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The construction industry

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21.1 Introduction

Construction of domestic and commercial structures as well as roads and other public works is performed in virtually all societies. In 2007, 7.8 million workers were employed in the construction sector in the USA, representing 5–6% of total nonfarm employment (source: US Bureau of Labor Statistics, Current Employment Statistics Survey). Occupational health issues, including respiratory disorders, among construction workers are often quite challenging. The great variation in work processes and tasks, as well as the continually changing workplace settings often impede the ability of managers and workers to anticipate, document and prevent hazardous exposures.

The multiplicity of potential respiratory hazards associated with construction jobs guarantees that many physicians will be challenged to manage respiratory diseases among construction workers and to assess the significance of job exposures on disease occurrence in the clinical findings. In this section, we discuss the types of exposures to respiratory hazards that may be encountered in the construction setting and the potential health effects, including (1) nonmalignant conditions; (2) malignancies; and (3) immunologic conditions, with an emphasis on asthma.

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21.2 Inhalation hazards in the construction industry

21.2.1 Introduction

The scope of construction projects ranges from simple, small-scale jobs such as building a deck or patio at a single family home, to massive and complex undertakings such as construction of dams, highways, power plants and office towers. Because of the nature of construction, workers in this industry may experience a diversity of worksite exposures. While a limited number of companies have hundreds or even thousands of employees, construction enterprises are typically small, often employing 75 or fewer individuals, with limited resources to address workplace safety and health. Work settings are frequently nonstandardized and changeable, and to maintain employment, workers often must change jobs and employers as some projects are completed and others are started. On the other hand, there are also large construction companies that can employ several thousand workers. Adjacent construction activities can result in exposures to substances that are unrelated to the worker's particular job tasks. Considering these factors, as well as the almost daily changes in weather and work locations, the evaluation and control of hazardous airborne exposures for a construction worker are uniquely challenging.

21.2.2 The hazards

Construction respiratory hazards can be grouped into three main categories: particulates (including fumes), gases and vapors, and sensitizers. This chapter summarizes some of the most commonly recognized hazards in construction work. Exposure to welding fumes can be encountered on construction sites with potential for acute and chronic lung effects, and metal fume fever; however, welding is covered elsewhere in this book (Chapter 14) and is not considered further here. Paints are frequently present during construction activities but the health effects of exposure to paints are covered elsewhere (Chapter 18). Building materials used in construction are often obtained in the region of the project, to reduce transportation costs of these often bulky and dense materials. The content of masonry, stone and other building materials is thus often determined by the locally available raw materials. To better anticipate potential workplace respiratory hazards, occupational physicians should become familiar with the mineralogy (and particularly the content of free silica and asbestiform fibers) of the materials commonly used for construction in their region. Other exposures often encountered are wood dust and asbestos in removing old pipe fittings in renovations and demolition construction work.

Respirable particles

These include silicates, crystalline silica, fibers, fumes, fungal and mold spores, and wood.

- Silicates – in the construction industry, silicates are often associated with the soil in which the construction activity is taking place. Silicates in the form of clay are commonly encountered during earth works, but may not pose much of a respiratory hazard if they remain damp. Portland cement dust, which may be released during some construction work, is composed largely of calcium silicates, aluminates and alumino-ferrites, but may also contain hexavalent chromium.

Crystalline silica – the form of crystalline silica most commonly associated with construction is quartz. Quartz is a major component of the earth's crust and is found in many types of rock, especially sandstone and granite. Respiratory hazard ensues when quartz or other forms of crystalline silica (cristobalite, tridymite) are mechanically disturbed and rendered into respirable-sized particles. Construction sand can be 80–99% quartz, depending on the source. Masonry is generally obtained from natural mineral sources, which also often contain quartz. Mortar for building masonry structures generally consists of silica sand combined with Portland cement and water. Concrete is a mixture of cement, water and appropriately sized mineral aggregate. The aggregate comprises a controlled mixture of sized rock, gravel and sand. The combination of masonry, concrete and steel re-enforcement is prized the world over for its strength, longevity and low maintenance. Hazardous exposures to respirable crystalline silica are possible whenever particulates are generated through disturbance of rock, concrete, mortar or masonry, during new construction, renovation or demolition. Proper engineering controls must be used to prevent dust from becoming airborne.

Fibers – for occupational health purposes, particles with a length-to-diameter ratio of 3 : 1 or greater are considered to be fibers. Respirable fibers are less than 1.3 μm in diameter and can be up to 200 μm long. Fibers may either be man-made (fibrous glass, mineral wool and refractory ceramic fibers) or naturally occurring, such as asbestos. Asbestos is the term used for a special group of naturally occurring silicate minerals. There are several forms of asbestos; the most common is chrysotile, a fibrous form of serpentine. When disturbed, asbestos breaks into respirable filaments. In the USA, Europe and elsewhere, because of restrictions on its use (29CFR 1910.1001 OSHA, 40CFR61 and 40CFR763 EPA, Commission Directive 1999/77/EC), asbestos is generally only encountered in the construction industry during renovations and demolition of industrial and commercial structures in which it was used for thermal insulation. Fibrous glass is used for thermal and acoustic insulation, in the form of flexible blankets or rigid boards, and is also used in bathroom fixtures such as tubs, sinks and shower stalls. Fibrous glass may also be added to particular types of concrete and mortar for its strength and thermal properties. Mineral wools have applications similar to those of fibrous glass. Refractory ceramic fibers are spun from molten kaolin clay, silica and minor amounts of oxides. Because of their thermal insulation properties, refractory ceramic fiber products are used to insulate furnaces, stoves and chimneys, and to protect industrial equipment from high temperatures.

Fumes – fumes encountered in the construction industry include metals from welding/torch cutting, products of combustion including diesel and other fuels, and hot asphalt (see http://www.osha.gov/SLTC/weldingcuttingbrazing/chemicals.html).

Fungi and molds – contaminated drywall, carpet, wood or other surfaces may be encountered especially during renovation and demolition. Varieties of aspergillus, plasmopara viticola, dictyostelium discoideum, tricoderma koningii, slime molds and other fungi and molds may be present.

- Wood – beech and oak are confirmed human carcinogens. Birch, mahogany, teak and walnut are suspected human carcinogens. A number of commercially important tree species are also known or suspected to induce respiratory sensitization (see Appendix D of 2006 ACGIH TLV, p. 84). Sawing or other contact with wood that has been treated to retard deterioration may result in worker exposures to oxides of chromium, copper and arsenic. Chromated copper arsenate, acid copper chromate, ammoniacal copper arsenate and ammoniacal copper zinc arsenate are or were common compounds used in wood treatment.

Gases

Gaseous exposures during construction work may include oxygen, ozone, oxides of nitrogen and acetylene used in welding and oxy-acetylene cutting of metals.

Chemical vapors

Chemical vapors may be present from evaporation of solvents, paints, laquers, fuels and oils associated with heavy construction equipment or from off-gassing of construction materials such as carpeting and plywood.

Sensitizers and asthmagens

Diisocyanates are important sensitizers often encountered in the construction industry and may be components of adhesives, epoxies, paints and spray thermal insulation. Other sensitizing exposures include chromium and nickel compounds (for welders and cutters); resins (electricians); soldering fumes and welding fumes (welders); wood dust and formaldehyde (construction carpenters); water-based paints with azidine and lacquers with formaldehyde and microbiocides (painters and lacquerers); chromium-containing cement dust and epoxy adhesives (bricklayers and tile setters); and methylmethacrylates (reinforced concrete layers). Numerous other man-made and naturally occurring substances are classified as asthmagens (see AOEC website list: http://www.aoec.org/tools.htm).

21.3 Diseases associated with exposures in construction work

21.3.1 Chronic obstructive pulmonary disease and the pneumoconioses

Chronic obstructive pulmonary disease (COPD) is characterized by airflow limitation that is not fully reversible. Predominant pathological features of COPD are emphysema, small airways disease and chronic bronchitis. The association between occupational exposures to dusts, gases and fumes and COPD was firmly established through a series of systematic epidemiological investigations. In 2002, the American Thoracic Society estimated that, based on the available epidemiologic evidence, about 15% of all cases of

COPD in the US population were attributable to occupational exposures. Nevertheless, because COPD is also associated with tobacco smoking, which is prevalent among construction workers and other blue collar populations, the role of occupational exposures in the etiology of COPD is often neglected.

Depending on the specific work processes and the effectiveness of dust control activities, construction workers can potentially be exposed to relatively high levels of fibrogenic mineral dusts (e.g. asbestos and silica), causing pneumoconiosis, and non- or weakly-fibrogenic dusts, which can also be associated with adverse lung effects (e.g. emery, graphite, gypsum, marble, mica, plaster of Paris, Portland cement, silicon, soapstone). Other harmful exposures in construction that can increase the risk of chronic airflow limitation include irritant gases and fumes (e.g. welding, painting, blasting fumes, combustion exhaust, asphalt, adhesives, sealants, hydrochloric acid), man-made mineral fibers and organic dust (e.g. wood). Airflow limitation in construction workers may thus be related to mineral dust-induced pneumoconiosis and nonfibrotic changes in airways associated with exposures to dusts, gases and fumes. The effects of each of these agents may be aggravated in some exposed individuals by associated mycobacterial lung infections. Although the adverse effects of many of these agents has been established in epidemiologic studies conducted across a wide spectrum of industrial workers, epidemiologic research carried out among construction workers has helped to ascertain the potential of the above agents for causing respiratory mortality and morbidity in these workers.

COPD Mortality Studies

Taken together, studies carried out among construction workers in different countries have shown a clear pattern of elevated respiratory disease mortality, although there is variation in the strength of the association with construction employment; the differences may in part be explained by differing construction techniques, materials, and dust control programs.

In the USA, surveillance data indicate that the number of deaths from asbestosis and silicosis is highest in workers who report they have worked primarily in the construction industry. Asbestosis deaths represented about one-third of all pneumoconiosis mortality during the 10-year period from 1990 to 1999 and the annual number of asbestosis deaths among US residents continues to increase. Occupations with the highest adjusted proportional mortality rate (PMR) from asbestosis are insulation workers, boilermakers, plumbers, pipe-fitters, plasterers, electricians, welders, brick and stone masons, crane and tower machine operators, and carpenters. Reports of deaths from silicosis in the USA declined from 1968 to 1999; in recent years the construction industry has accounted for 13.4% of all deaths from silicosis. Occupations with elevated PMR from silicosis included machine operators and construction labourers.

US surveillance data also demonstrate elevated COPD mortality in the construction industry (Table 21.1). Occupations with elevated mortality included a number of construction trades: excavation and loading machine operators, followed by drywall installers, painters, construction and maintenance, carpenters and construction labourers. Smoking can potentiate the effect of construction exposures on COPD. A mortality study of California construction workers found an elevated adjusted standardized mortality ratio (SMR) for COPD, but SMRs for other unhealthy life-style-related causes of death were also significantly elevated.

Table 21.1 Summary of epidemiologic findings: mortality studies among construction workers

Mortality studies	Outcome	Finding	Comment
Work-related Lung Disease Surveillance Report 2002 (2003) US Department of Health and Human Services, Public Health Service, CDC/NIOSH.	COPD	PMR = 1.19 (1.16–1.23)	Risk higher in construction trades, excavation, machine operators
Burkhart, G. *et al.* (1993) *Am. J. Ind. Med.* **24**: 413–425.	COPD	SMR = 1.2 (0.89–1.58) white workers SMR = 1.5 (0.74–2.65) black workers	Increase in unhealthy lifestyle-related causes of death
Bergdahl, I.A. *et al.* (2004) *Eur. Respir. J.* **23**: 402–406 (*N* = 317,629)	COPD	HR = 1.10 (1.06–1.14) all workers	Exposure to inorganic dust
		HR = 2.30 (1.07–4.96) never smokers	Exposure to inorganic dust
		HR = 3.9 (2.50–5.94) never smokers	Exposure to gases and irritants
		HR = 4.4 (2.80–7.04) never smokers	Exposure to fumes
Thuret, A. *et al.* (2007) *J. Occup. Environ. Med.* **49**: 546–556 (*N* = 12,788)	NMRD	SMR = 77 (56–102)	Only mortality from cancer was elevated

NMRD = non-malignant respiratory disease

In a mortality study of 317,629 Swedish male construction workers, followed from 1971 to 1999, the COPD mortality hazard ratio was higher among never smokers for exposure to inorganic dust (hazard ratio, HR = 2.30, 1.07–4.96), gases and irritants (HR = 3.85, 2.50–5.94) and fumes (HR = 4.44, 2.80–7.04). On the other hand, in a mortality study of a cohort of 12,788 French construction workers, followed up from 1974 to 1999, SMR was primarily increased for cancers of the digestive and respiratory system.

COPD Morbidity Studies

Several large epidemiologic studies have shown associations between deficits in ventilatory lung function and construction work. A US population-based study found elevated adjusted odds ratio for COPD (based on spirometry criteria) for persons who reported their longest held job to be in the construction industry, in comparison to those who reported their longest held job as office workers, although the increase was not statistically significant (OR = 1.3, 95% CI 0.8–2.3). COPD morbidity was observed to be significantly increased among nonsmoking construction trade labourers, and in African-Americans and Mexican-Americans construction workers.

Among Norwegian tunnel workers with exposures to both respirable dust and quartz (mean exposures 1.2–3.6 and 0.019–0.044 mg/m^3, respectively), FEV_1 was significantly decreased and was also further reduced in association with blasting fumes. Among Dutch concrete workers the prevalence of COPD (based on spirometry) was 7% vs 3% in a comparable control group of nonexposed workers. The workers demonstrated significant deficits of lung function (FEV_1/FVC and MMEF) in association with average concentrations of 0.8 mg/m^3 respirable concrete dust and 0.06 mg/m^3 respirable silica. Among Dutch construction workers, lung function was significantly lower in comparison to a reference population, after adjusting for age and pack-years smoked; chest radiological changes (profusion category 1/1 or greater predominantly irregular opacities) were associated with a further increased risk of airflow limitation. Increased risks of airflow obstruction have also been observed among construction painters, arc welders and construction insulators.

Elevated risks of chronic bronchitis have been reported among construction workers exposed to spray-painting, asbestos, man-made mineral fibers, metal fumes, arc welding operations, and heavy construction and tunnel operations.

Conclusion

Considerable epidemiologic evidence supports a causal link between the development of COPD (including the health outcomes of airflow limitation, chronic bronchitis and emphysema) and occupational exposures in construction work, broadly defined as gases, vapors, dusts and fumes. When a clinician evaluates the effect of occupational exposure in an individual, the available epidemiologic evidence needs to be considered together with the individual's occupational exposure history, as well as the magnitude of any other risk factors for respiratory disease, such as tobacco smoking. It is difficult to precisely quantify the relative contributions of smoking and occupational exposures in an individual worker. However, the epidemiologic evidence makes it clear that inhalation exposures that are routinely encountered in construction work can cause and contribute to the development of obstructive lung disease, and simply because a construction worker has been an active smoker does not mean that occupational factors did not play an important role in the development of his or her lung disease.

The literature cited above emphasizes the importance of prevention of COPD in construction workers through the application of best practices for exposure control. Evaluation of individual occupational exposures should be done and, whenever possible, hazardous exposures should be reduced or eliminated through substitution of less hazardous materials or engineering controls (e.g. process enclosure, workplace ventilation). Administrative controls and revised work practices may also help limit hazardous occupational exposures. Finally, comprehensive programs for application of personal protective equipment (e.g. respirators) should be recommended when other measures are infeasible or insufficient by themselves. In addition, construction workers exposed to conditions and agents that have been associated with significant adverse respiratory health effects should be monitored for their respiratory health, using standardized respiratory questionnaires and lung function testing. In individuals whose respiratory health monitoring results suggest adverse effects, interventions should be initiated. Periodic discussions with individual workers about their lung function test results (level of lung function or the rate of lung function decline) can help to guide decisions and may improve adherence to actions directed at preventing further excessive lung function loss. Additional steps to decrease inhalation of noxious particulates and gases are usually the most important interventions.

Among smokers, complete smoking cessation may be required to halt excessive lung function decline. The potential for additive effects of smoking and occupational exposure on excessive decline in lung function should be explained to individuals who smoke and are exposed to occupational respiratory hazards. Weight gain also contributes to lung function decline, due to loss of fitness and reductions in total lung capacity. Management commitment to an integrated worksite health and safety program provides a key foundation for success in maintaining a healthy workforce. Programs are likely to be more effective when they address workers' concerns about health risks on the job as well as wellness issues. Smoking (for example) should be addressed in the broader context of a comprehensive worksite health and safety policy. Intervention at the individual level is then more likely to be successful.

21.4 Asthma and selected immunologic conditions

This section focuses largely on asthma and follows with brief consideration of some other immune-mediated respiratory conditions that may occur among construction workers, such as hypersensitivity pneumonitis and beryllium disease.

21.4.1 Asthma

Although there has been considerable attention given to dust diseases and cancer outcomes in construction, investigation of work-related asthma in this sector has been neglected. As discussed above, both airborne sensitizing and irritating agents can be encountered in the construction environment.

Population-based studies

A number of studies have been published from a range of countries and with various outcome definitions. Most but not all studies found construction workers to be at increased risk of asthma. It should be emphasized that workers may experience new-onset occupational asthma (OA) from job-related exposure to sensitizers. However, individuals with pre-existing asthma may experience worsening of their asthma at work associated with exposures to nonspecific dust or irritants, a condition termed work-aggravated asthma (WAA). WAA occurs in approximately 1 in 4 working adult asthmatics, and is associated with a diminished quality of life. Construction work often involves exposures to agents and conditions associated with WAA such as chemicals, including cleaning products, paints and solvents; dust; second-hand cigarette smoke; gases, fumes, odours or smoke; exertion; very cold air; and hot, humid or polluted outdoor air. Investigators have estimated the prevalence rate of various reported respiratory conditions based on a national probability sample of construction workers from data collected for the 1988 National Health Interview Survey. Prevalence rates of respiratory conditions among (white) men who indicated they had experience in the construction industry were compared with those found among other workers who participated in the survey. Asthma was reported less frequently by construction workers than by the other workers. The authors felt that, since sensitized individuals or those having a significant response to workplace irritants (perhaps work-aggravated or work-exacerbated asthma) 'may voluntarily leave the construction workforce, additional research should investigate the potential role of health-related employment migration in reducing the rate of asthma reported by construction workers'. This possible explanation regarding survivor bias/dropout should be borne in mind (that is, relative risks for asthma morbidity in the construction industry may be underestimated).

Specific occupations

The incidence of asthma among male workers in the construction industry in Finland was examined as a follow-up to a population-based study. The study was a comprehensive registry-based nationwide follow-up (cohort) study, and thus provided relatively rigorous evidence. The authors determined asthma incidence for men without pre-existing asthma employed in the construction trade and a comparison group employed in administrative work, for the interval from 1986 to 1998. Follow-up was conducted using two national registries (Medication Reimbursement Register and the Finnish Register of Occupational Diseases). Significantly increased risks for asthma onset were demonstrated for a number of construction occupations, as shown in Table 21.2. Among those with the highest risks were painters and lacquerers and insulation workers, where isocyanates may be used. Of interest, only 2% of the cases of asthma among construction workers had been recognized as OA (i.e. through the Finnish national compensation process), suggesting a lack of recognition or reluctance to file claims. In a separate report, Vandenplas *et al.* described two cases of OA in construction (wood-roof maintenance) workers. Of note, both affected individuals were sensitized to a prepolymer, but not the monomer of toluene diisocyanate (TDI). The risk for sensitization to newer oligomer forms of isocyanates has been of increasing concern.

Table 21.2 Epidemiologic study of the risk of asthma in construction work[a]

Occupation	N	Population	Incidence rate per 1000 workers per year	Relative risk (95% CI)
Administrative, managerial and clerical work	1,275	79,087	1.23	1.00 (referent)
Motor vehicle drivers	114	3992	2.15	1.71 (1.41–2.07)
Sheet metal workers	70	3166	1.62	1.59 (1.25–2.02)
Plumbers	193	6502	2.20	1.90 (1.63–2.21)
Welders and flame cutters	56	1664	2.53	2.34 (1.79–3.06)
Construction carpenters	406	16,546	1.77	1.51 (1.35–1.68)
Cabinet makers and joiners	18	737	1.85	1.77 (1.11–2.82)
Painters and lacquerers	182	6319	2.10	1.75 (1.50–2.04)
Bricklayers and tile setters	82	2818	2.09	1.83 (1.46–2.28)
Concrete shutterers and finishers	33	1067	2.17	1.67 (1.19–2.37)
Insulation workers	51	1950	1.96	1.78 (1.34–2.35)
Assisting building workers	325	12,348	1.92	1.65 (1.11–2.38)

[a]Table adapted from Karjalainen, A., Martikainen, R., Oksa, P., Saarinen, K., Uitti, J. (2002) Incidence of asthma among Finnish construction workers. *J. Occup. Environ. Med.* 44: 752–757.

Exposure to isocyanates during construction activities

Studies from Canada, the USA and France have identified the potential for exposure to methylene diphenyl diisocyanate (MDI), a commonly used type of isocyanate, during construction activities, including during the process of insulating buildings with sprayed polyurethane foam. Concentrations exceeding established limits were observed for both indoor and outdoor sprayers. Both the applicator and assistants could be exposed. In a recent study which measured both monomer and oligomeric MDI, the average monomer concentration exceeded the permissible exposure limit (ceiling) at distances ranging up to 6–12 m. The current ACGIH TLV of 0.005 ppm is one-quarter of the PEL. The aerosol particle size measurements indicated a mean respirable fraction of 20%, while approximately two-thirds of the total mass of the airborne particles in the spray foam aerosol were greater than 3.5 μm in diameter. Recent investigations have linked skin contact with isocyanates to respiratory sensitization, implying that exposures to larger 'nonrespirable' particles may also be biologically relevant.

21.4.2 Other immunologic conditions

Beryllium

A large survey was undertaken to screen for beryllium disease among 3842 current and former construction workers at Department of Energy (DOE) nuclear sites in the USA. Screening with a beryllium blood lymphocyte proliferation test (BeLPT) was offered to all current workers as well as many who had left employment years before the examination took place. The findings indicated that only a minority of workers had any awareness of the presence of beryllium (Be), let alone knowledge of potential work tasks or locations in which exposure to Be could have taken place. About one-third reported exposure to beryllium; overall 2.2% had at least one abnormal BeLPT and 1.4% were also abnormal on a second test. Having worked in a building with potential beryllium exposure (i.e. where beryllium activities had taken place) was a strong and significant predictor for an abnormal BeLPT (odds ratio 3.4, 95% CI 1.3–8.8). A small number of participants (five) were diagnosed with chronic beryllium disease (CBD), a rate that was lower than the expected prevalence in other more highly exposed populations, where the rate of CBD among those sensitized to beryllium has been reported occasionally as high as 50%. The Be exposure among these construction workers was different (probably lower) than in production facilities; however, coupled with the BeLPT findings, this study indicates that significant exposures can occur among construction workers, most likely during maintenance, repairs, renovation or demolition in facilities where beryllium was used.

Hypersensitivity pneumonitis

Hypersensitivity pneumonitis (HP) is a lung disorder which occurs in a small proportion of individuals exposed to organic dusts, and may also be triggered by commonly encountered workplace chemicals such as isocyanates. There are few reports of HP specifically occurring in construction workers; however, the possibility should be kept in mind. There is a likelihood of exposure to hazards for HP and a related disorder, organic dust toxic syndrome, during demolition and renovation of old or abandoned structures, especially in agricultural environments, such as grain storage bins. Hypersensitivity pneumonitis has been recognized in the construction industry in Spain among stucco makers and plasterers exposed to Esparto grass. Esparto grass is a plant widely distributed in the south of Europe and North Africa, used in the manufacturing of clothing and especially as supporting material for plaster plaques and molds in the building industry. Cases of HP have been reported in individuals who have demonstrated precipitating antibodies to one of several workplace agents, including *Aspergillus fumigatus*, thermophilic microorganisms and Esparto extract. In fact, in Spain, Esparto is one of the most frequently identified agents causing HP.

21.5 Occupational cancers

21.5.1 Epidemiologic studies of cancer

Many (but not all) published studies of male construction workers from North America and Europe have documented an increased risk of several specific malignancies (Table 21.3). The observation of an excess risk for lung cancer has been a particularly consistent finding, and the risks observed in construction have in general remained significantly elevated after controlling for the effects of tobacco smoking. For many cancer hazards found in the construction work environment, increased risks for both adenocarcinoma and squamous lung cancer histologies have been observed. Significant increases in proportionate mortality have also been observed for cancers of the nasopharynx and larynx among male construction workers. Increased risks have also been observed for upper gastrointestinal cancers, particularly adenocarcinoma. An elevated overall risk of cancer-related mortality has also been observed in some but not all studies of construction workers. Fewer investigations have been reported among female construction workers and few studies are available from Asia or South America,

Table 21.3 Epidemiologic studies of the risk of malignancy in construction work

Malignancy	Statistic	Value[a]	Implicated job/agent	Reference and comments[b]
All cancer	SMR	0.89	All construction	Arndt, V. *et al.* (2004) *Occup. Environ. Med.* **61**: 419–425.Cohort
Bone sarcoma	OR	2.93	Construction workers	Merletti, F. *et al.* (2006) *Int. J. Cancer* **118**: 721–27. CC, Smk Adj
Bone sarcoma	OR	4.25	Carpenters, joiners	Merletti, F. *et al.* (2006) *Int. J. Cancer* **118**: 721–727. CC, Smk Adj
Buccal cavity	PMR	1.43	All construction	Wang, E. *et al.* (1999) *Appl. Occl. Environ. Hyg.* **14**: 45–58. Cohort
Esophageal adenocarcinoma	IRR	3.8–4.5	Construction (high exposed, asbestos and cement)	Jansson, C. *et al.* (2005) *Cancer Causes Control* **16**: 755–764. Cohort, Smk Adj
Gastric (cardia)	IRR	2.3–4.8	Construction (high exposed, asphalt fumes, wood dust)	Jansson, C. *et al.* (2005) *Cancer Causes Control* **16**: 755–764. Cohort, Smk Adj
Gastric	IRR	1.3–1.5	Cement, quartz, diesel	Sjodahl, K. *et al.* (2007) *Int. J. Cancer* **120**: 2013–2018. Cohort, Smk Adj
Laryngeal	OR	2.42	Cement, high exposed	Dietz, A. *et al.* (2004) *Int. J. Cancer* **108**: 907–911. CC, Smk Adj
Larynx and hypopharynx	OR	2.61	Concrete workers	Boffetta, P. *et al.* (2003) *Cancer Causes Control* **14**: 203–212. CC, Smk Adj
Laryngeal (squamous)	RR	1.7	All construction (asbestos, wood)	Brown, L.M. *et al.* (1988) *Cancer Res.* **48**: 1960–1964. CC, Smk Adj
Lip cancer	RR	1.7	Construction work (sunlight)	Nordby, K.C. *et al.* (2004) *Cancer Causes Control* **15**: 619–626. Cohort, no exp-resp
Lung	OR	1.4	All construction	Richiardi, L. *et al.* (2004) *Cancer Causes Control* **15**: 285–294. CC, Smk Adj
Lung	SMR	0.70–0.83	Heavy equipment operators, Diesel	Jarvholm, B. *et al.* (2003) *Occup. Environ. Med.* **60**: 516–520. Cohort, Smk Adj Reduced cancer risk with use of closed cabs
Lung	SMR	1.12–1.37	Truck drivers, Diesel	Jarvholm, B. *et al.* (2003) *Occup. Environ. Med.* **60**: 516–520. Cohort, Smk Adj
Lung	SMR	0.88	Asphalt workers	Bergdahl, I.A. *et al.* (2003) *Am. J. Ind. Med.* **43**: 104–108 (exposures and cancer incidence lower after 1965)

Lung (nonadenocarcinoma)	OR	1.4–2.5	Silica, concrete	Siemiatycki, J. *et al.* (1989) *Am. J. Ind. Med.* **16**: 547–567. CC, Smk Adj
Lung	PMR	1.13	All construction	Wang, E. *et al.* (1999) *Appl. Occl. Environ. Hyg.* **14**: 45–58. Cohort
Lung (all cell types)	OR	1.5–3.6	Wood dust exposed, (mainly carpenters)	Barcenas, C.H. *et al.* (2005) *Am. J. Ind. Med.* **47**: 349–357. 05, CC, Smk Adj (light smokers included as nonsmokers)
Malignant melanoma (head, eye, neck)	RR	2–3.4	Sunlight (high exposed)	Hakansson, N. *et al.* (2001) *Epidemiology* **12**: 552–573. Cohort
Myeloma	IRR	1.3	Diesel exhaust exposed	Lee, W.J. *et al.* (2003) *Int. J. Cancer* **107**: 134–138. Cohort, Smk Adj, no exp-response
Pharynx	PMR	1.34	All construction	Wang, E. *et al.* (1999) *Appl. Occl. Environ. Hyg.* **14**: 45–58. Cohort
Sino-nasal (adenocarcinoma)	OR	5.8	Carpenters (wood)	Luce, D. *et al.* (1992) *Am. J. Ind. Med.* **21**: 163–175. Smk Adj
Sino-nasal (squamous)	OR	3.7–8.1	Construction, carpenters	Luce, D. *et al.* (1992) *Am. J. Ind. Med.* **21**: 163–175. CC, Smk Adj

[a]For most studies, only male construction workers were included.

[b]CC indicates case-control design; Smk Adj indicates study adjusted for tobacco smoking.

but several of these studies have observed an increased risk of cancer mortality among these construction workers.

Lung cancer hazards have been recognized from various construction exposures, including asbestos, silica and certain man-made vitreous fibers (particularly refractory ceramic fibers), as well as insulation materials made from asbestos-contaminated vermiculite. Important exposures to these materials have occurred in new construction, and although application of these materials has been restricted, potential hazards continue during repair, renovation and demolition of various structures. Other potentially carcinogenic exposures have been identified in construction workplaces. Workplace exposures to cement dusts, whose hazardous constituents can include silica and asbestos, as well as hexavalent chromium, have been documented as a cancer risk. Other cancer hazards that have been reported in specific construction environments include arsenic, found in treated wood products, beryllium and nickel compounds. Diesel exhaust exposure in construction has been documented to result in airborne levels of polycyclic aromatic hydrocarbons (PAHs, recognized lung carcinogens) that can exceed recommended levels. There is some evidence that use of air-conditioned cabs on diesel equipment is protective. Asphalt fumes in road construction and roofing tars can also result in exposures to PAHs, and fumes from solvents used in various processes may include exposures to toxins to the lymphatic and hematologic systems. Exposures to fumes containing cadmium, nickel and chromium have been documented in welders. Formaldehyde is used in many adhesives and coatings, and potentially important exposures have been documented in construction settings. Construction, repair and demolition projects in the nuclear industry can entail significant exposures to ionizing radiation.

Despite the complexity of the construction work environment and the difficulty in documenting exposures for individuals in construction work, epidemiologic studies in this industry have related several exposures to particular cancer risks. Some studies among construction workers who have high levels of exposure to solar radiation have demonstrated elevated rates of skin cancers, including squamous carcinoma of the lip, and malignant melanoma of the face and eye. Lung cancer in construction workers has been associated with exposures to asbestos and cadmium, while laryngeal cancer and malignant mesothelioma have been related to exposure to asbestos fibers.

Studies of wood dust exposures among carpenters and special trades construction workers have associated inhalation of these dusts with cancers of the nose and sinus mucosae. The evidence of carcinogenicity of hardwoods is judged to be stronger than for soft woods, although both exposures have been implicated. There is also some evidence that inhalation of wood dusts may result in other cancers, including lung cancer and bone sarcomas.

21.5.2 Neoplasms in construction workers: diagnosis and management issues

The clinician may not infrequently encounter a malignant neoplasm arising in an individual who has worked in the construction industry. The contribution of the workplace to the etiology must be considered, and is often a challenging issue. As described elsewhere in this chapter, depending on the specific tasks and processes, construction work can involve exposure to several agents and dusts which are recognized carcinogens. Because of the nature of construction work, exposures are often extremely variable between tasks and projects, and few data are available to document the frequency, duration and levels of exposure to most workplace hazards in construction. Additionally, construction settings are often arrayed such that significant exposures can result from adjacent activities (such as cutting, grinding, welding, insulating, etc.), and individuals experiencing such 'bystander' exposures may be unaware of the risk or the need for protection. When evaluating a construction worker with a malignancy, the clinician may be presented with a formidable challenge in documenting the worker's history of exposure to potential carcinogens. It may be necessary to review in considerable detail the projects and tasks in which the patient participated or was a significant bystander, querying specifically about carcinogens that are potentially present during specific types of construction. Table 21.3 catalogs a number of major studies which have assessed the association of construction work with cancer.

21.5.3 Cancer in construction workers: summary

Attribution of causality is challenging for a cancer patient with prior reported exposures to carcinogens in construction work. Similar to other occupational exposures, the probability of a work-related malignancy increases with the intensity, frequency and duration of reported exposures. Conversely, the likelihood that a tumor is causally related to exposure decreases when the latency period is atypical (i.e. unusually long or short), if there is documentation of the effective application of exposure controls and when there are substantial exposures to competing causes such as tobacco smoking. In some individuals, the etiology can be presumptively confirmed by the demonstration in tissues of the agent and/or response (e.g. lung cancer in a worker who has been diagnosed with asbestosis or silicosis, or in a patient whose sputum cytology or lung tissue has demonstrated asbestos fibers or ferruginous bodies). At times, the specific cell-type of the tumor is an important factor (e.g. mesothelioma is presumed occupational in an individual with prior workplace asbestos exposure). Diagnosis and management of malignancy attributed to exposures in construction work is, in general, not different from the treatment of similar cancers in other settings, although concurrent occupational diseases may complicate treatment or obviate curative resection.

21.6 Other conditions

Construction workers may also develop respiratory infections and irritant effects related to exposures. For completeness, it should be noted that construction work presents a greatly increased risk of trauma due to injuries on the job.

21.6.1 Infections

Construction workers involved in excavation in tropical or subtropical areas may be at risk for nocardia, particularly if they have risk factors for deficient cell-mediated immunity such as immunosuppressive therapy or lymphoma. When soil is disturbed during road work and other construction activities in endemic regions, workers may be exposed to fungal spores and thereby be placed at risk for developing certain fungal lung infections. Histoplasmosis (often associated with bird droppings) and coccidioidomycosis commonly occur in individuals with normal immune systems. Construction workers with silicosis are at increased risk for tuberculosis and nontuberculous mycobacterial infections. Legionnaires' disease has been related to construction activities involving excavation as well as work in proximity to water cooling towers.

21.6.2 Irritant effects

Depending on the agent and intensity of exposures, construction workers can experience upper respiratory tract mucous membrane irritation, bronchitis, bronchiectasis and acute respiratory distress syndrome. Painters and other construction workers may experience mucous membrane and lower respiratory tract irritation associated with multiple dust exposures as well as inorganic and organic chemicals such as hydrochloric acid and organic solvents, including components of paints, varnishes or lacquers such as methyl ethyl ketone, acetone and *n*-butyl lactate.

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Occupational and Environmental Lung Diseases

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