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Environmental Exposures and Erectile Health

Luke Curtis*

Adjunct Professor of Public Health, East Carolina University, USA

Abstract

It is moderately well known that exposure to first and second hand tobacco smoke can significantly increase risk of erectile dysfunction (ED). Less well known are other environmental triggers that have been associated with significantly higher rates pf erectile dysfunction including exposures to pesticides, solvents, endocrine disrupting chemicals like bisphenol A and phthalates, and multiple chemical and psychological stressors seen in military populations like Gulf War Veterans. Other exposures that may be possibly linked to higher rates of erectile dysfunction include radiation, $PM_{2.5}$, and other outdoor air pollutants, and indoor heavy mold growth/ water damage. This review will attempt to comprehensively and concisely review environmental causes of erectile dysfunction. More clinical and research attention is needed to examine the relationships between toxic exposures and erectile health and sexual / reproductive health in general. Further understanding of these toxic exposures may been helpful in avoiding harmful exposures, and also in treating men suffering from erectile dysfunction and other sexual health issues.

***Corresponding author**

Luke Curtis, Adjunct Professor of Public Health, East Carolina University, USA

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INTRODUCTION

Erectile dysfunction [1] is an all too common problem which is estimated to affect an estimated 13.1% to 71.2% of all men worldwide [2]. Meta analyses have reported that erectile dysfunction is associated with significantly increased risk of many other serious health conditions including: 1) All-Cause Mortality (RR= 1.24, 95% CI 1.11-1.59, p<0.001, 7 studies with 111,460 subjects) process [3], 2) Cardiovascular Disease (RR=1.450, 95% CI 1.361-1.546, p< 0.001, 4 studies, 91,831 subjects) [4], and 3) Depression (RR=2.92, 95% CI 2.3-3.60, p<0.001, 6 studies, 22,257 subjects [5].

While the dangers of smoking on cardiovascular and erectile health are moderately well known, research and review on other environmental exposures and erectile dysfunction are less common.

This review will attempt to comprehensively and concisely review environmental factors involved in erectile function. It is hoped that this review might provide helpful ideas about limiting chemical exposures and ideas about possible further research in environmental exposures and erectile/ sexual health.

MATERIALS AND METHODS

This largely systematic review was compiled by searching the PUB MED, EMBASE, and Google Scholar Databases/ Search Engines up until April 7, 2024. Search terms included sexual function terms such as terms like “erectile dysfunction”, “erectile function”, ”sexual health” and “impotence” and environmental factors such as “Air Pollution”, “$PM_{2.5}$”, “Wildfire”, “Hazardous Waste”, “Industrial pollution”. “Metals- Lead, Arsenic, Cobalt, Mercury” “Occupations”, “Farming”, “Mining”, “Endocrine Disrupting Chemicals”, “Gulf War”, and “mold”,. Searches will involve human studies and will not look for studies involving animals or cultured cells. This paper will focus on environmental exposures not relating to smoking tobacco or marijuana. The consumption of alcohol, drugs, foods, non-alcoholic beverage, and food supplements will also not be covered in this review. While SARS Covid 2--Covid 19 infections have been linked to long term erectile dysfunction, this review will not will not cover infectious causes of ED [6-9]. The effects of smoking have already been fairly well described in other publications. A brief summary of the effects of a few selected studies on tobacco, Cannabis, and e-cigarette smoking will be given. For the other environmental exposures, an effort will be made to collect all of the English language summaries which compare environmental exposures to erectile health. A total of 34 studies relating environmental exposures to erectile dysfunction were found, including 9 papers on pesticides, solvents, and carbon disulfide, 6 papers on endocrine disrupting chemicals, 7 papers on lead and other heavy metals, 5 papers on Gulf War Veteran exposures, 1 paper on hazardous waste, 3 papers on outdoor air pollution, and 3 papers on radiation. Finally, a discussion of the possible links between mold exposure, sinusitis, and erectile dysfunction will be presented.

Since the total number of studies retrieved for each toxicological exposure are small, and the studies have considerable heterogeneity, performing a meta-analysis on this data would probably not be particularly helpful.

RESULTS OF THE REVIEW

For the discussion on effects of tobacco/ Cannabis/e cigarette

smoking and erectile function- only a concise discussion of a few selected papers will be given. An April 6, 2024 search of Pub Med found 904 entries under "erectile dysfunction" and "smoking".

Prologue- Brief Review of Smoking-Active, Passive and Effects of Smoking Cessation

Tobacco smoke (both in active smokers and in passive or secondhand smoke) contains high concentrations of particulates smaller than 2.5 microns ($PM_{2.5}$), and carbon monoxide, as well as smaller levels of nicotine, and over 7,000 other chemicals including at least 79 carcinogenic chemicals such as benzo (a) pyrene [10-13]. The mechanisms in which smoking can damage erectile dysfunction are thought to involve several factors such as damage to the endothelial blood vessel cells, reduction in nitric oxide (NO) availability, increased blood coagulation, reduced microcirculation, and increased oxidative damage [10,14,15].

Many large epidemiological studies have linked active and passive smoking to much higher rates of erectile dysfunction. A 2013 meta-analysis of 9 published studies involving 28,586 men reported a 51% significantly increased risk of erectile dysfunction in smokers versus non-smokers (OR 1.51, 95% CI 1.34-1.71). A 2014 meta-analysis of 10 studies and 50,360 men also reported that every 10 cigarettes smoked per day was associated with a 14% significantly increased risk of erectile dysfunction (OR 1.14, 95% CI 1.10 to 1.09) [16]. A study of 2,309 men in the Boston area reported that men who never smoked but were exposed to second hand smoke had a statistically insignificant 33% increase in erectile dysfunction (OR= 1.33, 95% CI 0.69-2.55) [17].

Cannabis or Marijuana

Cannabis smoke contains many of the same toxic components found in tobacco smoke, including high levels of $PM_{2.5}$, carbon monoxide, and at least 110 carcinogenic chemicals [18]. A meta-analysis of 5 published studies involving 3,395 men reported that erectile dysfunction was found in 69.1% of the Cannabis smokers and 34.7% in the men who did not use Cannabis [19]. The risk of erectile dysfunction was almost four times as great in the Cannabis smoking men versus the Cannabis non smokers (OR 3.83, 95 CI 1.30-11.28) [19].

E Cigarettes or Vaping

A study 13,711 adult US men reported that daily use of e-cigarettes was associated with a significantly greater risk for erectile dysfunction as compared to never e-cigarette users (adjusted OR 2.24, 95% CI 1.50- 3.34) [20]. It is believed that e-cigarettes may increase risk of erectile dysfunction by increasing oxidative stress and by damaging to the endothelial cells of the blood vessels [21].

For the remaining toxic exposures-an effort will be made to read, cite and summarize all of the English language summaries which I was able to find by searching PUB Med, EMBASE, and Google Scholar.

Pesticides, Solvents, Carbon Disulfide

This search found 7 studies related to pesticides and erectile dysfunction [22-28], 1 study relating to solvent exposure and erectile dysfunction [27], and 1 study relating to carbon disulfide exposures [29].

A representative study of 671 US men-from the USA NHANES (National Health and Nutrition Examination Survey) reported that men in upper quartile of urinary levels of chlorpyrifos metabolite 3,5,6,-trichloro -2-pyrindinol (TCPy) had significantly higher risk of erectile dysfunction than the lowest quartile (aOR=2.04, 95% CI of 1.11-3.72) [23]. Another NHANES study of 555 men reported that higher urinary levels of another organophosphate metabolite called diethylphosphate (DEP) was associated with significantly increased risk of erectile dysfunction (Highest vs. lowest quartile of urinary DEP OR 1.33, 95% CI 1.14-2.77, p =0.041) [28]. Amr [22], reported that erectile dysfunction was significantly more common in 208 pesticide formulators as compared to 223 unexposed control subjects [22]. A study of 199 Argentinian men reported that exposure to pesticides (OR 7.1, 95% 1.5-33.0) and solvents (OR 12.1, 95% CI 1,.2-124.8) were associated with significantly greater risk of erectile dysfunction [24]. Peck [25] described 4 farmers who developed erectile dysfunction following occupational exposure to chlorinated pesticides such as dieldrin [25].

On the other hand, a study of 1,311 men from the NHANES study reported no significant association between urinary levels of the herbicide 2,4,D (2,4-dicholorophenoxyacetic acid [27]. An Ontario study of 101 erectile dysfunction subjects and 210 matched controls reported that blood levels of both polychlorinated pesticides and chlorinated biphenyls were similar in both groups [26].

A study of 478 male cabinet workers in Denmark reported that exposure to lacquer and other solvents was associated with significantly higher erectile dysfunction rates.

The exact mechanisms in which pesticide and solvent exposures can cause erectile dysfunction are not well known but are hypothesized could be due to some of the following factors (the mechanisms can be different between various different pesticides) [30]:

1) Moderate pesticide exposure has been linked to significantly higher depression rates [31].

2) Damage to vascular and neurological systems

3) Hormone disruptions including lower testosterone levels and damage to Leydig cells with produce testosterone in the testicles.

4) Oxidative Damage [30].

Vanhoorne [29], reported erectile dysfunction was significantly more common in 116 carbon disulfide exposed rayon works as compared to 79 unexposed control workers (16.2% vs 3.9%, p=0.02) [29]

Endocrine Disrupting Chemicals Such as Phthalates, Bisphenol A, and Stilbene

This search found 6 papers examining the relationships between erectile dysfunction and exposure to endocrine disrupting chemicals [32-37].

A number of endocrine disrupting chemicals have been associated with poorer erectile function. Such endocrine disrupting chemicals include bisphenol A and phthalate chemicals which are both used to manufacture plastics. A nationally representative study of 3,746 US men aged 20+ years reported that higher levels of several urinary phthalates were associated with significantly higher rates of erectile dysfunction [36]. A French study of 97 men occupationally exposed to phthalates reported significantly lower levels of serum testosterone and significantly higher rates of self-reported erectile dysfunction as compared to controls [33]. A study of 135 workers occupationally exposed to high airborne levels of bisphenol A reported that the risk of having trouble getting an erection was significantly greater as compared to 365 unexposed workers (OR 4.5, 95% CI 2.1-9.8, p<0.001) [35]. A study of 353 men treated in a Chinese infertility clinic reported that reduced erectile difficulties were significantly more common among men with high levels of bisphenol A in blood (8.68-21.93 ng/ml bisphenol A in blood) versus low level bisphenol A (0.38-3.79 ng/ml) (OR= 2.40, 95% CI 1.18-4.88) [32]. Mean urinary bisphenol A levels were 57.9 µg/gr creatine versus 1.2 µg/gr creatine in unexposed workers [35]. Occupational exposure to the stilbene derivative DAS (4,4'diaminostilbene-2,2'-disulfonic acid) has been linked to significantly higher rates of erectile dysfunction [34]. A small study of 30 male workers occupationally exposed to stilbene reported significantly lower sexual interest and sexual function as compared to 35 control men [37].

Lead and Other Heavy Metals

This review located 7 human studies which examined the relationships between occupational or environmental metal exposures and erectile [38-44].

A number of metals may harm erectile function. Having a mining related job was associated with significantly increased risk of ED in 138 Democratic Republic of the Congo copper and cobalt miners as compared to 139 bakers (adjusted OR 2.6, 95% CI 1.3-5.3, p<0.001) and significantly lower free testosterone (mean ng/dl 8.11 vs 10.52 p<0.001) [42]. Erectile dysfunction was also significantly more common in 26 men with high lead levels versus 24 men with lower lead levels [39]. A study of 1,328 men in the 2001-2 and 2003-4 NHANES (National Health and Nutrition Examination Study) reported that increased urinary levels of cobalt (OR 1.36, 95% CI 1.10-1.73, p = 0.020) and antimony (OR 1.53, 95% CI 1.08-2.40, p =0.041) were, after adjustment for cofactors, associated with significantly greater levels of erectile dysfunction [27]. Another study analyzing 3,681 men in the NHANES study reported that men in the upper tertile of blood cadmium levels had a significantly greater risk of erectile dysfunction as compared to men in the lowest tertile of blood cadmium levels (OR 2.089, 95% CI 1.554-2.809, p<0.001) [41].

A Turkish study examined blood lead levels, cardiovascular health, and erectile health in a group of 65 men occupationally exposed to lead (median blood lead levels of 19 µg/dL, range of 3.2 to 89.6 µg/dL lead) and 32 less exposed men (median blood lead levels of of 0.5 µg/dL , range of 0.1 to 1.7 µg/dL lead). The lead exposed patients had significantly poorer erectile function and significantly poor left ventricular function as opposed to the controls not heavily exposed to lead [40].

A study of 24 men heavily exposed to lead (mean blood level lead of 42.1 µg/dl) had significantly poorer erectile function as compared to 26 men less heavily exposed (3.2 µg/dl) [39]. An Egyptian study reported that a group of 34 men with erectile dysfunction had significantly higher blood levels of lead as compared to 15 controls [38].

Gulf War Syndrome and Other Military Exposures

This search found 5 articles which examined the possible associations between Gulf War exposures and erectile dysfunction [45-49].

Military personal and civilians are often exposed to many different chemical, physiological, and psychological factors than can affect sexual health. Veterans of the 1991 Persian Gulf War were exposed to a wide range of stressful conditions including psychological distress from combat resulting in depression and post-traumatic stress disorder (PTSD), oil well fires, high airborne levels of fine sand, pesticides, anti-nerve gas pills, depleted uranium, and toxic waste burn pits [50-54]. Some researchers suggest that exposure to multiple toxic agents may have synergistic effects in terms of increased adverse health effects [51].

An enormous study of 647,203 US male Iraq and Afghanistan veterans reported that sexual dysfunction was seen in 10.6% of veterans with a diagnosis of post-traumatic stress disorder as compared to 2.3% of veterans with no PTSD or mental health disorders [46]. A neurological study of 65 US veterans with Gulf War Syndrome reported significantly higher rates of cholinergic autonomic nerve dysfunction-and significantly higher rates of erectile dysfunction as compared to 31 controls [47]. The incidence of erectile dysfunction was 14.2% in a group of 921 US Veterans [49].

A 2007 Iranian study 185 married male veterans of the 1980-1988 Iran-Iraq War who were exposed to chemical weapons reported that 49.2% (almost half) were experiencing long-term erectile dysfunction [45]. A UK study reported that the rate of sexual dysfunction was significantly higher in a group of 1,296 veterans with Gulf War Syndrome versus 12,364 matched veterans with no Gulf War Syndrome (adjusted OR 13.1, 95% CI 7.7-22.3, p <0.001) [48].

Hazardous Waste

This search found 1 study relating exposure to hazardous waste and erectile dysfunction [55].

A large hazardous waste case involved drinking water contaminated with significant amounts of trichloroethylene, tetrachloroethylene, and vinyl chloride at Marine Base Camp Lejeune, North Carolina from 1953 until 1987. A study of 172,128 veterans exposed to contaminated water at Fort Lejeune and 168,361 control subjects at Fort Pendleton, CA (unexposed to contaminated water) reported that Camp Lejeune veterans had a statistically greater risk of developing Parkinson's Disease (OR 1.70, 95% CI 1.39-2.07, p<0.001) and erectile dysfunction (OR 1.12, 95% CI 1.09-1.14, p<0.001) [55].

Outdoor Air Pollution

This review found 3 studies relating exposure to outdoor air pollution and erectile dysfunction [56-58].

Many studies and reviews have linked even modestly elevated concentrations of outdoor air pollutants to significantly poorer cardiovascular, cerebrovascular (stroke), infectious, and mental health neurological outcomes [59-62]. Exposure to higher levels of outdoor air pollutants may also be associated with significantly poorer erectile and sexual function.

A 2024 online questionnaire study of 5,024 Chinese men (median age 29 years) analyzed possible associations between sexual function and exposure to average outdoor levels of 6 pollutants PM10, $PM_{2.5}$, SO2, CO, NO2, and O3 [57]. Higher levels of outdoor NO2 were associated with significantly poorer erectile health scores on the IIIEF-5 International Index of Erectile Function-5 and higher $PM_{2.5}$ ambient concentrations were associated with significantly poorer premature ejaculation scores on the PEDT= Premature Ejaculation Diagnostic Tool [57].

A US nationally representative study of 412 US Men aged 57 to 85 years reported that exposure to higher ambient outdoor levels of particulates smaller than 2.5 microns ($PM_{2.5}$), ozone (O3), and nitrogen dioxide were associated with non statistically significant increases in erectile dysfunction. For a 7 year moving average, each interquartile increase in $PM_{2.5}$ is associated with an 18% increase risk of erectile dysfunction (OR 1.18, 95% CI 0.92, 1.46) [58]. Another representative study of 2,115 US men reported that increasing outdoor $PM_{2.5}$ was not associated with significantly greater risk of erectile dysfunction (OR 0.80, 95% CI 0.52-1.24, p=0.32) [56].

Exposures to Ionizing and Nonionizing Radiation

This study found 3 studies relating exposures to ionizing and non-ionizing radiation and erectile dysfunction [63-65].

Some studies suggest that long weekly use of cellular phones are associated with significantly increased risk of erectile dysfunction and other sexual problems in women and men [63,64]. A study of Ukrainian men aged 35 to 55 years with a regular sexual partner who were exposed to radiation from the 1986 Chernobyl Nuclear Power Plant Disaster reported very high levels of chronic erectile dysfunction [65]. Moderate to severe erectile dysfunction was reported in 71.0% of 186 men in the heavily radiation exposed Kyiv and Zhytomyr regions and in 45.5% of 123 men in the less heavily exposed Ivano-Franivsk and Chernivtsi regions [65].

Possible Links between Indoor Mold/ Mycotoxin/ Water Damage to Sinusitis and Erectile Dysfunction

Sinusitis/ rhinitis is strongly associated with both erectile dysfunction and indoor mold exposure. Several studies have reported that chronic sinusitis is associated with significantly higher rates of erectile dysfunction. For example, a nationally representative Taiwanese prospective study of 14,039 erectile dysfunction patients and 140,387 matched controls reported that chronic rhino sinusitis was very significantly associated with erectile dysfunction (HR=1.51, 95% OR: 1.33-1.73, p < 0.0001) [66]. This study was corrected for many confounding factors such as age, location of residence and many health conditions including cardiovascular disease, diabetes, and asthma. A Massachusetts study of 17,891 men reported that chronic rhino sinusitis was associated with a doubled risk of erectile dysfunction (OR=2.0, 95% CI 1.8-2.4, p<0.001) [67].

Several studies have reported that surgical treatment of chronic sinusitis patients is associated with both significantly reduced sinusitis symptoms and significantly improved erectile function [68,69].

Many studies have reported that chronic sinusitis is associated with indoor exposures to mold/ water damage and/ or fungal presence in the sinuses. A meta-analysis of 31 published studies reported that exposure to indoor visible mold (OR: 1.82, 95% CI 1.56-2.12) and indoor mold odor (OR: 2.18, 95% CI 1.76-2.71) were associated with significantly greater risk of rhinitis/ sinusitis [70]. A Minnesota study reported that 94 out of 101 consecutive (93%) surgical rhino sinusitis patients met criteria for allergic fungal sinusitis [71].

A number of published studies have reported that chronic sinusitis patients frequently improve significantly when treated with reduced indoor mold exposure. Dennis examined 634 consecutive chronic rhino sinusitis patients and found that of the 364 patients who were able to significantly reduce indoor mold exposure and who received topical antifungal topical medications, 94% were able to significantly reduce symptoms and have normal endoscopic sinus exams [72]. A meta-analysis of 12 published studies reported that professional remediation of mold and water-damaged homes was associated with significant reductions in both wheezing (OR: 0.64, 95% CI 0.55-0.75) and rhinitis symptoms (OR: 0.57, 95% CI 0.49-0.66) [73].

The possible mechanisms in which exposure to fungi and their allergens and mycotoxins might be harmful to erectile health and sexual health in general are not well known. The mold related adverse sexual health effects could possibly be due to the

inflammatory and hormonal altering effects of fungal allergens and fungal mycotoxins such as zearalenone [74,75].

Although there is good data linking chronic sinusitis with erectile dysfunction, and solid data linking fungal exposure in indoor environments and/or in the nasal sinuses with chronic sinusitis, there is a dearth of information linking fungal exposure with erectile dysfunction. Perhaps some of the readers have interesting cases of sexual dysfunction associated with indoor mold exposure and/or sinus fungi they might want to report. Future epidemiological and clinical studies might find it useful to investigate possible associations between environmental exposures including indoor molds/ bacteria and sexual/ reproductive health.

DISCUSSION AND CONCLUSIONS

Many toxic exposures have been linked to erectile dysfunction including active and passive tobacco smoking, Cannabis smoking, exposure to solvents, pesticides, endocrine disrupting chemicals, heavy metals, and to toxic chemicals/ psychological stressors in warfare. Erectile dysfunction may possibly be linked to other exposures such as outdoor air pollutions, ionizing radiation, hazardous waste, and indoor exposures to mold/ water damage. The harmful effect of many of these toxic exposures may possibly be worsened synergistically by other toxic exposures, psychological stress, nutritional or genetic problems, or other comorbid medical conditions.

Further investigation of the relationships between environmental exposures and erectile function are clearly needed [76]. Questions about smoking, occupation, food and water consumption, and indoor and outdoor chemical exposures should be asked during all workups of sexual and reproductive function. Likewise, questions about smoking and other toxic exposures should probably be made for every comprehensive study of sexual and reproductive health. Studies with examine the possibly links between indoor mold/ bacteria/ water damage might be especially interesting since mold exposure is strongly associated with sinusitis and sinusitis is strongly associated with erectile dysfunction.

Reducing toxic exposures from smoking and other sources are critical for optimum erectile and sexual health. There are many methods which are helpful in quitting smoking including high tobacco taxes, public smoking bans, public/ media/ clinical health warnings, social and psychological support, and pharmacotherapy such as nicotine gum may all be useful [10]. Many methods are useful in reducing community and workplace exposure to toxic chemicals, including better occupational and environmental laws, more indoor ventilation, use of less toxic chemicals, and personal protective equipment like masks, gloves, clothing, etc.

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CONFLICT OF INTEREST STATEMENT

I declare no conflict of interests. I have no financial interests in companies which provide analysis or remediation of mold and moisture problems, medical treatment, and psychological/ psychosexual treatment.

AUTHOR CONTRIBUTION

Luke Curtis performed all of the work including the literature review, and writing and editing the paper.

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