

## Benzene and Leukemia

Benzene is a highly volatile aromatic hydrocarbon solvent which is present in most petroleum distillates such as Stoddard solvent and mineral spirits. Recent advances in the purification process for these solvents has reduced the benzene content significantly, but it is still present in products such as WD-40 and Liquid Wrench as well as many solvents used in the printing industry and elsewhere. In the 1950s and into the 1960s, benzene content in some of these solvents was as high as 5 to 15%. Benzene is also a significant component of gasoline and other fuels and is used extensively in various manufacturing processes.

Acute exposure to benzene results in the usual symptomatology from excess solvent exposure including dizziness, drowsiness, rapid heart rate, headaches, tremors, confusion, unconsciousness, and death. While these symptoms are certainly quite serious, exposures to low levels of benzene for just a few years can result in a series of blood dyscrasias which are caused by attack of the blood-forming elements including the bone marrow. Early indicators of these hemotoxic problems include anemias, leukopenias, thrombocytopenias, aplastic anemias, and pancytopenias. While many of these conditions may be considered as part of what is called myelodysplastic syndrome, they also may progress to even more serious leukemias and lymphomas. Most commonly, benzene exposure has been associated causally with acute myelogenous leukemia (AML). This condition may also be referred to as acute myeloblastic leukemia, acute myelocytic leukemia, acute granulocytic leukemia, and acute non-lymphocytic leukemia. Other types of leukemia including chronic myelogenous leukemia (CML), acute lymphocytic leukemia (ALL), and chronic lymphocytic leukemia (CLL) have been linked to benzene exposure. Non-Hodgkin's Lymphomas (NHL), Hodgkin's disease, and multiple myelomas also are related to benzene exposure.

Dr. Parent has written several causation reports relating benzene exposure to various leukemias, pre-leukemias, and lymphomas. These reports address the Hill Criteria for establishing causation and have passed Daubert challenges. An example of an earlier causation report follows.

\* View Report

### Selected References

Arp, Jr., E. W., Wolf, P. H. and Checkoway, H., Lymphocytic leukemia and exposure to benzene and other solvents in the rubber industry. *Journal of Occupational Medicine*, 25(8), 598-602 (1983).

Agency for Toxic Substances and Disease Registry (ATSDR), Toxicological profile for benzene. Agency for Toxic Substances and Disease Registry (ATSDR). 487 pages (2005).

Austin, H., Delzell, E. and Cole, P., Benzene and leukemia. A review of the literature and a risk assessment. *American Journal of Epidemiology*, 127(3), 419-439 (1988).

Baccarini, V., Businco, L. and Passalacqua, F., Toxic effects of benzene in the printing trades. *Bollettino Della Societa Italiana Di Biologia Sperimentale*, 25, 276-277 (1949).

Beach, J. and Burstyn, I., Cancer risk in benzene exposed workers. *Occupational and Environmental Medicine*, 63(1), 71-72 (2006).

Bergsagel, D. E., Wong, O., Bergsagel, P. L., Alexanian, R., Anderson, K., Kyle, R. A. and Raabe, G. K., Benzene and multiple myeloma: appraisal of the scientific evidence. *Blood*, 94(4), 1174-1182 (1999).

Bezabeh, S., Engel, A., Morris, C. B. and Lamm, S. H., Does benzene cause multiple myeloma? An analysis of the published case-control literature. *Environmental Health Perspectives*, 104(Suppl 6), 1393-1398 (1996).

Bloemen, L. J., Youk, A., Bradley, T. D., Bodner, K. M. and Marsh, G., Lymphohaematopoietic cancer risk among chemical workers exposed to benzene. *Occupational and Environmental Medicine*, 61(3), 270-274 (2004).

Brunekreef B, Risk assessment of leukaemia and occupational exposure to benzene. *British Journal of Industrial Medicine*, 47(10), 717-718 (1990).

Checkoway, H., Wilcosky, T., Wolf, P. and Tyroler, H., An evaluation of the associations of leukemia and rubber industry solvent exposures. *American Journal of Ind. Medicine*, 5(3), 239-249 (1984).

Chen, Y. H., Su, W. L. and Liou, S. H., Benzene-induced myelodysplastic syndrome. *Journal of the American Board of Family Practitioners*, 14(1), 71-74 (2001).

Finkelstein, M. M., Leukemia after exposure to benzene: temporal trends and implications for standards. *American Journal of Industrial Medicine*, 38(1), 1-7 (2000).

Glass, D. C., Gray, C. N., Jolley, D. J., Gibbons, C., Sim, M. R., Fritschi, L., Adams, G. G., Bisby, J. A. and Manuell, R., Leukemia risk associated with low-level benzene exposure. *Epidemiology*, 14(5), 569-577 (2003).

Glass, D. C., Gray, C. N., Jolley, D. J., Gibbons, C. and Sim, M. R., The health watch case-control study of leukemia and benzene: the story so far. *Annals of the New York Academy of Science* 1076, 80-89 (2006).

Goldstein, B., Benzene exposure and leukemia. *Epidemiology*, 15(4), 509-510 (2004).

Hardell, L., Lindstrom, G., van Bavel, B., Fredrikson, M. and Liljegren, G., Some aspects of the etiology of non-Hodgkin's lymphoma. *Environmental Health Perspectives*, 106(Suppl 2), 679-681 (1998).

Heineman, E. F., Olsen, J. H., Pottern, L. M., Gomez, M., Raffn, E. and Blair, A.,

Occupational risk factors for multiple myeloma among Danish men. *Cancer Causes and Control*, 3(6), 555-568 (1992).

Infante, P. F., Benzene exposure and multiple myeloma: a detailed meta-analysis of benzene cohort studies. *Annals of the New York Academy of Science*, 1076, 90-109 (2006).

Issaragrisil, S., Kaufman, D. W., Anderson, T., Chansung, K., Leaverton, P. E., Shapiro, S. and Young, N. S., The epidemiology of aplastic anemia in Thailand. *Blood*, 107(4), 1299-1307 (2006).

Jakobsson, R., Ahlbom, A., Bellander, T. and Lundberg, I., Acute myeloid leukemia among petrol station attendants. *Archives of Environmental Health*., 48(4), 255-259 (1993).

Kirkeleit, J., Riise, T., Bratveit, M. and Moen, B. E., Increased risk of acute myelogenous leukemia and multiple myeloma in a historical cohort of upstream petroleum workers exposed to crude oil. *Cancer Causes and Control*, 19(1), 13-23 (2008).

Montane, E., Ibanez, L., Vidal, X., Ballarin, E., Puig, R., Garcia, N., Laporte, J. R. (Catalan Group for Study of Agranulocytosis and Aplastic Anemia), Epidemiology of aplastic anemia: a prospective multicenter study. *Haematologica*, 93(4), 518-523 (2008).

Nilsson, R. I., Nordlinder, R., Horte, L. G. and Jarvholm, B., Leukaemia, lymphoma, and multiple myeloma in seamen on tankers. *Occupational and Environmental Medicine*, 55(8), 517-521 (1998).

O'Connor, S. R., Farmer, P. B. and Lauder, I., Benzene and non-Hodgkin's lymphoma. *Journal of Pathology*, 189(4), 448-453 (1999).

Persson, B., Fredriksson, M., Olsen, K. et al., Some occupational exposures as risk factors for malignant lymphomas. *Cancer*, 72(5), 1773-1778 (1993).

Persson, B. and Fredrikson, M., Some risk factors for non-Hodgkin's lymphoma. *International Journal of Occupational Medicine and Environmental Health*, 12(2), 135-142 (1999).

Savitz, D. A. and Andrews, K. W., Risk of myelogenous leukaemia and multiple myeloma in workers exposed to benzene. *Occupational and Environmental Medicine*, 53(5), 357-358 (1996).

Smith, M. T., Skibola, C. F., Allan, J. M. and Morgan, G. J., Causal models of leukaemia and lymphoma. International Agency for Research on Cancer (IARC), Science Publication, Volume 157, 373-392 (2004).

Smith, M. T., Jones, R. M. and Smith, A. H., Benzene exposure and risk of non-Hodgkin lymphoma. *Cancer Epidemiology Biomarkers and Prevention*, 16(3), 385-391 (2007).

Steinmaus, C., Smith, A. H., Jones, R. M. and Smith, M. T., Meta-analysis of benzene exposure and non-Hodgkin lymphoma: biases could mask an important association. *Occupational and Environmental Medicine*, 65(6), 371-378 (2008).

Teitelbaum, D. T. and Brautbar, N., Benzene and multiple myeloma: appraisal of the scientific evidence. *Blood*, 95(9), 2995-2997 (2000).

Wong, O. and Raabe, G. K., Multiple myeloma and benzene exposure in a multinational cohort of more than 250,000 petroleum workers. *Regulatory Toxicology and Pharmacology*, 26, 188-199 (1997).

Wong, O., Risk of acute myeloid leukaemia and multiple myeloma in workers exposed to benzene. *Occupational and Environmental Medicine*, 52(6), 380-384 (1995).

Wong, O. and Raabe, G. K., Non-Hodgkin's lymphoma and exposure to benzene in a multinational cohort of more than 308,000 petroleum workers, 1937 to 1996. *Journal of Occupational and Environmental Medicine*, 42(5), 554-568 (2000).