of interest affect a study's conclusions, determining them is important. EPA should be aware of studies funded or conducted by industry, if the group/company makes a profit from the product, or if the mission of the group interferes with safety, such as promoting use of recycled tires. This explains why time has been taken to study this issue. Provided comments are not a review of whether the studies have data gaps or are well done, although a few notes have been given in this regard.

Since the mid-1990s, **numerous studies have shown that industry-funded research tends to favor its sponsors' products.** This effect has been documented in research financed by chemical, pharmaceutical, surgical, food, tobacco, and, we have learned most recently, sugar companies. **For decades, industry-funded research helped tobacco companies block regulations by undermining evidence that cigarettes kill.** Precisely because of the **very real risk of bias,** prestigious scientific journals have long required researchers to disclose their sources of support.

Comments presented here include:

- Identification of conflicts of interest – EPA's "Tire Crumb and Synthetic Turf Field Literature and Report List as of Nov. 2015" (pp. 1-30)
- Recommendations for studies to be added with little or no conflicts of interest (pp. 31-59)
- Other data for consideration with little or no conflicts of interest (pp. 60-72)

**Identification of Conflicts of Interest – EPA's "Tire Crumb and Synthetic Turf Field Literature and Report List as of Nov. 2015"**

| | Study | Author(s) | Group(s) | Conflict of Interest? | Reason for Conflict of Interest | Notes |
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| **1.** | Leaching of DOC, DN and Inorganic Constituents from Scrap Tires | Selbes M., Yilmaz O., Khan A.A., Karanfil T. (2015). Chemosphere. 139:617-23.<br>(Selbes M[1], Yilmaz O[1], Khan AA[2], Karanfil T[3].) | [1]Department of Environmental Engineering and Earth Sciences, Clemson Univ.<br>[2]Department of Civil Engineering, Clemson Univ.<br>[3]Department of Environmental Engineering and Earth Sciences, Clemson Univ.<br>tkaranf@clemson.edu | N | N/A | |

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| **2.** | Environmental and Health Impacts of Artificial Turf: A Review | Cheng H.[1], Hu Y., Reinhard M. (2014). Environ Sci Technol. 48(4):2114-29. | [1]State Key Laboratory of Organic Geochemistry Guangzhou Institute of Geochemistry, Chinese Academy of Sciences Guangzhou 510640, China. | N | N/A | Not a study; a literature review only. |
| **3.** | Environmental Sanitary Risk Analysis Procedure Applied to Artificial Turf Sports Fields | Ruffino et al. (2013). Environ Sci Pollut Res Int. (Ruffino B[1], Fiore S, Zanetti MC.) | [1]DIATI-Department of Environment, Land and Infrastructure Engineering, Politecnico di Torino, Corso Duca degli Abruzzi, 24 10129 Torino, Italy. barbara.ruffino@polito.it | Y | Promotes recycling used tires (see notes). | "Management of the huge quantity of end-of-life tires (ELTs) collected every year leads to several options among which the preferable ones seem to be recycling and reuse, that allow the high quality of component materials to be fully exploited…" http://www.ucprc.ucdavis.edu/P-LCA2014/media/pdf/Papers/LCA14_Crumb%20Rubber%20Pavements.pdf "Management of end-of-life tyres (ELTs) has become a critical problem worldwide… Since landfill disposal has been banned in most Countries, alternative final destinations have been sought, with a major effort being placed in trying to exploit in the most efficient manner the high energy potential of ELTs. Nevertheless, due to the fact that rubber employed in tyre fabrication is the result of specialized materials' selection, recycling and reuse seem to be preferable options for such a high-quality waste material (Santagata and Zanetti, 2012)." http://opensample.info/order/ad6145a12f3aa43693b0e51dee50a107761f3af0 |

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| **4.** | New Approach to the Ecotoxicological Risk Assessment of Artificial Outdoor Sporting Grounds | Krüger O.[1], Kalbe U., Richter E., Egeler P., Römbke J., Berger W. (2013). Environ Pollut. 175:69-74. | [1]BAM Federal Institute for Materials Research and Testing, Division 4.4 Thermochemical Residues Treatment and Resource Recovery, Unter den Eichen 87, 12205 Berlin, Germany. oliver.krueger@bam.de | N | N/A | |
| **5.** | Artificial Turf Football Fields: Environmental and Mutagenicity Assessment | Schilirò T.[1], Traversi D., Degan R., Pignata C., Alessandria L., Scozia D., Bono R., Gilli G. (2013). Arch Environ Contam Toxicol. 64(1):1-11. | [1]Department of Public Health and Microbiology, University of Torino, Via Santena, 5bis, 10126, Torino, Italy. tiziana.schiliro@unito.it | N | N/A | This study was financed by the Department of Sport and Recreation of the city of Torino, Italy. |
| **6.** | Bioaccessibility and Risk Exposure to Metals and SVOCs in Artificial Turf Field Fill Materials and Fibers | Pavilonis B.T.[1], Weisel C.P., Buckley B., Lioy P.J. (2013). Risk Anal. | Environmental and Occupational Health Sciences Institute, Robert Wood Johnson Medical School. | Y | Promotes recycling used tires (see note). | The study was supported by contract #SHW10-004 from the NJ Department of Environmental Protection, Recycling Program and Planning.<br>This study found lead and other toxins in both the plastic rug and tire crumb infill. Lead was also was found in simulated body fluids meaning there is little or no protection of any kind against the lead getting out of the material into the body.<br>"Since it is possible that children may be exposed to potentially high concentrations of lead while using artificial turf fields we recommend, at a minimum, all infill and fibers should be certified for low or no lead content prior to purchase and installation." |

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| | | | | | | The main outcomes of concern:<br>• The finding of lead and chromium in both the tire crumb and the plastic rug and body fluids at sometimes extremely high levels EVEN IN NEW FIELD CARPETS.<br>• Benzothiazole derivatives and 4-(tert-octyl) phenol were also found. Both are probable carcinogens.<br>"Lead was detected in almost all field samples for digestive, sweat, and total extraction fluids with digestive fluid extract of one field sample as high as 260 mg/kg. Metal concentrations were not markedly different across the three different sample types (new infill, new turf fiber, tire crumb field sample). However, one of the new turf fiber samples contained relatively large concentrations of chromium (820 mg/kg) and lead (4,400 mg/kg) compared to the other samples tested…the variability of lead contained in the infill material is large and can span more than two orders of magnitude. One field [tire crumb] sample did contain a high lead level (260 mg/kg) which was on the same order of magnitude as the NJ DEP cleanup value (400 mg/kg)."<br>Lead-free is the only acceptable level for child products (and indeed for people in general.). There is NO safe level of lead for children. And yet many of our children are playing often, if not daily, on fields that may contain lead and certainly do contain many other toxic substances. Finding ANY lead in any play area for children of any age is unacceptable. Every effort should be made to eliminate ALL unnecessary sources of lead in the environment, especially a child's environment. Lead in artificial turf is not only totally unnecessary but dangerous to health. |

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| | | | | | | The levels of bioaccessibility would have been greatly underestimated; this study did not use biologically relevant tire crumb particle sizes or incubation times when determining the bioaccessibility of SVOCs and metals in simulated lung fluids. Tire crumbs do not float in the air. Athletes are inhaling particulate matter often only a few microns in diameter. Further, the particulate matter may stay lodged in the lungs for months, not 24 hours. Surface area is a key factor in determining bioavailability. The toxicants in dust are far more bioavailable than those in crumbs, which in turn are more bioavailable than those in whole tires. |
| **7.** | Review of the Human Health & Ecological Safety of Exposure to Recycled Tire Rubber Found at Playgrounds and Synthetic Turf Fields | Cardno Chem Risk. (2013). | Prepared for: Rubber Manufacturers Association, Washington, DC. | Y | Prepared for Rubber Manufacturers Association | |
| **8.** | Health Risk Assessment of Lead Ingestion Exposure by Particle Sizes in Crumb Rubber on Artificial Turf Considering Bioavailability | Kim S.[1], Yan J.Y., Kim H.H., Yeo I.Y., Shin D.C., Lim Y.W. (2012). Environ Health Toxicol. 27:e2012005. | [1]Institute for Environmental Research, Yonsei University, Seoul, Korea. | N | N/A | The authors have no conflict of interest to declare on this study. |

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| **9.** | Zinc Leaching from Tire Crumb Rubber | Rhodes E.P.[1], Ren Z., Mays D.C. (2012). Environ Sci Technol. 46(23):12856-63. | [1]Department of Civil Engineering, University of Colorado Denver, Campus Box 113, PO Box 173364, Denver, Colorado. | N | N/A | |
| **10.** | Comparison of Batch and Column Tests for the Elution of Artificial Turf System Components | Krüger O.[1], Kalbe U., Berger W., Nordhauβ K., Christoph G., Walzel H.P. (2012). Environ Sci Technol. 46(24):13085-92 | [1]BAM Federal Institute for Materials Research and Testing , Unter den Eichen 87, 12205 Berlin, Germany. oliver.krueger@bam.de | N | N/A | Faulty testing method: sand is routinely used to filter pollutants out of stormwater. Krueger's method included filter sand at the top and bottom of the column to "disperse the flow." The filter sand may also have reduced the levels of leachates that were measured. Addition of extraneous filtering media into a system does not yield a realistic model. |
| **11.** | Design of a New Test Chamber for Evaluation of the Toxicity of Rubber Infill | Gomes JF [1], Mota HI, Bordado JC, Baião M, Sarmento GM, Fernandes J, Pampulim VM, Custódio ML, Veloso I. (2011). Toxicol Mech Methods. 21(8):622-7 | [1]IBB/Centre for Chemical and Biological Engineering, Instituto Superior Técnico-UTL , Lisboa , Portugal. jgomes@deq.isel.ipl.pt | N | N/A | |
| **12.** | An Evaluation of Potential Exposure to Lead and Other Metals as the Result of Aerosolized Particulate Matter from Artificial Turf Playing Fields | Shalat, S.L. (2011). | Division of Environmental Health. Submitted to the New Jersey Department of Environmental Protection. | N | N/A | This study examined the levels of PM 100 and respirable lead dust measured by a stationary air monitor, a mobile air monitor on a robot remotely controlled by a computer, and by a personal breathing space air monitor on a child running soccer drills. Total inhalable particles and inhalable lead levels were lowest when measured by the stationary air monitor.<br>The study found lead in the field dust in the respirable air space of a robot and real player; highly variable but |

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| | | | | | | sometimes very high (note most facilities would NOT allow testing). The concerns about lead exposure have taken on a new urgency following the release in June 2012 of a study completed for the New Jersey DEP which found artificial fields made of tire crumb can contain highly elevated levels of lead much greater than the allowed levels for children:<br>• It reports concerns with regard to potential hazards that may exist for individuals, and in particular, children, who engage in sports activities on artificial fields<br>• Inhalable lead present in artificial turf fields can be resuspended by even minimal activity on the playing surface. |
| **13.** | Artificial-Turf Playing Fields: Contents of Metals, PAHs, PCBs, PCDDs and PCDFs, Inhalation Exposure to PAHs and Related Preliminary Risk Assessment | Menichini et al. (2011). Sci Total Environ. 409(23):4950-7.<br>(Edoardo Menichini[a], Vittorio Abate[a], Leonello Attias[b], Silvia De Luca[a], Alessandro di Domenico[a],<br>Igor Fochi [a], Giovanni Forte[a], Nicola Iacovella[a], Anna Laura Iamiceli[a], Paolo Izzo[b], Franco Merli[a], Beatrice Bocca[a]) | [a]Department of Environment and Primary Prevention, Istituto Superiore di Sanità, Viale Regina Elena 299, 00161 Rome, Italy.<br>[b]National Centre for Chemical Substances, Istituto Superiore di Sanità, Viale Regina Elena 299, 00161 Rome, Italy. | N | N/A | |

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| **14.** | Human Health Risk Assessment of Synthetic Turf Fields Based Upon Investigation of Five Fields in Connecticut | Ginsberg[1] et al. (2011). J Toxicol Environ Health A. 74(17):1150-74. | [1]Connecticut Dept of Public Health, Hartford, Connecticut. gary.ginsberg@ct.gov | N | N/A | Faulty testing method, faulty risk assessment method. The authors excluded benzene from the risk assessment based on results from personal air monitor samples taken from a grass field approximately 15 months after the original sampling was taken. It is not plausible to suggest that air samples taken more than a year later, in a different season, can serve as an adequate background control. The authors failed to mention the second round of sampling in this report although it was discussed in a separate report generated by this research project. The addition of implausible post hoc control data and the lack of transparency in this article violate good scientific practices.<br><br>**Thirteen compounds** were included in the cancer risk assessment. Cancer unit risks were obtained from standard toxicology databases for four of those, **two of those included human epidemiologic data**. Unit risk estimates for the other nine carcinogens were estimated, assumed or obtained from nonstandard sources.<br><br>Of the dozens of chemicals known to be contained in tire crumb, twenty-seven chemicals of potential concern were identified by the CT DPH for the risk assessment portion of the "Connecticut Study." (A total of five documents comprise the Connecticut Study.) Thirteen chemicals were identified as carcinogens and included in the cancer risk assessment. The study authors were only able to identify unit risk estimates from standard governmental databases for four of the thirteen carcinogens in the cancer risk assessment. Unit risk estimates for the other nine carcinogens were assumed or obtained from nonstandard sources. This study demonstrates both the lack of necessary toxicity information to do a quantitative risk assessment and the inappropriate risk assessment methodology. |

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| | | | | | | The Connecticut study used a component-based risk assessment method in which the risks posed by the individual chemicals were simply summed, ignoring any possible interaction effects. However, the Connecticut risk assessment relied on an inappropriate methodology and both approaches relied on extremely incomplete toxicity databases. There are too many possible synergistic or antagonistic interactions between combinations of chemicals to predict the overall toxicity of the mixture with any confidence.<br>Other issues with study methods:<br>**1.** The study inappropriately used component-based risk assessment methods.<br>**2.** The study did not include a legitimate estimate of the risk from respirable rubber dust and carbon black. The 2010 study done by the University of Connecticut Health Center (UCHC) had used stationary air monitors to measure PM 10 levels on the turf fields near simulated games using 3-4 players and up wind of turf fields (Simcox, Bracker, & John, 2010). However, as noted earlier, the Norwegian study found increased levels of PM 2.5, not PM 10. PM 2.5 is also considered to be more of a health threat than PM 10.<br>Although personal air monitors were used in other parts of the study, they were not used to measure PM 10, PM 2.5 or carbon black. As indicated by the Shalat study, this may have led to a significant underestimation of the levels of respirable particles that players were exposed to. No good explanation exists for this oversight. |

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| | | | | | | Since the UCHC study found no significant difference between the upwind and the on-field levels of PM 10, the DPH study authors concluded that particulate matter posed zero risk for the purposes of their health risk assessment.<br>**3.** The study assumed that the levels of VOCs and SVOCs measured on sunny days when the temperatures were generally in the low 80's would be a suitable average of levels of these chemicals for the four warmest months of the year, and that no VOCs or SVOCs would be emitted the other four months of the year when the fields were used. However, the rate at which VOCs and SVOCs off gas increases exponentially as temperatures increase. Exposures at a 100° F day and a 60° F do not equal the exposure from two 80 °F days. Further, it cannot be argued that these exposure levels could be applied to areas with higher temperatures, such as Texas, Southern California, or even Eastern Washington. Eastern Washington had far too many days last summer with the temperature in the 90's for these exposure levels to be relevant.<br>**4.** No model of inhalation by soccer goalies and younger people who spend much time on or close to the surface has been conducted.<br>**5.** Three carcinogens that were identified as Contaminants of Possible Concern were excluded from the cancer health risk assessment without explanation.<br>**a. Ethylbenzene:** It is unclear why this carcinogen was not included in the risk assessment. Ethylbenzene would have made a significant contribution to the overall risk. |

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| | | | | | | Ethylbenzene has been considered a carcinogen by California's OEHHA since 2004. A cancer unit risk value was established by OEHHA in 2007.<br>**b. Methyl isobutyl ketone:** The risk assessment also did not include methyl isobutyl ketone. Methyl isobutyl ketone was declared to be a carcinogen by OEHHA in 2011, but no unit risk was established. Given the lengths the authors went to in order to obtain unit risk estimates for chemicals that are still not considered to be carcinogens, it is odd that this chemical was excluded from the risk analysis with no discussion or indication as to why.<br>**c. Styrene:** In the study, the authors state that the data on styrene is limited and conflicting but that styrene has positive mutagenicity data and that its main metabolite, styrene oxide, is a known carcinogen. Because they considered styrene a potential carcinogen, they added an additional uncertainty factor to styrene's RFC when calculating its hazard index in a separate part of the study. Nonetheless, styrene was omitted from the cancer health risk assessment.<br>California's OEHHA declared styrene to be a carcinogen in 2010.An updated cancer risk assessment was published by the Connecticut Department of Public Health in 2011, after additional measurements were taken in October of 2010. This risk assessment also did not include styrene (Simcox N. J., et al., 2011). |

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| | | | | | | OEHHA currently estimates the unit risk for styrene oxide to be 4.6 x$10^{-5}$. Had styrene been included in the risk estimate with this as a conservative estimate of its unit risk, styrene would have been the largest contributor of risk.<br>**6.** The limitations of the toxicity data were not fully discussed, thus giving readers an overly optimistic view of the accuracy and precision of the estimates. Although the authors noted how they obtained their cancer unit risk, reference concentration, and acute target level for each chemical in a table, the body of the report does not indicate that most of the table is filled in based on assumptions of toxic equivalency or estimated relative potencies. There was no discussion of the limitations of drawing conclusions about human health effects based on animal studies.<br>A discussion of the chemicals involved in Connecticut's study, and the nature of the toxicology data for each chemical is provided below. The Connecticut study drew data from the Environmental Protection Agency's (EPA) Integrated Risk Information System (IRIS) database, California's Office of Environment Health Hazard Assessment (OEHHA) Toxicity Criteria Database, as well as other standard government sources. The information below contains information from the above referenced sources as well as the International Agency for Research on Cancer (IARC), and the National Toxicology Program (NTP).<br>The first four chemicals have sufficient data to have established cancer unit risks in one or more standard toxicology databases.<br>**Benzene** – Adequate animal studies and human epidemiological data are available. The OEHHA cancer unit risk estimate was at least 3.7 times greater than the EPA IRIS |

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| | | | | | | unit risk estimate. The authors of the Connecticut study decided that neither either estimate was demonstrably more accurate, so the study authors averaged the two unit risk estimates to create a new unit risk estimate for use in their study (Ginsburg & Toal, 2010).<br><br>**Methylene Chloride** – Adequate animal studies and human epidemiological data are available. The study used the EPA IRIS cancer unit risk.<br><br>**Naphthalene** – The unit risk was from OEHHA's database and was based on studies conducted in rodents. There are a couple of cancer case series in humans, but the EPA and IARC consider these to be insufficient evidence of carcinogenicity in humans.<br><br>**Benzo(a)pyrene** – The unit risk was from OEHHA's database and was derived from a few studies on hamsters. While OEHHA staff felt that the studies on benzo(a)pyrene were not ideal for calculating a cancer unit risk, the toxicology data on other PAHs were even less complete (Office of Environment Health Hazard Assessment, 2011).<br><br>**Benz(a)anthracene Benzo(b)fluoranthene Benzo(k)fluoranthene Chrysene**<br><br>The next four chemicals, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, and chrysene are all polycyclic aromatic hydrocarbons (PAHs).<br><br>The U.S. EPA determined that these are probable carcinogens but lacked information sufficient to allow for direct estimation of cancer unit risks. However, the EPA did publish, "EPA Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons." In this document, the relative potencies of seven PAHs were estimated based on the effects of dermal exposures to the |

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| | | | | | | PAHs in mice. These potencies were rounded to a single order of magnitude. The authors of the Connecticut study assumed that the relative potencies of the PAHs derived from dermal exposures in mice were equivalent to the relative potencies for inhalation exposures in humans, thus allowing for the derivation of unit risks for these chemicals.<br><br>There is uncertainty from using mice to model human toxicity. Uncertainty from using dermal studies to model inhalation risk. Uncertainty from computing relative potencies to estimate unit risks rather than computing unit risks directly from sufficient data. Rounding error. Uncertainty from using hamsters to model human toxicity. Uncertainty from exposing hamsters to inhalation of benzo(a)pyrene in a particle bound form or dissolved in a medium to estimate response to exposure to the gas. Uncertainty was multiplied by uncertainty which was multiplied by rounding error, and the result was represented as a scientifically supported risk calculation accurate to two significant digits.<br><br>**Chloromethane:** The study authors stated that the cancer unit risk for chloromethane (methyl chloride) was obtained from documentation for California's Proposition 65. However, no citation was given and the source was unable to be identified. Chloromethane is not considered by California or the EPA to a carcinogen. There is some evidence from a mouse study that chloromethane may cause renal tumors, but the relevance of this study to humans is questionable due to differences in rodent and human physiology.<br><br>**1-Methylnaphthalene 2-Methylnaphthalene 2,6 Dimethylnaphthalene**<br><br>Three chemicals, 1-methylnaphthalene, 2-methylnaphthalene, and 2,6 dimethylnaphthalene are not |

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| | | | | | | classified by the EPA or California as carcinogens. , 1-Methylnaphthalene and 2,6 dimethylnaphthalene do not even appear in the EPA's IRIS or OEHHA's toxicity criteria database. 2-Methylnaphthalene is listed in IRIS as unclassifiable as to carcinogenicity due to insufficient data. The limited animal studies thus far on the methylnaphthalenes have not yielded clear evidence of oncogenetic effects for these chemicals (Lin, Wheelock, Morin, Baldwin, & al, 2009).<br><br>**Benzothiazole**: The risk estimate for benzothiazole must be considered speculative, at best. It is also not considered to be a carcinogen in the EPA IRIS or the OEHHA database. There was not enough information on benzothiazole to estimate a unit risk directly from studies on the chemical itself. Rather, a related chemical 2-MBT (2-mercaptobenzothiazole) was used. In a study for the National Toxicology Program, rats and mice were orally exposed to 2-MBT dissolved in corn oil and the animals displayed elevated rates of cancers at various sites. A researcher attempting to assess the risk of 2-MBT in water calculated cancer unit risks based on the study's data. The author's calculations underestimated the total cancer risk because the calculations only considered the risk for renal cancer, even though the rodents developed multiple types of cancer. The authors of the Connecticut study converted the unit risk for an oral dose of 2-MBT to a unit risk for inhalation. Thus, the study authors used an underestimate the unit risk of orally administered 2-MBT in rodents as an estimate of the unit risk for inhaled benzothiazole in humans. |

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| **15.** | Synthetic Turf Field Investigation in Connecticut | Simcox et al. (2011). J Toxicol Environ Health A. 74(17):1133-49. | [1]University of Connecticut Health Center, Farmington, Connecticut. simcox@uchc.edu | Y | Promotes recycling used tires (see note). | Funding for this project was provided by the Connecticut Department of Environmental Protection.<br>The addition of post hoc 'control' data from personal air monitor samples violates generally accepted rules of scientific methodology. Control and test groups should have been declared and created at the beginning of the study. Further, background air pollution levels vary from day to day and from season to season. Thus it is implausible to suggest that an air sample gathered over a year later, during a different season, could serve as a control. |
| **16.** | Benzothiazole Toxicity Assessment in Support of Synthetic Turf Field Human Health Risk Assessment | Ginsberg et al. (2011). J Toxicol Environ Health A. 74(17):1175-83.<br>(Gary Ginsberg[a*], Brian Toal[a] & Tara Kurland[b]) | [a]Connecticut Dept of Public Health , Hartford, Connecticut.<br>[b]Clark University , Worcester, Massachusetts. | N | N/A | Not a study; it is a literature review only.<br>The Connecticut study used a component-based risk assessment method in which the risks posed by the individual chemicals were simply summed, ignoring any possible interaction effects. However, the Connecticut risk assessment relied on an inappropriate methodology and both approaches relied on extremely incomplete toxicity databases. There are too many possible synergistic or antagonistic interactions between combinations of chemicals to predict the overall toxicity of the mixture with any confidence.<br>This article gives the justification for the toxicity estimates for benzothiazole (BZT) used in the synthetic turf risk assessments performed by the Connecticut Department of Public Health (DPH). BZT was slightly more acutely toxic than 2-mercaptobenzothiazol (2-MBZT) in tests on laboratory animals, and showed genetic toxicity in one strain of salmonella while 2-MBZT did not show genetic toxicity in any strains. Given the chemical structure of BZT, and the positive |

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| | | | | | | genetic toxicity test result, the authors chose to estimate the cancer risk from BZT based on the chemical 2-MBZT. While 2-MBZT did appear to be slightly less toxic than BZT in several tests, the authors' approach seems reasonable, and is far preferable to leaving the risk from BZT out of the health risk assessment entirely. |
| **17.** | Hydroxypyrene in Urine of Football Players After Playing on Artificial Sports Fields with Tire Crumb Infill | Van Rooij[1] and Jongeneelen. (2010). Int Arch Occup Environ Health. 83(1):105-10. | [1]IndusTox Consult, PO Box 31070, 6503 CB, Nijmegen, The Netherlands. joost.vanrooij@industox.nl | Y | Promotes recycling used tires (see note). | This study is funded by the following organizations in the Netherlands: KNVB, NOC*NSF, WG Materialen, VACO, DSM, RecyBem and Ten Cate.<br>**"Old tires, great agreements**<br>RecyBEM B.V. and the Association Tire and Environment come together in the execution of the Decision Management Car Tires.<br>As a member of the Association Tire and Environment, Yde van der Veen has been made responsible for processing used car tires in an environmentally-friendly way by virtue of the decree. The RecyBEM B.V. was founded as an execution organization for the Decision Management Car Tires to ensure that all used car tires on the Dutch market are collected structurally and are reprocessed in an environmentally-friendly way.<br>RecyBEM B.V. exercises supervision on the collection companies contracted by RecyBEM B.V. You can also recognize BEM-certified collection companies, such as Yde van der Veen by the use of the uniform tire recycling receipt of RecyBEM B.V. and the Association Tire and Environment."<br>http://www.ydevanderveen.nl/en/recybem-en<br>Exposure was only measured for one day, at 2.5 hrs. All players were age 20 or older; no children were included in study. |

| Identification of Conflicts of Interest – EPA's "Tire Crumb and Synthetic Turf Field Literature and Report List as of Nov. 2015" | | | | | | |
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| | Study | Author(s) | Group(s) | Conflict of Interest? | Reason for Conflict of Interest | Notes |
| 18. | Risk Assessment of Artificial Turf Fields | Connecticut Department of Energy & Environmental Protection. (2010). Connecticut Departments of Public Health and Environmental Protection and the Connecticut Agricultural Research Station. | Connecticut Department of Energy & Environmental Protection. (2010). Connecticut Departments of Public Health and Environmental Protection and the Connecticut Agricultural Research Station. | Y | This study relies on data collected by Synthetic Turf Field Investigation in Connecticut by Simcox et al. (2011). J Toxicol Environ Health A. 74(17):1133-49, which also has a conflict of interest. | Failure to disclose the use of a post hoc control group. The Connecticut study used a component-based risk assessment method in which the risks posed by the individual chemicals were simply summed, ignoring any possible interaction effects. However, the Connecticut risk assessment relied on an inappropriate methodology and both approaches relied on extremely incomplete toxicity databases. There are too many possible synergistic or antagonistic interactions between combinations of chemicals to predict the overall toxicity of the mixture with any confidence.<br>---<br>"Their "headline" conclusion, however, reflects none of that concern: 'Results indicate cancer risks slightly above de minimis levels for all scenarios evaluated …' The conclusion fails to indicate that such risks are highly improbable, reflecting a series of systematic overestimates of exposure and risk, and including a contaminant that is almost certainly not actually off-gassing from the tire crumb. The CASE Peer Review Committee strongly urges DPH to revise its risk assessment and then present its findings with appropriate cautions. At the least, the various assumptions underlying the risk assessment should be compiled and presented in a manner so that they can be understood by non-scientists (e.g., parents and journalists) reading the report." http://www.ct.gov/deep/lib/deep/artificialturf/case_artificial_turf_review_report.pdf |

| Identification of Conflicts of Interest – EPA's "Tire Crumb and Synthetic Turf Field Literature and Report List as of Nov. 2015" | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **19.** | Toxicological Assessment of Coated Versus Uncoated Rubber Granulates Obtained from Used Tires for Use in Sport Facilities | Gomes et al. (2010). J Air Waste Manag Assoc. 60(6):741-6. (Gomes J[1], Mota H, Bordado J, Cadete M, Sarmento G, Ribeiro A, Baiao M, Fernandes J, Pampulim V, Custódio M, Veloso I.) | [1]IBB/Center for Chemical and Biological Engineering, Instituto Superior Técnico, and Chemical Engineering Department, Instituto Superior de Engenharia de Lisboa, Lisboa, Portugal. jgomes@deq.isel.ipl.pt | N | N/A | |
| **20.** | Characterization of Substances Released from Crumb Rubber Material Used on Artificial Turf Fields | Li et al. (2010). Chemosphere. 80(3):279-85. (Li X[1], Berger W, Musante C, Mattina MI.) | The Connecticut Agricultural Experiment Station. | N | N/A | |
| **21.** | Evaluating and Regulating Lead in Synthetic Turf | Gregory Van Ulirsch[1], Kevin Gleason[2], Shawn Gerstenberger[3], Daphne B. Moffett[1], Glenn Pulliam[4], Tariq Ahmed[4], Jerald Fagliano[4] (2010). Environ Health Perspect. 118(10): 1345–1349. | [1]Agency for Toxic Substances and Disease Registry, Atlanta, Georgia. [2]New York State Department of Health, Troy, New York. [3]Department of Environmental and Occupational Health, University of Nevada Las Vegas, Las Vegas, Nevada. [4]New Jersey Department of Health and Senior Services, Trenton, New Jersey. | N | N/A | Not a study; literature review only. |

| Identification of Conflicts of Interest – EPA's "Tire Crumb and Synthetic Turf Field Literature and Report List as of Nov. 2015" | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **22.** | Safety Study of Artificial Turf Containing Crumb Rubber Infill Made from Recycled Tires: Measurements of Chemicals and Particulates in the Air, Bacteria in the Turf, and Skin Abrasions Caused by Contact with the Surface | California Office of Environmental Health Hazard Assessment. (2010). Prepared for the California Department of Resources Recycling and Recovery. | California Office of Environmental Health Hazard Assessment. (2010). Prepared for the California Department of Resources Recycling and Recovery. | Y | Prepared for the California Department of Resources Recycling and Recovery. CalRecycle, as part of OEHHA, promotes recycling used tires. | This study examined the temperature at four artificial turf fields. It measured the VOCs in the air above the air at the four fields. Air for the VOC samples was collected from stationary monitors placed beneath galvanized steel garbage cans for 45 minutes. PM 2.5 samples were also collected from three fields, however, the results from two fields were below the limit of detection. The results from the third field were inconsistent. The study also looked at MRSA risk. While artificial turf has not been shown to harbor or transmit the MRSA virus, its abrasiveness significantly increases the risk of epidermal injuries that could result in a MRSA infection. |
| **23.** | An Assessment of Chemical Leaching, Releases to Air and Temperature at Crumb-Rubber Infilled Synthetic Turf Fields | Lim L., Walker R. (2009). | New York State Department of Environmental Conservation, New York State Department of Health. | Y | Promotes recycling used tires (New York State Department of Environmental Conservation). | This report only involved two artificial turf fields, both of which were located in downtown New York City, making it very difficult to separate out signal from noise when attempting to measure possible off-gassing from the fields. PM 10 and PM 2.5 were measured, but the measurements at Thomas Jefferson Field were deemed unreliable due to the implausible relationship between the PM 2.5 and PM 10 readings. The temperature readings on the fields clearly demonstrated that once the ambient temperature reached the 80's, the fields could become hot enough to significantly increase the risk of heat-related illness. |

| Identification of Conflicts of Interest – EPA's "Tire Crumb and Synthetic Turf Field Literature and Report List as of Nov. 2015" | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **24.** | A Scoping-Level Field Monitoring Study of Synthetic Turf Fields and Playgrounds | Highsmith R., Thomas K.W., Williams R.W. (2009). EPA/600/R-09/135. | National Exposure Research Laboratory, U.S. Environmental Protection Agency. | N | N/A | "This report was prepared for the U.S. Environmental Protection Agency (EPA) Tire Crumb Committee, a cross-Agency workgroup."<br>This study examined airborne PM 10 and VOCs at four outdoor fields and one outdoor playground. Additionally the extractable heavy metals from surface wipes, the tire crumb and the turf blades from each location were also measured. Bioaccessibility of the lead in the tire crumb was estimated using the protocols for assessing the bioaccessibility of lead in soil. |
| **25.** | Air Quality Survey of Synthetic Turf Fields Containing Crumb Rubber Infill | Vetrano, K.M., Ritter G. (2009). | Prepared by TRC for the New York City Department of Mental Health and Hygiene, New York, New York. | N | N/A | |
| **26.** | New Jersey Investigation of Artificial Turf and Human Health Concerns | New Jersey Department of Health and Senior Services. (2008). Fact Sheet. Consumer and Environmental Health Services. Epidemiology, Environmental and Occupational Health. Trenton, New Jersey. | New Jersey Department of Health and Senior Services. (2008). Fact Sheet. Consumer and Environmental Health Services. Epidemiology, Environmental and Occupational Health. Trenton, New Jersey. | N | N/A | |

| Identification of Conflicts of Interest – EPA's "Tire Crumb and Synthetic Turf Field Literature and Report List as of Nov. 2015" | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **27.** | A Review of the Potential Health and Safety Risks from Synthetic Turf Fields Containing Crumb Rubber Infill | Denly E., Rutkowski K., Vetrano K.M. (2008). | Prepared by TRC for the New York City Department of Mental Health and Hygiene, New York, New York. | N | N/A | Not a study; it's a literature review only. This report is a review of the literature on tire crumb and artificial turf safety. It also provides information on the manufacture of tires and the chemicals contained in tires.<br>"In a letter dated May 14 of that year [2008], Landrigan and two other doctors at the center advised the Health Department to not release the 'deeply flawed' report, calling it 'superficial and one-sided.' City Limits obtained the damning five-page letter through another Freedom of Information Law request.<br>The literature review 'does not present a fair and balanced assessment of the issues surrounding the potential health hazards of synthetic turf,' the letter read. 'It is not up to the high standard of work that we have come to expect from the New York City Department of Health and Mental Hygiene in this administration.' The letter went on to identify four 'proven and potential' hazards of synthetic turf made from recycled tires. The first and 'best established' was exposure to 'excessive heat,' with such medical consequences as 'foot burns, dehydration and heat exhaustion.' The doctors warned that watering the fields to cool them down could actually do more harm than good: 'That can set the stage for skin infections,' because 'residual water droplets may act as bacterial incubators.'<br>This observation led to a more in-depth discussion of the second risk: MRSA, the antibiotic-resistant staph infection that can be acquired through turf burns. MRSA clusters from turf burns had been reported in The New England Journal of Medicine, the doctors noted, and in the CDC's Morbidity and Mortality Weekly Report. |

| Identification of Conflicts of Interest – EPA's "Tire Crumb and Synthetic Turf Field Literature and Report List as of Nov. 2015" | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| | | | | | | Lastly, the letter raised the risk of chemical exposures, acknowledging that the scientific literature was 'much less well developed' on these hazards than on the dangers from heat and MRSA. 'Several credible studies' had found the tire crumb contained 'known human carcinogens' and 'neurotoxic chemicals,' as well as lead, chromium and arsenic. The city's literature review relied on reports of human exposure to toxic chemicals from poured- or hard-rubber products, 'very different from the particulate rubber infill found in synthetic turf fields' and therefore 'only remotely relevant' to its topic.<br>The letter was blunt in its criticism: 'Overall the draft report from [TRC Companies] on the health hazards of synthetic turf is incomplete, it relies on irrelevant data sources, it uses a deeply flawed approach to risk assessment, it glosses over glaring gaps in the data, and it far too readily dismisses proven risks to human health. It does not take into account the unique exposures and the special vulnerabilities of young children. It concludes quite inappropriately that absence of evidence of risk is evidence of no risk.'"<br>http://citylimits.org/2010/08/24/it-wont-taste-great/ |
| **28.** | Synthetic Turf: Health Debate Takes Root | Claudio L. (2008). Environ Health Perspect 116(3): A116–A122. | Mount Sinai School of Medicine, New York, New York. | N | N/A | Not a study; opinion piece only |
| **29.** | Artificial Turf: Safe or Out on Ball Fields Around the World | Lioy P., Weisel C. (2008). Editorial. J of Expos Anal Environ Epidem. 18:533-534 | Exposure Science Division, Environmental and Occupational Health Sciences Institute of Robert Wood Johnson Medical School. | N | N/A | Not a study; it is an editorial providing an opinion only. |

| Identification of Conflicts of Interest – EPA's "Tire Crumb and Synthetic Turf Field Literature and Report List as of Nov. 2015" | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **30.** | Hazardous Chemicals in Synthetic Turf Materials and their Bioaccessibility in Digestive Fluids | Zhang et al. (2008). J Expo Sci Environ Epidemiol. 18(6):600-7. (Zhang JJ[1], Han IK, Zhang L, Crain W.) | [1]School of Public Health, University of Medicine and Dentistry of New Jersey. jjzhang@eohsi.rutgers.edu | N | N/A | |
| **31.** | Mapping, Emissions and Environmental and Health Assessment of Chemical Substances in Artificial Turf | Nilsson N.H., Malmgren-Hansen B., Thomsen U.S. (2008). | Danish Ministry of the Environment, Environmental Protection Agency. | Y | Promotes recycling used tires (see note). | Study financed by Danish EPA.<br>**"3.2 Tyres (Waste strategy 2005-2008)**<br>Landfilling of used tyres has been banned as of 16 July 2001 according to the Statutory Order No 648 of 29 June 2001 on the revision of Statutory Order No 619 of 27 June 2000 on Waste. Collection and recovery of tyres is regulated by the Statutory Order on a Fee on Tyres and a Recovery Subsidy No 111 of 5 February 2000.<br>…An intermediary goal was that at least 80% of all discarded tyres from private cars, vans, and motorbikes will be collected and recycled or incinerated before 1997. According to the agreement, 80% of all discarded tyres must be recycled or incinerated before 2000. Since 2001, the collection rate has been close to 100%. Goals for 2008:<br>• 90% reuse or recycling of all discarded tyres<br>On 20 February 1995, the Minister for Environment and Energy entered into an agreement with the tyre and motor trade associations, the Association of Danish Recycling Industries and municipal associations on a take-back scheme for discarded tyres. Through the agreement it is ensured that discarded tyres are collected and recycled or incinerated, thus avoiding landfilling and ensuring resource utilisation of waste tyres…"<br>http://scp.eionet.europa.eu/facts/factsheets_waste/2006_edition/Denmark |

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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **32.** | Evaluation of Health Effects of Recycled Waste Tires in Playgrounds and Track Products | California Office of Environmental Health Hazard Assessment. (2007). Prepared for the California Integrated Waste Management Board. | California Office of Environmental Health Hazard Assessment. (2007). Prepared for the California Integrated Waste Management Board. | Y | CalRecycle, as part of COEHHA, promotes recycling used tires. | Not a study; a literature review only. Reviews numerous related studies on shredded and poured in place recycled tire products. It also contains an original study of oral toxicity based on gastric digestion simulation of tire shreds. |
| **33.** | Examination of Crumb Rubber Produced from Recycled Tires | Incorvia Mattina M.J., Isleyen M., Berger W., Ozdemir S. (2007). The Connecticut Agricultural Research Station, New Haven, CT. | The Connecticut Agricultural Research Station, New Haven, Connecticut. | N | N/A | |
| **34.** | Artificial Turf: Exposures to Ground-Up Rubber Tires - Athletic Fields - Playgrounds - Gardening Mulch | Brown, D., Alderman, N., Addiss, S., Bradley, J. | Environment and Human Health, Inc. (2007). | N | N/A | Non-profit organization<br>Study referenced in this source is Examination of Crumb Rubber Produced from Recycled Tires, Incorvia Mattina M.J., Isleyen M., Berger W., Ozdemir S. (2007). The Connecticut Agricultural Research Station, New Haven, CT. |
| **35.** | Environmental and Health Evaluation of the Use of Elastomer Granulates (Virgin and from Used Tyres) as Filling in Third-Generation Artificial Turf | Moretto. (2007). France. | ALIAPUR in partnership with Fieldturf Tarkett and the ADEME (Environmental French Agency). | Y | ALIAPUR in partnership with Fieldturf Tarkett | |

| Identification of Conflicts of Interest – EPA's "Tire Crumb and Synthetic Turf Field Literature and Report List as of Nov. 2015" | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **36.** | Preliminary Assessment of the Toxicity from Exposure to Crumb Rubber: Its Use in Playgrounds and Artificial Turf Playing Fields | LeDoux T. (2007). | Division of Science, Research and Technology. New Jersey Department of Environmental Protection. | N | N/A | Not a study; literature review only. |
| **37.** | A Case Study of Tire Crumb Use on Playgrounds: Risk Analysis and Communication When Major Clinical Knowledge Gaps Exists | Anderson et al. (2006). Environ Health Perspect.114(1):1-3. (Mark E. Anderson,[1,2] Katherine H. Kirkland,[3] Tee L. Guidotti,[4] and Cecile Rose[5]) | [1]Department of Community Health Services, Denver Health, Denver, Colorado. [2]Department of Pediatrics, Univ. of Colorado Health Science Center, Denver, Colorado. [3]Association of Occupational and Environmental Clinics, Washington, DC. [4]Department of Environmental and Occupational Health, Mid-Atlantic Center for Child Health and the Environment, School of Public Health and Health Sciences, George Washington Univ. Medical Center, Washington, DC. [5]Departments of Medicine/ Preventive Medicine and Biometrics, National Jewish Medical and Research Center, Denver, Colorado. | N | N/A | Not a study; it's a commentary only. The authors declare they have no competing financial interests. |

| Identification of Conflicts of Interest – EPA's "Tire Crumb and Synthetic Turf Field Literature and Report List as of Nov. 2015" | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **38.** | A Survey of Microbial Populations in Infilled Synthetic Turf Fields | McNitt A.S., Petrunak D., Serensits T. (2006). | Penn State University, College of Agricultural Sciences, Department of Plant Science. | Y | This study was funded by the Synthetic Turf Council. In addition, Penn State has a partnership with FieldTurf. http://www.syntheticturfcouncil.org/?page=Research | This study does not address tire crumb. It is a study about the possible risk of Staph and MRSA infections on ST.<br>Compare with Weber State study Determination of Microbial Populations in a Synthetic Turf System<br>**Sample Size of Infill Material Being Tested**<br>•Weber State-10 Grams<br>•Penn State-.075 Grams<br>**Collection Time Frame of Samples**<br>•Weber State-Once a week for 14 weeks. Very controlled samples.<br>•Penn State-15 days, June only.<br>**Location of Samples**<br>•Weber State-1) Sideline, 2) 50 Yard Line and 3) end of field. 3 locations and same locations on both new and old field being sampled.<br>•Penn State-"High Use" and "Low Use" areas.<br>**Time of Study**<br>•Weber State-Height of the Actual Football Season when the fields were in use.<br>•Penn State-Height of Summer when field temperatures were at the peak.<br>**Technical Issues of reasons why the Penn St study did not find Pathogens (Staph)**<br>•Penn State-Shortened agitation times for the samples (shortened time means less chance for full discovery of Pathogens, technical; read study)<br>•Penn State-Failed to Isolate S. Aureus (Staph) on samples |

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| | Study | Author(s) | Group(s) | Conflict of Interest? | Reason for Conflict of Interest | Notes |
| | | | | | | **Conclusions**<br>**Weber State study**<br>"There is growing concern regarding the contribution of infilled turf fields on increased athlete infections. Abrasions that occur on these fields create a port of entry for pathogens such as Staphylococcus aureus that are present on the athlete's skin or possibly on the field's surface. This study compares the occurrence of microbial populations on two infilled synthetic turf fields (year old turf vs. 6 year old turf) in three locations. Both fields were sampled once a week for at least 14 weeks (exact number varied on field and location) during the late summer and fall of a football season. Sites sampled included the sidelines, the middle of each field, and the end of each field. Tryptic Soy Agar was used to determine total microbial load, Mannitol Salt Agar for Staphylococcus, and Eosin Methylene Blue Agar to count the number of enteric organisms such as Escherichia coli. Much higher microbial populations were found on the older turf field with as much as a 104 increase over similar locations on the newer turf. This suggests microbial populations can accumulate in synthetic turf infill from year to year. When comparing the bacterial load on different areas of the field, the sideline had the highest counts with an average of 1.12x108 CFUs (colony forming units) per gram of rubber infill on the older field. On the new synthetic turf, the area with the highest number of total microorganisms was also the sideline, with an average of 2.5x105 CFUs per gram of infill. A high number of salt-tolerant bacteria were able to grow on MSA, indicating possible staphylococci, with an average of 2.77x102 CFUs per gram on the new field and 6.58x103 CFUs per gram on |

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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| | | | | | | the older field. These results indicate that infill material can serve as a source for the spread of pathogens among student athletes, and that these organisms seem to accumulate over time posing a greater risk if proper turf cleaning is not regularly performed."<br><br>**Penn State study**<br>"...conclusion, there are generally lower numbers of total microbes present in the infill or fibers of the synthetic turf systems tested compared to natural turfgrass rootzones and *Staphylococcus aureus* bacterium were not found on any of the playing surfaces. *Staphylococcus aureus* bacterium were found on towels and other devices used by athletes." |
| **39.** | Artificial Turf Pitches: An Assessment of Health Risks for Football Players and the Environment | Norwegian Institute of Public Health and the Radium Hospital. (2006). Norwegian Institute of Public Health and the Radium Hospital, Oslo, Norway. | Norwegian Institute of Public Health and the Radium Hospital. (2006). Norwegian Institute of Public Health and the Radium Hospital, Oslo, Norway. | N | N/A | Demonstrated elevated Particulate Matter (PM) 2.5 and carbon black levels in indoor turf arenas that used tire crumb infills. |
| **40.** | Measurement of Air Pollution in Indoor Artificial Turf Halls | Dye C., Bjerke A, Schmidbauer N., Mano S. (2006). | Norwegian Pollution Control Authority/Norwegian Institute for Air Research, State Programme for Pollution Monitoring. | N | N/A | This study clearly demonstrated that tire crumb infill in indoor turf halls generated significant amounts of fine respirable dust in the form of rubber particles and carbon black. (Tire crumb in outdoor fields would obviously also generate significant amounts of fine respirable dust.) As the American Lung Association article explained, fine respirable dust in general, and carbon black in particular, are associated with numerous adverse health outcomes. There |

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| | | | | | | are no studies of fine respirable dust or carbon black exposure in the breathing space of field users during active field use conditions on indoor or outdoor fields. There are also no studies of the potential exposures to people living or attending class in buildings adjacent to artificial turf fields. |
| **41.** | Toxicological Evaluation for the Hazard Assessment of Tire Crumb for Use in Public Playgrounds | Birkholz[1] et al. (2003). J Air Waste Manag, 53:903-07. | [1]Enviro-Test Laboratories, Edmonton, Alberta, Canada. | Y | Promotes recycling used tires (see note). | "The Tire Recycling Management Association of Alberta provided funding through the Alberta Centre for Injury Control and Prevention. Harold Hoffman reviewed the initial proposal and provided comments." http://www.synturf.org/images/birkholz_crumb_safety_paper.pdf |

| Recommendations for Studies to be Added | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **Tire Crumb Components** | | | | | | |
| **42.** | News Release: Many carcinogens found in Yale analysis of crumb rubber infill and playground mulch surfacing | Benoit, G. (2015) | Yale University for Environment and Human Health, Inc. | N | N/A | EHHI is a non-profit organization.<br>Yale researchers document that no toxicological information exists for approximately half of the 96 identified chemicals in tire crumb; inadequate information is available on many other chemicals.<br>http://seas.yale.edu/news-events/news/study-led-gaboury-benoit-looks-chemicals-synthetic-playing-surfaces-0<br>http://www.ehhi.org/turf/findings0815.shtml<br>http://www.ehhi.org/turf/metal_analysis2016.shtml |
| **43.** | Scrap Tire Mulch on Duluth Public Schools' Playgrounds | North Shore Analytical for Duluth Parents for Healthy Playgrounds (2015). | North Shore Analytical for Duluth Parents for Healthy Playgrounds | N | N/A | Kirsling raised funds through a GoFundMe website |
| **44.** | Carbon black, titanium dioxide, and talc | WHO, IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. (2006: Lyon, France) | WHO, IARC Working Group on the Evaluation of Carcinogenic Risks to Humans | N | N/A | Carbon black - "...Three studies of female rats that inhaled carbon black and three additional studies of female rats exposed intratracheally found significant increases in the incidence of malignant lung tumours, providing sufficient evidence that carbon black can cause cancer in animals. Solvent extracts of carbon black were used in one study of rats in which skin tumours were observed after dermal application and several studies of mice in which sarcomas were seen following subcutaneous injection, providing sufficient evidence that carbon black extracts can cause cancer in animals..."<br>Titanium dioxide - "...In two studies of rats that inhaled titanium dioxide, one observed an excess incidence of lung |

| Recommendations for Studies to be Added | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| | | | | | | tumours in both sexes and another in females only. Studies of rats exposed intratracheally found increases in the incidence of lung tumours. No increases were observed among mice and hamsters exposed intratracheally. Other studies that used different routes of administration did not observe excesses in tumour incidence. On the basis of the results of an increased incidence of lung tumours in rats, the Working Group concluded that there was sufficient evidence that titanium dioxide is carcinogenic in experimental animals..."<br><br>Talc - "...In one study of rats that inhaled talc, an excess incidence of malignant lung tumours was seen in females. The same study observed an excess incidence of pheochromocytomas in the adrenal medulla in both sexes, but the Working Group was divided as to whether these rare tumours could be attributed to exposure to talc. Other studies in rats and mice using different routes of administration did not find an excess of cancer, and two studies in rats were considered to be inadequate for evaluation. Based on the one positive study, the Working Group found that there was limited evidence of carcinogenicity of inhaled talc in experimental animals. There was no agreement within the Working Group as to whether the evidence on pheochromocytomas should be taken into account in the evaluation of animal data..." |

| Recommendations for Studies to be Added | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **45.** | Identification of Benzothiazole Derivatives and Polycyclic Aromatic Hydrocarbons as Aryl Hydrocarbon Receptor Agonists Present in Tire Extracts | He G[1], Zhao B, Denison MS. Environ Toxicol Chem. 2011 August ; 30(8): 1915–1925. doi:10.1002/etc.581 | [1]Department of Environmental Toxicology, University of California, Davis, California | N | N/A | "Leachate from rubber tire material contains a complex mixture of chemicals previously shown to produce toxic and biological effects in aquatic organisms. The ability of these leachates to induce Ah receptor (AhR)-dependent cytochrome P4501A1 expression in fish indicated the presence of AhR active chemicals, but the responsible chemicals and their direct interaction with the AhR signaling pathway were not examined. Using a combination of AhR-based bioassays, we have demonstrated the ability of tire extract to stimulate both AhR DNA binding and AhR-dependent gene expression and confirmed that the responsible chemicals were metabolically labile. The application of CALUX (chemical-activated luciferase gene expression) cell bioassay-driven toxicant identification evaluation not only revealed that tire extract contained a variety of known AhR-active polycyclic aromatic hydrocarbons but also identified 2-methylthiobenzothiazole and 2-mercaptobenzothiazole as AhR agonists. Analysis of a structurally diverse series of benzothiazoles identified many that could directly stimulate AhR DNA binding and transiently activate the AhR signaling pathway and identified benzothiazoles as a new class of AhR agonists. In addition to these compounds, the relatively high AhR agonist activity of a large number of fractions strongly suggests that tire extract contains a large number of physiochemically diverse AhR agonists whose identities and toxicological/biological significances are unknown." |
| **46.** | Release of Polycyclic Aromatic Hydrocarbons and Heavy Metals from Rubber Crumb in | Marsili L, Coppola D, Bianchi N, Maltese S, Bianchi M (2015) J Environ Anal Toxicol 5: | [1]Department of Physical Sciences, Earth and Environment, Siena University, Via Mattioli 4, | N | N/A | "Synthetic turf, made with an infill of rubber crumb from used tyres or virgin rubber, is now common in many sporting facilities. It is known that it contains compounds such as polycyclic aromatic hydrocarbons (PAHs) and heavy metals. |

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| | Synthetic Turf Fields: Preliminary Hazard Assessment for Athletes | 265. doi:10.4172/2161-0525.1000265 | 53100 Siena, Italy.<br>[2]Department of Political Science and International, Siena University, Via Mattioli 10, 53100 Siena, Italy. | | | We evaluated in nine samples of rubber crumb the total content of some heavy metals (Zn, Cd, Pb, Cu, Cr, Ni, Fe) normally found in tyres by microwave mineralization and the levels of the 14 US EPA priority PAHs by Soxhlet extraction and HPLC analysis. **The results showed high levels of PAHs and zinc in all rubber crumb samples compared to rubber granulate limits set by Italian National Amateur League (LND).** Following the precautionary principle, a risk assessment at 25°C was done, using the Average Daily Dose (ADD) assumed by athletes, expressed in terms of mass of contaminant per unit of body weight per day (mg/kg day), and the Lifetime Average Daily Dose (LADD) and then evaluating the Hazard Index (HI) and the Cumulative Excess Cancer Risk (∑ECR). In the different rubber granulates samples the HI ranges from a minimum of 8.94×10-7 to a maximum of 1.16×10-6, while the ∑ECR ranges from a minimum of 4.91×10-9 to a maximum of 1.10×10-8.<br>Finally, the aim of this study was to estimate the "hazard" for athletes inhaling PAHs released at the high temperatures this synthetic turf may reach. Then a sequence of proofs was carried out at 60°C, a temperature that this rubber crumb can easily reach in sporting installations, to see whether PAH release occurs. **The toxicity equivalent (TEQ) of evaporates from rubber crumb is not negligible and represents a major contribution to the total daily intake of PAHs by different routes."**<br>**Study showed that on warm (80° F or higher) sunny days when fields can heat to 140° F they can release very high levels of carcinogenic PAHs.** The exposure of an athlete exercising on the field for 8 hours per week would be |

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| | | | | | | approximately 1,000 times the toxic equivalent of the virtually safe level of exposure to benzo(a)pyrene in food. Authors stated, **"The main conclusion we can draw from this preliminary study, which will be validated by further field and laboratory research, is that although synthetic turf offers various advantages over natural grass, the quantity of toxic substances it releases when heated does not make it safe for public health."** Main points: 1. Continuous release of carcinogenic PAHs. 2. On warm sunny days fields can release unhealthy levels of PAHs.<br>.." Most of all, evaporation at high temperatures may - expose users of sports grounds, who are often children between 5 and 13 years of age, in a very sensitive phase of growth, to many of these toxic compounds. The results of the present study demonstrate that PAHs are continuously released from rubber crumb through evaporation. Athletes frequenting grounds with synthetic turf are therefore exposed to chronic toxicity from PAHs. The main conclusion we can draw from this preliminary study, which will be validated by further field and laboratory research, is that although synthetic turf offers various advantages over natural grass, the quantity of toxic substances it releases when heated does not make it safe for public health. When we extrapolated the data obtained in laboratory, the toxicity equivalent (TEQ) of the different compounds evaporating from the crumb was far from negligible and would contribute substantially to an athlete's total daily PAH intake<br>Conclusion…The literature and the present study show that crumb contains PAHs and heavy metals. Fine dust may become airborne and leachate may filter into the soil. The |

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| | | | | | | magnitude of human exposure depends on chemicals of concern concentration in field, exposure parameters describing human physiology (e.g. dermal contact, body weight) and population-specific parameters describing exposure behaviour (exposure frequency, duration). Randomly ingested crumb may release these compounds in the digestive tract. Most of all, evaporation at high temperatures may expose users of sports grounds, who are often children between 5 and13 years of age, in a very sensitive phase of growth, to many of these toxic compounds.<br>The results of the present study demonstrate that PAHs are continuously released from rubber crumb through evaporation.<br>Athletes frequenting grounds with synthetic turf are therefore exposed to chronic toxicity from PAHs.<br>The main conclusion we can draw from this preliminary study, which will be validated by further field and laboratory research, is that although synthetic turf offers various advantages over natural grass, the quantity of toxic substances it releases when heated does not make it safe for public health. When we extrapolated the data obtained in laboratory, the toxicity equivalent (TEQ) of the different compounds evaporating from the crumb was far from negligible and would contribute substantially to an athlete's total daily PAH intake. In fact, all rubber crumb samples of this study exceeded the Dlgs. 152/2006 [8] for B[b]F, B[ghi]Per and Zn,..all PAHs, except Chry, were over the threshold |

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| **47.** | Hazardous organic chemicals in rubber recycled tire playgrounds and pavers | Llompart, M.[a], Sanchez-Prado, L.[a], Lamas, J. P.[a], Garcia-Jares C.[a], Roca, E.[b], Dagnac, T.[c] (2013). Chemosphere, 423-431. | [a]Departamento de Quimica Analitica, Nutricion y Bromatologia, Facultad de Quimica, Universidad de Santiago de Compostela, Santiago de Compostela 15782, Spain.<br>[b]Departamento de Ingeniería Química, Escuela de Ingenieria, Universidad de Santiago de Compostela, Santiago de Compostela 15782, Spain.<br>[c]INGACAL (Galician Institute for Food Quality)–CIAM (Agrarian and Agronomic Research Centre), Laboratory of Food/Feed Safety and Organic Contaminants, Apartado 10, E-15080 A Coruña, Spain.<br>*Corresponding author. Tel.: +34 881814225.<br>E-mail address:<br>maria.llompart@usc.es<br>(M. Llompart) | N | N/A | "In this study, the presence of hazardous organic chemicals in surfaces containing recycled rubber tires is investigated. Direct material analyses using solvent extraction, as well as SPME analysis of the vapour phase above the sample, were carried out. Twenty-one rubber mulch samples were collected from nine different playgrounds. In addition, seven commercial samples of recycled rubber pavers were acquired in a local store of a multinational company. All samples were extracted by ultrasound energy, followed by analysis of the extract by GC–MS. The analysis confirmed the presence of a large number of hazardous substances including PAHs, phthalates, antioxidants (e.g. BHT, phenols), benzothiazole and derivatives, among other chemicals. The study evidences the high content of toxic chemicals in these recycled materials. The concentration of PAHs in the commercial pavers was extremely high, reaching values up to 1%. In addition, SPME studies of the vapour phase above the samples confirm the volatilisation of many of those organic compounds. Uses of recycled rubber tires, especially those targeting play areas and other facilities for children, should be a matter of regulatory concern." |

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| **48.** | Empire State Consumer Project 2015 Children's Products Safety Report | Chittenden, C., Muir, E. (2015). (Artificial Turf pp. 18-20, Artificial Mulch pp.21-22, Attachments pp. 32-33.) | Empire State Consumer Project, Inc. | N | N/A | Non-profit organization<br>"The attached table (last page of attached) lists results obtained on materials used in rubber mulch. Rubber mulch is made of ground recycled tires like those used for making artificial turf fields. The mulch is advertised as a garden and playground mulch. Some products are marked "Playground safety tested." There are no government standards for testing the safety of rubber mulch for playground use or for garden use. The East Rochester, New York school district is using Nike Grind for the infill on its artificial turf field.<br>Among other health effects caused by arsenic and cadmium, both are known to be human carcinogens (cancer classification NTP). Zinc is known to cause respiratory and digestive health effects, and pancreatic and kidney damage http://www.atsdr.cdc.gov/substances/index.asp. Inhalation, ingestion, and dermal exposure to toxic chemicals are all concerns where children play. Where foods are grown for human consumption, toxic chemicals potentially leaching into plants is also a concern that warrants study.<br>**We have included only chemicals that show levels higher than current acceptable limits. The 'limits' are NYS DEC soil cleanup guidelines for brownfields. These are minimum requirements and do not imply safety. Limits must be adjusted downward when multiple chemicals are found together.** US EPA limits for groundwater and wildlife exposure have not been included.<br>Although some chemicals show values below equipment detection limits, in some cases, detection limits may be higher than DEC limits; these chemicals warrant further analysis." |

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| **Particulate Matter (PM)** | | | | | | |
| **49.** | American Lung Association, non-profit: State of the Air 2015: Particle Pollution | American Lung Association. (2015). | American Lung Association (2015) | N | N/A | This article explains health risks associated with respirable dust, or the PM 10 and PM 2.5 and carbon black that you have been hearing about. (PM size 10 microns, or 2.5 microns and smaller, is abbreviated as PM 10 and PM 2.5.) Short-term exposure risks include increased severity of asthma attacks in children; increased hospitalizations for asthma in children; death from respiratory and cardiovascular disease, including stroke; and increased numbers of heart attacks. |
| **Toxicity** | | | | | | |
| **50.** | Carbon nanotubes introduced into the abdominal cavity of mice show asbestos-like pathogenicity in a pilot study | Poland Craig A, et al. Nature Nanotechnology 2008. 3: 423-428. | | N | N/A | |
| **51.** | Supplementary Guidance for Conducting Health Risk Assessment of Chemical Mixtures | EPA Risk Assessment Forum Technical Panel. (2000). Washington DC. | U.S. Environmental Protection Agency | | | **Thus far, risk assessments on tire crumb, a complex chemical mixture, have not been conducted in a manner consistent with these guidelines.** The guidelines define a complex mixture thus: "A mixture containing so many components that any estimation of its toxicity based on its components' toxicities contains too much uncertainty and error to be useful…Risk assessments of complex mixtures are preferably based on toxicity and exposure data on the complete mixture..." Appendix B p.2 |

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| **52.** | Assessing the carcinogenic potential of low-dose exposures to chemical mixtures in the environment: the challenge ahead | Goodson, W. H., Lowe, L., & al, e. (2015). Carcinogenesis, S254-S296. | (Over 141 affiliations; see hyperlink.) | N | N/A | This paper reports that the World Health Organization and the International Agency for Research on Cancer (IARC) suggest that the fraction of cancers attributable to toxic environmental exposures is between 7% and 19% of all cancers; other sources suggest the proportion of cancers due to unknown causes may be much higher. Supported by over 500 references, this paper presents evidence of physiologic mechanisms that predict/explain how chemicals that are not carcinogens when acting alone (heavy metals, endocrine disruptors, and others) can collectively work through different pathways (such as immune suppression) at different points in time to ultimately induce cancer. Note: Other articles in the supplement would also prove relevant. |
| **53.** | Toxicity and metabolism of methylnaphthalenes: Comparison with naphthalene and 1-nitronaphthalene | Lin, C. Y., Wheelock, A. M., Morin, D., Baldwin, R. M., & al, e. (2009). Toxicology, 16-27. | | N | N/A | |
| **54.** | Automobile Tires a Potential Source of Highly Carcinogenic Dibenzopyrenes to the Environment | Ioannis Sadiktsis, et al. Environ. Sci. Technol. Feb 21, 2012, 46, 3326−3334. | | N | N/A | "…Through the release of PAHs from stockpiled scrap tires, PAH emissions from pyrolysis of scrap tires or leaching of PAHs from recycled tire rubber material, tires are a source of environmental pollution of PAHs throughout their entire lifecycle." |

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| **55.** | Prevention of Childhood Lead Toxicity | AAP COUNCIL ON ENVIRONMENTAL HEALTH. Prevention of Childhood Lead Toxicity. Pediatrics. 2016;138(1):e20161493 | AAP Council on Environmental Health | N | N/A | "…All authors have filed conflict of interest statements with the American Academy of Pediatrics. Any conflicts have been resolved through a process approved by the Board of Directors. The American Academy of Pediatrics has neither solicited nor accepted any commercial involvement in the development of the content of this publication…<br><br>FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.<br><br>FUNDING: No external funding.<br><br>POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose."<br><br>"...Consumer products such as children's toys, lunch boxes, crayons, and lipstick that are contaminated with lead have received a great deal of attention. These products constitute a small source of lead intake for most children, but they can be the major source for an individual child. Moreover, because lead exposure is cumulative and there is no apparent threshold for the adverse effects of lead exposure, all sources of lead exposure should be eliminated. It is the responsibility of the relevant federal agencies, such as the CPSC and the Food and Drug Administration (FDA), to promulgate and enforce standards that will protect children from lead-contaminated consumer products...<br><br>...Lead toxicity results in substantial, population-level effects on children's intellectual abilities, academic abilities, problem behaviors, and birth weight... |

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| | | | | | | **Recommendations for Government**<br>1. The federal government should expand the resources currently offered by the HUD to local and state governments for lead hazard control work.<br>2. The federal government should provide both financial and nonfinancial resources and technical guidance through the CDC, the EPA, and the HUD to state and local public health agencies as well as environmental and housing agencies engaged in childhood lead poisoning prevention efforts.<br>3. The US EPA and HUD should review their protocols for identifying and mitigating residential lead hazards (eg, lead-based paint, dust, and soil) and lead-contaminated water from lead service lines or lead solder and revise downward the allowable levels of lead in house dust, soil, paint, and water to conform with the recognition that there are no safe levels of lead.<br>4. The federal government should resume and expand its vital role in providing federal public health leadership in childhood lead poisoning prevention work through the CDC. Allocation of additional resources would be necessary to accomplish this goal.<br>5. The Centers for Medicare & Medicaid Services, which is responsible for regulating clinical laboratory testing through the Clinical Laboratory Improvement Amendments of 1988,69 should expeditiously revise current regulations for allowable laboratory error permitted in blood lead proficiency testing programs |

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| | | | | | | from ±4 µg/dL (±40 ppb) to ±2 µg/dL (±20 ppb) for blood lead concentrations ≤20 µg/dL (≤200 ppb).12 In the future, when feasible, allowable laboratory error permitted in blood lead proficiency testing programs should be reduced even more, to ±1 µg/dL (±10 ppb) for blood lead concentrations ≤20 µg/dL (≤200 ppb).<br>6. The federal government should continue to conduct the NHANES and provide national data on trends in blood lead concentrations. These newer data should be used by the CDC to periodically formulate a new reference value and guide clinical and public health interventions.<br>7. The federal government should continue to regularly survey children and adolescents in the NHANES for ADHD and conduct disorder by using validated diagnostic surveys from the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition to examine the association of lower blood lead concentrations with these conditions.<br>8. Local or state governments, in consultation with pediatricians, should develop policies and regulations requiring the remediation of lead-contaminated housing and child care facilities, including the elimination of lead hazards during transfer of rental units or renovation or demolition of older housing.<br>9. State and local governments should collect, analyze, and publish blood lead test results performed in their jurisdictions and should regularly publish reports of age of housing and other risk factors for children |

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| | | | | | | having blood lead concentrations ≥5 µg/dL (≥50 ppb). These reports should be readily available to pediatricians, health care providers, and the public.<br>10. Federal, state, and local governments should provide resources for environmental evaluations and case management of children who have blood lead concentrations ≥5 µg/dL (≥50 ppb), in conjunction with the child's primary care provider.<br>11. State and local governments should take steps to ensure that water fountains in schools do not exceed water lead concentrations of 1 ppb."<br>AAP echoes CDC: Lead is extremely brain toxic (neurotoxin); dangerous even at low levels! Lead standards only create ILLUSION of safety.<br>"When lead was taken out of products like paint and gasoline, levels of the metal in the blood of U.S. children dropped...<br>"...Most existing lead standards fail to protect children," members of the AAP's environmental health council report in a statement published Monday in the journal Pediatrics. Standards for the amount of lead that can be present in paint, water, dust and soil are not based on health standards, the pediatricians say, but instead on what's been feasible to attain. Such standards, they write, create "an illusion of safety..."<br>"...It's unethical, of course, to purposefully poison kids with varying amounts of lead and then see what happens with their blood lead level and how that corresponds to developmental problems." |

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| | | | | | | "We cannot have our children be canaries in the coal mine, where they get exposed first and then we have to try to fix it. If we want to actually do the right thing, we should prevent it from happening in the first place."<br>https://www.aap.org/en-us/about-the-aap/aap-press-room/Pages/With-No-Amount-of-Lead-Exposure-Safe-for-Children,-American-Academy-of-Pediatrics-Calls-For-Stricter-Regulations.aspx?nfstatus=401&nftoken=00000000-0000-0000-0000-000000000000&nfstatusdescription=ERROR:+No+local+token |
| **56.** | Nano particles in Automobile Tires | Felix, D.G., SivaKumar, G. IOSR Journal of Mechanical and Civil Engineering. Ver. I (Jul-Aug. 2014), PP 07-11 | Department of Mechanical Engineering. Panimalar Engineering College. Chennai-123 | N | N/A | Study illustrates where tire manufacturers apply nanoparticles in a tire, various functions played in a tire, and types of nanoparticles found in tires. They are made of metals, ceramics, and carbon structures. Relevance to athletic fields is that substances can be released into air, soil and water pathways, and since nanoparticles actually can travel through solids like glass, can be in the school building or grounds quite easily. |
| **57.** | Polycyclic aromatic hydrocarbon exposure, urinary mutagenicity, and DNA adducts in rubber manufacturing workers | Peters S[1], Talaska G, Jönsson BA, Kromhout H, Vermeulen R. (2008). | [1]Environmental Epidemiology Division, Institute for Risk Assessment Sciences, Utrecht University, Utrecht, the Netherlands. | N | N/A | "Workers in the compounding, mixing, and curing departments were at highest genotoxic risk among rubber manufacturing workers. Increased levels of urinary 1-hydroxypyrene, mutagenicity, and urothelial cell DNA adducts were found in these workers. Urothelial cell and PBMC DNA adducts were not related, hinting possibly to the presence of specific bladder carcinogens in the rubber manufacturing industry." |

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| **58.** | Exposure related mutagens in urine of rubber workers associated with inhalable particulate and dermal exposure | R Vermeulen, R Bos, J Pertijs, and H Kromhout. (2003) | Environmental and Occupational Health Division, Institute of Risk Assessment Sciences, Utrecht University, Utrecht, The Netherlands | N | N/A | "Results suggest that the dermal exposure route may contribute more to the level of genotoxic compounds in urine of rubber workers than the inhalation route. Although the study was limited in size, the results warrant further investigation in the importance of and ways to effectively control the dermal exposure route in the rubber industry." |
| **59.** | The rubber manufacturing industry: a case report and review of cutaneous exposure and sequelae | Powers C[1], Lampel HP[2]. (2015). | [1]School of Medicine, Duke University, Durham, NC<br>[2]Department of Dermatology, Duke University, Durham, NC | N | N/A | "Exposure to chemical carcinogens in rubber manufacturing remains a serious occupational health concern. Workers are exposed to these carcinogens via skin or inhalation. Rubber manufacturing work is associated with a high prevalence of dermatologic diseases such as eczema, allergic contact dermatitis and atopic dermatitis. The role that epidermal exposure plays in the development of malignancies historically associated with the rubber industry is less certain. We present a case relevant to this discussion and review the role of skin exposure in the rubber industry, providing an overview of the cutaneous and systemic manifestations of occupational exposures in modern day rubber workers." |
| **60.** | Mortality among rubber chemical manufacturing workers | Prince MM[1], Ward EM, Ruder AM, Salvan A, Roberts DR. (2000). | [1]National Institute for Occupational Safety and Health (NIOSH), Division of Surveillance, Hazard Evaluation, and Field Studies, Industrywide Studies Branch, 4676 Columbia Parkway, Cincinnati, OH | N | N/A | "IHD mortality among workers in the rubber chemicals department was elevated, particularly among those under 50 years of age. Potential occupational risk factors for IHD include the rotating shift pattern for employees assigned to two chemical production departments and chemical exposures present in the rubber chemicals department." |

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| **61.** | Cancer risk in the rubber industry: a review of the recent epidemiological evidence | Kogevinas M1, Sala M, Boffetta P, Kazerouni N, Kromhout H, Hoar-Zahm S. (1998). | [1]Respiratory and Environmental Health Research Unit, Institut Municipal d'Investigació Mèdica, Barcelona, Spain. | N | N/A | "Magnitude of the observed risks varied considerably between studies, but overall the findings indicate the presence of a widespread moderate increased cancer risk among rubber workers. The most consistent results were for bladder, laryngeal, and lung cancer and for leukaemia. Excess risks were also found for other neoplasms but an evaluation of the consistency of the findings is difficult because of the possible selective reporting of results. Recent studies do not provide information associating specific exposures with cancer risk. The preventive measures taken in the rubber industry in recent years may decrease risks, but this has not been documented yet in epidemiological studies." |
| **62.** | A case-control study of skin cancer in the tire and rubber manufacturing industry | Bourguet CC, Checkoway H, Hulka BS. (1987). | U | N | N/A | "A case-control study was conducted in the tire and rubber manufacturing industry to examine the association of squamous cell carcinoma of the skin with rubber manufacturing materials presumed to be contaminated by polycyclic aromatic hydrocarbons. Sixty-five cases were compared to 254 matched controls for exposure to carbon black, extender oils, lubricating oils, rubber solvents, and rubber stock. Both magnitude and duration of exposure were compared using data from company personnel records. Rubber stock and lubricating oils were associated with skin cancer. The relative risk (RR) associated with the highest levels of rubber stock exposure was 2.2, and with the highest level of lubricating oil exposure it was 6.5. In analysis of subgroups of study members, the associations were strongest among workers who were born after 1900 (rubber stock, RR = 11.6; lubricating oil, RR = 4.5) and among workers whose skin cancer was diagnosed before the age of seventy (rubber stock, RR = 23.2; lubricating oil, RR = 28.3)." |

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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **63.** | Exposure to nitrosamines, carbon black, asbestos, and talc and mortality from stomach, lung, and laryngeal cancer in a cohort of rubber workers | Straif K[1], Keil U, Taeger D, Holthenrich D, Sun Y, Bungers M, Weiland SK. (2000). | [1]Institute of Epidemiology and Social Medicine, University of Münster, Germany | N | N/A | "There is sufficient evidence for an excess occurrence of stomach and lung cancer among rubber workers. However, evidence for causal associations with specific exposures is still limited. A cohort of 8,933 male German rubber workers was followed for mortality from January 1, 1981 through December 31, 1991. Work histories were reconstructed using routinely documented cost center codes. For each cost center code, calendar time-and plant-specific levels of exposure to nitrosamines, asbestos, talc (low, medium (m), and high (h)), and carbon black (two levels) were estimated by industrial hygienists. Rate ratios (RR) and 95% confidence intervals (CI) were calculated using Cox proportional hazards models, with the lowest exposure level used as the reference category. Exposure was lagged 10 years to account for latency. Exposure-response relations between exposure to asbestos and lung cancer mortality (RRm = 1.3, 95% CI: 0.9, 1.9; RRh = 2.0, 95% CI: 0.9, 4.1) and between exposure to dust (talc and asbestos combined) and stomach cancer mortality (RRm = 1.8, 95% CI: 0.9, 3.8; RRh = 2.7, 95% CI: 1.0, 7.1) were observed. Exposure to nitrosamines was not associated with mortality from stomach or lung cancer. These results suggest that the increased mortality from lung and stomach cancer among rubber workers is associated with exposure to asbestos and dust, respectively." |

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| **64.** | Cancer mortality and morbidity among rubber workers | Monson RR, Fine LJ. (1978). | U | N | N/A | "Mortality and morbidity from cancer among a cohort of 13,570 white male rubber workers were examined. Each man worked for at least 5 years at the Akron, Ohio, plant of the B. F. Goodrich Company. The potential period of follow-up was from January 1, 1940 to June 30, 1976. Departmental work histories were based primarily on records maintained by Local no. 5, United Rubber Workers. The occurrence of cancer was measured by death certificates and by a survey of Akron-area hospital tumor registries from 1964 to 1974. Two types of analyses were made: 1) an external comparison of mortality rates of rubber workers versus rates of U.S. white males, and 2) an internal comparison of cancer morbidity rates among persons who were employed in various work areas of the plant. Excess cases of specific cancers (observed/expected numbers) among workers in specific work areas included: stomach and intestine: rubber making (30/14.4); lung: tire curing (31/14.1), fuel cells and/or deicers (46/29.1); bladder: chemical plant (6/2.4), and tire building (16/10.7); skin cancer: tire assembly (12/1.9); brain cancer: tire assembly (8/2.0); lymphatic cancer: tire building (8/3.2); and leukemia: calendering (8/2.2), tire curing (8/2.6), tire building (12/7.5), elevators (4/1.4), tubes (4/1.6), and rubber fabrics (4/1.1). Agents that may be responsible for these excesses were considered." |

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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **65.** | Mutagenic Potential of Artificial Athletic Field Crumb Rubber at Increased Temperatures | Dorsey, M.J.[1], Anderson, E.[2], Ardo, O.[2], Chou, M.[2], Farrow, E.[2], Glassman, E.[2], Manley, M.[2], Meisner, H.[2], Meyers, C.[2], Morley, N.[2], Rominger, J.[2], Sena, M.[2], Stiefbold, M.[2], Stites, B.[2], Tash, M.[2], Weber, E.[2], Counts, P.E.[1] (2015). | [1]Faculty members at Wyoming High School<br>[2]Advanced Placement Biology students | N | N/A | "Rubber tires contain several compounds that are known or suspected carcinogens. Many carcinogens are mutagens (Griffiths et al. 2000), and fluctuation assays based on the Ames test can be used as an initial screen for mutagenic potential. Granulated crumb rubber from recycled tires is commonly used in the creation of artificial athletic fields, and the surface temperature of these fields can reach levels far above the ambient temperature. In this study, crumb rubber samples taken directly from four separate artificial athletic field surfaces were used to make leachates using water at different temperatures. For each of these fields, leachates obtained in water at 70ºC showed significant mutagenic potential ($p \leq .001$) in Salmonella typhimurium fluctuation assays. Leachates obtained in water at 40ºC showed no mutagenic potential for any of the fields tested. For one field, crumb rubber heated in water at tempera-tures as low as 50ºC resulted in significant mutagenic potential ($p \leq 0.001$). Water used in an experiment designed to mimic the irrigation of an artificial athletic field also showed mutagenic potential ($p \leq 0.001$) in a fluctuation assay. These results suggest that at the higher temperatures such as those on artificial athletic field surfaces, the crumb rubber infill on these artificial athletic fields can become the source of a water soluble agent with mutagenic potential in bacteria." |

| Recommendations for Studies to be Added | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **Health Effects** | | | | | | |
| **66.** | Determination of Microbial Populations in a Synthetic Turf System | Bass, Jason J. and Hintze, David W. (2013) | Weber State University | N | N/A | Compare with Penn State study A Survey of Microbial Populations in Infilled Synthetic Turf Fields<br>**Sample Size of Infill Material Being Tested**<br>•Weber State-10 Grams<br>•Penn State-.075 Grams<br>**Collection Time Frame of Samples**<br>•Weber State-Once a week for 14 weeks. Very controlled samples.<br>•Penn State-15 days, June only.<br>**Location of Samples**<br>•Weber State-1) Sideline, 2) 50 Yard Line and 3) end of field. 3 locations and same locations on both new and old field being sampled.<br>•Penn State-"High Use" and "Low Use" areas.<br>**Time of Study**<br>•Weber State-Height of the Actual Football Season when the fields were in use.<br>•Penn State-Height of Summer when field temperatures were at the peak.<br>**Technical Issues of reasons why the Penn St study did not find Pathogens (Staph)**<br>•Penn State-Shortened agitation times for the samples (shortened time means less chance for full discovery of Pathogens, technical; read study)<br>•Penn State-Failed to Isolate S. Aureus (Staph) on samples |

| Recommendations for Studies to be Added | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| | | | | | | **Conclusions**<br>**Weber State study**<br>"There is growing concern regarding the contribution of infilled turf fields on increased athlete infections. Abrasions that occur on these fields create a port of entry for pathogens such as Staphylococcus aureus that are present on the athlete's skin or possibly on the field's surface. This study compares the occurrence of microbial populations on two infilled synthetic turf fields (year old turf vs. 6 year old turf) in three locations. Both fields were sampled once a week for at least 14 weeks (exact number varied on field and location) during the late summer and fall of a football season. Sites sampled included the sidelines, the middle of each field, and the end of each field. Tryptic Soy Agar was used to determine total microbial load, Mannitol Salt Agar for Staphylococcus, and Eosin Methylene Blue Agar to count the number of enteric organisms such as Escherichia coli. Much higher microbial populations were found on the older turf field with as much as a 104 increase over similar locations on the newer turf. This suggests microbial populations can accumulate in synthetic turf infill from year to year. When comparing the bacterial load on different areas of the field, the sideline had the highest counts with an average of 1.12x108 CFUs (colony forming units) per gram of rubber infill on the older field. On the new synthetic turf, the area with the highest number of total microorganisms was also the sideline, with an average of 2.5x105 CFUs per gram of infill. A high number of salt-tolerant bacteria were able to grow on MSA, indicating possible staphylococci, with an average of 2.77x102 CFUs per gram on the new field and 6.58x103 CFUs per gram on the older field. These results indicate that infill material can serve as a source for the spread of pathogens among |

| Recommendations for Studies to be Added | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| | | | | | | student athletes, and that these organisms seem to accumulate over time posing a greater risk if proper turf cleaning is not regularly performed."<br><br>**Penn State study**<br>"...conclusion, there are generally lower numbers of total microbes present in the infill or fibers of the synthetic turf systems tested compared to natural turfgrass rootzones and *Staphylococcus aureus* bacterium were not found on any of the playing surfaces. *Staphylococcus aureus* bacterium were found on towels and other devices used by athletes." |
| **67.** | A High-Morbidity Outbreak of Methicillin-Resistant Staphylococcus aureus among Players on a College Football Team, Facilitated by Cosmetic Body Shaving and Turf Burns | Elizabeth M. Begier[1,4], Kasia Frenette[1], Nancy L. Barrett[1,2], Pat Mshar[1], Susan Petit[1,2], Dave J. Boxrud[5], Kellie Watkins-Colwell[3], Sheila Wheeler[3], Elizabeth A. Cebelinski[5], Anita Glennen[5], Dao Nguyen[4,6], James L. Hadler[1], The Connecticut Bioterrorism Field Epidemiology Response Team[a] | [1]Infectious Diseases Division, Hartford<br>[2]Connecticut Active Bacterial Core Surveillance Project, Connecticut DPH, Hartford<br>[3]Student Health Services of Sacred Heart University, Fairfield, Connecticut<br>[4]Epidemic Intelligence Service Program, Centers for Disease Control and Prevention, Atlanta, GA<br>[5]Division of Public Health Laboratories, Minnesota Department of Public Health, Minneapolis, MN<br>[6]Los Angeles County Department of Health Services, Los Angeles, CA | N | N/A | "Potential conflicts of interest. All authors: No conflict."<br>"Players who sustained turf burns had a risk of infection that was 7 times higher than that for players without turf burns…<br>MRSA was likely spread predominantly during practice play, with skin breaks facilitating infection. Measures to minimize skin breaks among athletes should be considered, including prevention of turf burns and education regarding the risks of cosmetic body shaving. MRSA-contaminated pool water may have contributed to infections at covered sites, but small numbers limit the strength of this conclusion. Nevertheless, appropriate whirlpool disinfection methods should be promoted among athletic trainers." |

| Recommendations for Studies to be Added | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **68.** | Synthetic Turf Heat Evaluation – Progress Report | Penn State's Center for Sports Surface Research. (January 2012). | Penn State's Center for Sports Research | Y | Penn State has a partnership with FieldTurf. | Lowest temp in a test of synthetic fields on an average 76 degree air temp day...154. See pp. 12-14 for outdoor testing."No product in this test substantially reduced surface temperature compared to the traditional system of green fibers filled with black rubber in both the indoor and outdoor test. Reductions of five or even ten degrees offer little advantage when temperatures still exceed 150 °F. Until temperatures can be reduced by at least twenty or thirty degrees for an extended period of time, surface temperature will remain a major issue on synthetic turf fields." |
| **69.** | Synthetic Surface Heat Studies | Williams, C.F., and Pulley, G.E. (2002) | Brigham Young University | N | N/A | |
| **70.** | Associations between health effects and particulate matter and black carbon in subjects with respiratory disease | Jansen Karen L., et al. Environ Health Perspect. 2005. 113:12: 1741–1746. | | N | N/A | |
| **71.** | Acute respiratory inflammation in children and black carbon in ambient air before and during the 2008 Beijing Olympics | Lin W., et al. Environ Health Perspect. 2011 Oct;119:10:1507-12. | | N | N/A | |
| **72.** | Association of black carbon with cognition among children in a prospective British cohort study | Sugilia S. Franco, et al. American Journal of Epidemiology 2007, 167:3:280-286. | | N | N/A | |

| Recommendations for Studies to be Added | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **73.** | Does traffic exhaust contribute to the development of asthma and allergic sensitization in children: findings from recent cohort studies | Lennart, B. Bertil, F. Environmental Health 2009, 8:17. | | N | N/A | |
| **74.** | Occupational Exposure in the Rubber Manufacturing Industry | IARC Monographs Volume 100F, Supplementary Web Tables, Section 2, Cancer in Humans. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. | World Health Organization (WHO), International Agency for Research on Cancer (IARC | N | N/A | These web tables formed part of the original submission and have been peer reviewed. They are posted as supplied by the Working Group. Readers are requested to report any errors to: edit-vol100F@iarc.fr. |
| **75.** | Tire-Derived Flooring Chemical Emissions Study and Indoor Reference Exposure Levels (iRELs) | Office of Environment Health Hazard Assessment's (OEHHA), CalRecycle, California Department of Public Health's (CDPH). 2011. | Office of Environment Health Hazard Assessment's (OEHHA), CalRecycle, California Department of Public Health's (CDPH) | Y | CalRecycle, as part of OEHHA, promotes recycling used tires. | |
| **76.** | Dermal exposure to chemicals in the workplace: just how important is skin absorption? | Semple, S. Occup Environ Med 2004;61:376-382 doi:10.1136/oem.2003.010645. | Department of Environmental & Occupational Medicine, University of Aberdeen | N | N/A | |

| Recommendations for Studies to be Added | | | | | | |
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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **77.** | Nanotechnology: Toxicologic Pathology | Ann F. Hubbs,[1] Linda M. Sargent,[1] Dale W. Porter,[1] Tina M. Sager,[1] Bean T. Chen,[1] David G. Frazer,[1] Vincent Castranova,[1] Krishnan Sriram,[1] Timothy R. Nurkiewicz,[2] Steven H. Reynolds,[1] Lori A. Battelli,[1] Diane Schwegler-Berry,[1] Walter McKinney,[1] Kara L. Fluharty,[1] and Robert R. Mercer[1]<br>Toxicol Pathol. Author manuscript; available in PMC 2015 Dec 1.<br>Published in final edited form as:<br>Toxicol Pathol. 2013 Feb; 41(2): 395–409.<br>Published online 2013 Feb 6.<br>doi: 10.1177/0192623312467403<br>PMCID: PMC4665093<br>NIHMSID: NIHMS723787 | [1]Health Effects Laboratory Division, National Institute for Occupational Safety and Health, Morgantown, West Virginia<br>[2]Center for Cardiovascular and Respiratory Sciences, West Virginia University School of Medicine, Morgantown, West Virginia<br>Address correspondence to: Ann F. Hubbs, Health Effects Laboratory Division, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, 1095 Willowdale Rd, Morgantown, WV 26505; Email: vog.cdc@sbbuha | N | N/A | |

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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **78.** | nanoCOLT - Long-term effect of modified carbon black nanoparticles on healthy and damaged lungs | Prof. Dr. Bernd Müller, Philipps-University of Marburg, Marburg (DE)<br>Press Release (16.10.2014, in GERMAN only). *Biowissenschaftler erforschen Auswirkungen von Nanopartikeln - Marburger Lungenspezialist leitet bundesweiten Forschungsverbund* (uni-marburg.de) | FB 20 Medizin und Universitätsklinikum - Klinik für Innere Medizin - Pneumologie, Philipps-University of Marburg, Marburg (DE), Institut für Anatomie - AG Barriere-Organe, University Lübeck, Lübeck (DE), Fraunhofer Institute for Toxicology and Experimental Medicine (ITEM), Hannover (DE), Engler-Bunte-Institute - Division of Combustion Technology (EBI vbt), Karlsruhe Institute of Technology (KIT), Karlsruhe (DE), Experimental Pneumology, Research Center Borstel - Leibniz-Center for Medicine and Biosciences, Borstel (DE) | N | N/A | |
| **79.** | Toxicological Profile for Synthetic Vitreous Fibers | Syracuse Research Corporation for U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. 2004. | Syracuse Research Corporation for U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. | N | N/A | |

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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **80.** | International Agency for Research on Cancer (IARC) - Summaries & Evaluations: The Rubber Industry (Group 1) | International Agency for Research on Cancer (IARC). | International Agency for Research on Cancer (IARC). | N | N/A | |
| **81.** | Work Environments and Exposure to Hazardous Substances in Korean Tire Manufacturing | Naroo Lee[1] Byung-kyu Lee,[2] Sijeong Jeong,[2] Gwang Yong Yi,[1] and Jungah Shin[1]<br>Saf Health Work. 2012 Jun; 3(2): 130–139.<br>Published online 2012 Jun 8.<br>doi: 10.5491/SHAW.2012.3.2.130<br>PMCID: PMC3440462. | [1]Occupational Safety and Health Research Institute, Incheon, Korea.<br>[2]Korea Occupational Safety and Health Agency, Incheon, Korea.<br>Corresponding author.<br>Correspondence to: Naroo LEE. Occupational Safety and Health Research Institute, Korea Occupational Safety and Health Agency, 478, Munemi-ro, Bupyeong-gu, Incheon 403-711, Korea.<br>Tel: +82-32-510-0802, Fax: +82-32-518-0864, Email: ten.ahsok@eelooran | N | N/A | |

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| | **Study** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **82.** | Urban Airborne Particulate Matter: Origin, Chemistry, Fate and Health Impacts | Springer-Verlag Berlin Heidelberg. Edited by Fathi Zereini, Clare L. S. Wiseman. 2010. | Institute for Atmospheric and Environmental Sciences. Department of Environmental Analytical Chemistry, J.W. Goethe-University. Adaptation and Impacts Research Group. Institute for Environmental Studies. University of Toronto. | N | N/A | |
| **83.** | Effects of Chemical Co-exposures at Doses Relevant for Human Safety Assessments | European Centre for Ecotoxicology and Toxicology of Chemical (ECETOC). Technical Report No. 115. ISSN-0773-8072-115 (print). ISSN -2079-1526-115 (online). Brussels, July 2012. | European Centre for Ecotoxicology and Toxicology of Chemical (ECETOC) | N | N/A | |
| **84.** | Leaching of Phenols from Tire Shreds in a Noise Barrier | Håøya, A.O.[1], Aabøe, R.[2], Edeskär, T.[3]. | [1]RAMBØLL.<br>[2]Norwegian Public Roads Authorities, (NPRA) Norway.<br>[3]Luleå University of Technology, Sweden. | N | N/A | |

| Other Data for Consideration | | | | | | |
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| | **Title** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **News Reports/Video** | | | | | | |
| **85.** | Field Turf admits lead is in their [artificial turf] product but opposes signs to inform the public | YouTube posted (April 7, 2016). | SF Parks | N | N/A | Video<br>"March 11, 2016 testimony by Field Turf Mid-Atlantic Sales representative to the Ways and Means Committee of the Maryland General Assembly in a hearing on HB883 seeking to require informational signs at the entrance to artificial turf fields regarding precautions recommended by the CDC to safeguard children from exposures to lead. When asked by Delegate Mary Washington (D43, Baltimore City) about the status of a law suit against Field Turf regarding lead content, and whether Field Turf's artificial turf products contain lead, the response was 'Yes, there is lead in our product.'" Yet Field Turf opposes HB883." |
| **86.** | NBC News - How Safe is the Artificial Turf on Your Child's Sports Field ? (cancer) | Gosk, S. | NBC News | N | N/A | Video |
| **87.** | Is Rubber Mulch a Safe Surface for Your Child's Playground? | Rappleye, H., Gosk, S., Monahan, K., Alba, M. | NBC News | N | N/A | Video |
| **88.** | E:60 Sports Matter: Turf Wars: How Safe Are The Fields Where We Play? | Foudy, J. (November 24, 2015). | ESPN | N | N/A | Video |

| Other Data for Consideration | | | | | | |
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| | **Title** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **89.** | Children and synthetic turf | Forman, J., Landrigan, P., Brown, D., Michels, K., Alderman, N. | Mount Sinai School of Medicine, Children's Environmental Health Center at Mount Sinai Hospital, Environment and Human Health, Inc. | N | N/A | Video includes pediatricians, toxicologists and others discussing plastic turf in addition to other toxins. |
| **90.** | The Health Hazards of Artificial Turf Crumb Rubber Playing Fields | Landrigan, P. | Children's Environmental Health Center at Mount Sinai Hospital | N | N/A | Video |
| **91.** | Are we treating women athletes like guinea pigs? | International News Review | International News Review | N | N/A | Video |
| **92.** | Playground Hazards: Are Rubber Chips Toxic? | Enninga, H. | WDIO-TV, LLC | N | N/A | Video<br>"'He would come home with a black dust on him,' Kirsling said. 'It would be all over his legs. I mean, his legs would be black if he wore shorts.'<br>Then one day this May, Kirsling said he realized those playground drawbacks might be more serious.<br>'(Jack) would come home and he would blow his nose, and it would be gray from the dust,' Kirsling said. He would say, 'I have a headache. I have a scratchy throat.'<br>After Kirsling spoke to other parents who had also noticed similar symptoms, his initial endearment turned to alarm.<br>'It seems very odd that more than one child is coming home and saying the same things,' Kirsling said. 'Something doesn't seem right here.'"<br>See: Scrap Tire Mulch on Duluth Public Schools' Playgrounds |

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| | **Title** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **93.** | Student suffers severe injuries during punishment | Smith, M. | ABC 7 KVIA | N | N/A | Video<br>"It took less than 200 yards for Brandon Chacon, 15, to bruise and blister his hands beyond recognition Tuesday. Chacon, taking part in a football drill known as "bear crawls," is now unable to play football all because of a punishment administered by an assistant coach…<br>On Tuesday the temperature was around 96 degrees... Studies done by Penn State University show that turf, like the kind on El Dorado's new football field, can see temperatures 35-55 degrees hotter than normal grass. Previous studies done by Texas A&M show turf can reach temperature above 160 degrees in the state of Texas." |
| **94.** | Football player burns hand on hot turf after coach's practice punishment | Newton, J. | News 8 WTNH | N | N/A | Video<br>"…players at Stratford High, forced to crawl on the artificial turf with their bare hands during the September heat wave.<br>Pictures…showing one student-athlete's hand with a huge blister covering most of his palm. Apparently caused by the extreme temperature of the turf, against his bare skin.<br>'Ridiculous. That was insane. That can cause an infection,' said Felicia Murray, who has a daughter at the school.<br>Our own thermometer showed temperatures of the artificial grass hovering around 150 degrees." |

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| | **Title** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **Other Testimonial** | | | | | | |
| **95.** | Life After Crumb Rubber | Lindstrum, A. Playground Underlayment Committee. | Playground Underlayment Committee | N | N/A | "The Crumb Rubber underlayment was unacceptable to many parents for a variety of reasons. It off-gassed heavily year-round, though it was much stronger in hot weather. The smell had a strong chemical quality to it, similar to industrial solvents and tires. A number of adults and children reacted strongly to the Crumb Rubber after being on the playground for only minutes. Some had allergic reactions and had to get medical attention. Others got headaches and nausea. Enough people reacted strongly enough that the school had an unusually difficult time scheduling volunteers for playground duty during recess…" |
| **Overviews** | | | | | | |
| **96.** | Written Testimony before the Connecticut General Assembly on Children | Wright, R., Evans, S. (2016). | Children's Environmental Health Center at Mount Sinai Hospital | N | N/A | Testimony in Support of Raised Bill 5139, An Act Concerning the Use of Recycled Tire Rubber at Municipal and Public School Playgrounds.<br>"Given the hazards associated with recycled tire rubber, it is our recommendation that these products never be used as surfaces where children play." |
| **97.** | Dr. Landrigan Answers Back-to-School Questions | Landrigan, P. | Children's Environmental Health Center at Mount Sinai Hospital | N | N/A | |
| **98.** | Reducing Environmental Cancer Risk: What We Can Do Now | President's Cancer Panel. (2010). Bethesda: U.S. Department of Health and Human Services. | | N | N/A | |

| Other Data for Consideration | | | | | | |
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| | **Title** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **99.** | Substantial contribution of extrinsic risk factors to cancer development | Wu, S., Powers, S., Wei, Z., & Hannun, Y. A. (2016). Nature, 43-47. | | N | N/A | |
| **100** | Artificial Turf: Exposures to Ground Up Rubber Tires on Athletic Fields and Playgrounds | Environment and Human Health, Inc. (EHHI) | Environment and Human Health, Inc. (EHHI) | N | N/A | Non-profit organization |
| **101** | Overview of the Risks of Synthetic Turf Fields | Brown, D. | Environment and Human Health, Inc. (EHHI). (April 4, 2015). | N | N/A | Non-profit organization<br>Dr. David Brown, among other qualifications, is a former Deputy Director of The Public Health Practice Group of ATSDR at the CDC. In this article, he details weaknesses in scientific studies and holes in the "collective database" to date. This overview outlines why children are specifically at higher risk to toxins, and why he and many other epidemiologists, toxicologists, and public health officials are concerned about tire crumb. Instead of conducting research proactively, prior to health effects, Dr. Brown asserts that "a natural experiment is being conducted in which thousands of children are being exposed on playing fields to rubber 1) known to contain carcinogens and 2) documented to produce cancer in workers in the tire manufacturing plants." |
| **102** | Fact Sheet: CPSC, EPA & CDC on Artificial Turf Safety & Precautions | Safe Healthy Playing Fields Coalition. (July, 2015). | Safe Healthy Playing Fields Coalition | N | N/A | Non-profit organization<br>The Consumer Product Safety Commission (CPSC) and the Environmental Protection Agency (EPA) have retracted prior assurances regarding artificial turf, in acknowledgement of multiple concerns raised by the scientific community and the public. The Centers for Disease Control and Prevention (CDC) |

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| | **Title** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| | | | | | | identifies artificial turf as one of seven sources of lead exposure for children. |
| **103** | Crumb Rubber | Gilbert, S. | Toxipedia | N | N/A | Provides thorough overview of tire crumb. |
| **104** | Tire Crumb Synthetic Turf Study Reference Materials | | QWERTY Media Resources | N | N/A | "This resource is being posted and maintained for educational, journalistic, and reference purposes. The content continues to be vetted and updated for factual accuracy." Provides thorough overview of synthetic turf including history. |
| **News Articles** | | | | | | |
| **105** | Texas Football Succumbs to Virulent Staph Infection From Turf | Epstein, V. Bloomberg. (December 21, 2007). | Bloomberg L.P. | N | N/A | Player suffers from MRSA recurrence via turf burn/Texas has 16x higher player MRSA infection rate than national avg.<br>"'Mom, I can't move my arms or legs.'" Boone, 16, wide receiver, 'was suffering from a recurrence of...MRSA, which his doctor said he got through an abrasion from playing on artificial turf,' Baker said. Texas has artificial turf at 18 percent of its high school football stadiums, according to Web site Texasbob.com. It also has an MRSA infection rate among players that is 16 times higher than the estimated national average, according to three studies by the Texas Department of State Health Services." |
| **106** | DCR removes tire mulch from local playgrounds | Oliveira, R. Jamaica Plain Gazette. (December 3, 2010). | Jamaica Plain Gazette | N | N/A | "The JP Moms group's efforts to get rid of the rubber mulch were based on fears that regular exposure to volatile organic compounds in the tires might have long-term negative health impacts. Some also said that exposure to the tires caused them to have respiratory issues, and complained that the light-weight material is easily spread throughout the park and carried home in children's' clothes." |

| Other Data for Consideration | | | | | | |
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| | **Title** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| **107** | Feds promote artificial turf as safe despite health concerns | Frank, T. USA Today. (March 16, 2015). | USA Today. | N | N/A | The article describes how the Synthetic Turf Council has mischaracterized the results of some studies on artificial turf fields and has ignored scientists' warnings about children possibly ingesting lead in turf and tire crumbs. The article describes the differing opinions of different health departments, and how the EPA ignored internal warnings from its scientists. It also discusses how the CPSC pronounced artificial turf, 'safe to play on,' whereas the CDC listed artificial turf as one of the top sources of lead exposure, along with paint and costume jewelry, for children. |
| **108** | Critics say EPA played dual role in recycled tire controversy | Gutierrez, M. San Francisco Chronicle. (February 21, 2015). | San Francisco Chronicle. | N | N/A | This article discusses the EPA's role in promoting the use of tire crumb and how it ignored its own scientist's concerns about the safety of using tire crumb in children's play areas. It also discusses the apparent link between tire crumb and increased lymphoma and leukemia incidence in soccer players. |
| **109** | Combinations of 'safe' chemicals may increase cancer risk, study suggests | Harris-Lovett, S. Los Angeles Times. (July 1, 2015). | Los Angeles Times | N | N/A | "…it's plausible that consuming mixtures of these chemicals is riskier than consuming any one individually.<br>'To me, it's not a surprise,' said Birnbaum (Director of the National Institute of Environmental Health Sciences, NIEHS, of the NIH). Scientists know that small effects from many chemicals can add up to cause other diseases, she said. For instance, chemicals known as endocrine disruptors can lead to neurological, immune system and reproductive problems, among others.<br>Considering the safety of individual chemicals is a lot like looking at the trees, but missing the forest, Birnbaum said. |

| Other Data for Consideration | | | | | | |
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| | **Title** | **Author(s)** | **Group(s)** | **Conflict of Interest?** | **Reason for Conflict of Interest** | **Notes** |
| | | | | | | When doing research to determine chemical safety, 'we've got to start thinking more about what reality is,' she said.<br>This could mean sweeping changes in rules about the levels of chemicals considered safe in drinking water, food, and air.<br>'I'd like to see regulators and policy makers start looking at the totality of the exposure instead of one chemical at a time,'" she said. |
| **Other Miscellaneous** | | | | | | |
| **110** | Bioavailability Study Models | N/A | N/A | N | N/A | When reading the details of all the bioavailability studies, shreds and crumbs are used even when modeling bioavailability in simulated lung fluid. Athletes are not inhaling crumbs because the crumbs aren't floating in the air! They are inhaling PM 2.5 and PM 10 which remain in the lungs for days to months, not 24 hours. Similarly, ingestion is crumbs and dust via hand to mouth behavior. A half inch long shred is not a good model. |
| **111** | Human Rights Tribunal of Ontario between Players on National Teams Participating in the FIFA Women's World Cup Canada and Canadian Soccer Association, Fédération Internationale de Football Association | Boies, Schiller & Flexner LLP<br>Ryder, Wright, Blair & Holmes LLP<br>Osler, Hoskin & Harcourt LLP<br>(September 23, 2014). | Boies, Schiller & Flexner LLP<br>Ryder, Wright, Blair & Holmes LLP<br>Osler, Hoskin & Harcourt LLP | N | N/A | Synthetic turf named "inferior, dangerous and discriminatory."<br>Suit filed against FIFA January 2015: discrimination for forcing to play on synthetic turf, World Cup 2015. The women dropped it, due to FIFA's lack of response, and some players said FIFA was going to retaliate against them personally. After what the women experienced this year, FIFA will NEVER again hold ANY World Cup on synthetic.<br>"1) by forcing them to compete on a surface that fundamentally alters the way the game is played, (2) by |

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| | | | | | | subjecting them to unique and serious risks of injury, and (3) by devaluing their dignity, state of mind and self-respect as a result of requiring them to play on a second-class surface before tens of thousands of stadium spectators and a global broadcast audience."<br>"No soccer player prefers FieldTurf. It pales in comparison to a well-manicured grass pitch and takes some getting used to."<br>"Turf exposes players to injuries that do not exist on natural grass, such as skin lesions, abrasions and lacerations."<br>"In addition, artificial turf is uniquely vulnerable to degradation upon installation as a result of the effects of weathering, brushing and painting. CSA's site choice for the finals is particularly susceptible to such adverse effects as it is in use more than 200 days a year according to a report published in 2013. This type of use makes artificial turf an even more dangerous and difficult surface on which to play."<br>"force the top female soccer players in the world to play their preeminent event under inferior, dangerous and discriminatory conditions."<br>Also see p. 7 - turf burn, other dangers of synthetic turf. |
| **112** | Public Health Statement for Lead | ATSDR. (August 2007). CAS# 7439-92-1 | ATSDR | N | N/A | Synthetic turf is known to give players horrible turf burns frequently. It opens them up to more infection and apparently, more lead exposure.<br>"More lead can pass through skin that has been damaged (for example, by scrapes, scratches, and wounds)." |

**Other Data for Consideration**

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| **113** | Surface Temperature of Synthetic Turf | Penn State Center for Sports Surface Research. The Sportsturf Scoop: Surface Temperature of Synthetic Turf | Penn State Center for Sports Surface Research | Y | Penn State has a partnership with FieldTurf. | "Children less able to adapt to changes in temperature...How does high surface temperature affect field users?...Greater chance of heat-related issues. Discomfort, dehydration, heat stroke." Some believe that the tire crumb infill is to blame for high temperatures. However, no matter what type of infill is used, "Fibers are a major contributor to high surface temperatures." |
| **114** | Miscellaneous Extreme Temperature Information | N/A | N/A | N | N/A | **Sample Temperatures 2015 WWC**<br>**Air** / **Synthetic Turf**<br>82 °F / 150 °F<br>/ From 86 °F to over 122 °F within 5 minutes.<br>77 °F / 131 °F<br>64 °F / 129 °F<br>77 °F / 109 °F<br>78 °F / 120 °F<br>*Sources:*<br>*https://en.m.wikipedia.org/wiki/2015_FIFA_Women%27s_World_Cup*<br>*http://news.nationalpost.com/sports/soccer/womens-world-cup-offence-is-hot-and-the-fields-are-hotter-renewing-complaints-over-artificial-turf*<br>*http://t.thestar.com/#/article/sports/soccer/2015/06/08/womens-world-cup-heats-up-as-pitch-level-mercury-soars.html* |

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| | | | | | | • **Kansas City, Missouri, Stanley-Durwood Soccer Stadium**<br>  ○ 95 °F air, 159 °F synthetic turf http://www.sportingnews.com/soccer/story/2014-08-23/alex-morgan-nwsl-portland-thorns-hot-turf-field-uswnt<br>• **On a 98 °F (37 °C) day, MU's Faurot Field had a surface temperature of 173 °F (78 °C)**. The temperature of the nearby natural grass was only 105 °F (41 °C). Even at head-level, the temperature over the artificial turf was 138 °F (59 °C).[13]<br>  ○ Dr. Brad Fresenburg, turfgrass specialist from the University's Division of Plant Sciences, explains the danger of artificial turf is that the rubber and plastic materials used absorb more of sunlight's heat energy than natural grass, causing extraordinarily high temperatures. http://plasticfieldsfornever.org/ArtificialTurfBooklet.pdf "Synthetic Turf Playing Fields Present Unique Dangers," *Applied Turfgrass Science,* November 3, 2005.<br>• **Columbia, Missouri: Professor says "the fibers in a synthetic field control the heat**."<br>According to a news report in the *Columbia Missourian* (6 September 2013), the Faurot Field at the University of Missouri's Memorial Stadium registered a high of 151 degrees during the school's football season opener on |

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| | | | | | | Saturday 31 August. "A team of turf experts used an infrared thermometer to measure the heat coming off of the field in Memorial Stadium." "The National Weather Service in St. Louis [had] reported Saturday'' high temperature in Columbia as 100 degrees, but that reading was on a natural grass surface about 6 feet above the ground." The service's hydrologist, Mark Fuchs, said "on an artificial-turf surface, the temperatures jump." The Division of Plant Sciences professor Brad Fresenburg had this to say about the heating of the artificial turf fields: sunlight plays a vital role in turf temperature. "If we've got the sun in the air and there's a clear blue sky, we're easily going to be in the 150s. It could even be in the 160s." "We know that the fibers in a synthetic field control the heat." "Artificial fields are made of petroleum-based fibers that absorb heat as weather conditions change. Mid- to late afternoon, when direct sunlight has had its greatest effect on temperature, is usually when turf fields reach high temperatures. Much like vinyl in cars, the fibers capture and hold heat until the field has time to cool. Often, the fields get so hot that the heat can be felt through the soles of shoes." "Temperature readings vary depending on the kind of surface, amount of cloud cover, humidity, wind speed and thermometer height during the time of the reading. A slight breeze, for instance, can change temperatures by 20 or 30 degrees." "The clarity of the sky and the time of day — that makes a huge difference in what reflects off of that field as far as heat. The sky, if it's more clear blue, that's going to allow the field to absorb more heat." Source: Beth Castle, "Artificial turf turns up the heat on Faurot Field," in the *Columbia Missourian*, 5 |

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| | | | | | | September 2013, at http://www.columbiamissourian.com/a/165243/artificial-turf-turns-up-the-heat-on-faurot-field/ . See pdf here.<br>• **Cooling the synthetic field only lasts 5 minutes**<br>Irrigation of the synthetic turf had a significant result cooling the surface from 174 °F to 85 °F but after five minutes the temperature rebounded to 120 °F. The temperature rebuilt to 164 °F after only twenty minutes. http://plasticfieldsfornever.org/ArtificialTurfBooklet.pdf |