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Mesothelioma in vehicle mechanics: is the risk different for Australians?

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Background The question of whether vehicle mechanics have an increased risk of mesothelioma has important public health implications. Calculations of relative risk using case reports from the Australian Mesothelioma Registry (AMR) indicate increased risks; however, this contrasts with the results of 19 epidemiologic studies that have found no association.

Aim To evaluate potential explanations for the discrepancy of findings from epidemiologic studies and AMR reports.

Methods We evaluated three hypotheses as possible explanations for the inconsistency between the AMR-based calculations and the findings from published epidemiologic studies: (i) differences in exposure characteristics of Australian vehicle mechanics versus vehicle mechanics in North America and Europe, (ii) limitations of the AMR data and (iii) errors in the risk calculations based on AMR data. We reviewed available exposure information specific to Australian vehicle mechanics and AMR data, obtained from the Australian National Occupational Health and Safety Commission, for this evaluation.

Results We did not identify differences in workplace exposures, processes or fibre type among Australian vehicle mechanics compared to vehicle mechanics in other countries. Our analysis of primary AMR data identified several errors in exposure classification and in the assumptions used to calculate relative risk.

Conclusions Discrepancies between epidemiologic studies and AMR-based calculations cannot be explained by differences in exposure. These discrepancies are most likely attributable to inadequate occupational information and classification in the AMR from 1986 forward and to erroneous assumptions used to derive relative risk estimates for mesothelioma among Australian vehicle mechanics.

Key words Asbestos; brakes; epidemiology; mesothelioma registry; motor mechanics; motor vehicle mechanics.

Introduction

The question of whether vehicle mechanics have an increased risk of developing mesothelioma from their exposure to asbestos during brake work has been addressed in numerous epidemiologic studies in North America and Europe [1–19] (Table 1) and summarized in two meta-analyses [20,21] and a qualitative review [22]. The studies found no evidence of an association between work as an auto mechanic or brake work and mesothelioma. This finding has been disputed, however, with authors citing case reports of mesothelioma among auto mechanics and limitations in the epidemiologic studies [23,24].

The epidemiologic findings are in disagreement with calculations using the Australian Mesothelioma Registry (AMR). In a document prepared for the World Trade Organization (WTO), one panellist estimated that vehicle mechanics have a 10-fold increased incidence of mesothelioma based on data from the AMR [25]. AMR data were also used in similar calculations that suggested increased risk [26,27]. We explored three possible explanations for this apparent discrepancy: (i) exposure differences between North American and European versus Australian vehicle mechanics, (ii) limitations of the AMR data and (iii) errors in the risk calculations using the AMR data.

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Table 1. Summary of findings and key characteristics of epidemiologic studies of mesothelioma among vehicle mechanics

First author	Publication year	Study type	Exposure category	Exposed or observed cases	Exposed controls or expected cases	Total cases	Total controls	Relative risk estimate and 95% CI
Järvholm	1988	Cohort	Car mechanics	1	21 905 workers followed 19 years for incidence and 13 years for mortality			NA
Hansen	1989	Cohort	Auto mechanics	1[a]	21 800 workers followed 10 years			NA
Gustavsson	1990	Cohort	Bus garage workers	2	695 workers followed 35 years for mortality and 27 years for incidence			NA
McDonald	1980	Case–control	Garage	11	12	156	156	0.91[b] (0.35–2.34)[b]
Teta	1983	Case–control	Automobile repair and related service	1	5	147	464	0.65 (0.80–5.53)
Spirtas	1985	Case–control	Brake lining installation or repair	N/A	N/A	259	259	1.0 (0.6–1.6)
Woitowitz	1994	Case–control	Motor vehicle mechanics	16	28	324	497	0.87[b] (0.43–1.70)[b]
Teschke	1997	Case–control	Vehicle mechanics	6	20	51	154	0.8 (0.2–2.3)
Agudo	2000	Case–control	Mechanics, motor vehicles	3	14	54	162	0.62[b] (0.11–2.36)[b]
Hansen	2003	Case–control	Repair of motor vehicles and motorcycles	10	12.5	N/A	N/A	0.8 (0.4–1.5)
Hessel	2004	Case–control	Brake lining installation or repair	12	28	147	358	1.04 (0.46–2.22)
Welch	2005	Case–control	Tire or brake repair	8	6	24	24	1.50 (0.36–6.45)
Rolland	2006	Case–control	Skilled auto mechanic: maintenance or repair	NA	NA	375	714	1.15 (0.53–2.47)
Peterson	1980	PMR	Mechanics and repairmen, automobile (n = 1833 deaths)[c]	0[a]	0	NA	NA	0
Olsen	1987	PIR	Repair of motor vehicles and motorcycles (total number of deaths NA)[c]	0	N/A	NA	NA	0
Coggon	1995	PMR	Motor mechanics (n = 15 435 total deaths)[c]	12[a]	26	NA	NA	0.46 (0.24–0.80)
Milham	2001	PMR	Automobile mechanics and repair workers (n = 10 473 total deaths)[c]	7	9	NA	NA	0.75 (0.30–1.55)[b]
NIOSH	2002	PMR	Automobile mechanics (n = 66 787 total deaths)[c]	15[a]	19	NA	NA	0.81 (0.45–1.34)[b]
McElvenny	2005 (Appendix)	PMR	Motor mechanics (total number of deaths[c] NA)	60	80[b]	NA	NA	0.48 (0.37–0.62)

CI = confidence interval; NIOSH, National Institute of Occupational Safety and Health; PIR = proportionate incidence ratio; PMR = proportionate mortality ratio; NA = not applicable and N/A = not available.

[a]Results presented for pleural cancer.

[b]Values have been calculated using EpiInfo v3.2 (http://www.cdc.gov/EPIINFO/epiinfo.htm)

[c]Total number of deaths (all causes) among auto/vehicle mechanics.

Methods

To evaluate potential exposure differences, we considered three questions regarding exposure characteristics of Australian versus North American/European vehicle mechanics: (i) Are exposure levels to airborne asbestos fibres higher in Australia? (ii) Are there differences in the brake-handling procedures? and (iii) Do the asbestos fibre types used in brake linings differ? Published studies and unpublished reports were the source of information used to address these three exposure-related questions [28–42].

To better understand the types of data included in the AMR, we reviewed the literature describing AMR data collection procedures and evaluated de-identified information from the AMR pertaining to individuals reportedly engaged in brake manufacturing and/or repair. The AMR began as the Australian Mesothelioma Surveillance Program or the 'Program' in 1980 [43]. For each case, a full occupational and environmental history was obtained by direct interview [43]. Starting in 1986, the Program was replaced by a 'Register', which involved less systematic data collection resulting in less rigorous occupational and environmental data. Since 1986, ~40% of the exposure information is collected via a short questionnaire with the remaining collected by other programs [44].

Beginning in 1996, the National Occupational Health and Safety Commission (NOHSC) of Australia reports of AMR data listed a category called 'circumstances of exposure' that included 'brake linings—made/repaired'. The final NOHSC publication to provide information on this category included 78 total mesothelioma cases with occupational and non-occupational brake work (59 cases of exclusive exposure to brakes and 19 cases with other asbestos exposures) for the period 1986–2001 [44].

From NOHSC, we obtained de-identified hard-copy forms and electronic data pertaining to these 78 cases. Because the electronic database contained substantially less information, we relied on the hard-copy forms for our analysis. Through detailed record review, we identified which of the 78 cases from the AMR would be classified as motor mechanics according to the rules of the Australian Census. Classifying AMR data proved difficult given the paucity of information and NOHSC has now abandoned the use of the 'circumstances of exposure' categories in its reports and uses only industry and occupational history information.

Results

A comparison of asbestos exposure levels in Australia, USA and Europe is presented in Table 2. Exposure surveys among Australian vehicle mechanics report generally low (<0.1 f/cc) airborne asbestos concentrations. In the USA and Europe, personal sample concentrations ranged from 0.002 to 2.33 f/cc for passenger cars and light trucks and from <0.003 to 7.09 f/cc for heavy trucks and buses. For passenger vehicles and light truck repair, 8-h time-weighted average (TWA) concentrations ranged from <0.002 to 0.68 f/cc (mean, 0.04 f/cc). For heavy trucks and buses, the mean reported 8-h TWA was 0.2 f/cc (range, 0.002–1.75 f/cc). Exposure levels have decreased over time in both Australia and the USA [29,32–36,39,41]. Thus, available data show no discernable differences in Australian workplace asbestos concentrations (peak or TWA asbestos exposures) compared to North America and Europe. However, these data are limited by lack of exposure information for earlier time periods, which makes them somewhat less relevant due to the long latency of mesothelioma. On the other hand, studies designed to simulate historical mechanic exposures did not find asbestos concentrations above the current US Occupational Safety and Health Administration permissible exposure limit of 0.1 f/cc [42].

Brake repair cleaning practices used in Australian garages included use of aerosol brake cleaners for dust control and degreasing, squirt bottles for washing brake parts, spraying compressed air to dry brake assemblies and removing dust using a scalpel and then dry wiping [29]. In the USA, brake-cleaning methods included the above methods, plus wet and dry brushing and various vacuum enclosures. Surveys of both Australian and American garages provide no evidence that grinding, sanding or drilling, which could result in additional exposures, were more common in Australia than in the USA. These activities were rarely undertaken after the late 1970s in either country [29,39,41].

In Australia, as in North America and Europe, raw chrysotile asbestos was used in the manufacture of brake disc pads, brake linings and brake blocks [29]. Armstrong *et al.* [45] stated that crocidolite was used in brakes in Western Australia; however, there are no published data that confirm this statement. Given that amosite, crocidolite and other amphibole asbestos varieties were not considered suitable for brake products [39] and that chrysotile asbestos is much softer than the amphiboles, much easier to process, more abundant and has good heat resistance, it is unlikely that crocidolite was used in brakes.

In our evaluation of the original AMR data, we identified 48 of the original 78 cases that could be considered 'possible' motor mechanics after inclusion of all potentially related occupational categories such as apprentice mechanic, motor mechanic of farm machinery, diesel motor mechanics and motor mechanics working in the armed forces (Figure 1). The thirty remaining cases were (i) individuals who were not 'professional' vehicle mechanics, (ii) worked near mechanics but did not personally conduct the work, (iii) worked in brake manufacturing or (iv) women whose husbands were

Table 2. Summary of exposure surveys of asbestos levels among motor vehicle shops

Author	Population/site	Work activity	Sample type/duration	Number of samples	Results	Comments
Australia						
Francis [30]	Measurements by factory inspectorate in New South Wales, Australia	Blowing out brake drums finishing/ riveting	NA NA	NA NA	<1 f/ml 2–4 f/ml	Presented at Second Australian Pneumoconiosis Conference
VOHSC [31]	Survey conducted by Victoria Department of Labour of Australian automotive firms	'Large specialist automotive brake and clutch firms'	NA	NA	<0.1 f/ml	'Occasional' excursions up to 1.0 f/ml
VOHSC [31]	Same as above	'Smaller independent firms'	NA	NA	0.2–0.3 f/ml, TWA <0.1 f/ml	NA
NICNAS [29]	Ten surveys in Western Australian brake shops, 1979–1989	'Brake maintenance', one sample 'grinding brake discs and linings'	P (one sample 175–185 min; two samples 3 h; remainder duration NS)	6	All but one ≤0.1 f/ml (by MFM), single sample collected in 1983 = 0.7 f/ml (3 h duration)	Report noted 'majority' of fibres <0.1; limited information so unsure of peak versus TWA exposures
NICNAS [29]	Same as above	'Brake maintenance', including belt/radius grinding	A (two samples 10 min; remainder duration NS)	9	Two of nine exceeded detection limit (DLV = 0.01–0.5 f/ml) • Belt grinding: 1979, 0.4 f/ml, 10 min • Task NS: 1982, 10 f/ml; duration NS	Same as above; did not include results from brake bond ing
NICNAS [29]	Same as above	'Brake maintenance'	Type and duration NS	5	<0.2–1.3 f/ml	Same as above; samples collected 1981
NICNAS [29]	Aftermarket survey of five automotive service garages in 1996 (four automobile, one bus)	Drum and disc brake changing	P, A (1–2 h, MFM analysis)	5 (P), 31 (A), collected from 10 workers	<0.05 f/ml (P), <0.03 f/ml (A)	Stated that service stations 'rarely undertook cutting, grinding or sanding' activities; <0.01 asbestos equivalents by TEM
Yeung *et al.* [28]	Four Australian garages (three for passenger cars and light vehicles, one for truck brakes)	Servicing brakes	P (77–125 min)	4	ND (DLV = 0.05 f/ml)	Samples collected in 1995

Table 2. *Continued*

Author	Population/site	Work activity	Sample type/duration	Number of samples	Results	Comments
Europe						
Hickish and Knight [32]	Car and truck exposures in England	Servicing brakes	P (2 × 45 min, collected >8 h)	6	TWA 0.68 f/cc (car), TWA 1.75 f/cc (truck)	Evaluated use of compressed air, samples collected during 11 brake jobs
Rödelsperger *et al.* [37]	Service stations for cars, trucks and buses in Germany	Servicing brakes	P, A (<3–60 min)	31 samples (car), 36 samples (truck and bus)	Mean 0.04–0.12 f/cc (car), mean 0.05–0.39 f/cc (truck and bus)	–
Plato *et al.* [40]	Repair shops in Sweden	Vehicle repair work	P (8 h)	103 mechanics	TWA 0.02–0.20 f/cc	Exposure data collected from 1976 to 1988
USA						
Johnson *et al.* [33]	NIOSH survey of seven garages	Servicing brakes	P, A (5.7 h TWA, 0.5–3.0 min for peak)	94 TWA, 6 peak	TWA 0.01–0.20 f/cc, 0.45–14.54 f/cc (peak)	Evaluated various cleaning techniques
Roberts [34]	NIOSH study of one garage	Servicing brakes	P (4.3 h TWA, 1 min for peak)	1 TWA, 1 peak	TWA 0.04 f/cc, 0.33 f/cc (peak)	Re-evaluation of one garage included in Johnson *et al.*
Roberts [35]	NIOSH study of one garage	Servicing brakes	P (6.2 h TWA, 1–3 min for peak)	2 TWA, 2 peak	TWA 0.006–0.04 f/cc, 0.25–0.37 f/cc (peak)	Evaluated cleaning with compressed air and solvent
Roberts and Zumwalde [36]	NIOSH survey of six garages	Servicing brakes	P, A (2.3–6.2 h TWA, 0.33–21 min for peak)	13 TWA, 23 peak	TWA 0.01–0.28 f/cc, 0.00–15.0 f/cc (peak)	Evaluated various cleaning techniques
Moore [38]	31 US garages	Servicing brakes	P (10–60 min; mean 29 min)	35	<0.01–0.15 f/cc	Evaluated various cleaning techniques
Sheehy *et al.* [39]	NIOSH study of engineering control technologies in garages	Servicing brakes	P, A (120 min)	83 P	<0.003–0.016 f/cc	Evaluated various cleaning techniques
Paustenbach *et al.* [41]	Review of US, European and Australian exposure data	Brake repair activities	P	~200	TWA <0.002–0.68 f/cc (car), TWA 0.002–1.75 f/cc (truck)	–
Blake *et al.* [42]	Exposure simulation of brake repair	Four brake drum replacement	P, A (262–395 min)	6 P, 9 A	0.0042–0.0937 f/cc (P) 0.0010–0.0031 f/cc (A)	Evaluated filing, sanding and arc grinding

A, area (static) sample; DLV, detection limit value; f/cc, fibres per cubic centimetre: f/ml, fibres per millilitre; MFM, standard membrane filter method (light microscopy); min, minute; NICNAS, National Industrial Chemicals Notification and Assessment Scheme; NIOSH, National Institute for Occupational Safety and Health; NA, not applicable or not available; ND, not detected; NS, not stated; P, personal sample; TEM, transmission electron microscopy and VOHSC, Victoria Occupational Health and Safety Commission.

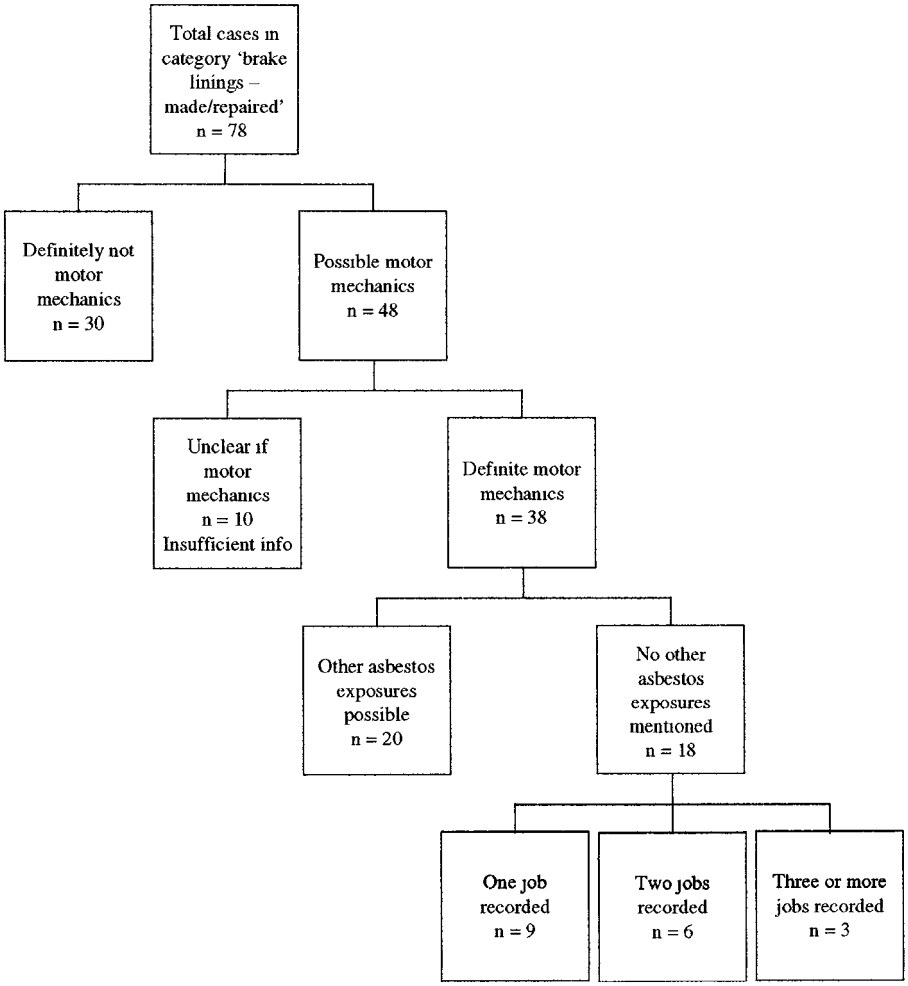

Figure 1. Analysis of AMR data.

mechanics (Figure 1). None of these cases would be classified as a 'motor mechanic' using Census coding procedures. Thirty-eight cases of the possible 48 possible mechanics were identified as 'definite' motor mechanics; of whom, 18 had no other recorded asbestos exposure. However, 15 of those 18 individuals had only one or two jobs recorded raising concerns about the completeness of their occupational histories. Twenty of the 38 cases had other occupational asbestos exposures determined by matching their occupational histories against a previously published list of asbestos-related jobs [5].

Calculations that used the AMR data to estimate the relative risk of mesothelioma for Australian vehicle mechanics have been presented in various reports and letters [25–27]. In a WTO report regarding human health risks associated with chrysotile asbestos, one of the panellists stated that the AMR data included 58 mesothelioma cases among brake mechanics with no other exposure to asbestos. This number, combined with an estimated 200 000 current and former vehicle mechanics in Australia to calculate disease rates, would result in a disease rate that is ~10-fold higher than background mesothelioma rates assumed to be one to two cases per million/year [25]. This background rate, however, is likely too low for Australia, given the potential environmental crocidolite exposure in certain regions of the country [46,47].

Based on our review of AMR records, not >18 individuals (instead of 58) potentially fit the definition of 'brake mechanics with no other exposures to asbestos'. Moreover, only three of those cases seem to have a detailed occupational history with at least three jobs recorded. In addition, the size of the population of vehicle mechanics cannot be accurately estimated because it should include all former and current mechanics over the previous 25–40 years. The estimate for the population size calculation was based on the assumption that the ratio of current to ever motor mechanics is 1:2; however, in the USA, the ratio of current to ever mechanics was

estimated to be 1:5 [48]. Without better methods, the actual numbers of current and former motor vehicle mechanics remain unknown.

Using the same AMR data, Leigh and Driscoll [26] provide a table of lifetime risk of 0.7% for vehicle mechanics, compared to 0.39% for 'All Australian Men'. However, these risk calculations have the same limitations as the WTO report and in addition, they do not take into account competing risks and age-specific relative risks or disease rates.

Discussion

Our review identified no discernable differences in workplace levels of exposure, processes or fibre type among Australian vehicle mechanics compared to vehicle mechanics in other countries. Instead, our analysis of primary AMR data identified several errors in exposure classification and in the assumptions used to calculate relative risk.

Another proposed explanation for this discrepancy is that the numerous epidemiologic studies are flawed and mask a 'true' increased risk [23,24]. A full review and discussion of each study's methods and quality are beyond the scope of this paper, but have been addressed elsewhere [21,22]. Nevertheless, the consistency of findings across numerous epidemiologic studies conducted by various researchers in different populations using a variety of study designs and data collection procedures argues against the presence of systematic bias in the same direction in all those studies.

Ongoing disease surveillance based on accurate cancer data as recorded in a registry system such as the AMR can provide important public health information [43, 44]. However, we noted that the use of the AMR data to accurately classify individuals as motor mechanics is problematic. This is primarily due to incomplete work histories and frequent job misclassification.

Overall, we observed that the mesothelioma rate calculation and risk estimate in the WTO report (i) overestimated the number of mesothelioma cases among motor mechanics without other occupational asbestos exposures, (ii) used an unverifiable estimate for the number of motor mechanics and (iii) underestimated the background rate for mesothelioma. This research is the first study to evaluate exposure classification of vehicle mechanics work in the AMR data; however, our analysis should not be viewed as an attempt to estimate the actual risks of mesothelioma among vehicle mechanics. We did not conduct a formal data collection nor did we have the data to adequately enumerate the population at risk. The most reliable method of identifying occupational risk using AMR data would be a formal epidemiologic study involving systematic case ascertainment, rigorous work history data collection and careful enumeration of the source population. Currently available data on vehicle mechanics from existing epidemiologic studies should be used instead of 'rough' estimates or calculations.

Key points

- There is a discrepancy between the reports of increased risk of mesothelioma among motor vehicle mechanics in Australia and the null findings from published epidemiologic studies in North America and Europe. Unlike North American and European studies, the Australian reports are based on informal calculations using the data from the AMR.
- The observed discrepancy cannot be explained by the differences in asbestos exposure among motor mechanics in Australia and in other countries; however, there seem to be several errors in the AMR data and in the assumptions used to calculate relative risk.
- Estimating risks should be done using carefully designed epidemiologic studies and not from calculations based on case-only data.

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Conflicts of interest

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References

1. Järvholm B, Brisman J. Asbestos associated tumours in car mechanics. *Br J Ind Med* 1988;**45**:645–646.
2. Hansen ES. Mortality of auto mechanics: a ten-year follow-up. *Scand J Work Environ Health* 1989;**15**:43–46.
3. Gustavsson P, Plato N, Lidstrom EB, Hogstedt C. Lung cancer and exposure to diesel exhaust among bus garage workers. *Scand J Work Environ Health* 1990;**16**:348–354.
4. McDonald AD, McDonald JC. Malignant mesothelioma in North America. *Cancer* 1980;**46**:1650–1656.
5. Teta MJ, Lewinshon HC, Meigs JW, Vidone RA, Mowad LZ, Flannery JT. Mesothelioma in Connecticut, 1957–1977. Occupational and geographic associations. *J Occup Med* 1983;**25**:749–756.

6. Spirtas R, Keehn R, Wright W, Stark A, Beebe G, Dickson E. Mesothelioma risk related to occupational or other asbestos exposure: preliminary results from a case-control study. *Am J Epidemiol* 1985;**122:**518.
7. Woitowitz HJ, Rödelsperger K. Mesothelioma among car mechanics? *Ann Occup Hyg* 1994;**38:**635–638.
8. Teschke K, Morgan MS, Checkoway H *et al.* Mesothelioma surveillance to locate sources of exposure to asbestos. *Can J Public Health* 1997;**88:**163–168.
9. Agudo A, González CA, Bleda MJ *et al.* Occupation and risk of malignant pleural mesothelioma: a case-control study in Spain. *Am J Ind Med* 2000;**37:**159–168.
10. Hansen J, Meersohn A. *Kraeftsygelighed blandt danske lonmodtagere (1970–97) fordelt pa Arbejdstilsynets 49 branchegrupper.* Kraeftens Bekaempelse, Kobenhavn: Institut for Epidemiologisk Kraeftforskning, 2003.
11. Hessel PA, Teta MJ, Lau E, Goodman M. Mesothelioma among brake mechanics: an expanded analysis of a case-control study. *Risk Anal* 2004;**24:**547–552.
12. Welch LS, Acherman YIZ, Haile E, Sokas RK, Sugarbaker PH. Asbestos and peritoneal mesothelioma among college-educated men. *Int J Occup Environ Health* 2005;**11:**254–258.
13. Rolland R, Gramond C, Berron H *et al. Pleural Mesothelioma: Professions and Occupational Areas at Risk among Humans. Based on Data from the French National Mesothelioma Monitoring Program (PNSM).* Institut de Veille Sanitaire, Saint-Maurice, France, 2005. http://www.invs.sante.fr [in French] (6 June 2006, date last accessed).
14. Petersen GR, Milham S. *Occupational Mortality in the State of California 1959–61.* National Institute for Occupational Safety and Health Research Report No.1-CP-33353, U.S Department of Health, Education, and Welfare. Division of Surveillance, Hazard Evaluations, and Field Studies, Cincinnati, OH, 1980.
15. Olsen JH, Jensen OM. Occupation and risk of cancer in Denmark: an analysis of 93,810 cancer cases, 1970–1979. *Scand J Work Environ Health* 1987;**13(Suppl. 1):**1–91.
16. Coggon D, Inskip H, Winter P, Pannett B. Differences in occupational mortality from pleural cancer, peritoneal cancer, and asbestosis. *Occup Environ Med* 1995;**52:**775–777.
17. Milham S, Ossiander E. *Occupational Mortality in Washington State 1950–1999.* Epidemiology Office, Washington State Department of Health, Olympia, WA, 2001.
18. National Institute for Occupational Safety and Health. *Letter to M.J. Teta from J.T. Walker Regarding Inquiry about PMRs for Auto Mechanics, with Attached Data Sheets.* Department of Health and Human Services, Public Health Service, Cincinnati, OH, 2002.
19. McElvenny DM, Darnton AJ, Price MJ, Hodgson JT. Mesothelioma mortality in Great Britain from 1968 to 2001. *Occup Med (Lond)* 2005;**55:**79–87.
20. Wong O. Malignant mesothelioma and asbestos exposure among auto mechanics: appraisal of scientific evidence. *Regul Toxicol Pharmacol* 2001;**34:**170–177.
21. Goodman M, Teta MJ, Hessel PA *et al.* Mesothelioma and lung cancer among motor vehicle mechanics: a meta-analysis. *Ann Occup Hyg* 2004;**48:**309–326.
22. Laden F, Stampfer MJ, Walker AM. Lung cancer and mesothelioma among male auto mechanics: a review. *Rev Environ Health* 2004;**19:**39–61.
23. Lemen RA. Asbestos in brakes: exposure and risk of disease. *Am J Ind Med* 2004;**45:**229–237.
24. Egilman DS, Billings MA. Abuse of epidemiology: automobile manufacturers manufacture a defense to asbestos liability. *Int J Occup Environ Health* 2005;**11:**360–371.
25. World Trade Organization. *European Communities—Measures Affecting Asbestos and Asbestos-Containing Products.* Report of the Panel. WT/DS135/R. World Trade Organization, Geneva, Switzerland, 2000.
26. Leigh J, Driscoll T. Malignant mesothelioma in Australia, 1945–2002. *Int J Occup Environ Health* 2003;**9:**206–217.
27. Leigh J. *Letter to USEPA Regarding 1986 EPA "Gold Book" Guidance for Preventing Asbestos Related Disease among Auto Mechanics. Request for Correction.* Available on Regulations.gov website as Docket ID EPA-HQ-OPPT-2003-0074 and Document ID EPA-HQ-OPPT-2003-0074-0011. New South Wales, Australia: University of Sydney, 2003.
28. Yeung P, Patience K, Apthorpe L, Willcocks D. An Australian study to evaluate worker exposure to chrysotile in the automotive service industry. *Appl Occup Environ Hyg* 1999;**14:**449–458.
29. National Industrial Chemicals Notification and Assessment Scheme. *Chrysotile Asbestos: Priority Existing Chemical Report No. 9.* Canberra, ACT, Australia: National Industrial Chemicals Notification and Assessment Scheme, 1999.
30. Francis E. Industry usage of asbestos and exposure to dust. In: *Second Australian Pneumoconiosis Conference.* University of Sydney, Sydney, Australia, Paper E-2. February 20-23, 1978.
31. Victorian Occupational Health Safety Commission. *Consultative Document: The Proposed Victorian Asbestos Regulations (Draft),* VOHSC, Melbourne, Australia, 1987.
32. Hickish DE, Knight KL. Exposure to asbestos during brake maintenance. *Ann Occup Hyg* 1970;**13:**17–21.
33. Johnson P, Zumwalde RD, Roberts D. *Industrial Hygiene Assessment of Seven Brake Servicing Facilities.* Cincinnati, OH: National Institute of Occupational Safety and Health, Division of Surveillance, Hazard Evaluations, and Field Studies, Industry-wide Studies Branch, Industrial Hygiene Section, 1979.
34. Roberts DR. *Industrial Hygiene Report: Asbestos at Allied Brake Shop, Cincinnati, Ohio.* Cincinnati, OH: Industrial Health Section, Division of Surveillance, Hazard Occupations, and Field Studies, National Institute of Occupational Safety and Health, 1980.
35. Roberts DR. *Industrial Hygiene Report—Asbestos: Reading Brake and Alignment Service, Reading, Ohio.* Cincinnati, OH: Industrial Hygiene Section, Industry-wide Studies Branch, Division of Surveillance, Hazard Occupations, and Field Studies, National Institute of Occupational Safety and Health, 1980.
36. Roberts D, Zumwalde R. *Industrial Hygiene Summary Report of Asbestos Exposure for Brake Mechanics.* Cincinnati, OH: National Institute for Occupational Safety and Health, 1982.
37. Rödelsperger K, Jahn H, Brückel B, Manke J, Paur R, Woitowitz H-J. Asbestos dust exposure during brake repair. *Am J Ind Med* 1986;**10:**63–72.
38. Moore LL. Asbestos exposure associated with automotive brake repair in Pennsylvania. *Am Ind Hyg Assoc J* 1988; **49:**A12–A13.
39. Sheehy JW, Cooper TC, O'Brien DM, McGlothlin JD, Froehlich PA. *Control of Asbestos Exposure during Brake*

Drum Service. Cincinnati, OH: DHHS (NIOSH) Publication No. 89-121. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Division of Physical Sciences and Engineering, 1989.

40. Plato N, Tornling G, Hogstedt C, Krantz S. An index of past asbestos exposure as applied to car and bus mechanics. *Ann Occup Hyg* 1995;**39:**441–454.
41. Paustenbach DJ, Richter RO, Finley BL, Sheehan PJ. An evaluation of the historical exposures of mechanics to asbestos in brake dust. *Appl Occup Environ Hyg* 2003;**18:** 786–804.
42. Blake CL, Van Orden DR, Banasik M, Harbison RD. Airborne asbestos concentration from brake changing does not exceed permissible exposure limit. *Regul Toxicol Phamacol* 2003;**38:**58–70.
43. Ferguson DA, Berry G, Jelihovsky T *et al.* The Australian mesothelioma surveillance program 1979–1985. *Med J Aust* 1987;**147:**166–172.
44. National Occupational Health and Safety Commission. *The Incidence of Mesothelioma in Australia 1999 to 2001: Australian Mesothelioma Register Report.* NOHSC, Canberra, Australia, 2004; 34.
45. Armstrong BK, Musk AW, Baker FE *et al.* Epidemiology of malignant mesothelioma in Western Australia. *Med J Aust* 1984;**141:**86–88.
46. Rogers AJ, Yeung P, Johnson A, Leigh J, Davidson P. Trends in occupational groups and industries associated with Australian mesothelioma cases 1979–1995. *Ann Occup Hyg* 1997;**41(Suppl. 1):**123–128.
47. Gun RT. Mesothelioma: is asbestos exposure the only cause? *Med J Aust* 1995;**162:**429–431.
48. Nicholson WJ, Daum SM, Lorimer WV *et al. Investigation of Health Hazards in Brake Lining Repair and Maintenance Workers Occupationally Exposed to Asbestos.* Contract 210-77-0199. PB83-220897. U.S. Department of Commerce, National Institute for Occupational Safety and Health, Cincinnati, OH, 1984.