Scientific Committee on Epidemiology in Occupational Health (ICOH)

NIOSH

EPIDEMIOLOGY IN OCCUPATIONAL HEALTH

Cincinnati
Sept. 23-25.
1992

9th INTERNATIONAL SYMPOSIUM

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

CDC
CENTERS FOR DISEASE CONTROL

UNIVERSITY OF CINCINNATI
Department of Environmental Health, Office of Continuing Education

9th International Symposium

Epidemiology In Occupational Health

BOOK OF ABSTRACTS

WELCOME

We hope that the 9th International Symposium will continue in the outstanding tradition of the earlier meetings on Epidemiology in Occupational Health. Over two hundred and fifty epidemiologist from the United States will be joined by over a hundred and fifty of their colleagues from all over the world at this meeting. In preparing for this symposium, we were struck by the growing diversity of occupational epidemiology which is being applied to an increasingly diverse set of problems ranging from work-related psychological disorders to traumatic injuries. This variety is reflected in the symposium presentations. From the perspective of the three sponsoring organizations, the Scientific Committee on Epidemiology in Occupational Health (ICOH), the National Institute for Occupational Safety and Health, and the Department of Environmental Health at the University of Cincinnati, this meeting will be a success if the scientific information presented at the meeting enhances your understanding of the causation and prevention of occupational health and safety problems. We would like to express our appreciation to many of our associates from all three organizations who have contributed to planning for the symposium. We welcome you to Cincinnati and to the meeting. If we can be of assistance to you, please contact one of the symposium organizers.

<div align="right">

Lawrence Fine, Symposium Chair

Andrea Okun, Symposium Vice-Chair

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Leo Szilard

"A scientist's aim in a discussion with his colleagues is not to persuade, but to clarify."

<div align="right">

recalled on his death, 30 May 64

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THE SYMPOSIUM

The Scientific Committee on Epidemiology in Occupational Health of the International Commission on Occupational Health (ICOH) began its activities in 1980 and has, during its short existence, already become an important forum for the exchange of experience in the field of occupational epidemiology. A symposium is held each year (except during the years of the ICOH triennial congress) with the purpose of bringing together active research workers in occupational epidemiology to discuss methodology, findings, and applications of their work.

Previous symposiums were held in Helsinki, Finland (1980), Montreal, Canada (1982), Singapore (1983), Como, Italy (1985), Los Angeles, USA (1986), Stockholm, Sweden (1988), Tokyo, Japan (1989) and Paris, France (1991). The next triennial congress will be held in Nice, France (1993) and the 10th International Symposium on Epidemiology in Occupational Health will be held in Santiago, Chile, 1994.

TIME AND PLACE

The 9th International Symposium on Epidemiology in Occupational Health will be held September 23-25, 1992, at the Omni Netherland Plaza, Cincinnati, Ohio.

OFFICIAL LANGUAGE

The official language of the symposium is English, which will be used for all presentations and printed materials.

PLANNING COMMITTEE

Lawrence Fine (Symposium Chair)

Andrea Okun (Symposium Vice-Chair)

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Thomas Bender

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Robert Castellan

Anne Fidler

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Richard Lemen

Theodore Meinhardt

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Kyle Steenland (USA)

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David Wegman (USA)

Scientific Committee on Epidemiology in Occupational Health

International Commission on Occupational Health

National Institute for Occupational Safety and Health

Centers for Disease Control

U.S. Public Health Service

U.S. Department of Health and Human Services

University of Cincinnati

Department of Environmental Health

Office of Continuing Education

KEYNOTE PRESENTERS

Dr. Margaret Becklake

Professor

McGill University

Montreal Canada

Dr. Dirk Heederik

Professor

Wageningen Agricultural University

Wageningen, The Netherlands

Dr. Frederica Perera

Assistant Director

Columbia University Comprehensive Cancer Center

New York, New York

Dr. Haruhiko Sakurai

Professor

Kelo University School of Medicine

Tokyo, Japan

Dr. Tores Theorell

Professor

National Institute for Psychosocial Factors and Health

Stockholm, Sweden

SYMPOSIUM SCHEDULE

WEDNESDAY, SEPTEMBER 23	THURSDAY, SEPTEMBER 24	FRIDAY, SEPTEMBER 25

8:45 - 9:15   Welcome
9:15 - 11:45   Keynote and Plenary Presentations
          Hall of Mirrors Ballroom
	8:45 - 11:40 Keynote and Plenary Presentations
	          Hall of Mirrors Ballroom
		8:45 - 11:40 Keynote and Plenary Presentations
		          Hall of Mirrors Ballroom

11:45 - 12:40   Luncheon
          Pavillion Ballroom
	11:40 - 12:40 Luncheon
	          Pavillion Ballroom
		11:40 - 12:40 Luncheon
		          Pavillion Ballroom

POSTER VIEWING 12:40 - 1:40	POSTER VIEWING 12:40 - 1:40	FREE TIME 12:40 - 1:10
CONCURRENT SESSIONS 1:40 - 3:20 Cancer 1 - *Hall of Mirrors Ballroom* Methods - *Caprice Ballroom* Neurotoxins - *Salons D&E* Reproductive Disorders - *Salons H&I*	CONCURRENT SESSIONS 1:40 - 3:20 Cancer 3 - *Hall of Mirrors Ballroom* Musculoskeletal Disorders - *Caprice Ballroom* Injury 1 - *Salons D&E* Exposure 2 - *Salons H&I*	CONCURRENT SESSIONS - 1:10 - 3:20 Cancer 5 - *Hall of Mirrors Ballroom* Cancer 6 - *Caprice Ballroom* Injury and Musculoskeletal - *Salons D&E* Respiratory Disease 2 - *Salons H&I*
CONCURRENT SESSIONS 3:50 - 5:30 Cancer 2 - *Hall of Mirrors Ballroom* Exposure 1 - *Caprice Ballroom* Cytotoxins and Solvents - *Salons D&E* Agriculture - *Salons H&I*	CONCURRENT SESSIONS 3:50 - 5:30 Cancer 4 - *Hall of Mirrors Ballroom* Respiratory Disease 1 - *Caprice Ballroom* Cardiovascular Disease - *Salons D&E* Surveillance - *Salons H&I*	CONCURRENT SESSIONS 3:20 - 4:40 Cancer 7 - *Hall of Mirrors Ballroom* Solvents and Noise - *Caprice Ballroom* Physical and Mental Stressors - *Salons D&E* Metals - *Salons H&I*

6:30 - 7:15   Board Buses to Riverfront
          Omni Netherland Plaza Lobby
          and
          The Quality Hotel
 	
7:30 - 10:30   Star of Cincinnati Dinner Cruise
	6:30 - 7:15 Board Buses to Museum Center
	          Omni Netherland Plaza Lobby
	
	7:15 - 12:00 A Cincinnati Evening
	          The Museum Center at
	          Union Terminal
		4:40 - 5:40 Farewell Reception
		          Pavillion Ballroom

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Keynote and Plenary Presentations

8:45   **Introduction:** Dr. Lawrence Fine, Symposium Chair

8:50   **Session Chair:** Dr. Christer Hogstedt, ICOH Scientific Committee Chair

       Welcome: Dr. J. Donald Millar, Director, NIOSH
                 Dr. Sven Hernberg, President, ICOH

9:15   **Keynote Presentation:**
       The Epidemiological Challenges of Obstructive Lung Disease: What
        Fraction may be Work-related?
       Dr. Margaret Becklake

9:55   **Coffee Break**

       Session Chair: Dr. Patricia Buffler

10:25   **Keynote Presentation:**
       Biomarkers and Molecular Epidemiology of Cancer
       Dr. Frederica Perera

11:05   **Plenary Presentation:**
       Full Cohort Analysis of Digestive and Respiratory Cancer Risk
        Among Autoworkers
       E. Eisen, P. Tolbert, R. Monson, T. Smith, L. Pothier, M. Hallock, S. Woskie,
       S. K. Hammond

11:25   **Plenary Presentation:**
       Use of Multiple Cause Mortality Data in Epidemiologic Analyses: Standard
        U.S. Rate and Proportion Fills Developed by NIOSH/NCI
       K. Steenland, S. Nowlin, B. Ryan, S. Adams

11:45   **Luncheon/*Pavillion Ballroom***

12:40   **Poster Viewing/*North Hall***

Cancer 1

Session Chair: Mr. Robert Rinsky

1:40   Genetic Susceptibility and Occupational Exposures in the Etiology of Leukemia and Non-Hodgkins Lymphoma
L.M. Pottern, L.M. Brown, M.S. Linet, A. Blair

2:00   Larynx Cancer and Occupation: Preliminary Results from the IARC Multicentric Case-Control Study
P. Boffetta, F. Berrino, J. Esteve, F. Merletti, P. Pisani, L. Raymond, A. Tuyns, A. Del Moral Aldaz, A. Zubiri

2:20   Occupational Risks of Bladder Cancer in France: A Multicentric Case-Control Study
S. Cordier, J. Clavel, J.C. Limasset, D. Hemon

2:40   A Case-Control Study of Multiple Myeloma and Occupation
P. Demers, T. Vaughan, T. Koepsell, N. Weiss, J.L. Lyon, G.M. Swanson, R. Greenberg

3:00   Pancreatic Cancer and Occupational Exposures
T. Partanen, R. Degerth, T. Kauppinen, I. Mearelli, S. Hernberg, A. Ojajärvi, H. Koskinen, G. Moneta, L. Teppo

Cancer 2

Session Chair: Dr. James Lockey

3:50   Cancer Mortality Among Jewelry Workers
R.B. Hayes, M. Dosemeci, M. Jeffs, A. Blair

4:10   The Occupational Cancer Incidence Surveillance Study (OCISS): Risk of Lung Cancer by Length of Employment for White and Black Males
P. Burns, C.S. Lin, G.M. Swanson

4:30   Occupational Physical Activity, Socio-Economic Status and Risks of Fifteen Cancer Sites in Turkey
M. Dosemeci, R. Hayes, A. Blair, R. Vetter, R. Hoover, M. Tucker, M. Unsal

4:50   A Cohort Mortality Study of Workers Employed in a French Stainless Steel Factory
J. Moulin, P. Wild, B. Mantout, P. Portefaix, M. Fournier Betz, G. Smagghe

5:10   A Nested Case-Control Study of Lung Cancer Mortality in Welders and Other Metal Workers
K.S. Hansen, J. Lauritsen

Methods

Session Chair: Dr. Leslie Stayner

1:40   G-Estimation of the Effect of Formaldehyde Exposure on the Mortality of Chemical Workers
J. M. Robins

2:00   Does the Healthy Worker Effect Decline with Time?
J. Weinkam, W. Rosenbaum, T. Sterling

2:20   Arsenic, Circulatory Disease, and the Healthy Worker Survivor Effect
I. Hertz-Picciotto, H.M. Arrighi

2:40   Is the Model with the Largest Exposure Effect the Best Model?
A. Salvan

3:00   Comparison of Several Tests for Heterogeneity
K. Ulm

Exposure 1

Session Chair: Dr. Thomas Smith

3:50   Patterns of Electric and Magnetic Field Exposure in the Utility Industry
H. Kromhout, D.P. Loomis, D.A. Savitz, G.J. Mihlan, T.D. Bracken

4:10   How Many Exposure Assessments: A Guide to Optimum Design Strategy
R. Shukla, G. Lemasters, Y. Li

4:30   Using the Video Imaging Technique for Assessing Exposure in Livestock Insecticide Applications
H. F. Nicholson, B.C. Kross, A. Blair, L.K. Ogilvie

4:50   Retrospective Pesticide Exposure Assessment in Case Control Studies. Inter-Rater Agreement
L. Miligi, L. Settimi, M. Martuzzi, G. Masala, A. Seniori Costantini, P. Vineis

5:10   Mental Retardation and Parental Occupational Exposure: A Comparison Between Personal Interviews and Job-Exposure Matrices
N. Roeleveld, G.A. Zielhuis

Neurotoxins

Session Chair: Dr. Nicola Cherry

1:40   The Influence of Overtime on the Assessment of Neurobehavioral Effects of Petroleum Naphtha Exposure in an Occupational Setting
S. P. Proctor, R.F. White, T. Robbins, D. Echeverria, E. Eisen

2:00   Visual Dysfunction Among Styrene Exposed Workers
D. Mergler, D. Campagna, S. Bélanger, G. Huel, G. Truchon, C. Ostiguy, D. Drolet

2:20   A Neurobehavioral Evaluation of PCE Exposure in Patients and Dry Cleaners: A Possible Relationship Between Clinical and Pre-Clinical Effects
D. Echeverria, R. White

2:40   Prevalence of Depression Among Electrical Workers
D. Savitz, C.A. Boyle, P. Holmgreen

3:00   Early Indication of Nervous System Dysfunction Among Manganese Exposed Workers
D. Mergler, G. Huel, R. Bowler, S. Belanger, M. Baldwin, A. Iregren, L. Martin, A. Smargiassi, B. Beauvais, R. Tardif, N. Gignac

Cytotoxins and Solvents

Session Chair: Dr. Paolo Vineis

3:50   The Influence of Low Level Exposure to Benzene on White Blood Cell Counts
K. Van Damme, L. Casteleyn, J-C. Van Der Auwera, E. Chellini, A. Huici

4:10   Cytogenetic Effects of Formaldehyde Exposure in Students of Mortuary Science
A. Suruda, P. Schulte, M. Boeniger, R. Hayes, G. Livingston, K. Steenland, P. Stewart, R. Herrick, D. Douthitt, and M. Fingerhut

4:30   Cross-Sectional Study of Effects of Acetone Exposure on Workers' Health
K. Omae, T. Satoh, H. Nakashima, T. Takebayashi, H. Sakurai

4:50   Working and Life Conditions of Petrochemical Workers
F. M. Fischer, A. Berwerth, A. de C. Bruni

5:10   Cytogenetic Study in Female Nurses Occupationally Exposed to Cytotoxic Drugs
S. El-Ghazali

Reproductive Disorders

Session Chair: Dr. Grace Lemasters

1:40   Is Metal Welding Causing Impairment of Male Fecundity?
        J. Bonde

2:00   Male Reproductive Abnormalities Among Lead-Exposed Battery Plant Workers
        A. Osorio, M. Handley, J. Andrew, A. Mendonca, R. Davis, D. Katz

2:20   Paternal Exposures and Cardiovascular Malformations
        A. Correa-Villaseñor, C. Loffredo, C. Ferencz, The Baltimore-Washington Infant Study
        (BWIS) Group

2:40   The Semiconductor Health Study: Methods for Prospectively Assessing Reproductive Function
        in Wafer Fabrication Employees
        E. B. Gold, B. Eskenazi, M. O'Neill Rasor, S.K. Hammond, B. Lasley, S. Samuels,
        C. Hines, M.B. Schenker

3:00   Spontaneous Abortions With and Without Chromosomal Aberrations in Relation to
        Occupational Factors
        I. Hansteen, S.I. Fandrem, H. Kjuus

Agriculture

Session Chair: Dr. Linda Rosenstock

3:50   Patterns of Pesticide Exposure Among Midwestern Farmers: Issues for Epidemiologic
        Research
        A. Blair, S.H. Zahm

4:10   The Role of Epidemiology in the Development of Environmental Indicators: Occupational and
        Residential Exposure to Organophosphate and Carbamate Pesticides
        R. Allen, J. Blondell, M. Clock

4:30   Respiratory Symptoms, Spirometry, and Chronic Occupational Paraquat Exposure
        R. McConnell, N. Castro Gutierrez, K. Andersson, F. Pacheco Anton, C. Hogstedt

4:50   A Survey of Keratoses Among Paraquat Production Workers and Their Friends
        S. Cooper, T. Downs, K. Burau, S. Tucker, L. Whitehead, G. Delclos, M. Key, B. Huang,
        T. Davidson, P. Buffler

5:10   Respiratory Disease and Lung Function Among Tobacco Field Workers
        S. Romazini, B. Olivier-Roussel, A. Perdrix, V. Droy, M.R. Tendero, J.A. Jourdain,
        R. De Gaudemaris

Keynote and Plenary Presentations

8:45 **Session Chair:** Dr. Richard Lemen

8:50 **Keynote Presentation:**
The Psychosocial Work Environment and Cardiovascular Disease
Dr. Tores Theorell

9:30 **Plenary Presentation:**
Job Stress and Cardiovascular Risk Factors in a Japanese Working Population
Dr. Takashi Haratani

9:50 **Plenary Presentation:**
Measurement and Evaluation of Symptom Intensity to Improve Understanding of Acute Respiratory Health Effects
Dr. David Wegman

10:10 **Coffee Break**

Session Chair: Dr. Ralph Buncher

10:40 **Plenary Presentation:**
Lung Function Among Insulation Workers: A Combined Cross-Sectional and Longitudinal Study
B. Netterstrøm, J. Clausen

11:00 **Plenary Presentation:**
Study of Mortality Based on the UK National Registry for Radiation Workers
C. Muirhead, G.M. Kendall, B.H. MacGibbon

11:20 **Plenary Presentation:**
Childhood Cancers and Paternal Exposure to Ionizing Radiation: Findings from the Oxford Survey of Childhood Cancers (OSCC)
T. Sorahan, P.J. Roberts

11:40 **Luncheon/*Pavillion Ballroom***

12:40 **Poster Viewing/*North Hall***

Cancer 3

Session Chair: Dr. Gilles Theriault

1:40   Non-Malignant Pleuro-Pulmonary Disease and the Development of Malignant Mesothelioma in Western Australian Crocidolite Workers
N. De Klerk, A.W. Musk, J.L. Eccles, M.S.T. Hobbs

2:00   A Case-Control Study of Mesothelioma and Exposure to Biogenic Silica Fibers
T. Sinks, M. Goodman, L. Kolonel, B. Anderson

2:20   Lung Cancer and Airways Obstruction Among Metal Miners Exposed to Silica and Low Levels of Radon Daughters
P. Carta, P.L. Cocco, G.F. Picchiri

2:40   The 1891-20 Birth Cohort of Quebec Chrysotile Miners and Millers: A Preliminary Report on Mortality 1976 to 1988
F.D.K. Liddell, A.D. McDonald, J.C. McDonald

3:00   Malignant Mesothelioma in Quebec Chrysotile Miners and Millers: A Preliminary Report
A.D. McDonald, F.D.K. Liddell, (presented by **J.C. McDonald**)

Cancer 4

Session Chair: Dr. William Fayerweather

3:50   Cancer Risk Among 3,890 Workers Employed at the Industrial Branch of the Shipyard of Genova, Italy: A Retrospective Cohort Study
F. Merlo, G. Reggiardo, E. Garrone, M. Ceppi, R. Puntoni

4:10   Occupational Exposure to Chemical Agents and Risk of Lymphomas and Leukemias in the Wood Industry
T. Kauppinen, T. Partanen, R. Luukkonen

4:30   Mortality and Cancer Incidence in a Cohort of Chimney Sweeps: An Extended Follow-Up Study
B. Evanoff, P. Gustavsson, C. Hogstedt

4:50   Excess Cancer Incidence in Workers Exposed to Fluoride
P. Grandjean, K. Juel, J.H. Olsen

5:10   Lung Cancer Mortality Amongst Former Workers at the Radium Hill Uranium Mine in South Australia
A. Mylvaganam, A.J. Woodward, P. Crouch, D.C. Thomas

Musculoskeletal Disorders

Session Chair: Dr. Sherry Baron

1:40   A Cross-Sectional Study of Carpal Tunnel Syndrome Symptoms Among Trade and Office Workers
M. Kelsh, H. Morgenstern, D. Ke

2:00   Surveillance for Work-Related Carpal Tunnel Syndrome
B. Silverstein, J. Kalat, J. Burt, R. Hughes, C. Karr, J. Kaufman, M. Miller, R. McDowell, D. Moore, D. Sebesta, N. Villacres

2:20   Surveillance of Cumulative Trauma Disorders in North Carolina: Advantages and Disadvantages of Using Workers' Compensation Data
L. Frazier, D. Loomis

2:40   Estimated Prevalence and Work-Relatedness of Self-Reported Carpal Tunnel Syndrome (CTS) Among U.S. Workers
S. Tanaka, D.K. Wild, P. Seligman, V. Behrens, V. Putz-Anderson

3:00   Medical Insurance Claims and Occupation Disease Surveillance: Cumulative Trauma in the Auto Industry
R. Park, N. Nelson, M. Silverstein, F. Mirer

Respiratory Disease 1

Session Chair: Dr. Robert Castellan

3:50   Accidental Gassing Incidents and the Respiratory Health of Pulpmill Workers
P. Henneberger, B.G. Ferris, Jr.

4:10   Immunologic Sensitization to Tetrachlorophthalic (TCPA)-Exposed Workers in Relation to Exposure Measures
G. Liss, D. Bernstein, L. Genesove, J. Roos, J. Lim

4:30   Respiratory Symptoms and Pulmonary Functions of Cement Factory Workers at a Nigerian Cement Factory
G.E. Erhabor, J.O. Ojo, A.F. Oluwole, O.I. Asubiojo, F.A. Akeredolu

4:50   The Relationship Between Pneumoconiosis and Cancer
G. Shen, X. Chen, Y. Wang, X. Zeng

Injury 1

Session Chair: Dr. Thomas Bender

1:40   Work-related Electrical Fatalities in Australia, 1982-1984
        T.R. Driscoll, P.L. Harvey-Sutton, M.S. Frommer, J.E. Harrison, (presented by **J. Leigh**)

2:00   The Regional Rural Injury Study (RRIS)-I: A Model for National Surveillance of Injuries in Agriculture
        S.G. Gerberich, R.W. Gibson, P.D. Gunderson, L.R. French, F.B. Martin, J.A. True, J. Shutske, C. Renier, W.P. Carr

2:20   Logging Fatalities in the United States: An Update
        D. E. Fosbroke, J.R. Myers

2:40   Fatal Occupational Injury Rates in Quebec 1981-1988
        M. Rossignol, M. Pineault

3:00   Population-Based Case Control Study of Nonfatal Falls on Farms in Wisconsin
        D. Nordstrom, D. Stueland, P. Layde

Cardiovascular Disease

Session Chair: Dr. Christina Reuterwall

3:50   Case-Control Study Regarding Myocardial Infarction, Shiftwork and Occupational Exposure to Noise
        H. Mann, P. Cremer, D. Nagel, B. Labrot, J. Strok

4:10   Cardiovascular Diseases Among Foundry Workers Exposed to Carbon Monoxide
        R-S. Koskela, M. Klockars, E. Järvinen

4:30   Increased Risk of Myocardial Infarction Among Bus Drivers in Urban Areas
        L. Alfredsson, N. Hammar, C. Hogstedt

4:50   SHEEP - Stockholm Heart Epidemiology Program: Study Design
        C. Reuterwall, A. Ahlbom, F. Diderichsen, U de Faire, J. Hallqvist, C. Hogstedt, G. Pershagen, T. Theorell, A. Wolk, and the SHEEP Study Group

5:10   The Relationship Between Job Strain, Ambulatory Blood Pressure and Hypertension
        P. Landsbergis, P.L. Schnall, J.E. Schwartz, K. Warren, T.G. Pickering

Exposure 2

Session Chair: Ms. Patricia Stewart

1:40   Extrapolation of Past Fiber Exposures in the Production of Man-Made Vitreous Fibers
T. Smith, M. Quinn, M. Wilcox, R. Yu, T. Schneider, G. Marsh

2:00   An Evaluation of New Fiber and Co-Exposure Data for the U.S. Cohort of Fibrous Glass Production Workers
G.M. Marsh, R.A. Stone, V.L. Henderson, T.J. Smith, M.M. Quinn, M.A. Wilcox

2:20   Defining an Optimal Dose Metric for the Epidemiologic Study of Obstructive Lung Disease in Coal Miners
N.S. Seixas, T.G. Robins, M.P. Becker

2:40   Retrospective Exposure Assessment Using an Independent Panel of Experts
J. Ives, R. Wagner, P. Bartee, S. Wood, C. Fryman, A. Mitchinson

3:00   An Empirical Assessment of the Effect of Different Summary Worklife Exposure Measures on the Estimation of Risk in Case-Control Studies of Occupational Cancer
C. Soskolne, M. Suarez-Almazor, K. Fung, G. Jhangri

Surveillance

Session Chair: Dr. William Halperin

3:50   Surveillance of Occupational Skin Disease in the United Kingdom - The Occ-Derm Project
N.M. Cherry, M.H. Beck

4:10   Epidemiologic Surveillance for Occupational Lead Poisoning in Washington State Using Workers' Compensation and Other Sources of Data: Analysis and Recommendations
J. Kaufman, J. Burt, B. Silverstein

4:30   Occupational Mortality in Italy: A Record-Linkage Based Surveillance System
G. Costa, S. Lagorio, F. Faggiano

4:40   Adjustment for Smoking, Alcohol Consumption, and Socio-economic Status in the California Occupational Mortality Study
J. Beaumont, J. Singleton, G. Doebbert, K. Riedmiller, R. Brackbill, K. Kizer

5:10   Organizational Correlates of Work-Related Disability
H. Shannon, V. Walters, W. Lewchuk, J. Richardson, D. Verma, T. Haines, L.A. Moran

Keynote and Plenary Presentations

8:45   **Session Chair:** Dr. Hernan Sandoval

8:50   **Keynote Presentation:**
Epidemiology as a Tool for Occupational Standard Setting
Dr. Haruhiko Sakurai

9:30   **Keynote Presentation:**
How Should We Characterize Occupational Exposures for Epidemiological
Purposes? - Lessons from the Past
Dr. Dirk Heederik

10:10   **Coffee Break**

       Session Chair: Dr. Marilyn Fingerhut

10:40   **Plenary Presentation:**
Variability of Exposure to Postural Load on the Back in Occupational Groups
A. Burdorf

11:00   **Plenary Presentation:**
Case-Cohort Study Designs in Occupational Epidemiology
B. Armstrong

11:20   **Plenary Presentation:**
Physical Job Demands, Job Control and Pregnancy Outcome
E. Wergeland, K. Strand, E.H. Endresen, T. Bjerkedal

11:40   **Luncheon/*Pavillion Ballroom***

Cancer 5

Session Chair: Dr. Theodore Meinhardt

1:10   An Exposure-Response Analysis of Cancer Mortality Among A Cohort of Workers Exposed to Ethylene Oxide
L. Stayner, K. Steenland, A. Greife, R. Hornung, R. Hayes, S. Nowlin, J. Morawetz, V. Ringenburg, L. Elliot, W. Halperin

1:30   Cancer Incidence in the Polyurethane Foaming Industry
L. Hagmar, Z. Mikoczy, H. Welinder

1:50   Acute Myeloid Leukemia Among Petrol Station Attendants
R. Jakobsson, A. Ahlbom, T. Bellander, I. Lundberg

2:10   Cohort Mortality Study of Filling Station Attendants
S. Lagorio, F. Forastiere, A.M. Bargagli, I. Iavarone, N. Vanacore, P. Borgia, C.A. Perucci

2:30   Cancer Incidence in a Cohort of Sewage Workers
L. Friis, C. Edling, L. Hagmar

Cancer 7

Session Chair: Dr. Cynthia Robinson

3:20   Cause of Death and Cancer Incidence Among Nurses
V. Rafnsson, H. Gunnardóttir

3:40   Cancer Risks Among Female Agricultural Workers in Sweden
K. Wiklund, J. Dich

4:00   Cancer Risk Among Urban Policemen in Rome
F. Forastiere, C.A. Perucci, A. Di Pietro, A. Bargagli, M. Miceli, E. Rapiti, P. Borgia

Cancer 6

Session Chair: Dr. Thomas Sinks

1:10   Evaluating the Efficacy of Colorectal Cancer Screening in Pattern and Model Makers
K. Parsons, R.Y. Demers

1:30   Colorectal Cancer and Physical Activity
M. Fredrikson, G. Arbman, O. Axelson, E. Nilsson, R. Sjödahl

1:50   Colon and Stomach Cancer Mortality Among Automotive Wood Model Makers
R. Roscoe, K. Steenland, C. McCammon, S. Schober, C. Robinson, W. Halperin, M. Fingerhut

2:10   Mortality of Urban Firefighters in Alberta: 1927-1987
T. Guidotti

2:30   20 Year Follow-up of Mortality of Coke Workers in Britain
J.F. Hurley, J.W. Cherrie, W.M. Maclaren

Solvents and Noise

Session Chair: Dr. Anne Fidler

3:20   Mortality of Paint Production Workers, Re-Analysis After Assessment of Exposure to Solvents
C. Zocchetti, S. Guercilena, A. Tironi, D. Consonni, A.C. Pesatori, P.A. Bertazzi

3:40   Glomerulonephritis and Solvent Exposure: A Case-Control Study of 298 Biopsy Proved Cases
B. Stengel, J.C. Limasset, J.C. Protois, S. Cénée, P. Brochard, D. Hémon

4:00   Liver and Kidney Function in House Painters with Long-Term Exposure to Organic Solvents
I. Lundberg, G. Hedenborg, M. Högberg, G. Nise, O. Vesterberg

4:20   Occupational Noise Exposure and Noise-Induced Hearing Loss: An Epidemiological Study in China Coal Mines
J. Xing, X. Shun, T. He, X. Liu

Injury and Musculoskeletal Disorders

Session Chair: Dr. Harlan Amandus

1:10   Self-Report Work Injury Experience of Minnesota High School Students
        W. Carl, D. Parker

1:30   A Case-Control Study of Risk Factors for Industrial Low Back Injury: The Utility of
        Preplacement Screening in Defining High Risk Groups
        C. Zwerling, J. Ryan, M. Schootman

1:50   Predictors of Sciatica in a Four-Year Follow-Up Among Elderly Municipal Employees
        H. Riihimäki, J. Seitsamo, K. Tuomi

2:10   Osteoarthritis of the Hip in Farmers
        D. Coggon, P. Croft, M. Cruddas, C. Cooper

Physical and Mental Stressors

Session Chair: Dr. Barbara Silverstein

3:20   Work Complaints and Physical Workload During Pregnancy
        A. Koemeester

3:40   Psychosocial Stressors at Work and Musculoskeletal Problems: A Study on a Representative
        Sample of the Dutch Working Population
        I. Houtman, P.M. Bongers, P.G.W. Smulders

4:00   A Cross-National Comparison of the Operating Characteristics of Job Stress and Mental Health
        Measures Between Japan and the U.S.
        C. Roberts, N. Kawakami, T. Haratani

4:20   Hearing Threshold Levels in a Nigerian Iron and Steel Factory: The Impact of Noise
        U.G. Oleru, S. Lawson

Respiratory Disease 2

Session Chair: Dr. Gregory Wagner

1:10   Occupational Dust Exposure and Lung Disease Among Sheet Metal Workers
        K. Hunting, L. Welch

1:30   Correlation Between Respiratory Symptoms and Accelerated Loss of Ventilatory Function in
        Asbestos-Exposed Workers: A Longitudinal Analysis
        C. Brodkin, S. Barnhart, G. Anderson, H. Checkoway, G. Omenn, L. Rosenstock

1:50   Prevalence and Incidence of Coalworker's Pneumoconiosis in U.S. Underground Miners
        M.D. Attfield

2:10   Surveillance of Asbestosis Deaths in the United States Using Multiple Cause of Death Data,
        1968-1988
        R.B. Althouse, T.B. Richards, S.R. Game, R.M. Castellan

2:30   Trends in Classification of Small Opacity Type in the Coalworker's X-Ray Surveillance
        Program, 1970-1989
        M.D. Attfield, K. J. Musgrave

Metals

Session Chair: Dr. Tee Guidotti

3:20   Impact of Unleaded Gasoline Regulation on Blood Lead Levels of Workers in Muffler Shops
        L. Goulet (presented by M. Rossignol), J. Blais

3:40   Nasal Septum Lesions Caused by Chromium Exposure Among Chromium Electroplating
        Workers
        S. Lin, J. Wang

4:00   Increased Lead Absorption Caused by Working Next to a Lead Recycling Factory
        K. Chao, J. Wang

ABSTRACT PRESENTATIONS

Wednesday, September 23, 1992
Plenary Presentations

FULL COHORT ANALYSIS OF DIGESTIVE AND RESPIRATORY CANCER RISK AMONG AUTOWORKERS

E. EISEN, P. TOLBERT, R. MONSON, T. SMITH, L. POTHIER, M. HALLOCK, S. WOSKIE, K. HAMMOND

Ellen A. EISEN, Susan R. WOSKIE: Dept. of Work Environment, University of Massachusetts Lowell, Lowell MA 01854; Paige E. TOLBERT, Richard R. MONSON, Lucille POTHIER; Occupational Health Program, Harvard School of Public Health, Boston, MA; Thomas J. SMITH, S. Katharine HAMMOND: University of Massachusetts Medical Center, Worcester, MA 01655 USA

OBJECTIVE: Previous reports have suggested excess digestive and respiratory cancers in occupational groups exposed to machining fluids. To better evaluate this risk, a large cancer mortality study was designed with special attention to detailed assessment of exposure.

METHODS: Extensive information was obtained on retrospective exposure to specific types of machining fluids as well as to components and additives. In addition, particle size distributions were characterized in order to permit the best possible estimates of dose to target tissues. Quantitative estimates of lifetime exposure to total particulate of straight, soluble, and synthetic fluids as well as to grinding, were calculated for over 30,000 autoworkers at two plants. In a full cohort analysis based on Poisson regression models, categories of exposure to grinding and each type of fluid were defined by quintiles of the distribution of deaths.

RESULTS: There were 8600 deaths. Results provide strong evidence for associations between straight oils and both rectal cancer (n-57) and larynx cancer (n=38), and between grinding and esophageal cancer (n=52). For cumulative exposures over 2.5 mg/m^3-yrs to straight oils the relative risks were 2-2.5 for both rectum and larynx cancer. For the same degree of exposure to grinding, the risk ratio for esophagus cancer was almost 3-fold (95%CI:1.1-7.5). For these cancers, the excess risk was uniform across the two plants and increased monotonically over exposure categories. There was also a suggestion of weaker associations of stomach and pancreatic cancer with grinding. Particle size distributions indicate that the majority of machining fluid particulate is larger than respirable, supporting the evidence of digestive and upper respiratory tract cancer risk. Nested cased-control analyses are underway to better characterize the specific etiologic agent by allowing control for confounding due to multiple exposures and the examination of specific components of the fluids.

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USE OF MULTIPLE CAUSE MORTALITY DATA IN EPIDEMIOLOGIC ANALYSES: STANDARD U.S. RATE AND PROPORTION FILES DEVELOPED BY NIOSH/NCI

K. STEENLAND, S. NOWLIN, B. RYAN, S. ADAMS

Kyle STEENLAND, Sue NOWLIN, Brent RYAN, Steve ADAMS: NIOSH, 4676 Columbia Parkway, R-13, Cincinnati, OH 45226, USA.

We have created U.S. mortality rates (age, sex, race, and calendar-time specific) and proportions using multiple cause-of-death data, for the years 1960-1989. Multiple cause-of-death data include the usual underlying cause-of-death from the death certificate, but also contributory causes and other significant conditions. U.S. multiple cause rates and proportions enable the user to calculate expected occurrences of disease on the death certificates of a cohort under study. There are an average of 2.66 causes/contributory conditions listed on U.S. death certificates, increasing over time from 2.54 in the 1960's to 2.76 in the 1980's. The ratio of multiple cause listings to underlying cause listings varies by disease, from low ratios for cancers to high ratios for diseases such as diabetes, arthritis, prostate disease, hypertension, pneumoconiosis, and renal disease. Use of these data is illustrated via an analysis of renal disease and arthritis among granite cutters, and of diabetes in a cohort of workers exposed to dioxin (outcomes of a priori interest). Multiple cause analysis (but not underlying cause analysis) revealed significant excesses of renal disease (PMR 2.12, 34 observed) and arthritis (PMR 2.01, 17 observed) among 991 granite cutters. For 5172 workers exposed to dioxin, neither multiple cause nor underlying cause analysis indicated any excess of diabetes. Good candidates for multiple cause analysis are diseases which are of long duration, not necessarily fatal, yet serious enough to be listed on the death certificate.

CANCER 1

GENETIC SUSCEPTIBILITY AND OCCUPATIONAL EXPOSURES IN THE ETIOLOGY OF LEUKEMIA AND NON-HODGKIN'S LYMPHOMA

L.M. POTTERN, L.M. BROWN, M.S. LINET, A. BLAIR

Linda M. POTTERN, Linda Morris BROWN, Martha S. LINET, Aaron BLAIR: National Cancer Institute, Executive Plaza North, Room 418, Bethesda, MD 20892, USA

Leukemia and non-Hodgkin's lymphoma (NHL) have been linked with agricultural and other occupational exposures, but the possible modifying influence of genetic susceptibility has not been extensively investigated. To investigate this relationship, we used data from a population-based interview study of 578 white men with leukemia, 622 with NHL, and 1,245 controls residing in Iowa and Minnesota. There was about twice the risk of leukemia and NHL for subjects reporting a parent or sibling with lymphatic or hematopoietic cancer compared to subjects without a family history. We recently examined possible interactions of occupational exposures and genetic factors in this population. Using non-farmers without a family history as the comparison group, we found that farmers who were both exposed to herbicides and had a positive family history had a leukemia risk of 3.5, non-exposed farmers with a family history had a risk of 1.8 and exposed farmers without a family history had no risk. Risks for NHL were similar to leukemia risks for non-exposed farmers with a family history and exposed farmers without a family history. However, the NHL risk for farmers exposed to herbicides who had a family history was 1.8. To evaluate the interaction of various non-agricultural occupational exposures with family history, we used subjects who did not have a family history or exposure to a specific substance at the referent group. Leukemia risks of 2.0 or greater were observed for subjects with a family history and exposure to gasoline, synthetic oils, metals, or asbestos while exposed subjects without a family history had no risk. Significantly elevated risks of NHL were seen for subjects with a family history and exposure to gasoline, synthetic oils, benzene, metals, and formaldehyde. These findings suggest that genetic susceptibility may be a modifier of leukemia and NHL risk among farmers and other workers exposed to certain occupational exposures.

LARYNX CANCER AND OCCUPATION: PRELIMINARY RESULTS FROM THE IARC MULTICENTRIC CASE-CONTROL STUDY

Franco BERRINO (1), Paolo BOFFETTA (2), Jacques ESTEVE (2), Franco MERLETTI (3), Paola PISANI (1, 2), Luc RAYMOND (4), Albert TUYNS (2), Angel Del Moral ALDAZ (5), Antonio ZUBIRI (6)

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During 1979-1982, a multicentric population based case-control study on cancer of the larynx and hypopharynx has been conducted in Calvados (France), Turin and Varese (Italy), Zaragoza and Navarra (Spain), and Geneva (Switzerland). Among males, over 1100 cases and 3000 controls were enrolled in the study. Details on the study design and results according to alcohol drinking and tobacco smoking have been published (1). Subjects were asked about their occupational history since 1945 and were classified as ever employed in 156 occupations and 70 industries. Odds ratios (OR) and 95% confidence intervals (CI) were calculated via logistic regression controlling for centre, age, alcohol drinking, tobacco smoking and socioeconomic class. Among the occupations at higher risk in this preliminary analysis were butchers (OR, 2.6; 95% CI, 1.2-5.4), wood machine operators (OR, 2.9; 95% CI, 0.9-9.8), blacksmiths (OR, 1.9; 95% CI, 1.0-3.8), mechanics (OR, 1.3; 95% CI, 0.8-2.2), potters (OR, 5.5; 95% CI, 1.3-22), reinforced concrete workers (OR, 2.4; 95% CI, 0.9-6.1), housebuilders (OR, 1.7; 95% CI, 0.9-3.2), plasterers (OR, 3.0; 95% CI, 0.6-14). Among the industries at higher risk were boot and shoe manufacture (OR, 1.4; 95% CI, 0.8-2.6), wood industries other than furniture making (OR, 2.3; 95% CI, 0.7-7.0), non ferrous metal production (OR, 2.6; 95% CI, 1.0-6.9), radio equipment manufacture (OR, 1.9; 95% CI, 0.7-5.6), shipbuilding (OR, 1.9; 95% CI, 0.8-4.7), hotels (OR, 2.0; 95% CI, 0.9-4.7), railroads (OR, 1.5; 95% CI, 1.0-2.4), and hairdressing (OR, 2.3; 95% CI, 1.0-5.3). For selected categories, duration of employment and time since beginning of employment were also investigated. The possible confounding effect of other factors, such as use of filter, colour of tobacco and dietary factors was not taken into account. The problem of multiple comparison has been addressed by applying the empirical Bayes ranking methodology proposed by Thomas and coworkers (2). In addition, a job-exposure matrix (3) for 16 chemicals or groups of chemicals has been applied to the occupational histories of cases and controls.

(1)   Tuyns et al., Int J Cancer 1988, 41, 483-91.
(2)   Thomas et al., Am J Epidemiol 1985, 122, 1080-95.
(3)   Ferrario et al., In: Progress in Occupational Epidemiology, Elsevier, Amsterdam, 1988, 379-82.

OCCUPATIONAL RISKS OF BLADDER CANCER IN FRANCE: A MULTICENTRIC CASE-CONTROL STUDY

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Relationships between occupational risk factors in France and bladder cancer were assessed from a hospital-based case-control study conducted between 1984 and 1987 in five regions representing different industrial activities (such as mines, textile, metal work, rubber and chemical industry). 765 cases (658 men, 107 women) and an equal number of controls were included in the study. Odds ratios adjusted on matching variables (age, residence, hospital), tobacco smoking and coffee consumption were estimated by unconditional logistic regression. A significantly increased risk of bladder cancer among men was observed in coal mining (OR = 3.46 95% CI 1.62-7.41), chemical industry (OR = 2.41 95% CI 1.18-4.91), and car manufacture (OR=1.89 95% CI 1.02-3.48). Aircraft and ship officers (OR=11.74 95% CI 1.44-95.41), managers (OR=1.78 95% CI 1.18-2.69), street vendors (OR=4.04 95% CI 1.08-15.10), miners (OR=2.30 95% CI 1.0-5.30) and machinery fitters (OR=1.53 95% CI 1.03-2.29), also presented an increased risk. Among women, working in the clothing industry was associated with an elevated odds ratio (OR=3.29 95% CI 1.22-8.91). Some occupational exposures, as assessed by expert evaluation, were significantly more frequent among cases: organic solvents (OR=1.43), industrial oils and greases (OR=1.50), welding fumes (OR=1.54) and coal dust (OR=2.07). Variations in risk associated with these exposures according to time period, duration and level, and their joint effects, will be presented. Also high risks observed in coal mining, petroleum refining, glass industry, chemical industry, steel foundry, car manufacture and mechanics are consistent with a role of exposure to polycyclic aromatic hydrocarbons and this relationship will be studied further.

A CASE-CONTROL STUDY OF MULTIPLE MYELOMA AND OCCUPATION

P. DEMERS, T. VAUGHAN, T. KOEPSELL, N. WEISS, J.L. LYON, G.M. SWANSON, R. GREENBERG

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We analyzed lifetime job histories from a population-based, case-control study to investigate the relationship between multiple myeloma and employment in various occupations and industries. Incident cases were identified through tumor registries that serve the Seattle, Detroit, Salt Lake City, and Atlanta metropolitan areas. Controls were selected by random digit dialing at three sites and area sampling at the fourth. Interviews were obtained from 89% (692) of eligible cases and 83% (1683) of eligible controls. Odds ratios were calculated after adjustment for sex, age, race, and study area.

An elevated risk was observed among persons ever employed as painters (odds ratio (OR) = 2.1, 95% confidence interval (CI) = 1.2-3.6), particularly for those employed for 10 or more years (OR= 4.1, 95% CI = 1.8-10.4). The association differed little between those who reported having been highly exposed to solvents or paints (OR = 2.3) and those who did not (OR = 2.0). A small excess risk was observed among agricultural workers employed for 10 or more years (OR = 1.3, 95% CI = 1.0-2.2) with a higher relative risk observed among farm laborers (OR= 1.8, 95% CI = 1.0-4.0). Among agricultural workers who reported having been highly exposed to pesticides the OR was 5.2 (95% CI = 1.6-21.1).

Some evidence, based upon smaller numbers, was also found to support an association with firefighting and employment in the petroleum and coal products manufacturing industries. Although an excess risk was observed among foresters and loggers (OR = 2.5, 95% CI = 1.1-12.0), little other evidence was found to support the previously-noted association with wood exposure. An excess risk was not observed among carpenters (OR - 1.0, 95% CI = 0.5-2.0), workers employed in lumber and wood products manufacturing (OR - 1.0, 95% CI = 0.6-2.0), or pulp and paper workers (OR = 0.4, 95% CI = 0.2-1.3. No evidence for an association with employment in the rubber or petroleum refining industries was found. An elevated risk of multiple myeloma was also observed among aircraft manufacturing workers, metal and plastic working machine operators, and miners. To our knowledge, these latter associations have not been previously reported, although an excess risk among some related occupational groups has been observed.

This study lends further support to previously reported associations between multiple myeloma and employment as painters and agricultural workers. The other associations observed in this study deserve evaluation in future studies.

PANCREATIC CANCER AND OCCUPATIONAL EXPOSURES

T. PARTANEN, R. DEGERTH, T. KAUPPINEN, I. MEARELLI, S. HERNBERG, A. OJAJÄRVI, H. KOSKINEN, G. MONETA, L. TEPPO

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Very little is known about workplace chemicals that affect the risk of pancreatic cancer (PC). Occupational determinants of PC were studied in a case-referent setting, the cases comprising the primary exocrinic PC cases (N=1419), and the referents the cases of stomach, rectum, and large intestine cancers(N=3510), diagnosed in Finland between 1984 and 1987 inclusive at 40 - 74 years of age, known to be dead April 1990. The number of responders to a mail questionnaire on work histories, living habits, and diseases, addressed to the next-of-kin, was 662 for the cases and 1,770 for the referents. The main industry where employed, main occupation held, and 17 occupational exposures were reconstructed from the elicited job histories from first job until 1974. The associations of PC risk with industries and occupations were scrutinized with logistic regression models, adjusted for gender, age, alcohol consumption, cigarette smoking, diabetes, and pancreatitis. Exposures were analyzed the same way, excluding administrators and managers from the analysis to control for social class. Significantly elevated PC risks were observed for the following three industries: market gardening, fruit, flower and seed growing; production of cement and building materials and distribution of non-food goods. Farming and stock-rearing were associated with significant deficit in risk. The following occupations were associated with a significantly increased risk: gardeners and groundsmen; textile fabrics production process workers (excluding weavers); transport and communications inspectors and supervisors; and warehousemen, storekeepers, and assistants in warehouses and stores. When low-level and substantial exposures were pooled for each of the 17 exposures and contrasted with background exposure, no significant elevations were observed in any of the adjusted ORs. The most noteworthy ORs were observed for organic solvents (1.4, 95% CI 0.9-2.1, 34 exposed cases), pesticides (1.6, 0.8-3.2, 13 exposed cases), and wood dust (1.3, 0.8-2.1, 25 exposed cases). The OR for substantial exposure to organic solvents was 2.0 (1.0-4.1, 14 exposed cases). Taken all the evidence available, it seems that the PC risk attributable to chemical exposures in workplace is not substantial. This study points toward the possible role of unidentified organic solvents and pesticides, but the excess risks were not high, and the evidence remains somewhat imprecise.

METHODS

G-ESTIMATION OF THE EFFECT OF FORMALDEHYDE EXPOSURE ON THE MORTALITY OF CHEMICAL WORKERS

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We use the method of G-estimation to estimate the effect of formaldehyde exposure on all cause mortality in a cohort of 25,000 chemical workers studied by Blair et al., (JNCI, 1986). We show that, in this cohort, employment history is simultaneously a confounder and an intermediate variable on the casual pathway from formaldehyde exposure to death. Further, we show that all standard methods such as Cox and Poisson regression that use a summary of exposure history up to time t (e.g., cumulative exposure, average exposure, duration of exposure) to predict the mortality rate at t will be biased for the casual effect of exposure when there is a covariate that is simultaneously a confounder and an intermediate variable (whether or not one adjusts for the covariate in the analysis). In contrast, a G-analysis is specifically designed to control for confounding by intermediate variables by never lumping exposures at different times. Specifically, we find a statistically significant negative association between cumulative formaldehyde exposure and age-specific mortality (controlling for age, calendar year, race, sex, plant, salary status, and time since hire) using a time-dependent Cox model with cumulative exposure as the exposure variable (p=.02). We show this artifactual negative association is due to the fact that unhealthy workers at increased risk of death terminate employment early. Further we find no association between cumulative formaldehyde exposure and age-specific mortality when controlling for employment history, (p=.947).

In contract, a G-analysis estimates a 6% loss in life expectancy for a subject exposed to one part per million of formaldehyde beginning at age 20 [95% confidence interval (1%, 11%)]. We also estimate a casual rate ratio of 124 [95% confidence interval (1.04, 1.44)] had the entire cohort been exposed at one part per million throughout versus had the entire cohort been unexposed throughout. The method of G-estimation generalizes and improves upon the G-computation algorithm and the G-null test previously proposed by Robins (Journal of Chronic Diseases, 1987).

DOES THE HEALTHY WORKER EFFECT DECLINE WITH TIME?

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Whether or not the Healthy Worker Effect decreases in time is an important question bearing on methods to control or adjust for the HWE in occupational health studies.

Using six years of data from the National Health Interview Survey (NHIS) and computing Standardized morbidity Ratios (SmR) equivalent to standardized mortality ratios (SMR), we find that SmRs for employed workers is < 1.00 throughout the entire range of age groups. However, the SmR for unemployed individuals is larger than 1.00, and is largest for unemployed individuals not seeking employment.

Those observations are consistent with recent reports by Steenland and Stayner who find that the apparent decline of the HWE is due to increased mortality of inactive (i.e. not working) persons. On the other hand, the SMRs for actively employed workers remains stable and in fact slightly declines over their lifetime.

Using data from a retrospective study of U.S. veterans, we also find similar to Steenland and Stayner that veterans who have remained employed have a SMR of < 1.00 consistently over their lifetime. Similar results have been obtained by other studies of SMRs of U.S. veterans. As a result, the assumption that the HWE declines in time appears to be unfounded. The design of occupational studies, the comparison of SMRs between multiple cohorts, and the interpretations of trends within cohort always need to be adjusted for the possible effects of employment status.

ARSENIC, CIRCULATORY DISEASE, AND THE HEALTHY WORKER SURVIVOR EFFECT

H.M. ARRIGHI, I. HERTZ-PICCIOTTO

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Arsenic is a known human toxin with documented cardiovascular effects. A reanalysis of circulatory disease mortality in an occupationally exposed cohort from Tacoma, Washington (n=2802) revealed no association with arsenic on circulatory disease when an external reference group was used. Further analyses were conducted to evaluate the use of external vs. internal referents and the influence of the healthy worker survivor effect (HWSE). With external referents, the overall standardized mortality ratio (SMR) was 0.95. Cumulative exposure categories were created with cutpoints in micrograms/meter^3-years: <750, <2000, <4000, <8000, <20,000, and <45,000. From the lowest to highest exposure category, the SMRs were 0.97, 0.90, 0.90, 0.97, 0.94, 1.0, and 0.90. Lagging cumulative exposure and restricting the analysis to survivors beyond a set number of years have been proposed as methods to control for the healthy worker survivor effect (HWSE). Neither of these methods using external referents (SMR analyses) modified the results. With a 10 year lag, the SMRs were 0.84, 0.94, 0.99, 0.85, 1.1, 0.94, and 0.86. However, lagging exposure assumes a latency period, which may not be appropriate for cardiovascular effects. With a 10 year restriction, the SMRs were 1.0, 0.95, 0.92, 0.97, 0.95, 1.0, and 0.90. Nevertheless, a comparison of SMRs across dose categories is potentially inaccurate, since the age distributions and the proportion currently employed differ by dose. For example, the median age is 41 years among the lowest exposed category vs. 64 years in the highest category. Similarly, the proportion of employed person-years is 26% in the lowest dose category vs. 59% in the highest category. Confounding by age or current employment status may, therefore, mask a dose effect using SMRs.

Internal comparisons were conducted using Poisson regression models. With the lowest dose group as referent (rate ratio = 1.0), rate ratios (RR) for the remaining exposure groups (lowest to highest) were: 0.92, 0.92, 1.0, 0.99, and 1.1 (The highest two categories were combined to increase precision.) Next, the HWSE was controlled by the inclusion of a covariate representing work status (currently employed versus retired or otherwise not employed). This model revealed a dose-response relation, with RR's of 1.0, 1.1, 1.2, 1.2, and 1.3.

These results suggest that the HWSE may have masked an effect of arsenic exposure on circulatory disease mortality. Plausibility of this association is supported by both experimental and epidemiologic data. Rats fed sodium arsenate had altered vascular responsiveness; cats developed electrocardiographic changes. Human populations exposed to high arsenic levels in drinking water experienced fibrous thickening of arterial walls and vascular alterations leading to blackfoot and Raynaud's diseases. Similar vascular disorders and abnormal electrocardiograms have been observed in arsenic exposed vineyard workers. The importance of both controlling for the HWSE and using an internal referent is indicated since no effect on circulatory disease mortality was observed with only one or the other analytic strategy. This may explain why previous results for this end point have been inconsistent. The occupational health significance for this work could be considerable since the high underlying rate of cardiovascular disease implies that a small increase in the RR represents a large increase in the number of cases attributable to arsenic exposure.

IS THE MODEL WITH THE LARGEST EXPOSURE EFFECT THE BEST MODEL?

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As epidemiologists, we are generally inclined to consider more credible those associations showing a stronger exposure-response relation, such as higher relative risks or rate ratios. Higher parameter estimates look particularly credible, because one usually exercises care to avoid sources of upward bias, such as bias from selection or misclassification or confounding. Whereas the "higher estimate" approach may often work in practice, such a criterion for credibility may, however, not have general validity and it may actually be in contradiction with a likelihood-based approach. There is a potential conflict between a "naive" approach based on the magnitude of parameter estimates and a "statistical" criterion based on maximization of the likelihood function. It is likely that most epidemiologists believe that the two approaches are equivalent or that they may at the most show trivial differences of no practical relevance. The goal of this presentation is to illustrate, by way of examples, situations in which there may be inconsistencies between the two approaches. In the examples, based on regression models with both published and artificial data, the maximum likelihood estimate for exposure-lag parameters was obtained by fitting models to lagged exposure with different values of the lag. In this way, it was possible to compare the behavior of the lag-likelihood statistics with that of the relative risk. The examples show that a higher estimate of the relative risk may be accompanied by an increase in the degree of its uncertainty, in which case the "higher estimate" criterion may not agree with the likelihood. The results of this exercise suggest that the "estimate" criterion may not be valid and that, once we can exclude sources of bias, epidemiologic inference should be based on the likelihood function.

COMPARISON OF SEVERAL TESTS FOR HETEROGENEITY

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Testing for heterogeneity is necessary in comparing the risk between groups with different exposure and even more important as a prestage test before pooling the results of several studies for an overview or a meta-analysis. An actual example, in the context of occupational epidemiology, is ethylene oxide. The epidemiological studies showed different results. Studies in Sweden have found an high risk for leukemia and stomach cancer, whereas other studies have not. In order to summarize all results, studies must be tested for homogeneity so they may be pooled together. The common test for this situation is (e.g., BRESLOW & DAY, 1987):

$$T^2 = \sum_i \frac{(O_i - E_i * SMR)^2}{E_i * SMR}$$

with O_i=observed number of events in study i; (i=1...,I) E_i=expected number and
$SMR = \sum O_i / \sum E_i$ the overall standard mortality ratio.
Applying this test to the data for stomach cancer (7 studies) leads to highly significant results
($T_1^2 = 33.16$). In order to validate this result, the test has been compared with other precedures

based on other approximations of the POISSON-distribution:

$$a) \quad T_2^2 = 4 * \sum_i [\sqrt{O_i} - \sqrt{E_i * SMR}]^2 \qquad \text{(square root transformation)}$$

$$b) \quad T_3^2 = \sum O_i * \ln(SMR_i / SMR)^2 \qquad \text{(maximum-likelihood theory)}$$

$$c) \quad T_4^2 = 2 * \sum O_i * \ln(SMR_i / SMR) \qquad \text{(likelihood ratio statistics)}$$

All tests are under H_o (same risk in all studies) approximately X^2-distributed with I-1 degrees of freedom. The application of these tests on the same data lead to the following results:

$$T_2^2 = 18.11; \quad T_3^2 = 26.10; \quad T_4^2 = 19.55.$$

All tests are statistically significant (p<0.01) but with differences. In order to compare all test procedures a simulation study was performed. With moderate sample sizes the results are as follows:
1) Usually all tests are close together;
2) Approximation to X^2-distribution is reasonably good; and
3) There is a slight advantage of test T_2^2, especially with small sample sizes.

Reference:
BRESLOW, N.E., & DAY, N.E., (Eds.) Statistical methods in cancer research. Vol 2. The design and analysis of cohort studies. IARC scientific publication no. 82. Lyon, 1987.

NEUROTOXINS

THE INFLUENCE OF OVERTIME ON THE ASSESSMENT OF NEUROBEHAVIORAL EFFECTS OF PETROLEUM NAPHTHA EXPOSURE IN AN OCCUPATIONAL SETTING

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Experimental studies have shown that fatigue resulting from simulated long work shifts can affect cognitive performance. But current review of the occupational epidemiology literature did not reveal any analyses of the effects of overtime in the assessment of neurobehavioral effects of toxic exposures. In this prospective cohort study involving 248 workers within the automotive industry, we examined the effect of various work time measures on neurobehavioral test performance and its influence on the study of the association between petroleum naphtha exposure and neurobehavioral effects. Day, week, month, and year work time measures were calculated from company payroll records. Cross-sectional analysis of Year 1 data by multiple linear regression demonstrated that overtime, particularly overtime hours in the week before testing [mean= 7.3 ± 7.6; defined as number of hours worked greater than 8 hours/day and greater than 5 days/week], was significantly associated with mood changes (Profile of Mood States (POMS): depression, fatigue and confusion), reduced attention, increased response time (time to complete Trails A and B; response time on Pattern Memory task), and with poorer performance on a computerized Vocabulary task. In Year 2, where subjects worked two times less overtime on average than in Year 1 [mean= 3.5 ± 5.0], overtime measures were not associated with any neurobehavioral test outcome. Length of time worked on test day before testing was a significant predictor of mood (increased depression, anger and fatigue on POMS).

In occupational studies of neurobehavioral effects, attention to overtime should be made in the study design and in the interpretation of results.

VISUAL DYSFUNCTION AMONG STYRENE EXPOSED WORKERS

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Neuro-optic pathways have been shown to be particularly vulnerable to organic solvent exposure. The present study was undertaken to examine the relationship between visual functions and styrene exposure. From a total of 151 workers from 3 glass-reinforced-plastic plants in Quebec, 128 (85%) agreed to participate in the present study. A self-administered questionnaire was used to obtain socio-demographic information, work history, a description of work activity and conditions, medical history and symptoms. Environmental and biological measures were made on the day(s) previous to administration of visual tests of near and far visual acuity (Snellen and National Optical Visual Charts), chromatic discrimination (Lanthony D-15 desaturated panel) and near contrast sensitivity (Vistech 6000) at 5 spatial frequencies (1.5, 3, 6, 12 and 18 cycles/degree). Tests were administered at least 14 hours after the cessation of exposure. Following application of exclusion criteria (<6 months in the plant, colorblindness, ocular disorders and injuries, diabetes) analyses were performed on 94 persons. They were relatively young (29y $\pm$ 8), with little seniority (5y $\pm$ 4). Styrene exposure for 8 hours (TWA) ranged from 6 mg.m^3 to 937 mg/m^3 (Q1: 21; Q3: 303), depending on job site. Post-shift urinary mandelic acid concentrations ranged from non-detectable to 2366 mg/g creatinine. Color vision loss, adjusted for age and alcohol consumption, was related to post-shift urinary mandelic acid (F=7.79; p$\leq$0.01), to styrene level at job site for those who did not wear a mask (F=14.66; p$\leq$0.001) and to a cumulative exposure index (F=9.35; p$\leq$0.01). No relationship was observed between exposure parameters and near or far visual acuity and near visual contrast sensitivity. Those (n-21) with the highest levels of post-shift urinary mandelic acid ($\geq$800 mg/g creatinine), presented significantly higher prevalences (Chi square: p$\leq$0.05) of acquired dyschromatopsia (52% vs 26%), blurred vision (52% vs 29%), tearing (43% vs 19%) and eye irritation (62% vs 30%). These results demonstrate a dose/response relationship between styrene exposure parameters and acquired color vision loss. Analysis of visual functions can provide important information on early neurotoxic effects of organic solvent exposure. Changes are actually being made in these workplaces at those job sites with the highest exposure and visual functions will be re-assessed.

A NEUROBEHAVIORAL EVALUATION OF PCE EXPOSURE IN PATIENTS AND DRY CLEANERS: A POSSIBLE RELATIONSHIP BETWEEN CLINICAL AND PRE-CLINICAL EFFECTS

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Long-term clinical deficits in visual/spatial function, short-term memory, cognitive flexibility, and disturbances in mood have been identified and followed in nine patients occupationally exposed to perchloroethylene (PCE). A frontal/limbic hypothesis is offered as the site of pathology. A separate cross-sectional study evaluated among dry cleaner personnel (n-65), the relationship between occupational exposure to PCE and performance (visual reproductions, pattern memory and recognition, digit span, symbol-digit, trailmaking, and vocabulary), mood (POMS), and symptoms. Similar impairments would suggest a continuum between clinical and pre-clinical effects from one solvent since solvent mixtures are not used to clean fabrics.

Sixty-five people employed in 24 shops in the Detroit area were stratified into low, moderate, and high current and chronic PCE exposure groups based on the concentration of PCE in their breath. An unexposed group was unavailable. Industrial hygiene measurements identified three PCE exposure zones for the counter clerks, pressers, and operators. The concentration of PCE in breath differed between job titles discriminating between 2.9 ppm, 6.5 ppm, and 11.4 ppm PCE, corresponding to estimated air levels of 11.2, 23.2, and 40.8 ppm respectively. For the current exposure analysis within each shop, a lower exposed counter clerk or presser as matched on age and education for each higher exposed operator. For the chronic lifetime exposure analysis, an index was based on the sum of current exposure category for each job title multiplied by duration on each job. The respective average employment for the low, moderate, and high exposure groups was 2.1, 3.9, and 14.6 years. A statistical significant linear exposure-effect was observed ($p < .05$).

Performance was analyzed using adjusted mean scores corrected for factors affecting performance found on multiple linear regression models. The chronic exposure index was the independent variable simultaneously controlling for acute PCE exposures. Significant pre-clinical decrements were found among the same individuals for visual reproductions (14.4%), the number correct (6.7%) and the latency (10%) for pattern memory, and the number correct (3.9%) for pattern recognition. There was no interaction between alcohol use and PCE exposure. The lack of a non-exposed group may explain the absence of significantly affected mood and symptoms. However, results do support the hypothesis that PCE exposure may affect frontal/limbic function on a continuum between clinical and preclinical CNS effects. CNS effects below 50 ppm, supporting the reduction of the OSHA standard to 25 ppm, show that behavioral testing can successfully be used as an early indicator of clinical CN health problems.

PREVALENCE OF DEPRESSION AMONG ELECTRICAL WORKERS

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Since the 1960s, concerns have been raised regarding possible adverse psychological consequences of exposures to electric and magnetic fields (EMF). It has been hypothesized that EMF may act to suppress the normal nocturnal rise in pineal melatonin production, which is potentially linked to depression.   To our knowledge no previous study has systematically examined indicators of depression using standardized assessment tools.

The Vietnam Experience Study, conducted by the Centers for Disease Control, included an extensive psychological assessment battery. We compared results from 183 current electrical workers (including 59 electricians, 27 electrical technicians, and 26 telephone repairers and installers) to 3861 other workers with respect to diagnosis of depression based on the Diagnostic Interview Schedule (DIS), symptoms reported in the DIS (weight gain or loss, sleep disturbance, slowness or restlessness, loss of interest in sex, feelings of worthlessness or guilt, trouble thinking, or thoughts of death); and Minnesota Multiphasic Personality Inventory (MMPI) scales for depression, hysteria, subjective depression, psychomotor retardation, physical malfunctioning, mental dullness, and brooding.   Each item was dichotomized based on standard criteria and prevalence ratios were calculated comparing electrical workers to non-electrical workers. All results were adjusted for years of work in current job (1-10, 11-15, 15+ years).

For all electrical workers, the prevalence ratio (PR) for depression in the last month was 1.5 (95% CI: 0.6-3.6), the PR for lifetime depression was 1.0 (95% CI: 0.5-1.6), and the PR for recurrent unipolar depression was 0.8 (95% CI: 0.4-1.7). Although results for individual occupations were quite imprecise, evidence of an increased risk of depression in the last month was noted for electricians (PR=2.6, 95% CI: 1.0-6.8). Depressive symptoms tended to be rarer among electrical workers, most notably weight gain or loss (PR=0.5, 95% CI: 0.1-1.3) and loss of interest in sex (PR=0.2, 95% CI: 0.0-1.1). Only for "trouble thinking" was risk even modestly elevated (PR=1.6, 95% CI: 0.8-2.9), with short-term electrical workers at more notably elevated risk compared to other short-term workers (PR=2.0, 95% CI: 0.8-4.8). Electricians tended to have elevated risks for sleep disturbances and fatigue (PRs=1.4), feeling of worthlessness and guilt (PR=2.4), and trouble thinking (PR=2.1), all imprecise estimates. Prevalence ratios for elevated MMPI scores were all close to the null, with individual estimates ranging from 0.6 (MMPI D Scale, subtle) to 1.3 (MMPI Hy Scale, subtle).   Analysis by duration of employment suggested that long-term electrical workers were more likely to have high scores on "brooding" (PR=1.9, 95% CI: 0.7-5.2).

Our ability to detect modest increases was limited by the numbers of such workers included in the study, the inherent uncertainty in attributing EMF exposure based on job title alone, and our inability to adjust for such neurotoxic agents as solvents.   Overall these results provide evidence against a widespread or sizable increase in depression or related symptoms among electrical workers.

EARLY INDICATION OF NERVOUS SYSTEM DYSFUNCTION AMONG MANGANESE EXPOSED WORKERS

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Manganese poisoning, first described in 1837, has since been noted in hundreds of cases of industrial workers and miners throughout the world. Characterized by signs and symptoms of extrapyramidal dysfunction, in its later stages, it presents many similarities with Parkinson's disease. The present study was undertaken in order to identify early indicators of manganese neurotoxicity among active workers in a ferro and silico manganese alloy production plant. An industrial hygiene sampling strategy was used to determine job site exposure; 93 personal entire workday samples were obtained. The geometric mean for manganese dust exposure for 8h shifts was 0.25 mg/m^3 (Q1: 0.14; Q3: 0.48) and for 12h shifts was 0.09 mg/m^3 (Q1: 0.04; Q3: 0.23) Worker participation in the study was 95% (n=115). A matched pair study design was used with potential referents (n=300), made up of non-exposed blue collar workers, recruited from the region. Following exclusion for previous head injury, neurological illness, alcohol and/or drug abuse and medication that may affect test performance, pairing was performed on the basis of age ($\pm$3y), sex, educational level ($\pm$2y), smoking habits and number of children (0,1,2,3 and more); years of residence in this area was used as an additional decisional variable in case of ex equo. Analyses were performed on 74 pairs, (age: 43y $\pm$ 5; educational level: 11y $\pm$ 2; 39% current smokers), who were also similar for non-paired variables such as alcohol consumption and family medical history. Workers' seniority was 14.6y $\pm$ 5. Average blood manganese level for workers and referents were 1.08 μg/100 ml $\pm$ 0.44 and 0.76 μg/100ml $\pm$ 0.25, respectively; the difference between pairs was significant (paired t-test; p<0.001). Inter-pair urinary manganese concentrations were similar. Reported symptoms that best discriminated between the two groups (McNemar statistic for paired analyses: p$\leq$0.05) included: fatigability, feelings of drunkenness, muscular weakness, movement difficulty, tremor, somnolence, insomnia, speech disturbance, articular pain, loss of memory and forgetfulness, irritability, nightmares, thirstiness, excessive salivation, sweating without physical effort, breathlessness without physical effort, palpitations, difficulty maintaining an erection, dissatisfaction with sex life. Results from a battery of neurophysiological and neuropsychological tests, administered over two 3-h periods, revealed significant differences (p$\leq$0.05 on paired t-test or Signed Rank, depending on the distribution of data) on tests requiring rapid alternating movements, tremor, short term memory, cognitive flexibility, olfactory perception threshold and mood. The overall pattern of signs and symptoms suggests early changes in extrapyramidal functions, which may be described as micromanganism.

REPRODUCTIVE DISORDERS

IS METAL WELDING CAUSING IMPAIRMENT OF MALE FECUNDITY

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Potential reproductive hazards in the occupational environment of welders include welding fume toxicicants (chromium, nickel, manganese; in some instances lead, cadmium and phenol), radiant heat strain and ionizing radiation. Prompted by results of Danish studies suggesting impaired fecundity of welders additional studies were designed to verify suggested effects on the male reproductive capacity. It was hypothesized that stainless steel welders are at risk because of high exposures to water soluble hexavalent chromium. This metal is causing reduced sperm count in rodents.

In a first approach semen quality was examined in a cross-sectional study of 81 welders and 54 non-welding workers. Three semen samples from each participant were provided by masturbation at home and were examined within two hours by one experienced laboratory assistant using manual methods. Total sperm count, proportion sperm with normal forms, linear penetration rate and measures of motility were significantly reduced among male steel welders and evidence for exposure-response relation was revealed.

In a second approach data on reproductive and occupational exposure were obtained by mailed questionnaire from 673 male production workers. Infertile metal workers more often were welding during the period of unprotected intercourse than fertile metal workers during the period preceding a childbirth (OR 2.20, 95% CI 1.02-4.00).

Finally, in a third approach fertility in terms of birthrate was examined in a cohort of 3,702 metal workers over a follow-up of 47.674 person-years. Among subjects who had ever worked as welders the probability of having a child was slightly reduced the year following a year with welding even after control for differences in age, birthcohort, paternal parity, birth of a child in the preceding 5 years, smoking and consumption of alcoholic beverages (OR 0.89,95% CI 0.83-0.97).

Whenever a distinction could be made, effects were attributable to mild steel, not stainless steel, welding.

Findings in three observational studies of reproductive function of male welders applying different designs, methods and endpoints are remarkably consistent suggesting causal links between mild steel welding and reduced male reproductive capability. This unexpected finding needs verification and - if proven - additional efforts are needed to identify the harmful exposures.

MALE REPRODUCTIVE ABNORMALITIES AMONG LEAD-EXPOSED BATTERY PLANT WORKERS

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Lead has been associated with testicular atrophy in animals and hypospermia, asthenospermia and teratospermia in both animal and occupational studies. The human studies noted relatively high levels of airborne lead and used relatively inaccurate and imprecise methods of semen quality assessment. This study examined the reproductive effects of men exposed to lower air lead levels using both traditional and computer-aided sperm analysis. A cross-sectional study was conducted at a California battery plant. The evaluation of 66 men (57% participation rate) included: standardized questionnaire, physical examination of the genital area, venipuncture (blood lead, ZPP, FSH, LH, testosterone), and semen analysis. Blood lead ranged from 5 to 51 ug/dL (median=30), and ZPP ranged from 3 to 122 ug dL (median=28). Exposure categories were used to analyze for trend: 0-24 ug/dL low exposure, 25-39 ug/dl medium, and $\geq$ 40 ug/dL high. A non-statistically significant positive trend with exposure was observed for LH and testosterone (geometric mean, GM: 7.5, 7.6, and 9.5 mIU/ml, and 5.7, 5.8, and 6.3 ng/ml, respectively). Traditional sperm assessment resulted in a negative trend with exposure for total count (GM: 181, 169, and 145 million), a positive trend for motility (GM: 42.9%, 51.5%, and 52.4%), and no trend for morphology. Computer-aided sperm analysis revealed a positive trend with exposure for linearity of trajectory (mean: 0.57, 0.62, and 0.68, p=0.02), an overall decrease with highest exposure for amplitude of lateral head displacement (mean: 3.5, 3.5, and 2.9 um, p=0.06), a negative trend with exposure for mean angular displacement (mean: 14.8, 14.3, and 12.2 deg, p=0.08), and a decrease with highest exposure for curvilinear velocity (mean: 53.5, 58.7, and 50.3 um/sec, p=0.18). Preliminary computerized morphometric evaluation demonstrated that men with higher blood lead levels had lower sperm head width/length ratios (i.e. longer or more tapered heads) in comparison to men with lower lead levels. Multiple linear regression analysis to adjust for confounding did not alter these relationships. Thus, sperm abnormalities using traditional and computer-aided techniques, and suggestive LH and testosterone changes were observed among workers with blood lead levels $\geq$ 25 ug/dL. The current occupational OSHA lead standard allows workers with prior elevated blood lead levels to return to their regular worksite after two subsequent levels $\leq$ 40 ug/dL. The results of this study suggest that there may be adverse male reproductive effects among workers returned to the workplace, under the present OSHA lead standard.

PATERNAL EXPOSURES AND CARDIOVASCULAR MALFORMATIONS

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Associations between paternal occupational exposures and untoward pregnancy outcome have been suggested. Reports corroborating these associations, however, are limited. Methodologic issues that must be considered in studies concerning male effects on pregnancy outcome include: possible bias in the selection of study and comparison groups; sample size with sufficient number of exposed men to yield adequate statistical power; completeness of case ascertainment; use of a critical exposure period; and possible confounding by maternal factors and familial susceptibility. We addressed these issues in evaluating the association between paternal exposures and cardiovascular malformations (CVM), by using data from the BWIS, a population based case-control investigation of CVM and environmental factors (2310 cases, ascertained between 1981-87; 2801 controls, a random sample of infants from the live birth cohort that gave rise to the cases). Home interviews of case and control parents, conducted within a year of the study subject's birth, elicited information on parental occupational and home exposures to: painting; paint stripping; auto body repair; welding; batteries; lead soldering; jewelry making; stained glass crafts; solvents; anesthetics; pesticides; dyes; and ionizing radiation among other factors. Analysis focused on exposures incurred during the first trimester of pregnancy and previous three months. Among controls, paternal exposure reports included: pesticides (30%); carpentry (21%); painting (21%); degreasing solvents (17%); varnishing (8%); paint stripping (7%); lead soldering (6%); auto body repair (6%); welding (6%); laboratory chemicals (2%); ionizing radiation (1%); and dry cleaning solvents (0.4%). Considering all CVM a group, analysis showed no significant associations with paternal exposures. Analysis by specific cardiac diagnosis yielded similar results for twelve diagnostic groups. Three diagnostic groups, however, did show an association with paternal exposure reports: tricuspid and pulmonary atresia with lead soldering (57 cases; odds ratio [OR] = 3.3, 95% confidence interval [CI]: 1.7-6.7); pulmonic stenosis with dry cleaning solvents (100; OR = 6.6, 1.9-23.7); and atrio-ventricular septal defect with ionizing radiation (201; OR = 4.3, 1.8-10.2). Adjustment by cardiac family history and maternal factors did not alter the results. Although tricuspid and pulmonary atresia were not associated with maternal exposure reports of lead soldering, an association with indirect maternal exposure cannot be excluded. The associations with solvents and ionizing radiation are consistent with previous observations of paternal occupational exposures and pregnancy outcome; however, they have not been reported in relation to CVM and remain to be confirmed in other studies.

THE SEMICONDUCTOR HEALTH STUDY: METHODS FOR PROSPECTIVELY ASSESSING REPRODUCTIVE FUNCTION IN WAFER FABRICATION EMPLOYEES

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Prospective methods for monitoring reproductive function in workers have the potential to overcome some of the methodologic concerns that arise in occupational historical cohort or case-control studies of reproductive hazards. We designed and implemented prospective monitoring of women working in 5 semiconductor companies in two states, as part of a large study of reproductive and other health outcomes, to examine the effect of occupational exposures on menstrual cycle function and adverse pregnancy outcomes. We selected all women aged 18-44 years who were employed in fabrication of silicon wafers in these plants and a sample of women employed in non-fabrication jobs, frequency matched on 5-year age group and ethnicity. Following granting of informed consent, women completed a self-administered screening questionnaire. A detailed in-person interview was administered at baseline, to eligible women participating in the follow-up study, asking about demographic characteristics, medical and reproductive history, and work-related activities and exposures. Enrolled women completed a brief daily diary and monthly telephone interview covering menstrual, sexual, and lifestyle behaviors and job activities and collected 5ml of urine each morning for 6 months. Fabrication of silicon wafers in the semiconductor industry involves exposure of workers to many hazards which may have potential adverse reproductive health effects. Nearly half of the workers involved in these processes are pre-menopausal women. The exposures of interest include glycol ethers and other solvents, hydrofluoric acid, arsenic and boron compounds, electromagnetic fields (EMF), and ergonomic factors, such as long work shifts and long hours standing. A team of industrial hygienists (IH) assessed work activities and exposures to these potential hazards using: their own on-site measurements and observations of chemicals, processes and controls; responses from knowledgeable personnel at each plant regarding chemicals used and processes; and responses to interview questions by the women in the follow-up study. Over 400 women contributed at least one complete menstrual cycle of diaries and urine samples, for a total of over 2000 cycles of urine. All urine was screened for human chorionic gonadotropin (hCG) and early fetal losses were confirmed with immunoradiometric assays for hCG and urinary assays for luteinizing hormone and ovarian steroids. Methods for measuring central tendency, variability and probability of extreme menstrual cycles were developed. Comparisons were made of these menstrual cycle measures obtained from baseline interview and from daily diaries. Methods used in this study provide evidence for their feasibility in evaluating the effects of potential occupational reproductive hazards in large groups of non-clinic-based women.

SPONTANEOUS ABORTIONS WITH AND WITHOUT CHROMOSOMAL ABERRATIONS IN RELATION TO OCCUPATIONAL FACTORS.

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A case referent study was performed among all women admitted to Telemark Central Hospital for spontaneous abortions during the 4-year period 1985-89. The reference population was recruited from pregnant women attending the antenatal clinic at 17-18 weeks of pregnancy for ultrasound screening, matched for time of conception. The parents answered a detailed questionnaire concerning work-related and life style exposure factors together with medical and previous reproductive history. Chromosome analyses were performed on all aborted material with appropriate tissue samples and cord blood samples were taken at birth for chromosome analysis of the referents.

In all 793 families with spontaneous abortions answered the questionnaire. Chromosome results were obtained for 375 cases; 242 with normal and 133 with abnormal karyotypes. Among the 808 referents, chromosome analysis was done for 679, one of whom showed abnormal karyotype (45, XO).

There was a significant association between mother's smoking during pregnancy and spontaneous abortions (odds ratio (OR)=1.48, 95% confidence interval (CI) 1.11-1.99). When adjusting for mother's age, previous spontaneous abortions, martial status and smoking in a logistic regression analysis, elevated ORs were found for stress at work (OR=1.89, 95% CI 1.16-3.07) and at home (OR=6.54, 95% CI 1.8-23.6). More than half-day exposure to gases and video display terminals showed in an unvariate model OR=2.31 and OR=1.15 respectively, but they were not statistically significant in the logistic regression analysis. Exposure factors which did not show any elevated odds ratios between cases and referents were: job schedule (part-time/full-time), number of working years, physical strain, heavy lifting, heat, cold, noise, solvents, chemicals, metals and cosmetics.

When the spontaneous abortions were subdivided into cases with and without chromosome aberrations, odds ratio for smoking was significantly elevated for the group with normal chromosomes only, and mother's age for the group with abnormal chromosomes only, while stress at work and at home both were of significant importance for both groups.

The women with abortions had worked in only twenty different occupational groups (Nordic Classification of Occupations, 3-digit level). Elevated odds ratios for spontaneous abortion were observed for medical staff, office workers, sales workers and service personnel, but the elevations were not statistically significant in an univariate model.

CANCER 2

CANCER MORTALITY AMONG JEWELRY WORKERS

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Mortality was investigated for the years 1950-80, in 1,009 male members of a New York jewelry workers union, and for the years 1984-88 among 812 men and 528 women identified as jewelry workers on death certificates from 23 states. Malignant neoplasms were excessive for union members (PMR=1.17) and female jeweler deaths from the 23 states (PR=1.16). Deaths due to other causes were not unusual, except for excesses of circulatory system (PMR=1.10) and arteriosclerotic heart disease (PMR=1.25) in union males, and rheumatic heart disease in union males (PMR=3.02) and in male jewelers from 23 states (PMR=3.11). Significant excesses were identified for cancer of the colon among union males (PCMR=1.53), esophageal cancer among males from 23 states (PCMR=2.52), and stomach cancer among females from 23 states (PCMR=2.36). Females from 23 states also had a slight excess of cancer of the esophagus (PCMR=1.68); the men and women from 23 states had small excesses of colon cancer. Union men also had a slight excess of pancreatic cancer. Combining the results from all study groups showed a statistically significant excess only for cancer of the colon (PCMR=1.30; 95% C.I.: 1.02-1.63). Of the other cancers, excesses were shown for malignancies of the hematolymphopoietic system, with a combined PCMR=1.24 (95% C.I.: 0.96-1.59). Both non-Hodgkin's lymphoma and leukemia showed marginal excesses in all three study groups. The combined results for the three study groups were PCMR=1.32 (95% C.I.: 0.92-1.84) for non-Hodgkin's lymphoma, and PCMR=1.17 (95% C.I.: 0.75-1.74) for leukemia. The lack of site specificity for malignancies found to be in excess raises questions about the etiologic significance of these findings, although the wide variety of exposures in this industry, particularly to metals and solvents, could possibly involve excess risk for malignancy at multiple sites.

THE OCCUPATIONAL CANCER INCIDENCE SURVEILLANCE STUDY (OCISS): RISK OF LUNG CANCER BY LENGTH OF EMPLOYMENT FOR WHITE AND BLACK MALES

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The risk of lung cancer in the Occupational Cancer Incidence Surveillance Study (OCISS) was studied previously looking at usual occupation and industry. In continuing analyses, we analyzed lung cancer risk by length of employment among those ever employed in selected occupations and industries. Lung cancer risk was assessed by increasing years of employment to determine whether a dose-response relationship existed between lung cancer risk and length of employment. This case-control study included a total of 3792 male lung cancer cases and 1966 male colon and rectum cancer controls. Data was collected by telephone interview with the subject or their surrogate. The interview obtained data on lifetime work history, medical history, demographics and residential history. Occupation and industry data were coded using the 1980 U.S. Census Bureau classification codes. Analyses were performed for occupations and industries grouped by similar exposures as well as for individual occupations and industries. Odds ratios for occupations and industries were estimated using a logistic regression model controlling for age and smoking. Significant positive trends were observed for white males in the occupational groups agricultural workers, personal service workers, driver sales, metal finishers, furnace workers, drivers, and food workers. Black males show increases in lung cancer risk by length of employment for many of the same occupations as white males but in most cases the risk estimates are two to three times higher. Black males had significant positive trends for the occupations of mechanic and health technicians. Mechanics and health technicians with 10 or more years of employment had odds ratios of 5.0 and 15.4 respectively. Significant positive trends also were observed for white males and black males for certain industries. These industries included railroads and oil and gas sales for white males and farming, ferrous primary metal manufacturing, automobile repair, hospitals, guard service and odd jobs for black males. Overall, the risk estimates for industries employing black males are higher than for white males. In conclusion, we were able to detect a dose-response relationship for several occupations and industries when using length of employment as a surrogate for exposure. Black males, as compared to white males, appear to have a greater risk of lung cancer due to exposures in the workplace. These results signify the need to include blacks in studies of occupational exposures and to analyze workplace risks separately among white and blacks.

OCCUPATIONAL PHYSICAL ACTIVITY, SOCIO-ECONOMIC STATUS AND RISKS OF FIFTEEN CANCER SITES IN TURKEY

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A multiple-site case-control study of fifteen cancers (stomach, colon, rectum, larynx, lung, melanoma, skin, female breast, male breast, cervix, ovary, uterus, prostate, testis, and bladder) was conducted to evaluate their association with occupational physical activity and socioeconomic status (SES). A hospital-based study population (3,486 male cases and 379 female cases and 2,127 male and 244 female controls) was established in an oncological treatment center in Istanbul, Turkey, from 1979-1984. Assessment of physical activity and socio-economic status (SES) was based on job titles held by the study subjects. Two measures of physical activity were developed based on energy expenditure (EE) and standing time (ST) during working hours. Sedentary activity was defined as work with an EE of less than 8kJ/min, such as sitting with only hand work or light two arm work (e.g., office work). Moderate activity was defined as work with an EE of 8-12 kJ/min, such as heavy one arm or moderate two arm work (e.g., sweeping). High activity was defined as work with an EE of more than 12 kJ/min such as heavy two arm work or heavy body work (e.g. wall painting). Three ST scales were defined as sedentary (work requiring sitting more than 6 hours a day), moderate activity (sitting 2-6 hours), high activity (sitting less than 2 hours a day). A SES level (low, medium or high) was assigned for each occupation considering its income and training level. Observed risks were adjusted for age and smoking. Lower SES was significantly associated with excess risks of cancers of the larynx and cervix, while cancers of the prostate and female breast showed significant decreasing risk with decreasing SES. For the EE index, elevated risks were observed among workers who had sedentary jobs for cancers of the colon (OR = 1.6), rectum (OR = 1.3), melanoma (OR = 1.9), male breast (OR = 1.4), prostate (OR = 5.0) and ovary (OR = 2.0). Cancers of the colon and prostate showed significant increasing trend with decreased activity. Cervical cancer showed significantly decreasing risk with decreased activity (OR = 0.7 and OR = 0.3 for less active and sedentary jobs with p for trend = 0.004). Similar findings were observed for the ST index. Risks of cancers of the colon, rectum, larynx, ovary, and melanoma were enhanced after risks for physical activity indices were adjusted for SES, while the associations between physical activity and cancers of the prostate, cervix, and uterus was weakened after SES adjustment. The results of this study support previously reported associations between physical activity and cancers of the colon and rectum observed in developed countries, and provide new and additional evidence for cancers of the larynx, prostate, cervix, uterus, and melanoma and point out the importance of SES in evaluation of physical activity and cancers of the colon, rectum, larynx, prostate, breast, cervix, and melanoma in developing countries.

A COHORT MORTALITY STUDY OF WORKERS EMPLOYED IN A FRENCH STAINLESS STEEL FACTORY

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A prospective historical mortality study was carried out among the workers of a factory producing stainless steel in order to assess (i) the relationship between lung cancer and exposure to chromium compounds, to nickel compounds, to polycyclic aromatic hydrocarbons (PAH) and to silica, (ii) the risk of morality from cardiovascular diseases due to heat exposure. Four thousand two hundred and twenty seven men having at least three years of employment between 01.01.1968 and 31.12.1984 were followed up for mortality. Complete job histories since data of first employment were abstracted from the company files. In addition, a job-exposure matrix was set up in order to determine sub-groups of workers according to occupational exposure. The smoking habits of 24% of the cohort members were known from the interview of workers still active when data were collected.

The observed number of deaths (obs) were compared with the expected ones based on national and regional rates with adjustment for age, sex and calendar time (Standardized Mortality Ratio, SMR). The overall mortality did not differ from that expected (obs=484, SMR=1.02, 95% CI = 0.93-1.12), whereas a significant excess was observed for mortality from cirrhosis of the liver (obs = 57, SMR = 1.66, 95% CI = 1.26 - 2.15).

With regard to lung cancer mortality, non-significant excesses appeared in the whole study population (obs = 42, SMR = 1.30, 95% CI = 0.94 - 1.75) and among workers ever employed in stainless steel production (obs = 7, SMR = 1.04, 95% CI = 0.42 - 2.15), rolling mills (obs = 17, SMR = 1.51, 95% CI = 0.88 - 2.42) and maintenance (obs = 9, SMR = 1.45, 95% CI = 0.66 - 2.75) workshops. A significantly high SMR, however, was observed for mortality from lung cancer among foundry workers (obs = 11, SMR = 2.29, 95% CI = 1.14 - 4.09). This excess was higher for duration of employment $\geq$ 30 years (obs = 2, SMR = 3.33, 95% CI = 0.40 - 12.04) and for time since first employment $\geq$ 30 years (obs = 6, SMR = 3.24, 95% CI = 1.19 - 7.05). This excess was unlikely to be explained by smoking habits. When using the job exposure matrix in order to take into account exposure of interest, no significant lung cancer excess was observed among workers exposed to welding fumes, chromium VI, silica, PAH and acid mists. Neither did any excess appear when taking into account duration of exposure to these compounds and time since first exposure.

Concerning health adverse effects of heat exposure, no excess was observed for all cardiovascular diseases and for ischaemic heart diseases, whereas, for cirrhosis of the liver, significantly high SMRs were observed with an increasing trend with duration of exposure.

A NESTED CASE-CONTROL STUDY OF LUNG CANCER MORTALITY IN WELDERS AND OTHER METAL WORKERS

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Welding occupies a large fraction (1-2%) of the work force world wide. Several reports have indicated an association between welding fume exposure and lung cancer. Much focus has been on the exposure to stainless steel welding fumes, which contains known carcinogens such as hexavalent chromium. However, there is still some uncertainty about the significance of the association. We have conducted a nested case-control study on lung cancer mortality within a cohort of 10,059 welders and other metal workers, who had worked for at least one year in a welding company between 1964 and 1984. With a follow-up until 1985, 94 had died from lung cancer (cases), and 376 dead cohort members with a "non-respiratory" cause of death were matched on year of death and age at death, and used as controls. The comparison of exposures was carried out according to work histories and smoking habits, obtained by interviews of long time colleagues and spouses.

Exposure to the potential confounding factors tobacco smoking and asbestos, revealed significant elevated risk estimates. An increasing trend in the risk estimate with increasing tobacco consumption was demonstrated, but no important differences in smoking habits in welders and non-welders were found. Welding exposure of any kind showed a significant elevated odds ratio (OR) corresponding to a 70% excess of lung cancer (OR 1.67, 95% CI 1.04-2.67). The overall OR for mild steel welding ever was 1.65 (1.03-2.65). The risk estimate showed an increasing trend up to a duration of 11-15 years of welding exposure (4.21, 1.50-11.86, 8 obs.) The picture of stainless steel welding looked like that of mild steel welding with an overall OR for stainless steel welding ever of 1.54 (0.83-2.84) and 2.36 (1.02-5.49) after 11 or more years of stainless steel welding. Welding in stainless steel with fume producing welding processes, such as MMA, for two decades or more, exhibited a doubling of the risk estimate.

In conclusion our data showed an increase in lung cancer risk associated with stainless steel welding as well as mild steel welding, and the data indicate a dose-response relationship.

EXPOSURE 1

PATTERNS OF ELECTRIC AND MAGNETIC FIELD EXPOSURE IN THE UTILITY INDUSTRY

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Epidemiologic research on exposure to electric and magnetic fields (EMF) has been limited by the lack of quantitative exposure data. The situation is even more problematic than in studies on chemical exposures; not even sparse, biased exposure data exist to permit semi-quantitative estimates of historical EMF exposure. Nevertheless, estimates of past EMF exposures will have to be made for retrospective studies. The only available approach is to study the variability of present exposure to EMF. If the present nature of exposure to EMF can be understood and the underlying exposure determining factors can be recognized, it might be possible to extrapolate present exposure into the past.

To assess the variability of EMF exposure, we used data from the EPRI EMDEX-100 project, in which the exposure of utility employees at 59 sites in the US and three other countries was measured between October 1988 and September 1989. Approximately 50,000 hours of magnetic field and 23,000 hours of electric field exposure records taken at 10-second intervals were obtained, of which 70% were from work environments. Using 4411 magnetic field and 2082 electric field measurements with an averaging time of more than 4 hours, the within-and between-worker exposure variability and the between-and within-group variability was estimated for 16 job groups and 8 primary work environments. A second analysis focused on the influence on the exposure of variables like year and month of measurement, job, and during the measurements occupied environment (yes/no and time spent).

For both electrical and magnetic field exposures the between-worker component was largest for the majority of jobs. Linemen had the largest day-to-day variability in magnetic and electric field exposure, and this component outweighed the between-worker component. In most cases, the between-worker component for electric field exposure was smaller than the between-worker component for magnetic field exposure. However, the job groups "electricians" and "substation workers" showed considerably more between-worker electric field exposure variability.

The within-group (pooled between-worker, within groups) component was in both cases larger than the between-group component. The elasticity ratio for magnetic fields was only 0.30 (30% of the between-worker variance could be transformed in between-group variance by grouping the workers by job). Classifying the workers by primary work environment was not more elusive.

For both electric and magnetic field exposure occupied environment and season (month of the year) had a significant effect on exposure level, but together explained respectively only 23% and 24% of the total exposure variability. Differences between companies undoubtedly contributed to the large amount of unexplained exposure variability. Occupied environment explained almost 6% more of the variance than job group (R^2 respectively 0.22 and 0.16 for electric field and respectively 0.23 and 0.17 for magnetic field). Using occupied environment either as a dummy variable or as a time variable in the model did not make a difference (R^2 respectively 0.20 and 0.22 for electric field and respectively 0.22 and 0.23 for magnetic field). Exposure levels were significantly elevated in September and March for exposure to electric fields and in December for exposure to magnetic fields.

These analyses have convinced us of assessing historical EMF exposure by company and the necessity of unravelling the exposure determining factors, since the 16 job groups and 8 work environments are not specific enough to prevent serious exposure misclassification. Information on EMF exposure determining factors which are available in the past will have to assessed for each of the five involved companies and applied to randomly collected repeated measurements of utility workers' present exposure to EMF.

HOW MANY EXPOSURE ASSESSMENTS: A GUIDE TO OPTIMUM DESIGN STRATEGY

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Many occupational health studies relating workers' health to industrial exposure are often started with pilot studies so that the investigators could decide on sufficient number of measurements at a minimum cost to the study. This paper describes and utilizes one such technique for deciding optimum experimental design, based on the variability of the IH samples in a pilot study. Nested random effects model is suggested in which the exposure measurements are collected once a day, n_d days per week, n_w weeks per period in n_p periods of study. The variance of mean exposure is the sum of three components: the variance among the periods o^2_p, the variance among the weeks within period o^2_w, and the variance among the days within week o^2_d. Estimation of variance components in a pilot study can be used to gauge the change in precision and costs of various possible designs. It is necessary to balance precision and costs. Among all possible choices, the designs that keep precision of the mean exposure and the associated costs at acceptable levels could serve as potential designs for further studies.

Application is made on a pilot data set in an ongoing study of the effect of certain chemical exposure to an Air Force base worker population. The measurements were collected for 2 periods, 3 weeks within each period, and 5 days per week, thus giving as a (2-3-5) design in the pilot study. Based on the estimation of variance components, 30 designs were compared. Four designs appeared to perform as alternatives for the full scale study. The design, (2-4-3) and (3-2-4), cost 20% less than that of the pilot study and lose about 8% of accuracy in the mean exposure estimate. The design (3-3-3) cost 10% less than that of the pilot study and provided approximately the same accuracy. The design (3-4-2) appears to be more preferable choice because it costs 20% less than that of the pilot study and gives approximately the same accuracy of the mean exposure estimate.

USING THE VIDEO IMAGING TECHNIQUE FOR ASSESSING EXPOSURE IN LIVESTOCK INSECTICIDE APPLICATIONS

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The Assessment Methods for Pesticide Exposure (AMPE) study was conducted collaboratively by the National Cancer Institute and the University of Iowa - Institute of Agricultural Medicine and Occupational Health. The study was a methodological investigation to gather information on the reliability and comparability of differing approaches in obtaining historical information on agricultural pesticide exposure and to relate work practices with current monitoring techniques. An integral part of the Assessment of Methods for Pesticide Exposure (AMPE) has been the inclusion of the VITAE© (Video Imaging Technique for Assessing Exposure©) system developed by Dr. Richard Fenske of the University of Washington. Before the pesticide application by each farmer, a series of still frame video images were acquired using the VITAE© system. These image series include the front, left and right side, and back views of the head, arms, legs and torsoes of the applicators. This same video image series was acquired after the entire application process, to be used for calculation purposes at a later date. Immediately before the mixing step in the application process, fluorescein dye, Uvitex OB {2,5- Bis (5-tert-butyl-2-benzoxazolyl) thiophene}, was added at the rate of .3 gram per gallon of end product. The application process was then monitored, with times, rates and application methods noted on an industrial hygiene monitoring form. Video tapes of the applications were also made to document the operational setting. Eleven of the twenty farmers monitored exhibited dosages to livestock insecticide in time weighted average dosages ranging from 20 μg/hour to 66,797 μg/hour. The VITAE© system proved to be quite capable as a monitoring tool for pesticide exposure. Although there are limitations with the VITAE© as opposed to the dermal dosimeter technique, VITAE© has many advantages. First and foremost, is the ability for the applicator and researcher to visually see where and how dosage occurs. A second advantage of the VITAE© system is the lower cost per analysis as opposed to the cost per analysis for the dermal dosimeter technique. Another advantage is not encumbering the applicator with the sets of dosimeters that sometimes alter application technique. The VITAE©25 system is by far the least invasive of the two techniques. Images stored by the VITAE© system can be reviewed, restudied, recalculated, printed or turned into photographs for educational purposes.

RETROSPECTIVE PESTICIDE EXPOSURE ASSESSMENT IN CASE CONTROL STUDIES. INTER-RATER AGREEMENT

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The method used for retrospective pesticide exposure assessment in two Italian multicentric case control studies on cancer and pesticides is presented. The main steps of this approach are: a) a questionnaire with an agriculture section, containing 23 forms explicitly designed for specific crops, is used. "Key question" in these crop-forms is about crop diseases against which pesticides were applied. Furthermore, information on pesticides application techniques (mode, frequency, duration of application, protective equipments, personal hygiene) and on re-entry on the field after the application and pesticides storing are gathered too; b) local experienced agronomists evaluate the consistency of collected information and translate it into histories of pesticides exposures referred to type of treatment (e.g. herbicide), chemical families (e.g. triazine) and active ingredients (e.g. atrazine); c) a priory matrices, appropriately called Crop-Exposure-Matrices (CEMs), that cover the period 1955 up to now, were developed by the local agronomists in each study area. The CEMs are used to assess exposure when the information elicited by the subjects is too poor.

The reliability of the described exposure assessment approach is evaluated using the procedure utilized by Goldberg (1). A trial was carried out in one of the study area in order to determine the degree of agreement between two raters in identifying presence or absence of exposure in terms of chemical families. The two raters examined independently each job description (7 for grapevine, 3 for olive, 5 for seeds treatment, 3 for vegetables), the local CEM, containing 48 chemical families, was utilized as checklist. The agreement was assessed on binary scale (present, absent) considering separately each crop. The Cohen's kappa was used as index of agreement. The agreement was excellent in grapevine (k=0.84) and in seeds treatment (0.75) and good in olive (k=0.65) and vegetables (k=0.65). The results indicate a high degree of inter rater agreement and lend credibility to the validity of this type of retrospective exposure assessment.

1) Goldberg M.S., Siemiatycki J., Gerin M.: "Inter-rater agreement in assessing occupational exposure in a case-control study" Br. J. Ind. Med. 1986: 43: 667-676

MENTAL RETARDATION AND PARENTAL OCCUPATION EXPOSURE: A COMPARISON BETWEEN PERSONAL INTERVIEWS AND JOB-EXPOSURE MATRICES

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In a case-referent study on mental retardation in offspring and occupational exposure of the parents, two methods for the identification of risk factors were evaluated. Detailed occupational histories obtained by means of a personal interview were compared with the exposures generated by two different job-exposure matrices. The case group consisted of 306 mentally retarded children with unknown origin; the 322 referents were children with physical congenital handicaps. The interviews were made up of a detailed occupational history and questions about living environment and life-style habits. A calendar was used to focus the attention on the period under study. In the occupational history, questions about job title, industry and physical working environment were supplemented with a description of an ordinary work day and with industry-specific exposure check lists. The interviews were performed by two trained interviewers.

Information on job title and industry was used as input for a British and an American job-exposure matrix (Pannett 1985/Hoar 1980). In the analyses, 30 British and 42 American matrix exposure items could be compared with the self-reported exposures in the interview. As measures of agreement, the average number of concordant and discordant exposures were calculated, as well as sensitivities and percentages of false-positive exposures when the interview was set as a gold standard. Furthermore, the Odds ratios obtained through interview and matrices were compared for each exposure item.

The agreement between interview and matrices was low: the sensitivity ranged from 17.9% (American matrix, mothers) to 32.4% (British matrix, fathers) and the percentages of false-positive exposures from 66.7% to 96.0%. By means of the interview, significantly increased Odds ratios were observed for maternal exposure to radiation, mercury, organic solvents, paint, hair cosmetics, hexachlorophene, antibiotics and dust, and for working with copying machines or in occupations with bad climatologic circumstances and permanent contact with people. Only the latter was confirmed by the British matrix. Otherwise, most of the above mentioned associations were missed by the job-exposure matrices. It was concluded that these matrices were not applicable in this particular study nor in other reproductive epidemiologic studies in view of their general properties and limitations.

CYTOTOXINS AND SOLVENTS

THE INFLUENCE OF LOW LEVEL EXPOSURE TO BENZENE ON WHITE BLOOD CELL COUNTS

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It is generally reported in the literature that exposure to benzene levels below 10 ppm has no hepatotoxic effects. This conclusion does not seem to be based upon an epidemiological study designed to discover any such potential effect.

In a retrospective study, the white blood cell counts were used of 17404 blood samples taken since 1968 or since starting employment from 484 persons, representing all employees under preventive medical surveillance and still employed in one petrochemical plant at the end of 1989, whether they were benzene exposed or not.

General exposure data were derived from stationary air samples (n=3876), collected from 1978 onwards. The P90 value for benzene concentration varied from 2.3 ppm in 1978 to 0.7 ppm in 1988. Although exposure was probably higher before 1978, exposure to levels above 2 ppm on a time-weighted average is unlikely after 1971.

As a reference, we used the hematological data (n=13796 WBC counts from 1984 to 1988) of a control group of 2589 people employed in one chemical industry, in which benzene exposure was extremely rare.

A markedly higher proportion of WBC counts under 4000 per ml was found in the petrochemical plant as compared to the reference population. The difference reduced progressively over time, as benzene exposure did. This apparent association could of course also be explained by a possible laboratory bias: two different laboratories were involved and the laboratory methods in the petrochemical plant changed over time.

Although laboratory bias cannot be excluded in a direct way, it cannot explain all differences: when subdividing the petrochemical workers into groups, according to their frequency of benzene exposure, abnormal results were relatively more frequent among the more exposed group, whichever time period was compared. Also, the number of persons showing multiple abnormal results was relatively higher among the benzene exposed.

Since smoking is associated with an increase in white blood cells, differences in smoking history between the exposure categories were also considered, but seem to have no bearings on the findings.

The study offers forceful arguments against the continuing assumption that exposure to levels of benzene well below 10 ppm has no hematotoxic effects.

CYTOGENETIC EFFECTS OF FORMALDEHYDE EXPOSURE IN STUDENTS OF MORTUARY SCIENCE

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The effect of low-level exposure to formaldehyde on oral, nasal, and lymphocyte biological markers was studied prospectively in a group of 29 mortician students who were about to take a course in embalming. During the 85 day study period, the subjects performed an average of 6.9 embalmings and had average cumulative formaldehyde exposures of 14.8 ppm-hours, with an average air concentration of 1.4 ppm during embalming. Since the average time spent embalming was 125 minutes, formaldehyde exposures calculated as an 8 hour time weighted average (TWA) were 0.33 ppm on days when embalmings were done, which was less than the Occupational Safety and Health Administration permissible exposure limit of 1 ppm. Epithelial cells from the buccal area of the mouth showed a 12-fold increase in micronucleus frequency during the study period, from 0.046 ± 0.17 pre-exposure to $0.60 \pm 1.27/1000$ cells at the end of the course ($p<.05$). Nasal epithelial micronuclei increased 22%, from 0.41 ± 0.52 to $0.50 \pm 0.67/1000$ cells ($p=0.26$). In blood cells, the frequency of micronucleated lymphocytes increased 28%, from 4.95 ± 1.72 to $6.36 \pm 2.03/1000$ cells ($p<.05$) while sister chromatid exchanges decreased 7.5% ($p<.05$). A dose-response relationship was observed between cumulative exposure to formaldehyde and increases in buccal micronuclei in the 22 male subjects but not in the seven female subjects. We conclude that low-level exposure to formaldehyde is associated with cytogenetic changes in epithelial cells of the mouth and in blood lymphocytes. The significance of these changes is unknown.

CROSS-SECTIONAL STUDY OF EFFECTS OF ACETONE EXPOSURE ON WORKERS' HEALTH

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In order to clarify the effects of acetone (AC) exposure on health, a cross-sectional study was carried out in 110 AC-exposed and 67 reference male shift workers. The AC workers ranged from 18.7-56.8 years of age (m=37.6) and 0.5-34.3 years in length of AC exposure (m=14.9). The reference workers ranged from 20.7-57.5 years of age (m=41.9). Exposure levels of AC assessed by personal passive monitors and biological monitoring indices measured just after workers finished the dayshift were 19.6-1018 ppm in the breathing zone (AC-E, m=364), 2.5-422 ppm in alveolar air (AC-A, m=97.3), 4-220 mg/l in blood (AC-B, m=66.0), and 0.75-170 mg/l in urine (AC-U, m=37.8). The AC workers were classified into 3 groups according to AC exposure levels (Table 2). Health check items included a self-administered questionnaires (including AC-related symptoms, Manifest Anxiety Scale (MAS), and Self-rating Depression Scale (SDS), short computerized neurobehavioral test battery (including simple reaction time (SRT), digit span (DS), etc., measurement of a variation of R-R intervals on ECG (RR), and hematological and biochemical examinations. The schedule of health checks and exposure monitoring is shown in Table 1. Symptoms complained at the end of the work day with exposure-response relationships were "irritation of eyes", "tearing", and "nausea", and those within the last six months with exposure-response relationship were "heavy, vague, or faint feeling in the head", "nausea, "dull sense in the extremities", "thirst", "loss of weight", "decreased sense of taste", and "slow healing of external wound". At the age of 30-45, SRT and DS were significantly lower in AC workers, but exposure-response relationships were not clear. MAS and SDS scores, RR, hematological, biochemical, and phagocytic activity examinations did not show any AC-related differences between two groups. From these results, the current TLV-TWA of AC, 750 ppm recommended by the ACGIH, seems to be high to prevent the health effects of AC observed in this study.

Table 1. Schedule of health examinations and exposure monitoring.

a.   Before visit of our research team.
           Questionnaire on whole days of one shift cycle including holidays.

Table 2. AC exposure levels to classify AC workers

	lower	middle	higher
AC-E (ppm)	-250	-500	501-
AC-B (mg/1)	-45	-80	81-
AC-A (ppm)	-70	-140	141-
AC-U (mg/1)	-25	-50	51-

b.   On visit of our research team

	QU	RR	NB	BL	EX	BM
1st day morning	X	X	X	X	X	X
1st day afternoon	X	X	X		X	X
2nd day morning	X				X	X
2nd day afternoon	X	X	X	X	X	X
3rd-4th day*	X				X	X

QU: Questionnaire. RR: R-R intervals of ECG.
NB: Neurobehavioral test. BL: Blood exams.
EX, BM: Exposure & biological monitoring.
*If possible to carry out.

WORKING AND LIFE CONDITIONS OF PETROCHEMICAL WORKERS

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Workers in continuous processing plants face several disturbances caused by shiftwork in addition to the usual work risks. A comprehensive study of living and working conditions was completed among petrochemical workers in a polyethylene production plant in Cubatao, Brazil in 1988 and 1989. A cross-sectional design was used based upon models developed by Rutenfranz (1976), Haider et al. (1982), and Knutsson (1989). Using self-report questionnaire responses, it evaluated the stressors and strains upon this population. The participants were 34 male shiftworkers on 8-hr. rotating shifts of 42 hr. per week and 16 day workers (all but one were male) on 8-hr. fixed schedules of 40 hr. per week. Selection from among a total of 228 plant workers was according to age, years of service, and plant sectors. Results indicated shiftworkers, in comparison with the dayworkers, faced worse working conditions ($F = 4, 83, p=.03$) and greater restrictions in leisure-time activities ($F = 6, 35, p=.01$). However, alcoholic drinking and tobacco smoking habits were more widespread and stronger among the dayworkers than shiftworkers ($F = 5, 17, p=.02$). Disregarding work schedules, these habits were stronger for persons with management responsibilities than for the operations workers ($F = 2, 20, p=.05$). A multiple-regression analysis (MRA) of 1) readiness for work, 2) accidents during and after work, and 3) quality of family-social relationships indicated that the longer the years on shiftwork, and the worse perceived were their working conditions, the worse were their strains. All coefficients of MRA were above 0.40. There was also more disability time-off for the older shiftworkers than dayworkers ($F - 5.58, p=.05$). This study indicates that continuously rotating shiftworkers have significantly more negative factors affecting them both on and off the job than do their fixed-schedule dayworker colleagues.

CYTOGENETIC STUDY IN FEMALE NURSES OCCUPATIONALLY EXPOSED TO CYTOTOXIC DRUGS

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This study aiming to investigate cytogenetic endpoints as measured by sister chromatid exchanges (SCEs) and chromosome aberrations (CA) among female nurses occupationally handling cytotoxic drugs. 45 nurses working in oncology departments with daily exposure to antineoplastic drugs represented the exposed group. The most frequently used drugs were cyclophosphamide, methotrexate, adriamycin 5-fluoruacil and cisplatinum. The exposed group were matched as regards age, sex and socioeconomic status with 40 nurses who were never exposed to such drugs. All subjects had normal children and were not exposed to x-ray, drug therapy or viral infection for at least six months prior to the study. All were non-smokers. History of hormonal contraceptives, also some other behavioral parameters as cooking, watching television (hours/day), insecticide sprays (days/week) was taken into consideration. Two whole blood lymphocytic cultures were set up for each individual. The culture composed of RPMI media 1640 supplemented with 10% fetal calf serum, 1% phytohaemagglutinin (PHA) 0.5% glutamine, 0.1 sodium heparin, 0.1% penicillin and streptomycin for SCEs. Bromodeoxyuridine was added at a concentration of 50ug/culture. Harvest was done at 48 hr and 72 hr for (CA) and (SCEs) respectively. The mean $\pm$ SD of age was 38.35 $\pm$ 7.9ys among exposed group versus 39.87 $\pm$ 4.33 among controls, p>0.05. The duration of handling the cytotoxic drugs was 16.02 $\pm$ 6.8ys. Regarding (CA), it was 4.79 $\pm$ 1.3 among the exposed group versus 2.47 $\pm$ 0.7 among controls, p<0.0001. As for (SCEs), it was 10.53 $\pm$ 2.7 among exposed versus 8.70 $\pm$ 2.4 among controls p<0.0001. Recorded types of CA were chromatid gaps & breaks, dicentrics, exchange figures and accentric fragments. Correlation was proved between duration of handling cytotoxic drugs and SCEs frequency but not (CA) endpoint. Again, a positive correlation was proved between duration of oral contraceptives and SCEs.

In conclusion, our data revealed that handling cytotoxic drugs on an occupational level, have harmful mutagenic effects. Hormonal contraceptives should be avoided as a method of birth control among those nurses handling cytotoxic drugs to avoid synergistic or additive clastrogenic action.

AGRICULTURE

PATTERNS OF PESTICIDE EXPOSURE AMONG MIDWESTERN FARMERS: ISSUES FOR EPIDEMIOLOGIC RESEARCH

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Epidemiologic studies from a number of countries indicate that farmers tend to experience higher rates for selected cancers than the general population. The specific agents in the agricultural environment that might be involved have not been clearly identified, but pesticides have received the most attention. Despite strong associations between certain cancers and a few pesticides in several case-control studies, concerns have been raised with regard to exposure assessment. Specific concerns are that individual farmers use many different pesticides, that the specific pesticides used change radically from year to year, and that information from farmers or their next-of-kin is unreliable. Data from U.S. Department of Agriculture (USDA) surveys and from case-control studies conducted in the midwest by the National Cancer Institute (NCI) were used to evaluate these concerns. Annual pesticide use on various crops in the midwest from the USDA indicates that the average number of pesticide applications per crop per year seldom exceeds two. The number of pesticide applications for vegetables and fruit, however, is probably larger. The number of pesticides reported by farmers over their entire lifetime in NCI epidemiologic studies is also small. The proportion of farmers ever reporting use of more than five herbicides was 20% and 7% for insecticides. In a corroborative project involving 130 farmers and their pesticide suppliers we found that agreement was approximately 70% for herbicides and insecticides. As anticipated, surrogates were not able to provide as much information on pesticide use as the farmers themselves. Approximately twice as many surrogates as farmers were unable to provide clear responses regarding use of specific pesticides, i.e., they responded "I don't know." The relative ranking of pesticides by reporting frequency, however, was similar for the farmers and surrogates with correlation coefficients of 0.87 for herbicides and 0.67 for crop or animal insecticides. A study comparing the number of pesticides volunteered during an interview with the number after probing i.e., after the interviewer specifically asked about the use of each chemical, showed that probing greatly increased the number of pesticides recalled, particularly for pesticides used long ago and for short duration. These date indicate that many farmers do not use large numbers of pesticides, that surrogate respondents may be able to provide useful information, and that to obtain a complete listing of pesticides used it is necessary to ask the subjects about each directly.

THE ROLE OF EPIDEMIOLOGY IN THE DEVELOPMENT OF ENVIRONMENTAL INDICATORS: OCCUPATIONAL AND RESIDENTIAL EXPOSURE TO ORGANO-PHOSPHATE AND CARBAMATE PESTICIDES

R. H. ALLEN, J. BLONDELL, M. CLOCK

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Organophosphate (OP) and carbamate (CB) pesticides account for a significant number of human poisonings. For example, in 1990, there were 17,104 total poisonings with symptoms reported to cooperating U.S. Poison Control Centers, and 38% or 6499 were due to OPs and 1CBs. The increased regulatory emphasis of pollution prevention, farm worker safety, worker protection, better environmental statistics, safer pesticides, and reducing consumer/residential exposure to pesticidal products all challenge the traditional role of epidemiology in regulatory affairs. The objective of this report is to describe recent applications of epidemiology in the regulatory setting for the development of environmental indices of occupational and residential exposure to pesticides, using surveillance data on pesticide poisonings.

The methods include the use of poisoning surveillance data to rank over seventy-five OP and CB compounds; and the use of environmental epidemiology to inform regulatory priority setting, policy development, and current regulatory decision-making. National Poison Control Center data and worker poisoning surveillance data from California provide the primary source of residential and occupational exposure estimates used in the development of environmental indicators. In the record of U.S. occupational poisonings from 1977-1982, 71% of the hospitalized cases involved poisonings with organophosphates (OPs) and carbamates (CBs), where specific chemicals were noted, e.g., 80% of the time.

Results include the outcomes for parathion, aldicarb and several other compounds. For example, in more recent data from California, for 1982-89, there were 4764 occupational poisonings and 294 poisonings requiring hospitalization. Of this total, 136 occupational poisonings were for parathion and 27 were for aldicarb. Results also include lessons learned in the development of environmental indicators using environmental epidemiology in the regulatory arena, e.g., cancellation of 90 of the 99 uses of parathion based on excessive risk to workers. We conclude that environmental epidemiology concepts and environmental indices based on epidemiology data can serve to improve the scientific basis of environmental protection decisions and to protect the public health.

Disclaimer: The views expressed are those of the authors and do not necessarily represent the official position of the U.S. Environmental Protection Agency.

RESPIRATORY SYMPTOMS, SPIROMETRY, AND CHRONIC OCCUPATIONAL PARAQUAT EXPOSURE

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Chronic respiratory disease resulting from acute poisoning with paraquat has been reported. In addition, there have been case reports of poisoning and death from pulmonary fibrosis as a result of dermal exposure to paraquat. However, most epidemiologic studies have not shown long term pulmonary effects of heavy occupational paraquat exposure, although these studies have been flawed by insensitive methods and small sample sizes. In order to determine if chronic respiratory effects occur as a result of heavy occupational exposure to paraquat, a cross sectional study was conducted among workers at 15 large Nicaraguan banana plantations which relied on paraquat for the control of weeds. All workers were interviewed upon receiving job assignments for the day of the survey. Those who reported never having applied paraquat and those who reported more than two years of cumulative exposure as applicators of paraquat by knapsack sprayers were released from work for medical evaluation. One hundred thirty-four exposed workers and 152 unexposed workers were administered a questionnaire based on the British Medical Research Council respiratory questionnaire and a questionnaire interview asking about exposure. All participants underwent spirometric testing of forced expiratory volume in one second (FEV^1) and forced vital capacity (FVC). In the exposed group 71 (53%) reported having experienced a skin rash or burn resulting from paraquat exposure (highly exposed workers); 32 (25%) reported epistaxis, 77 (58%) nail damage, and 55 (42%) paraquat splashed in the eyes. There was a consistent dose-response relationship between exposure and the prevalence of dyspnea (all grades), chronic bronchitis, and episodic wheezing accompanied by shortness of breath (after adjusting for potential confounders). There was no relationship between exposure and FEV^1 or FVC. The frequent reports of skin rash or burns suggest that the dermal barrier to absorption may be compromised frequently under tropical working conditions. The high prevalence of respiratory symptoms associated with exposure, in the absence of spirometric abnormalities associated with exposure, in part could be a result of unmeasured gas exchange abnormalities among workers with long-term exposure to paraquat. Further study is needed to elucidate the chronic pulmonary effects of paraquat, a non-selective herbicide used in approximately 130 countries, where it is available to as much as 98% of agricultural workers.

A SURVEY OF KERATOSES AMONG PARAQUAT PRODUCTION WORKERS AND THEIR FRIENDS

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Two reports in the literature have suggested an excess of keratoses (a usually benign skin lesion that can be a precursor to skin cancer) among paraquat production workers in England and Taiwan. However, no control groups were incorporated in those studies. The aim of this study was to evaluate the contribution of occupational exposures to the prevalence of keratoses among workers in a paraquat production plant in Texas. The cross-sectional study design would allow for the comparison of the prevalence of keratoses between current workers of the plant and an age, race, sex frequency-matched group of their non-family friends who had never worked at the plant. About two friends were selected for each worker on average. Three sources of data for this study included: (1) an interview questionnaire to ascertain demographic and medical history data, occupational and residential history, and sun-exposure behavior, (2) a full body dermatology exam, and (3) company records to obtain a work history at the plant for exposure classification. The total plant population consisted of 95 employees and 51 contractors of which 80 workers (84%) and 37 contractors (73%) participated. A total of 247 friends of workers also participated in the study, for a total study population of 364. Overall, the prevalence odds ratio of keratoses of workers compared to friends was 1.1 (95% CI = 0.7-1.9). However, workers categorized by a high cumulative exposure index had an odds ratio of 1.8 times the friends (95% CI = 1.0-3.2) while low-exposed workers had an odds ratio of 0.7 (95% CI = 0.3-1.3). Due to the need to simultaneously control for multiple known risk factors for keratoses, a multiple logistic regression analysis was run to calculate the odds ratios of keratoses while controlling for age, age squared, skin type, freckling of skin, suntan activities, occupational exposure to polycyclic aromatic hydrocarbons, and residential sun exposure. The multiple logistic results confirmed the crude analysis. After controlling for the known risk factors, the odds ratio of keratoses of high-exposed workers compared to friends was 1.8 (95% CI = 0.8-3.9) while the comparable odds ratio for low-exposed workers was 0.6 (95% confidence interval = 0.2-1.7). The data do not demonstrate an excess of keratoses overall nor a linear dose-response. However, there may be a small excess of keratoses in the high-exposed subgroup of workers when compared to an unexposed group of friends.

RESPIRATORY DISEASE AND LUNG FUNCTION AMONG TOBACCO FIELD WORKERS

S. ROMAZINI, B. OLIVIER-ROUSSEL, A. PERDRIX, V. DROY, M.R. TENDERO, J.A. JOURDAIN, R. DE GAUDEMARIS

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Respiratory effects of occupational exposure to tobacco dust in plant producing cigarettes and cigars are well known. The aim of the present study was to investigate whether tobacco field workers differ from controls in their symptoms and lung function. A cross sectional survey was conducted among 289 tobacco field workers of both sexes, using questionnaires concerning age, sex, smoking habits, symptoms, exposure to tobacco and respiratory function tests. Two groups of workers (clerical staff from a neighboring agricultural office (n=202) and a sample of farmers (n=202) where selected as possible referents. The average length of exposure was 29.5 years. The mean area of tobacco fields was 11,356 square meters. Most tobacco workers (235) were exposed to T.N.L. variety of tobacco (81.3%). Seventy three subjects (25.6%) were exposed to Burley and 12 (4%) to Virginie. The main stages of processing were plucking off, hand picking and drying. Odds Ratio and 95% confidence intervals were estimated with logistic regression controlling for age, sex and pack-years. We found a significantly higher prevalence of cough (OR=3.17, 1.92-5.25 in comparison with farmers; OR=3.88, 2.37-6.34 in comparison with clerical staff), breathlessness (OR=2.49, 1.36-4.56 in comparison with farmers; OR=1.28-3.4 in comparison with clerical staff), dermatitis (OR=1.71, 1.07-2.76 in comparison with farmers; OR=2.15, 1.37-3.37 in comparison with clerical staff). No pronounced excesses were observed for attacks of shortness of breath with wheezing, asthma, rhinitis, eye irritation and fever. The results of the pulmonary function tests were compared with the predicted values for age, sex, and height (Quanjer, ECCS, 1983). Two hundred seventy two tobacco workers (96.5%) had normal FVC, 270 (95.7%) had normal FEV1 and 262 (92.9%) had normal MMEF. The functional data, in comparison with those of the reference populations, were not significantly decreased. No differences were found when analysis was conducted by duration of exposure, area of tobacco fields, and varieties of tobacco. Our data suggest that tobacco field workers have increased symptoms (cough, breathlessness, dermatitis). Concerning asthma and results of the pulmonary function tests, we can suspect a healthy worker effect.

Thursday, September 24, 1992
Plenary Presentations

JOB STRESS AND CARDIOVASCULAR RISK FACTORS IN A JAPANESE WORKING POPULATION

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To examine the effects of job stress on risk factors for cardiovascular disease in Japan, a cross-sectional study was conducted of male employees in two factories of a Japanese electrical corporation in 1984. The subjects were asked to complete questionnaires concerning job stress and other covariates. Their medical history was assessed through interviews by trained nurses. In addition, the nurses measured height, weight and blood pressure, and collected blood samples from each subject. Obesity was calculated using the Body Mass Index. The overall response rate was 88%. A total of 2,672 male respondents, excluding 158 with a medical history of hypertension, cardiovascular disease or diabetes mellitus, were subjected to the present analysis. Four job stressors were assessed: 1) hours of overtime, 2) job overload, 3) control over workpace, and 4) human relations at work. Four cardiovascular risk factors were examined in the physical check-up: 1) systolic blood pressure (SBP), 2) diastolic blood pressure (DBP), 3) total serum cholesterol, and 4) number of cigarettes smoked per day. Covariates were age, education, martial status, major occupational categories, rotating shift work, alcohol consumption, caffeine consumption, exercise, obesity, family history of heart disease, and type A behavior. Analysis of covariance controlling for these eleven covariates was employed to assess the effects of the job stressors and their interactions on the risk factors SBP and DBP were significantly higher in those working 51 or more hours of overtime per month than those working 50 or less hours ($p < 0.05$). SBP and DBP were significantly higher in those with lower control over workpace than those with higher control ($p < 0.01$). The interactive effects between overtime and control over workpace on SBP and DBP were significant ($p < 0.01$), showing the highest blood pressure in the group with more overtime and lower control over workpace. None of the job stressors were significantly related with total serum cholesterol or number of cigarettes smoked ($p > 0.95$). It is suggested that long working hours and little control over workpace are related to high blood pressure in Japanese male workers. The present study supported, in part, the job demand-control model, but failed to indicate the stress-buffering effects of human relations at workplace.

MEASUREMENT AND EVALUATION OF SYMPTOM INTENSITY TO IMPROVE UNDERSTANDING OF ACUTE RESPIRATORY HEALTH EFFECTS

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Most studies of respiratory irritants examine subjective symptoms recorded only as yes/no responses. In a study of respiratory irritation due to sodium borate particulates, we used a scale to permit estimation of the severity of irritant symptoms as well. The overall study was undertaken to evaluate dose response relationships for five irritant symptoms resulting from acute exposures to particulates present during processing of boron containing ores. The portion of the study presented here is an evaluation of the symptom intensity scale compared with simple yes/no responses and with responses recorded by pressing a button to mark the event on the continuous exposure recording.

A short term prospective cohort study was designed in which a pre-shift baseline health survey was followed by a continuous measure of exposure and hourly interview for irritant symptoms. At each interview symptom occurrence, timing and intensity were recorded. An intensity scale with ratio properties was developed for measuring the severity of irritant symptoms. The scale enabled subjects to rank the severity of the reported symptoms on a ten point scale, labeled from 0 (not at all) to 10 (very, very much (almost maximal)).

As an alternative to frequent symptom surveys, an electronic "event marker button" was inserted into the datalogger which was attached to each personal exposure monitoring device. By pushing the button, subjects were able to indicate the onset of an irritant symptom at any time during the workshift. Intensity of the marked symptom was not recorded.

The study population included 79 exposed and 27 unexposed workers tested hourly on four consecutive days (a total of over 2500 survey hours). Using the scaled results, it was possible to distinguish between the symptom intensity associated with daily living and the higher intensity attributable to work exposure. Nasal symptoms were the most prevalent, occurring 2, 3 and 9 times more frequently than cough throat irritation and breathlessness, respectively. All irritant symptoms were reported more often during periods of higher exposure. The exposure-response relationships were statistically significant and consistent across all symptom intensity levels. Almost half the symptoms had an intensity of 1 or less and less than ten percent were scored 5 or greater. Symptoms recorded by the event marker (i.e. unprompted symptom reports) also increased with exposure. When these were compared with the questionnaire reports, the marked events appeared to be equivalent to an intensity score of ≥ 3.

Further studies with the severity scale could permit control efforts to focus on the intensity as well as the frequency of respiratory irritant symptoms. If the event marker proves to consistently identify the more severe symptoms, the ease of its use may allow much more detailed study of acute irritant events in actual work environments.

LUNG FUNCTION AMONG INSULATION WORKERS: A COMBINED CROSS-SECTIONAL AND LONGITUDINAL STUDY

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In order to evaluate the effect of working with modern insulation materials (i.e. rock and glass wool), all members of the Copenhagen Union of Insulation Workers were invited to a health examination including lung function tests. 340 men (74%) agreed to participate. 166 bus drivers served as controls in the cross-sectional study. Age distribution, height and smoking habits were almost identical in the two groups. As lung function parameters FVC and FEV1 were used. There was no difference between FVC test results in insulation workers and controls except for ex-smokers, but insulation workers had highly significantly lower values of FEV1 than controls independent of smoking habits. Six years earlier 114 of the insulation workers had participated in a similar study and 59 of the bus drivers performed lung function tests 8 years after their first examination. These men were included in the longitudinal study. The decline in FVC in smoking insulation workers was significantly higher than in smoking bus drivers and the decline in FEV1 was significantly higher in insulation workers independent of smoking habits. Self-assessed former exposure to asbestos was not associated with lung function parameters in insulation workers, however assessment of exposure was uncertain. We conclude that working with modern insulation materials is associated with increased risk of developing obstructive lung disease.

Mean values of FVC and FEV1 (table 1) and average decline in lung function (table 2) in insulation workers and controls.

Smoking	FVC (1)			FEV1 (1)		
	Insul. Worker	Controls	p	Insul. Worker	Controls	p
Current	4.0	4.1	NS	2.5	3.4	***
Previous	3.4	4.3	**	2.1	3.6	***
Never	4.4	4.4	NS	2.8	3.7	***
All	4.0	4.2	NS	2.5	3.4	***

Smoking	FVC (1)			FEV1 (1)		
	Insul. Worker	Controls	p	Insul. Worker	Controls	p
Current	9.2	2.8	***	17.5	2.2	***
Previous	6.0	3.5	*	16.9	3.1	***
Never	3.6	3.8	NS	15.4	5.6	**
All	7.7	3.1	**	17.0	2.9	**

STUDY OF MORTALITY BASED ON THE UK NATIONAL REGISTRY FOR RADIATION WORKERS

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The International Commission on Radiological Protection (ICRP) has estimated the risks of radiation-induced cancer on the basis of studies of groups exposed to high radiation doses over a very short time, such as the Japanese atomic bomb survivors, and using radiobiological information to extrapolate these results to estimate the risks associated with chronic exposure to low radiation doses. An alternative, more direct means of estimating the risks associated with occupational radiation exposure, is to study radiation workers themselves. Consequently, the National Radiological Protection Board set up the National Registry for Radiation Workers (NRRW) in 1976 to provide the largest study of UK radiation workers. The first analysis of the NRRW was based on a cohort of 95,217 workers with about one million person-years. Using personal dosemeter measurements, the mean lifetime dose from external radiation was 33.6 mSv. The distribution of doses was highly skew; 62% of workers had a lifetime dose less than 10 mSv and 9% had a lifetime dose in excess of 100 mSv. By the end of follow-up 6,660 workers had died. There was a strong healthy worker effect; after excluding the first 10 years following the start of radiation work, the SMR was 85 (95% CI 83-87) for all causes and 86 (81-90) for all malignant neoplasms. The SMRs for most individual cancers were also less than 100, although that for thyroid cancer was significantly raised (SMR 303,95% CI 139-576, based on 9 deaths). However, there was no association between thyroid cancer and external dose, and the raised SMR may represent a chance finding. In an internal analysis that additionally adjusted for industrial category and first employer, there was a significant trend with dose in the risk of leukaemia (excluding chronic lymphatic leukaemia): excess relative risk (RR) 4.3 Sv^{-1} (90% CI 0.4, 13.6). There was also weak but non-significant evidence of a trend with dose in the risk of all cancers: excess RR 0.47 Sv^{-1} (90% CI-0.12, 1.20). When these results are extrapolated in a manner similar to that used by ICRP to predict cancer risks over a lifetime, the central estimates from the NRRW are about twice the ICRP risk estimates, but the confidence intervals are very wide and include the ICRP values. When taken in conjunction with other information, such as from a combined study of nuclear workers in the USA, there is insufficient evidence to justify changes in the risk factors recommended by ICRP.

CHILDHOOD CANCERS AND PATERNAL EXPOSURE TO IONIZING RADIATION: FINDINGS FROM THE OXFORD SURVEY OF CHILDHOOD CANCERS (OSCC)

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In 1990, Gardner et al published the results of a case-control study of leukaemia and lymphoma among young people near the Sellafield nuclear plant in West Cumbria. Excess risks of leukaemia and non-Hodgkin's lymphoma (particularly leukaemia) were associated with paternal employment and recorded external dose of whole body penetrating radiation during work at the plant before conception. The present study has sought additional information on the general topic of childhood cancers and paternal exposure to ionizing radiation from the records of the Oxford Survey of Childhood Cancers (OSCC).

Subjects for this analysis comprise 15,279 childhood cancer deaths occurring in children aged 0-15 years in England, Scotland and Wales during the period 1953-81. Each case child was individually matched with a healthy control child; controls were matched for sex and date of birth, and the residence of death for the case child was the same as the residence of birth for the control child. The parents of each case-control pair were interviewed by a single interviewer.

Paternal occupations were abstracted from the original interview folders and input, in text form, to computer files. An alphabetical list of all 13,604 unique job titles (job dictionary) was then supplied, devoid of any information on case/control status, to a medical physicist (P.J.R.), who selected those job titles with a potential for exposure to man-made external ionizing radiation at work. The relevant folders were then reviewed for additional information. Finally, the medical physicist classified the likely average external radiation exposure associated with each selected job title for the six month period before the birth of the relevant child, according the same dose groupings used by Gardner et al. A classification was also made for whether or not there was potential exposure to radionuclides.

For all childhood cancers, of the 8 fathers placed in the highest exposure group (10 or more mSv) 4 were case fathers and 4 were control fathers (RR=1.00 95% C.I.=0.25-4.00). Corresponding figures for the 5-9 mSv group were 8 and 4 respectively (RR=2.00, 95% C.I.=0.60-6.64), and corresponding figures for the lowest exposed group (1.4 mSv) were 55 and 42 respectively (RR=1.31, 95% C.I.=0.88-1.96). There were 27 case fathers with the potential for exposure to radionuclides and only 10 control fathers (RR=2.70, 95% C.I.=1.31-5.58). When these two radiation variables were analyzed jointly, the external radiation relative risks were reduced to 1.03, 0.93 and 0.59, whilst that for potential exposure to radionuclides was increased to 2.87 (95% C.I.=1.15-7.13). Findings from this study suggest that paternal exposure to radionuclides is a risk factor for childhood cancer, rather than exposure to external ionizing radiation, and that this risk is expressed for the overall grouping of all childhood cancers. Clearly research on other populations is required.

CANCER 3

NON-MALIGNANT PLEURO-PULMONARY DISEASE AND THE DEVELOPMENT OF MALIGNANT MESOTHELIOMA IN WESTERN AUSTRALIAN CROCIDOLITE WORKERS

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The aim of this study was to determine whether diffuse pleural thickening, pleural plaques or indeed any commonly recorded radiographic abnormality are associated with the subsequent development of malignant mesothelioma. All cases of mesothelioma (102) in the cohort of 6910 former Wittenoom crocidolite workers together with up to 6 controls per case had all available radiographs searched for at both the Perth Chest Clinic, where statutory x-rays are taken and stored indefinitely for all workers in the mining industry, and at teaching hospitals in Western Australia. These were scored by three independent readers according to the ILO Classification of Radiographs for the Pneumoconioses.

The duration and place of work at Wittenoom for each individual were obtained from employment records. The levels of airborne respirable fibers greater than 5 microns in length in various workplaces were measured in 1966. An estimate of the total exposure for each individual in fibers/ml-year was thereby calculated.

Conditional logistic regression analyses modelled the relative risk of mesothelioma incidence: covariates considered were log (cumulative exposure), years since first employed and level of radiographic abnormality.

Scores on x-rays were grouped in terms of tie before the death of the case. To adjust for the selection bias operating in the presence or absence of an x-ray all fitted models included indicator variables of presence or absence of an x-ray in any period. After inclusion of these variables in any models, the effects of each radiographic score were examined singly, then together, and then after adjustment for exposure.

X-rays were found from the relevant periods for 61 cases and 318 controls. Although radiographic abnormality was fairly common in all subjects (the average prevalence of profusion of small opacities $\geq$ 1/0 on the ILO scale was 20% for all selected control films), there was no radiographic sign included in the ILO Classification that occurred more commonly in cases than in controls, even after adjustment for exposure.

This study confirms the findings from other studies, that have either had too few subjects or that have been unable to adjust for level of exposure to asbestos, that there are no radiographic markers for the future development of malignant mesothelioma.

A CASE-CONTROL STUDY OF MESOTHELIOMA AND EXPOSURE TO BIOGENIC SILICA FIBERS

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The authors conducted the first study to test the hypothesized association between biogenic silica fiber (BSF) exposure and malignant mesothelioma. BSF are respirable, non-crystalline silica fibers originating from the mechanical breakdown of plants (e.g., sugarcane and rice). We measured exposures to BSF among workers in the Hawaii sugarcane industry. Harvest tractor drivers have the greatest average exposure (0.089 fibers/cc), other field workers have lower average exposures (0.016 fibers/cc), while the remaining sugarcane workers have almost no exposure to these fibers (<0.001 fibers/cc). Cases and category-matched cancer controls were identified through the Hawaii Tumor Registry for the years 1960-1987. Employment in the Hawaiian sugarcane industry was determined from union records, death certificates, and a population census conducted in 1942-43. The authors controlled for occupational asbestos exposure and sampled for both BSF and asbestos to document exposure in the sugarcane industry. A total of 93 cases and 281 controls were included in the analysis. Seven cases and nineteen controls had been sugarcane workers [Odds Ratio (OR)=1.1, 95% Confidence Interval (CI) 0.4, 3.8]. Mesothelioma was associated with exposure to asbestos (OR=2.2, 95% CI 1.2, 4.2). The findings suggest that BSF exposure in the Hawaiian sugarcane industry is not likely to pose as a risk for malignant mesothelioma.

LUNG CANCER AND AIRWAYS OBSTRUCTION AMONG METAL MINERS EXPOSED TO SILICA AND LOW LEVELS OF RADON DAUGHTERS

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Starting from a cross-sectional survey in 1973, the mortality of two cohorts of Sardinian metal miners was followed-up through December 31, 1988. In mine A the median quartz concentration in respirable dust was 1.2% and the exposure to radon daughters averaged 0.13 working level (WL), with the highest estimated cumulative exposures around 80-120 WLM. In mine B the silica content was much higher (6.5-29%) and the exposure to the radon daughters significantly lower than mine A. Smoking, occupational history, chest radiograph and lung function tests were available for all members at admission. One-thousand-seven-hundred-forty-one subjects entered the cohort providing 25842.5 person-years. Vital status was ascertained through the residence town registers and it was know for all the members of the two cohorts at the end of the follow-up. A copy of the death certificate was available for all deceased subjects (N°:187). Expected deaths from specific causes were derived from the five-years-age class and calendar-year-specific regional rates.

Mortality for all causes was slightly lower than expected and all cancer mortality was close to 100 in both mines. A significant excess for nonmalignant respiratory diseases was noticed in both mines (SMR 239;CI:176-324). Other specific cancers showed an increased, but not significantly higher, SMR. Twenty-four miners died from lung cancer, 17 from mine A (SMR 128, 95% confidence interval 80-205) and 7 from mine B (SMR 85, CI 41-178). The SMR for lung cancer was higher among underground workers of mine A (SMR 148, CI 82-266), with a significant upward trend with the duration of employment, but those with airways obstruction ran the highest risk (SMR:316, CI 148-674). A nested case-control study (four living controls for each case, matched by year of birth and smoking category) confirmed the independent effect of airways obstruction (OR: 2.58; CI: 1.00-6.86) and underground work in mine A (OR: 1.79, CI: 0.67-4.78) on lung cancer risk.
Basing on the present results, crystalline silica per se does not appear to independently affect lung cancer mortality, but an association between lung cancer and exposure to radon daughters, though within low levels, may be considered for miners from mine A, mainly for those with airways obstruction.

THE 1891-20 BIRTH COHORT OF QUEBEC CHRYSOTILE MINERS AND MILLERS: A PRELIMINARY REPORT ON MORTALITY TO 1988

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A research programme established at McGill University in 1966 included a mortality survey with the primary aim of "defining as accurately as possible the quantitative relationship between exposure to chrysotile asbestos and the incidence of lung cancer". Observations were made on a birth cohort (1891-1920) of nearly 11 thousand men (and almost 450 women) followed from first employment, as early as 1904, in the Quebec chrysotile mines and mills. Results to four points in time, the latest to the end of 1975, have been reported; a few figures in earlier publications have had to be very slightly revised. By the end of 1975, of the 10,926 men registered in the cohort, 1090 (10%) had been lost to follow-up, mostly never traced after leaving very short employment, and 4485 had died (41%); this left a cohort of 5351 men (49%) alive. Overall excess mortality was 2% at Asbestos and 10% at Thetford Mines; the lung cancer excess was around 25%.

In May 1992, we terminated a further follow-up, to the end of 1988, of the 5351 male members of the cohort who had survived into 1976, extending the original aim to the fuller determination of exposure-response relationships for respiratory, abdominal, and other cancers, for pneumoconiosis and for mesothelioma. Details of vital status are still incomplete for 15 men (0.3%); updating of exposure histories of those still employed in 1967 will not be completed until later this year.

From 1976 through 1988, there were 2827 deaths, bringing the accumulated total to 7312 (almost three-quarters of the 9821 men of known vital status). Of the 2905 men born 1891-1900 and living in 1926, only 88 (or 3%) were still alive in 1989; there were 644 survivors (18%) of the 3636 in the corresponding 1901-10 cohort, and 1777 survivors (48%) of the 3691 in the 1911-20 cohort. Subject-years analyses, with Quebec rates as reference, have been carried out on the 2827 deaths 1976-88. The SMR (all causes) was 1.07. At Asbestos and Thetford Mines, SMRs (all causes) were $1358/1330.9 = 1.02$ and $1469/1304.0 = 1.13$. The SMRs for various cancers were:-lung $327/229.8 = 1.42$; larynx $18/13.8 = 1.30$; oesophagus $10/13.7 = 0.73$; stomach $56/47.9 = 1.17$; colon/rectum $73/87.7 = 0.83$; other abdominal $63/61.5 = 1.02$. These analyses have been extended to preliminary examination of cancer risks in relation to dust exposure (million particles per cubic foot) accumulated to age 45. There were no indications of exposure-response relationships for cancer of larynx, oesophagus, stomach, or colon/rectum, or other abdominal cancers. In each of six classes of exposure up to 300 mpcf.y, the lung cancer SMR was close to 1.3 (a total of 254 cases of lung cancer, among 4384 men, against 190.6 expected), similar for Asbestos and Thetford Mines; there was no evidence of trend. For the 788 men exposed to between 300 and 1000 mpcf.y , the lung cancer SMR was $53/32.8 = 1.62$, and for the 164 men exposed to at least 1000 mpcf.y it was $20/6.3 = 3.16$.

Of the total of 7312 deaths to the end of 1988, eighty-six were ascribed on death certificates to pneumoconiosis, all but one since 1946. In all, there have probably been 33 deaths due to mesothelioma, 28 in miners and millers (see accompanying abstract).

MALIGNANT MESOTHELIOMA IN QUEBEC CHRYSOTILE MINERS AND MILLERS: A PRELIMINARY REPORT

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In 1966, a cohort comprising nearly 11,000 men born 1891 through 1920 and ever employed for one month or more in the Quebec chrysotile production industry, half at Asbestos and half at Thetford Mines, was registered for study. Reports on mortality to the end of October 1966, and to the end of 1969, 1973 and 1975 have been published. At these four points, the accumulated numbers of deaths thought due to malignant mesothelioma, as a proportion of all deaths, were 3 out of 2413, 6/3216, 8/4037 and 10/4547. Two of these cases had later to be deleted, leaving eight, all pleural in type.

A further follow-up was initiated in 1990 to determine the vital status on 1 January 1989 of 5351 survivors into 1976. Virtually all have been traced and by May 1992 details for only 15 were incomplete. This brings the total deaths to some 7310. Scrutiny of clinical and pathological information on the 2827 additional deaths indicates that there have probably been a further 25 more cases of mesothelioma, including one affecting both pleura and peritoneum. Thirteen of the 25 cases were coded to ICD 163 and the remaining 12 to a variety of codes. As only 17 of the newly ascertained cases were confirmed at autopsy, 25 may be an overestimate.

Among all 33 suspected mesotheliomas since 1925, the average age at death was 67 years; one was at age 40, the others at ages between 57 and 79 years. The 1725 deaths in the cohort at ages over 80 included 17 of the mesotheliomas. In the decades 1949-58, 1959-68, 1969-78, 1979-88, the numbers of deaths from mesothelioma were 1, 4, 8, and 20, respectively. There were more than twice as many cases in miners and millers from Thetford Mines (20) as from Asbestos (8); the remaining five cases were among men employed in a small asbestos products factory in Asbestos. The median duration of employment before 1977 was 29 years (range 2½ to 45 years); 19 of the cases (aged 53 years on average in 1977) continued in employment. All eight men employed five years or less had left work by 1945, three from the mines and mills in Asbestos and three from the factory there; these six comprised almost half the cases at Asbestos. There were no cases of mesothelioma among the 4438 members of the cohort (41%) employed for less than two years, eight cases among those 2448 (22%) employed for 2-10 years, and 25 mesotheliomas among the 37% of the cohort (4040 men) with at least 10 years employment. Time from first employment to death ranged from 21 to 60 years (median 47 years) with no important geographical difference.

The value of the parameter b in the Doll/Peto exponential mortality model: incidence = b x (years since first exposure)^2 was estimated as $0.24 \times 10^*$ for Thetford Mines; in Asbestos, b for miners and millers was about half as large (ca. $0.1 \times 10^*$), but that for factory workers at least an order of magnitude greater (ca. $4.5 \times 10^*$). It thus seems possible that the higher fibrous tremolite exposures thought to have occurred at Thetford Mines were sufficient to affect the risk of mesothelioma in the two mining areas. The adverse experience of the factory workers was probably related to the known use of crocidolite in that plant.

MUSCULOSKELETAL DISORDERS

A CROSS-SECTIONAL STUDY OF CARPAL TUNNEL SYNDROME SYMPTOMS AMONG TRADE AND OFFICE WORKERS

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Carpal tunnel syndrome has emerged as a significant occupational health problem resulting in numerous occupational health compensation claims, substantial costs, and disability. The objective of this study were to assess the magnitude of CTS symptoms among occupational groups that have not been well evaluated from an epidemiologic perspective, and to identify specific tasks associated with CTS symptoms. A self-administered questionnaire was mailed to a sample of workers from three local Southern California unions. The unions represent office workers (n=652, data entry operators, court clerks, and office clerks), construction carpenters (n=389), and sprinkler fitters (n=452). The constellation of symptoms used to define CTS included pain, tingling, and numbness in the wrist, hand, and/or fingers.

Office workers reported the highest prevalence rates of CTS symptoms (21.3%) followed by sprinkler fitters (18.4%) and carpenters (15.7%). Job task information was collected for work that involved repetitive motion activities, hours using a computer keyboard, hours using hand and power tools, and hours working with hands and arms above the shoulder level. Reported hours of work involving repetitive motion was the strongest predicator of CTS symptoms. Prevalence odds ratios (OR) and 95% confidence interval (95% CI) for office workers were 2.4 (0.9, 6.1) for 3-4 hours per day and 3.2 (1.4, 7.2) for five or more hours per day, and 1.5 (0.6, 3.5) and 3.1 (1.5, 6.3) respectively for carpenters and sprinkler fitters. Office workers with 6 or more hours of work above shoulder height had equivalent odds ratios for CTS symptoms [OR, 2.3 (1.4, 3.8); OR, 2.3 (1.4, 3.9) respectively]. Among carpenters and sprinkler fitters, hand tool use was more strongly associated with CTS symptoms than power tool use [OR, 1.8 (1.1, 3.1) and 1.2 (0.8, 1.9) for 6 hours or more of hand and power tool use respectively].

Epidemiologic research among occupations with dynamic tasks requirements that involve repetition and force is limited. This research has focused on occupations that have a variety of tasks and a wide range of repetition and force demands. Our results suggest that CTS prevalence can be reduced if the hours of repetitive motion work, work above shoulder height, and keyboard work are reduced. Further research is necessary to identify the specific aspects, e.g., posture, intensity of repetitive work, workplace and tool design, that can be modified to reduce CTS prevalence.

SURVEILLANCE FOR WORK-RELATED CARPAL TUNNEL SYNDROME

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Carpal tunnel syndrome (CTS), compression of the median nerve as it passes through the carpal tunnel, is characterized by pain, numbness or tingling in the median nerve distribution of the hand. Frequently reported work-related factors include repetitiveness, high hand forces, segmental vibration, wrist flexion or hyperextension, local contract stress at the wrist creases, and cold temperatures. The reported incidence of work-related CTS has been increasing since the mid 1980's. CTS has been described as a sentinel event for a variety of work-related upper limb disorders. Thus, identifying high risk workplaces for potential intervention and control is high priority. While workers compensation data has many limitations, can it be used to distinguish between "true" high and low risk industries and workplaces for CTS?

We used Washington State's exclusive worker's compensation data to calculate incidence rates for CTS. This system, covering 2/3 of the state workforce, used ICD-9 codes for billing purposes. All unique claims for ICD-9 354.0 between January 1, 1987-December 31, 1991 were identified (n=8,860). The 1990 incidence rate (IR) was 0.25 per 100 worker years. Washington industrial classes (WIC) with 15 or more cases during the 4 year period were included in the final data set used to identify "high risk" WICs. "High risk" WICs included those who were in 2 of 3 top 10 categories: 1) highest incident count, 2) highest incidence rate per 100 worker years, 3) highest acceleration ratio (1990 rate/1987 rate). Fish processing (IR 1.5) and poultry farms (IR=1.8) WICs met this criteria. Two fish processing plants and one poultry plant where chosen for study. Their 1990 CTS incidence rates were 7.4, 0.0 and 7.4, respectively. A "control plant" was chosen from a WIC (cloth printing) that had no reported ICD-9 coded CTS cases between 1987-1990, and that was comparable to the "high risk" plants demographically.

Jobs with at least 10 workers were chosen for study. Job analyses teams used check lists of recognized risk factors to quantify current exposures and examination teams performed clinical exams and detailed interviews of current workers. The period prevalence of CTS on interview was 27.5% in fish, 37.4% in poultry and 8.6% in cloth printing. Point prevalence based on examination and interview was 6.6%, 9.6% and 3.4% respectively. There was no difference in prevalence between the two fish processing plants. For all work-related upper limb disorders, point prevalence on exam and interview was 17.6%, 27%, and 10% respectively. Job analysis indicated that 72% of jobs analyzed in fish, 83% in poultry and 42% in the cloth printing plant jobs had cycle times of less than 30 seconds. In all plants, those specific jobs with the highest prevalence of CTS had the highest number of exertions per hour combined with the highest number of pinches or forceful hand exertions. Thus workers compensation data may be useful for identifying high risk industrial classes for CTS, but not necessarily identifying specific high risk plants.

SURVEILLANCE OF CUMULATIVE TRAUMA DISORDERS IN NORTH CAROLINA: ADVANTAGES AND DISADVANTAGES OF USING WORKERS COMPENSATION DATA

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Existing surveillance data on cumulative trauma disorders (CTDs) are limited to rates by industry. Workers Compensation (WC) claims data could provide additional detail about illnesses and exposures. We used WC data from 1986-1988 to describe CTD claims in North Carolina (NC). The goals of the study were: (1) To describe the computerized WC data base in NC, including how CTDs are coded, (2) To determine which industries had highest CTD claim rates, and (3) To compare NC CTD rates to rates in published studies of WC CTD claims in Ohio and Washington state.

The injury and illness coding manual used by the NC Industrial Commission is based on the Bureau of Labor Statistics (BLS) coding manual from several years ago. It contains brief clinical coding guidelines for specific disorders, but it does not contain the case definition of carpal tunnel syndrome used by NIOSH. NC enters detailed case information into the data base only when the claim is legally closed, and only for cases which are not classified as "medical only," (medical only cases have no lost work time and are relatively minor, clinically). Tendinitis and carpal tunnel syndrome were examined using nature of injury codes 260, 562 and 563, the accident code was 12 (overexertion) and the body part codes were 300, 310, 311, 313, 315, 318, 319, 320, 330, 340, and 398 (upper extremity). Industries were identified in the data base by BLS standard industrial codes. Industry-specific rates were calculated using denominators obtained from BLS.

These industries had the highest CTD rates (claims per 10,000 workers): Food Products, 5.6; Furniture Manufacturing, 4.2; Rubber and Plastics manufacturing, 3.4; Electrical Manufacturing, 3.3; Textiles, 2.8; Transportation Equipment Manufacturing, 2.5; Fabricated Metal Products Manufacturing, 2.5.

The types of industries with the highest CTD rates were similar in NC, Ohio and Washington. NC CTD rates were substantially lower than rates reported in Ohio or Washington, but differences in the way WC claims are coded prohibited a direct comparison of the magnitude of CTD rates in the 3 states. In contrast to NC, the Ohio and Washington articles reported on all incident cases, including those which are medical only cases. The three states use different injury/illness coding systems, although coding in NC and Ohio is similar. In Ohio, 5 additional CTD diagnosis codes are available to code claims. Washington uses a different industry coding system than Ohio or NC. NC CTD rates could be low because of lag in claim closure, selection biases from under-reporting of claims, reduced ergonomic exposures in NC industries, differences in diagnosis coding rules, or under-recognition of CTDs by NC physicians. WC claims data may be of value to identify industries where preventive interventions may be of benefit, and for detecting sentinel events. Standardization of data systems across states would improve the usefulness of WC data for surveillance. Use of standard case definitions for coding WC claims would improve the quality of the data for CTD surveillance.

ESTIMATED PREVALENCE AND WORK-RELATEDNESS OF SELF-REPORTED CARPAL TUNNEL SYNDROME (CTS) AMONG U.S. WORKERS

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Since the mid-1980's the Bureau of Labor Statistics has reported a sharp increase in the incidence of repetitive trauma injuries or cumulative trauma disorders (CTDs) among the U.S. workers. To estimate the magnitude of self-reported carpal tunnel syndrome (CTS) nationally, data from the Occupational Health supplement of 1988 National Health Interview Survey (NHIS) were analyzed. Among 127 million "current workers" (those who worked during the 12 months prior to the survey), the prevalence rate for self-reported CTS was 1.47% {95% C.I. 1.30 - 1.65}. The demographics and work-relatedness of self-reported CTS are described for this subset of 1.62 million "current workers" who reported CTS and experienced hand discomfort for one or more days. The prevalence rate of CTS was 1.63% for female {95% C.I. 1.39% - 1.87%} and 0.97% for male {95% C.I. 0.77% - 1.18%}. The female/male rate ratio for CTS was 1.7. The median age among those reporting CTS was 40 for female and 38 for male, while among those not reporting CTS, it was 39 and 37, respectively;. Occupational categories with the highest prevalence rates of self-reported CTS were: 1) mail and message distributing (3.24%), 2) health assessment and treatment (2.74%), 3) construction and extractive trades (2.49%), and 4) fabricators, assemblers, and inspectors (2.44%). Industrial categories with the highest prevalence rates were: 1) manufacturing of food and kindred products (2.46%), 2) repair services (2.40%), 3) transportation industry (excluding railroad and trucking) (2.34%), 4) constructin (2.1%), and 5) manufacturing of transportation equipment (mostly automobile) (2.08%). Among individuals who report repetitive bending or twisting of the hand and wrists at work, 2.01% {95% C.I. 1.72 - 2.30} reported CTS, compared to 0.55% {95% C.I. 0.42 - 0.68} of those without such exposure (rate ratio: 3.7). Among those who used vibrating tools, 2.03% {95% C.I. 1.50 - 2.56} reported CTS, while 1.11% {95% C.I. 0.95 - 1.27} of those who did not use vibrating tools reported CTS (rate ratio: 1.8). When the combined effects of these two stressors were examined, 2.36% {95% C.I. 0.72 - 2.99} of those who were exposed to both stressors reported CTS, while 1.74% {95% C.I. 1.45 - 2.03} of those exposed to neither stressor self-reported CTS (rate ratios: 4.2, 3.1, 1.0). Although there was a suggestion of an additive effect of these two types of stressors, the difference between "both stressors" and "either stressor" was not statistically significant. The NHIS identified occupations and industries with high risk of CTS and supports the relationship between ergonomic stressors and development of this condition. Periodic surveys can be used to monitor trends in disease, identify responsible risk factors and high risk industries and occupations toward which prevention effort should be directed.

MEDICAL INSURANCE CLAIMS AND OCCUPATIONAL DISEASE SURVEILLANCE: CUMULATIVE TRAUMA IN THE AUTO INDUSTRY

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Information sources are needed for occupational disease morbidity surveillance. Medical insurance claims over a 4 year period were linked with work histories for a large automotive manufacturer, identifying large numbers of cases of potentially work-related diseases, including 30,600 episodes of probable cumulative trauma disorders (CTD). CTD incidence rates were calculated within five diverse automotive plants, and high risk areas identified, however, unknown differences in medical insurance coverage by exposure group limited interpretation. Case-control analyses, with controls also identified by insurance claims, addressed coverage and produced age-and sex-adjusted estimates of risks. All five plants had departments with statistically significant, elevated risks for one or more of Carpal Tunnel Syndrome (CTS), CTD of other upper extremities, Rotator Cuff Syndrome (RCS), CTD of the neck and of the lower back. CTS risk was highest for assemblers in an axle plant (OR=4.2, 95% CI 1.9-9.4) and assembly plant spray painters (OR=3.6 95% CI .99-13); RCS risk was highest for stamping plant workers on large press lines (OR=3.3, 95% CI 2.1-5.1). Population attributable fractions were estimated to range from 0.2 (lower back) to 0.5 (Carpal Tunnel Syndrome). For CTDs other than those affecting the lower back, more than half of the work-related cases identified from medical insurance claims were not similarly identified on the plant OSHA 200 logs. The results imply that work-related musculoskeletal disease frequently is not recognized or does not come to the attention of employers. A substantial proportion of work-related CTD medical costs appear to be carried by private insurance rather than the workers compensation system. Medical insurance claim data linked with work history is a basis for practical and comprehensive surveillance for CTD and, potentially, a variety of other occupational diseases.

INJURY 1

WORK-RELATED ELECTRICAL FATALITIES IN AUSTRALIA, 1982-84

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Only a limited number of studies of work-related electrical fatalities have been published world-wide. Despite a vast amount of experimental and technical knowledge concerning the hazardous nature of electricity and the knowledge of measures required for electrical safety, electrical fatalities still account for between 4% and 12% of fatalities in the workplace. This paper reports the first detailed study of work-related electrical fatalities (WREFs) in Australia.

WREFs were studied as part of a larger investigation of all work-related fatalities (WRFs) which occurred in Australia during the three calendar years 1982, 1983 and 1984*. All work-related traumatic deaths in Australia are reported to a coroner, and the study team examined coroners' files throughout Australia to identify the cases which met the study definition of work-related death. Electrical fatalities formed a subset of these cases. Ninety-five WREFs, out of a total of 1,544 WRFS, occurred in members of the employed civilian labour force (ECLF) during the study period. All were male. this represented an incidence of 0.49/100,000 persons (0.79/100,000 males) in the ECLF. Electricity was the 5th highest cause of work-related fatalities in Australia. The incidence showed a peak in the 25-34 year age range, with the suggestion of a smaller peak above 55 years of age. Ninety-four percent of workers were performing their normal tasks at the time of the fatal event, suggesting that most of them should have been aware of the electrical hazard. Only 38% of them were doing work of an electrical nature at the time. The greatest number of deaths occurred on farms and non-construction industrial sites, with overhead powerlines and fixed wiring the main sources of current. Over half the deaths occurred with domestic voltages (around 24 V). Where specified, moisture and lack of adequate clothing were contributory factors in almost half the cases. Residual current devices (RCDs) would probably have prevented 65% of the WREFs not due to aerial powerlines. This study has established that electricity is a significant cause of workplace fatalities. Many of the electrical deaths may have been prevented by adequate training of the workers involved, use of RCDs or placement of overhead powerlines in more appropriate places.

*: Harrison et al. Med J Aust 1989;150:118-125

Presented by Dr. James Leigh, NIOHS, Worksafe, Australia

THE REGIONAL RURAL INJURY STUDY (RRIS)-I: A MODEL FOR NATIONAL SURVEILLANCE OF INJURIES IN AGRICULTURE

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Prior to the Regional Rural Injury Study-I (RRIS-I) effort, which has the most comprehensive agricultural population-based information on injuries in the country, there has been no system that could serve as a source for ongoing surveillance data and provide the basis for more specific analytic studies. The specific objectives of the project were to: 1) demonstrate the ability to collect injury data on rural populations in a five state region, based on methodology and tools developed in a previous population-based effort; 2) calculate regional and state-specific injury rates, among other analyses, for both farm and non-farm operation-related injuries (classified as intentional or unintentional) in rural/agricultural areas; 3) apply the results of the study to the planning and development of specific injury prevention and control programs in the region. RRIS-I, conducted in a large regional area involving Minnesota, Wisconsin, North Dakota, South Dakota, and Nebraska, is based on the Olmsted Agricultural Trauma Study (OATS), in which a telephone interview methodology validated telephone-interview injury data against medical records using the (Olmsted County) Rochester Epidemiology Project, an internationally recognized data base. A sophisticated comprehensive computer assisted telephone interview (CATI) system instrument developed for RRIS-I enables efficient data collection including demographic and exposure information on all farm household members, farm operation information, and whether or not any member was injured during 1990. The United States Department of Agriculture National Agricultural Statistics Service's (USDA NASS) Master Sampling Frame of Farm Operations was used to identify a stratified random sample of farming operations from each of five participating states. A total of 4,136 farm households (13,474 persons) participated in the RRIS-I. Data collection, for two phases, covered a twelve month period of time (January 01-June 30 and July 01-December 31, 1990). The rate for the first six months for farm and non-farm operation-related injuries was 61 and 52 per 1000 persons, respectively. Farm operation-related injuries were more frequent for males than females (88 and 28 per 1000 persons, respectively). The highest rates for farm injuries were among age groups 25-44, 45-64, and 65+, (101, 77, and 54 per 1000 persons, respectively). The lowest rate was 17 per 1000, among those less than 14 years of age. The rates for males, compared with females, were higher in all age groups. In the 25-44 year age groups, the rates were 143 per 1000 persons for males and 54 for females; for ages 45-64 the rates were 120 and 29, respectively, and for ages 65+ they were 75 and 23. Among those less than 14 years of age, the rates were 22 and 8 per 100, respectively. The major source of farming operation-related injuries was animals, accounting for an overall rate of 21 per 1000 persons; for males and females the rates were 24 and 16 per 1000 persons, respectively. The final phase of the RRIS-I project will include a major regional workshop in which data from this effort will be applied to the development of specific state and regional prevention and control plans. The RRIS-I methodology has been designed to serve as the basis for long term surveillance efforts at the state, regional, and national levels that can significantly impact the agricultural injury problem through ongoing identification of the magnitude of the problem and serve as a basis for analytic efforts. As a result, intervention efforts can be developed from sound scientific data and evaluated for efficacy through the surveillance system.

LOGGING FATALITIES IN THE UNITED STATES: AN UPDATE

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Forests provide the U.S. population with a variety of products ranging from paper and lumber to chemicals and synthetics, such as rayon. Each of these products originates with the harvesting, skidding, loading and transport of timber by workers in the logging industry. Traditionally, this industry has been one of the most dangerous in the country; the dangers stem from factors which are unique to logging. Trees are typically felled with a chainsaw, requiring loggers to work in close proximity to standing and falling timber. Shifts in weight or wind often cause trees to fall in unexpected directions. Steep terrain, underbrush, uneven footing, powerful equipment, and inclement weather add additional risks for loggers, equipment operators and other workers at logging sites. This study examines the distribution of logging fatalities by cause of death and region of the country using the National Traumatic Occupational Fatality (NTOF) surveillance system maintained by the National Institute for Occupational Safety and Health. NTOF data show that an average of 142 non-managerial logging workers died of work-related injuries each year from 1980 through 1988. Though the Pacific Coast pine/hardwood and the southern pine regions had the most fatalities (38 percent and 37 percent of the total number of U.S. fatalities, respectively), they also have the most logging activity, representing over two-thirds of the nation's timber production. The highest fatality rates were in the central hardwood and the eastern hardwood regions. Fatality rates in the mountain pine, Pacific Coast, plains bottomlands and southern pine regions were intermediate. The lowest fatality rates were in the Lake States pine/hardwood and in the northern hardwood/spruce/fir regions. Logging deaths were slightly higher than average in the 25-to 44-year age group. Logging occupations (e.g. fellers, buckers, choke setters) accounted for 65.6 percent of fatalities in the industry. Truck drivers and miscellaneous laborers represented an additional 11 and 8 percent of the deaths. The leading cause of death was being struck by falling objects (49.8 percent). Machinery-related (14.5 percent) and motor vehicle related-incidents (14.3 percent) were the next most common causes of death. Differences in forest type and harvesting operations are hypothesized to account for differences in regional fatality rates.

FATAL OCCUPATIONAL INJURY RATES IN QUEBEC 1981-1988

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The objective of this study was to estimate the rates of fatal occupational injuries in Quebec for the period 1981 to 1988. Numerators were obtained from the Quebec Worker's Compensation Board (QWCB) which has universal coverage in Quebec except for Federal employees and the self-employed. Denominators were obtained from Statistics Canada using the annual average estimates of the active population by age and sex for each year from 1981 to 1988. A total of 1,244 fatal injuries were compensated in those 8 years of which 96% occurred among males. Age-adjusted rates for males declined from 12.9 per 100,000 (95% confidence interval (CI): 11.3-14.8) in 1981 and 8.1 (95% CI: 6.9-9.6) in 1988, whereas rates in females remained stable around 0.5 per 100,000. Women experienced an excess of death from violent acts as compared to men with respectively 17.0% and 4.1% of all deaths. Motor vehicle accidents (MVA) were the leading cause of fatal injuries peaking in 1984 with 36.0% of all fatalities and declining thereafter to 20.7% in 1988, a trend noticeable in Quebec for MVA in general. A comparison of QWCB files with death certificates at the Coroner's office revealed that QWCB compensated 83.7% of all identifiable occupational fatalities, underestimating the death rates mainly in the trucking and farming occupations.

POPULATION-BASED CASE CONTROL STUDY OF NONFATAL FALLS ON FARMS IN WISCONSIN

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Accounting for one of five injuries and one-third of hospitalized injured persons, falls are the leading cause of all nonfatal injuries in the United States. Nonfatal work-related injuries occur more frequently in farmers than in other occupations. While injury rates in other industries have fallen, injury rates in agriculture have increased. Few analytic studies have attempted to identify risk factors for farm injuries. Our objective is to describe the spectrum, circumstances and extent of farmwork-related fall injuries requiring medical attention in a geographically defined rural population. Since March 1990 we have attempted to identify all farm-related unintentional injuries occurring in a geographically defined area in central Wisconsin which includes approximately 1,695 dairy farms. Case reporters include hospital emergency department staff, physicians in clinics, and chiropractors. Study method is case control design, and both types of subjects are interviewed by telephone. Using a random numbers table, controls are selected from a master list of farm operators in the study area. Participation rates exceed 90%. We registered 55 cases of farm falls over 12 months during 1990-91. These represent almost 18% of total farm injuries reported. Of the 55 falls, 11% were hospitalized, and one resulted in permanent disability. Two-thirds of the falls were from one level to a different level, the remainder were on the same level. There were falls from buildings and structures (35%), machines and vehicles (26%), and ladders and scaffolds (9%). In the study area, work-related fall injuries on farms occurred in 61.4 persons per 10,000 farm residents per year. Potential means of reducing the frequency and severity of falls on farms include: provide adequate handholds and footholds for work at elevation; provide energy-absorbing surfaces underneath areas with fall hazards to modify the energy exchange upon impact; improve coefficients of friction of barn and haymow floors and other surfaces as well as soles of shoes; and build haylofts into hills.

EXPOSURE 2

EXTRAPOLATION OF PAST FIBER EXPOSURES IN THE PRODUCTION OF MAN-MADE VITREOUS FIBERS

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The current update of the U.S. historical cohort of man-made vitreous fiber (MMVF) production workers includes employees at one or more of twenty glass plants that produced mineral wool, fiber glass filament, and/or fiber glass wool. As part of the current update of this cohort sponsored by the Thermal Insulation Manufacturers' Association, exposure data for several agents (asbestos, asphalt, formaldehyde, phenolics, aromatic hydrocarbons, and silica) are being obtained in addition to quantitative fiber measurements. This paper presents the methodology for estimating past fiber exposures. The plants started production as early as the 1930s. Exposure monitoring for fiber was not started until the 1960s, and the majority of measurements were made after the mid-1970s. Consequently, exposure intensity must be extrapolated for the earlier operations and jobs. These exposures were extrapolated using a three step procedure: (1) a process-exposure model was developed to identify sources of emissions and factors that might affect personal exposures in a work area; (2) an analysis was conducted of fiber exposure data (approximately 4,000 air monitoring measurements and associated production factors) to estimate average exposures and factors associated with significant differences across jobs, work areas, and time periods at each plant; and (3) multipliers associated with differences in exposure factors were used to extrapolate exposures for job/work area combinations that had not been measured. The factors affecting job exposure were associated with six types of exposure setting characteristics: work area (proximity to emission sources), product type (blanket, textile, etc.), product characteristics (fiber diameter, binder, etc.), process equipment, local exposure controls, and general plant characteristics. At a given plant, each job, work area, and time period had a subset of these factors which were associated with significant differences in exposure intensity. Differences across plants for the same types of jobs making the same products with similar equipment were attributed to differences in the general plant settings, e.g. makeup air. For retrospective extrapolation, it was assumed that if the job, product, equipment, and other factors remained constant then exposure also was constant. Past exposures were extrapolated using factors developed from the measured exposures. Potential errors in the extrapolation were evaluated and the possible effects on the epidemiologic analysis were assessed in a statistical analysis by Marsh and coworkers (reported in another Symposium paper).

AN EVALUATION OF NEW FIBER AND CO-EXPOSURE DATA FOR THE U.S. COHORT OF FIBROUS GLASS PRODUCTION WORKERS

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The ongoing U.S. historical cohort study of fibrous glass production workers has, to date, provided equivocal evidence on the relationship between fiber exposure and respiratory system cancer. A total evaluation of exposure-response has not been possible because of the lack of complete and accurate individual worker data on employment history, cigarette smoking, lifestyle factors, racial composition, and historical workplace exposures to fibers and other non-fiber agents. To provide a framework for a more comprehensive and rigorous evaluation of exposure-response, mortality surveillance and exposure assessment programs for the U.S. cohort were initiated in 1987 and 1988, respectively, by the University of Pittsburgh, Department of Biostatistics and the University of Massachusetts, Department of Family and community Medicine, at the request of the Thermal Insulation Manufacturers Association. The programs include enlargement and enhancement of the original cohort database and an expanded nested case-referent study of respiratory cancer that parallels the proposed IARC case-referent study of lung cancer among European workers.

Historical exposure profiles for individual members of the current study were estimated using an approach developed by Smith and co-workers that effectively integrates epidemiological and industrial hygiene methods. Included in the profiles are time period, plant and job-specific data on workplace exposures to respirable glass fibers and on co-exposures to six groups of agents: asbestos, arsenic, formaldehyde, phenolics, polycyclic aromatic hydrocarbon compounds, and silica.

An extensive descriptive analysis of the expanded exposure profile data for fibrous glass production workers from four of 11 study plants included a comparison of the original and new assessments of fiber exposure. Measures of fiber exposure included duration, cumulative, and average exposure. Important differences in estimated fiber exposures were found relative to time period and plant. The six co-exposures were characterized individually, jointly, and in conjunction with fiber exposure. The exposures to fiber and the other agents occurred at various levels and in various combinations in the different plants. The extent to which independent exposure effects can be identified statistically is addressed in a separate paper by Stone and Marsh.

DEFINING AN OPTIMAL DOSE METRIC FOR THE EPIDEMIOLOGIC STUDY OF OBSTRUCTIVE LUNG DISEASE IN COAL MINERS

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The assumptions contained in the use of simple cumulative exposure (sum of the product terms of exposure concentration and time) have been shown to be inappropriate for the study and many hazards. In particular, cumulative exposure assumes that risk is linearly proportional to concentration and length of exposure and independent of the time between exposure and outcome measurement. A new dose index is suggested that contains a limited number of assumptions, allows the metric to conform to the particular data under study and allows the inference of potential pathophysiologic mechanisms from the results. The index is:

$$EI_i = \Sigma(T_{ij}^b D_{ij}^c F_{ij})$$

where D is the dust concentration, T is the time prior to outcome measurement and F is the length of time spent by individual i in job j. The exponents c and b were estimated for a data set including 1185 underground coal miners studies for pulmonary function (FEV_1, FVC) and symptoms of obstructive lung disease (bronchitis, breathlessness, obstructive bronchitis and wheeze). The data was fit using linear or logistic regression models which included appropriate covariates. Exposure estimates were based on an unusually rich set of quantitative exposure data. The results indicate that the exponents for time prior to outcome and concentration, respectively, which fit these data best were 1 and 0.5 (FEV_1), 2 and 0 (FVC), 2 and 0.5 (bronchitis), 0 and 2 (breathlessness), 2 and 1 (obstructive bronchitis) and 2 and 2 for wheeze. The results provide no evidence of reversibility of these effects, and suggests for some outcomes (obstructive bronchitis and wheeze), there may be overloading of normal airways clearance mechanisms at higher dust concentrations. The model and the observed results are discussed in terms of the limitations of the procedures and data used.

RETROSPECTIVE EXPOSURE ASSESSMENT USING AN INDEPENDENT PANEL OF EXPERTS

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Epidemiologic research involves measuring the effect of exposures to specific agents on selected aspects of health in populations. Information on the time, amount and duration of exposure to agents enables investigators to develop estimates of "dose" and to study the magnitude of the effect of exposures on the development of disease. Certainty is impossible in the absence of adequate data and assessments of historical or retrospective exposures in the workplace are plagued with speculations. The more prolonged the history of exposures, the greater the speculation. A systematic, documented approach to developing an assessment of exposures retrospectively is described. Information concerning previous exposures to acrylonitrile (AN) was compiled for a cohort study of 467 exposed workers. The information included a comprehensive chronological history of the facility, detailed information on selected jobs and all available industrial hygiene data. Seventeen job titles were selected for assessment from a total of 265 job titles previously determined to have been associated with AN exposure. The selected job titles had to have been used consistently for at least five years for at least five employees and they represent the most common jobs in production, maintenance and the laboratory. Standardized interviews concerning these jobs were conducted with senior employees to determine major tasks, changes and perceived exposures. A panel of four highly qualified industrial hygienists was convened for three days to review the information and to classify job titles on the amount of exposure to AN throughout 1960-1985. Prior to arrival at the facility, each panelist received a protocol along with background information on the facility and the manufacturing process. Upon arrival, each panelist was given a concise summary of information about each job title. A tour of the facility and interviews with senior personnel was provided during the first day. Panelists individually classified each job title. Each panelist's decisions were then entered on a spreadsheet and given to other panelists on the third day to permit a review by the group. The panel established four exposure categories:<0.2 ppm, 0.2-2.0 ppm(low). 2.1-20.0 ppm(medium), and >20.0 ppm(high). The primary determinants for exposure classification were major process changes, time intervals and initiation of OSHA regulations. Disagreements among panelists regarding allocation of exposure classifications were few and resolved readily in group discussions. Other exposed jobs were classified using clearly specified assumptions. This approach to estimating exposures retrospectively can easily be reviewed by others to determine if and where misclassifications may have occurred.

AN EMPIRICAL ASSESSMENT OF THE EFFECT OF DIFFERENT SUMMARY WORKLIFE EXPOSURE MEASURES ON THE ESTIMATION OF RISK IN CASE-CONTROL STUDIES OF OCCUPATIONAL CANCER

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The effect of different summary measures of worklife exposure on the estimation of risk is reported. Two matched case-control studies associating sulfuric acid exposure and cancer from Baton Rouge and southern Ontario respectively were used. Five summary exposure measures were converted to discrete levels of exposure by selecting equivalent centile points on each measure's respective percentage frequency distribution for logistic regression modeling purposes. The southern Ontario data set exhibited only minor differences across all five exposure measures. The Baton Rouge data set, however, produced different results: the time-dependent measures appeared to underestimate risk. The measures are shown to be affected, in part, by misclassification that is a function of the retrospective exposure assessment estimation methodology employed. It is possible, therefore, to obtain different estimates of risk depending on the exposure measure selected. It is recommended that in the absence of proven models for assessing exposure, a variety of summary measures should be used to estimate risk. This approach would facilitate the comparison of findings across studies.

Note:

The manuscript upon which this abstract is based has just been accepted for publication in the Scand J Work Environ Health. February 7, 1992. It is unlikely to be published prior to the Symposium.

CANCER 4

CANCER RISK AMONG 3,890 WORKERS EMPLOYED AT THE INDUSTRIAL BRANCH OF THE SHIPYARD OF GENOVA, ITALY: A RETROSPECTIVE COHORT STUDY

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We have conducted a retrospective cohort study of workers who were employed between 1960 and 1988 at the Industrial Branch of the shipyard of Genova, Italy. These workers were assigned to ship repair, refitting, and construction. Occupational exposures to asbestos, silica dusts, welding fumes and gases, solvents, and paint removers are likely to have occurred right after World War II until the mid 1970s. We identified 3,890 males who met the inclusion criteria and their vital status was ascertained from January 1, 1960 through December 31, 1990. The causes of death were coded according to the International Classification of Diseases, 9th Revision. Expected mortality from site specific cause was computed using local death rates as standard reference figures. Lung cancer (No.=219) and pleural mesothelioma (No.=46) accounted for 36% and 7.5% of all cancer deaths (No. = 610). Standardized Mortality Ratios (SMRs) were significantly elevated for lung cancer (SMR = 149, 95%CI=130-170), pleural mesothelioma (SMR = 446, 95%CI=326-594), all cancers (SMR = 125, 95%CI=110-144) and all deaths (SMR = 110, 95%CI=105-115). Analyses by time since the onset and duration of exposure showed clear increasing dose-response relationships with lung cancer (Fig. la,b) and pleural mesothelioma, suggesting that the general level of exposure to lung and pleural carcinogens at the workplace has decreased over time. Indirect correction for smoking habits ruled out smoking as a serious confounding factor in the excess cancer(s) mortality detected by the study.
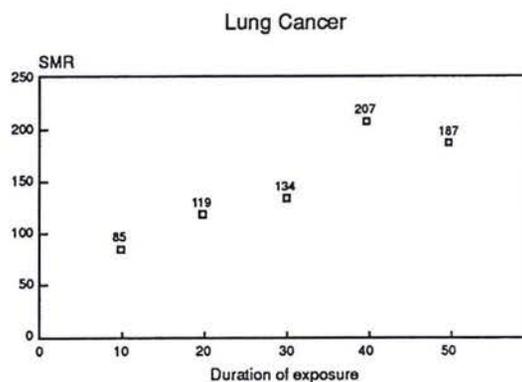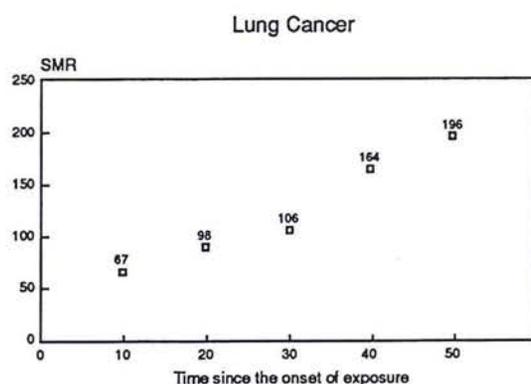
Lung Cancer

Lung Cancer

OCCUPATIONAL EXPOSURE TO CHEMICAL AGENTS AND RISK OF LYMPHOMAS AND LEUKEMIAS IN THE WOOD INDUSTRY

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Previous epidemiologic studies have suggested an excess of lymphomas and leukemias in woodworkers. The risk of these diseases was studied in the Finnish wood industry with a specific objective to identify possible causative agents. The cases were traced during the follow-up of a cohort of 7307 male workers from sawmills, particleboard mills, plywood mills, construction joinery mills, furniture factories and a plant manufacturing glues for the wood industry. There were altogether 24 cases including eight non-Hodgkin's lymphomas, four cases of Hodgkin's disease, and 12 leukemias. Each case was matched by age and survival status with one to eight referents (152 in all) selected from the cohort. Exposures to wood dust, formaldehyde, chlorophenols, terpenes, solvents, engine exhaust, pesticides and phenol were assessed on the basis of the occupational histories and a plant-and period-specific job-exposure matrix.

Increased odds ratios (OR) were found for lymphomas and leukemias (combined) and exposure to solvents (OR=5.6; 95% CI 1.0-32; 4 exposed cases) and formaldehyde (2.5; 0.8-7.6; 7 exposed cases) in conditional logistic regression analysis. Confounding was controlled by mutual adjustment but the ORs remained close to the unadjusted ORs both for solvents (OR=5.1) and formaldehyde (OR=2.3). Exclusion of the subjects exposed to both of these agents gave rather similar results (OR=3.4 and 2.0 respectively). The solvents involved in this study were generally mixtures containing several types of chemical agents, such as aromatic hydrocarbons, aliphatic hydrocarbons, esters, alcohols, ketones and glycol ethers. Small numbers of exposed cases did not allow an accurate analysis by the specific type of cancer, but both solvent exposure and formaldehyde exposure were more common among the cases of non-Hodgkin's lymphoma than among other cases. In conclusion, our study suggests that solvents related to woodwork may cause non-Hodgkin's lymphoma. The role of formaldehyde exposure should also be scrutinized more closely, even though there are only a few previous studies supporting this association. No clear associations were found between lymphomas or leukemias and other exposures including wood dust (mainly from pine, spruce and birch) and chlorophenols (mainly tetrachlorophenol).

MORTALITY AND CANCER INCIDENCE IN A COHORT OF CHIMNEY SWEEPS: AN EXTENDED FOLLOW-UP STUDY

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Despite 200 years of efforts to regulate safety in this occupation, chimney sweeps have increased mortality from cancer, ischemic heart disease, and respiratory disease. We examined mortality and cancer incidence in a cohort of 5542 Swedish chimney sweeps employed through their national trade union at any time between 1918 and 1980. Previous studies of this cohort found increased risks of ischemic heart disease, respiratory disease, accidental deaths, and a variety of neoplasms. By lengthening follow-up, we sought to strengthen previous associations and examine disease time trends. Mortality analysis was extended 7.5 years to cover the period 1952-1990; cancer incidence analysis was extended 6 years to cover the period 1958-1987.

New findings include increased prostate cancer incidence and mortality (SMR 169, 95% C.I. 106-256, 22 observed) and increased incidence of total hematopoietic cancers (SIR 151, 106-209 36 observed).

When we analyzed only the most recent follow-up period, previously observed risks persisted for total lung cancer (SIR 178, 99-293), oat cell lung cancer (SIR 240, 103-472), bladder cancer (SIR 247, 131-422), and esophageal cancer (O/E=2/1.1) Mortality from ischemic heart disease SMR 98, 76-123) and respiratory disease (SMR 111, 56-199) declined during recent follow-up, though significant excess mortality remained during analysis of the entire study period (ischemic heart disease SMR 128,112-145; respiratory disease SMR 159, 115-213).

In analyses of the entire study period, risks of ischemic heart disease and lung, bladder, and esophageal cancer were adjusted for smoking; esophageal cancer was also adjusted for alcohol use. All risks remained significantly elevated. Exposure-response analyses revealed significant positive associations between employment duration and risks for lung, esophageal, and total cancer mortality.

Chimney sweeps remain at increased risk for cancers of the lung, esophagus, and bladder. Our study supports a causal role for exposure to chimney soot, which contains carcinogens including PAHs. Extended follow-up of this cohort now demonstrates increased risks of prostate and hematopoietic cancers. The association of these cancers with combustion product exposure deserves further investigation.

EXCESS CANCER INCIDENCE IN WORKERS EXPOSED TO FLUORIDE

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In a recent animal carcinogenicity study, fluoride was considered an equivocal carcinogen. However, epidemiological studies of communities with fluoridated drinking water have been unable to detect any increase in cancer rates. We conducted a cohort study of 422 men employed for at least six months between 1924 and 1961 at a cryolite processing plant. Heavy fluoride exposure caused skeletal fluorosis in at least 74 men; daily fluoride absorption average about 35 mg. Mortality was recorded for 1941-1989 and cancer morbidity 1943-1987. A total of 296 deaths occurred, while 226 were expected from national mortality rates. Several causes, including respiratory cancer and violent death, contributed to this excess, while cardiovascular mortality was close to the expected number. A total of 118 cancer cases occurred in these workers; from Copenhagen rates, 103.7 cases were expected. Cancer of the lungs (N=34, O/E=1.31), larynx (N=5, O/E=2.29) and urinary bladder (N=17, O/E=1.84) were in significant excess. Although no stable relationship to the length of the employment was apparent, a latency of at least 10 years was apparent. Also, the cancer incidence was higher in men who had been hired at a young age. The pattern of low cardiovascular mortality and increased morbidity of cancer in the larynx, lungs and urinary bladder would suggest that this industrial cohort was exposed to an occupational carcinogen. The cohort having inhaled high concentrations of fluoride dust and not other suspected carcinogen, heavy respiratory exposure to fluoride may not be free of any cancer risk.

LUNG CANCER MORTALITY AMONGST FORMER WORKERS AT THE RADIUM HILL URANIUM MINE IN SOUTH AUSTRALIA

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This retrospective study examines the risk of radon-induced lung cancer mortality (LCM) amongst former workers at the Radium Hill (RH) uranium mine. The study cohort, identified from archived payroll information, comprised 2,574 workers (2,521 males and 53 females) employed at the mine from 1948-1962. The 66% trace rate previously reported (Woodward et.al., Canc. Caus. and Cont., 2,213-20,1991), was improved to 74% through subsequent trace activities which included matching the RH and Wittenoom-Gorge asbestos miner cohorts and a reunion of ex-RH residents. The 1,894 individuals traced included 616 deaths (54 lung cancer deaths). Questionnaire information on smoking and relevant occupational histories was obtained for 61% of the cohort, including 49% of the deaths.
The mean age at commencing work in RH was 31 years and mean employment duration was 17 months. The mean underground employment duration amongst 1,459 underground workers, was 12 months (range 10 days-9 years); levels of cumulative radon daughter exposures ranged from .07-112 WLM, with mean 7 WLM and median 3 WLM per person. The average intensity of exposure was 8.5 WLM/year (range 1.5-22 WLM/year).
We observed a significantly higher rate of LCM amongst underground workers at RH (SMR = 191, 95% CI 125-257) with reference to the Australian population, after age and calendar-year standardization; the elevated rate observed amongst surface workers (SMR = 155) was not statistically significant. The percentage of ever-smokers was 86% and 83% respectively, for underground and surface workers. Comparative analysis between exposure categories was based on time related allocation of person-years-at-risk to categories of exposure and attained-age and age and calendar-year standardized mortality rates. Results from Poisson regression modelling showed that workers exposed to over 40 WLM had a significantly higher LCM risk than surface workers (RR = 4.7, 95% CI 1.6-13.7), after age and calendar-year adjustment. We conclude that the elevated LCM risk observed is unlikely to be due entirely to the effect of smoking and other confounders. These findings indicate increased risk of radon-induced LCM amongst workers exposed to relatively low levels of ionizing radiation. The average cumulative radon daughter exposure of below-ground workers at RH is considerably lower than that of any other mining cohort followed for a comparable period but the excess risk per WLM is slightly larger than that from other low dose populations. These findings are relevant to risk assessments in modern mining and domestic radon epidemiology.

RESPIRATORY DISEASE 1

ACCIDENTAL GASSING INCIDENTS AND THE RESPIRATORY HEALTH OF PULPMILL WORKERS

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Workers in modern sulphate pulpmills are usually exposed to low levels of irritant gasses such as chlorine, chlorine dioxide, hydrogen sulphide, and sulphur dioxide. However, occasional accidental gas leaks can lead to exposure levels well above governmental standards. Studies in Canada have identified decrements in pulmonary function and increases in respiratory symptoms among pulpmill workers who had experienced overexposures to chlorine gas. In the current study, the respiratory health of pulp and paper workers from a company in Berlin, New Hampshire, was investigated. The subjects were selected from participants in a longitudinal study of respiratory health that had been initiated in Berlin, NH, in the 1960's. The participants in the longitudinal study were retested approximately every six years with spirometry and a questionnaire. An earlier analysis based on the 1979 and 1985 surveys revealed decrements in pulmonary function among men who had worked in the pulpmill. The current study utilized data from the 1985 survey and extended the earlier analysis to include both a new predictor variable (history of gassing) and new outcome variables (self-reported cough, phlegm, wheeze, dyspnea). There were 230 male subjects, all <75 years old and with a history of working for the local pulp and paper company. An individual was considered to have been "gassed" if, in response to an item on the survey questionnaire, he reported that he had been affected by gas or fumes at work or elsewhere and had sought medical care as a result of the incident. Those who had been gassed represented 34% of the 114 pulpmill workers and only 9% of the 116 subjects without pulpmill experience. Subjects who had both worked in the pulpmill and been gassed were compared to subjects who had worked elsewhere in the company and never been gassed. The mean percent predicted forced expiratory volume in one second (FEV1) for the exposed subjects (94.6%, SE=3.32) was significantly less than the corresponding value for the unexposed subjects (104.3%, SE=2.33) (p=0.03). Similar differences were observed in the mean percent predicted forced vital capacity (FVC) and FEV1/FVC, although these differences were not quite statistically significant (0.05<p<0.10). Also, the prevalences of self-reported respiratory symptoms were not greater among the pulpmill/gassed subjects. With only 12% of the pulpmill subjects still working in that process, the changes in pulmonary function appear to be non-reversible. Since it is not clear if these findings are applicable to current pulpmill workers, a new study was started in January, 1992 to address this issue.

IMMUNOLOGIC SENSITIZATION TO TETRACHLOROPHTHALIC (TCPA)-EXPOSED WORKERS IN RELATION TO EXPOSURE MEASURES

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Two cluster of OA caused by TCPA have been reported (Schlueter et al, 1978; Howe et al, 1983) but only in the latter study was specific IgE antibody to TCPA demonstrated. In response to respiratory complaints including 4 index cases of OA, we conducted a cross-sectional evaluation at a plant manufacturing solenoid coils with an epoxy resin where a new TCPA hardener had been introduced in 1988. The evaluation included TCPA air sampling, questionnaire, cross-shift spirometry (52 workers), and assays of TCPA-HSA serum specific IgE and IgG (49 workers). Exposure to TCPA was evaluated by 1) air sampling; 2) department title; 3) duration of employment (since 1988); and 4) cumulative exposure based on monthly company records of receipt of TCPA. Exposure was high before (ranging from 0.2 to 0.4 mg/m^3) but lower after introduction of ventilation (0.009 to 0.13 mg/m^3. Exposure was similar in all departments and could not be used to identify those sensitized. There was a very high prevalence of TCPA specific antibody: 15 (31% of 49 with IgE and 19 (39%) with IgG. Department titles did distinguish those with IgE, being positive in 7 (54%) of 13 with most direct exposure in molding or maintenance, 8 (25)) of 32 in coil assemble, and 0 of 4 in office (p for trend 0.019). Among non-office workers, those with and without IgE did not differ on mean duration of employment, but duration since 1988 was significantly longer in those seropositive (p=0.044). Compared to the lowest tertile of duration since 1988 (<1 year), the risk of being IgE positive was greatly increased in those with 1-2 years (OR 13.7, 95% CI 1.4-133; p=0.016), but was no greater in the highest tertile (OR 6.5, CI 0.68-63; p=0.10). Cumulative exposure ranged from <15,000 to >300,000 lb-months; IgE positivity was associated with cumulative exposure >100,000 lb-months. The proportion with IgE was twice that in never/ex vs current smokers(opposite to that observed by Venables et al, 1985). In logistic regression models among those hired since 1988, after adjusting for age and smoking, duration (per year) was associated with increased risk of IgE positivity (OR 3.97, CI 0.97-6.8). Respiratory complaints have decreased and no new cases of OA have occurred since ventilation was installed and TCPA exposures reduced to <0.1 mg/m^3. We conclude that TCPA was involved with IgE=mediated immunologic and respiratory sensitization. In this study, because TCPA concentrations were similar across departments, exposure measures other than direct ambient IH data were preferable to predict those developing TCPA sensitization.

RESPIRATORY SYMPTOMS AND PULMONARY FUNCTIONS OF CEMENT FACTORY WORKERS AT A NIGERIAN CEMENT FACTORY

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The cement industry is the most obvious source of industrial air particulate pollution in Nigeria, yet, there have been very few epidemiological studies related to this industry in the country. In this paper, we present the result of a comparative study of pulmonary functions and respiratory symptoms of cement workers in a cement factory in Southwestern Nigeria. We also report on the relationship between the pulmonary functions of the factory workers and the concentration of suspended particulate matter in the different working areas of the factory. A modified medical research council committee questionnaire was administered to 312 workers, randomly selected from different parts of the factory, and 120 non-factory workers from the same area of the country to assess respiratory symptoms of the subjects. Pulmonary function tests were performed with the aid of a spirometer and Wright Peak Flowmeter. Gross and size-segregated suspended particulate concentrations were measured in different parts of the factory using a hi-volume air sampler fitted with a six-staged impactor head. Statistical analysis of data was performed using the student's t-test. The cement factory workers have higher incidence of chronic non-specific lung diseases, and relatively lower lung functions than the control subjects. Among the factory workers, those that were directly exposed to cement dust, especially in the mill and packing plant, have higher incidence of respiratory symptoms than office workers. These results are supported by the finding that a strong correlation exists between each of the Forced Vital Capacity (FVC) and Forced Expiratory Volume per second (FEV) of the factory workers and the Total Suspended Particulate Concentrations (TSP) of the workers' sites, as shown by the following equations.

$FEV_1 = -0.00019 \ (TSP) + 3.471$ and

$FVC = -0.00018 \ (TSP) + 4.051$.

The factor of cigarette smoking was considered. Non-smoking factory workers had significantly lower lung function parameter than non-factory workers. Cigarette smoking factory workers had marginally lower lung function parameters than their non-smoking counterparts. The latter was however, found to be statistically insignificant.

THE RELATIONSHIP BETWEEN PNEUMOCONIOSES AND CANCER

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In order to know whether the incidence of cancer among pneumoconiosis cases occurs high or not, whether dust has carcinogenicity, we have researched all of 48,277 pneumoconiosis cases of Sichuan Province which were diagnosed during 1950-1986 according to "The Program of the Nation-wide Investigation in Pneumoconiosis Epidemiology". All data have been treated with IBM computer in analysis of the cancer mortality, the death causes and proportion of it among the subjects. By using the method of retrospective cohort study, for all kinds of cancer in the subjects in the period of January 1, 1970 to December 31, 1986 were compared with the general population in Sichuan Province (1983 - 1985). The SMRs were calculated. There were 265,956.5 man years for pneumoconiosis cohort, including the man years of 92,831 silicosis, 166,232 CWP and 2,076.5 asbestosis. In them, 411 cases died of cancer including the cases of 128 lung cancer, 97 liver cancer, 68 esophagus cancer and 51 stomach cancer.

In the total of subjects (1950-1986), the mortality of cancer was 1,566/100,000. Among pneumoconiosis death cases, the cancer death was ranked as fourth on the causes (6.25%). The cancer deaths in pneumoconiosis cases (1970-1986) were compared with control population mentioned above. The results were shown in following table.

It indicates that pneumoconioses and lung cancer is closely related. There was an excess mortality of lung cancer among any of asbestosis, silicosis and CWP cases and of which asbestosis cases is the highest one. It is known that asbestos has carcinogenicity. Whether the coal and silica dusts have it for lungs should be researched further.

Table   Results of the SMR of cancer

Pneumoconiosis types	Obs./Exp. (95% C.I.)				
	All cancer	Lung cancer	Liver cancer	Esophagus cancer	Stomach cancer
All of pneumoconiosis	0.69** (0.63-0.76)	1.86** (1.54-2.19)	0.78* (0.62-0.93)	0.48** (0.37-0.60)	0.39** (0.29-0.51)
Silicosis	0.82** (0.70-0.94)	2.35** (1.73-2.96)	0.81 (0.54-1.07)	0.43** (0.25-0.61)	0.43** (0.24-0.62)
CWP	0.82** (0.71-0.92)	1.45** (1.09-1.82)	0.66** (0.48-0.84)	0.51** (0.36-0.66)	0.40** (0.26-0.55)
Asbestosis	2.45** (1.235-3.54)	8.00** (1.60-14.40)	6.42** (1.66-11.18)	0.00	1.23 (0.47-2.93)

CWP=Coalworkers' pneumoconiosis
* $p < 0.05$; ** $p < 0.01$

CARDIOVASCULAR DISEASE

CASE-CONTROL STUDY REGARDING MYOCARDIAL INFARCTION, SHIFTWORK AND OCCUPATIONAL EXPOSURE TO NOISE

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Shiftwork and noise are occupational stressors with high prevalence in modern industry. Scandinavian studies have found a significant relationship between shiftwork, including nightwork, and myocardial infarction. Industrial noise has been discussed as a risk-factor for hypertension and therefore for myocardial infarction. Parallel existing studies were negative or largely inconsistent. We have conducted a case-control study of 65 patients with first myocardial infarction between 1986 and 1988, of which complete data about risk-factors, psychosocial and occupational variables and laboratory analysis could be obtained. These 65 patients were part of a total of 110 cases of myocardial infarction or acute death due to coronary heart attack which occurred in 20,000 workers of a metal working plant during the time period mentioned above. Controls were matched for age, length of employment, sex and nationality. The odds ratio (OR) for the variables were calculated using matched pairs. The correctness of the questionnaires regarding the shift rhythm were controlled using company-data. Regarding noise, the workers were asked whether industrial noise was perceived to be stressful (subj. noise). Reports of working history were analyzed by the company noise level expert and judged using the data available in his reports (obj. noise). For shiftwork in a 2 shift rhythm, not including nightwork, the OR was 1,75 (p=0,201 n.s.). For shiftwork in a weekly rotating 3-shift rhythm, including nightwork, the OR was 3,60 (p=0,007). The OR for subjective stress obtained from noise was 1,64 (p=0,194 n.s.) and for objective exposure to industrial noise with levels of 90 dB(A) or more, the OR was 2,0 (p=0,157 n.s.). Correlations between occupational variables and somatic risk-factors were detected for 3-shift rhythm and smoking (p<0,0001), for 3-shift rhythm and hyperlipemia (p<0,001), for subj. noise and hyperlipemia (p<0,05). Further correlations were detected for 2-shift rhythm and subj. noise (p=0,001), 2-shift rhythm and high temperature at the workplace (p=0,03), 3-shift rhythm and subj. noise (p<0,0001), 3-shift rhythm and high temperature at the workplace (p=0,025) and 3-shift rhythm and overtime (p=0,01). Further data regarding the multivariate analysis will be presented. The data show that shiftwork in a 3-shift rhythm is significantly associated with somatic risk-factors, other stressful working conditions and myocardial infarction. For subjective noise perception or objective noise exposure no association to myocardial infarction could be proven. We conclude that workside prevention programs regarding coronary heart disease should particularly focus on shiftworkers.

CARDIOVASCULAR DISEASES AMONG FOUNDRY WORKERS EXPOSED TO CARBON MONOXIDE

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Carbon monoxide (CO) was measured in 1972 in 52 iron, 5 steel, and 10 copper alloy foundries. The threshold limit value for CO ($50 \ cm^3/m^3$) was exceeded in 72% of the iron foundries, in 9% of the steel foundries, and in 20% of the copper alloy foundries. The blood carboxy hemoglobin content of iron foundry workers exceeded 6% COHb in 71% of the smokers and 28% of the nonsmokers. The aim of the present study was to investigate long-term effects of CO exposure on foundry workers' morbidity and mortality from cardiovascular diseases (CVD). The study population comprised (1) a cohort of 2,857 men hired in 1950-1972 by 20 Finnish foundries, and (2) 931 men who were still active in 1972 and exposed for a least 4.2 years and who took part in the health examination in 1973; 653 of them were also members of the cohort. The study groups were followed up to the end of 1987. For the cohort, the age-standardized incidence rate (ID/1000 person-years) of free medication for hypertension was 4.7 among workers not exposed to CO and 9.4 among those with CO exposure (p< .01); among iron foundry workers the rates were 4.7 and 9.9 (p< .01). During the period 1950-87, 255 CVD deaths were observed, whereas 283.5 were expected based on the national rates. The observed number of deaths due to ischemic heart disease (IHD) was 183 (202.8 expected). The iron foundry workers' mortality rate for CVD was 99% of the national expected value. No remarkable differences were found between the CO exposure categories. For the health examinated group, the age-standardized incidence rate of free medication for hypertension was 7.4 among non-smokers not exposed to CO and 18.5 among CO exposed smokers (p< .05); the difference originated in the iron foundry workers for whom the rates were 6.4 and 21.6 (p< .05). Age-standardized mortality rate (ID/1000 person-years) was 1.9 for non-smokers without CO exposure and 9.2 for those with both exposures (p< .025). This difference was caused by IHDs, for which the rates were 1.9 and 7.2. Altogether, the results indicate that CO exposure increases the risk of CVD morbidity and mortality. It has been shown elsewhere that carboxyhemoglobin, even at low levels interferes with cardiovascular function in patients who already have a reduced capacity to deliver oxygen to the heart. The pathologic manifestations of CO exposure may have been caused by reduced oxygen delivery to the heart or by chemical effects of CO on myocardial cell function or by accelerated atherosclerosis and coronary lipid deposition due to chronic arterial hypoxia related to COHb.

INCREASED RISK OF MYOCARDIAL INFARCTION AMONG BUS DRIVERS IN URBAN AREAS

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Previous studies have indicated that urban bus drivers have an increased risk of coronary heart disease. In the present study incidence of and mortality from myocardial infarction, as well as mortality from other causes among male bus drivers in Sweden, were investigated in three different substudies. In the first substudy the population defined by the 1970 census was followed regarding death during 1971-85 by means of the National Cause of Death Registry. The cause specific mortality among 9,446 male bus drivers was compared to that among other employed men. A 50% increased mortality from myocardial infarction was observed among bus drivers in the two counties where the two largest cities in Sweden are situated. No increased mortality from lung cancer, cancer (all sites combined) or from all causes combined was observed for these drivers. For bus drivers in predominantly rural areas no excess mortality, neither from myocardial infarction nor from any other cause, was observed.

In the second substudy, the relative risk of developing a first myocardial infarction among bus drivers, compared to that among other employed men, was studied by case-referent methods. The study base comprised the population in five Swedish counties during the period 1976-84. Cases of myocardial infarction were identified from both hospital discharges and deaths. Information about occupation was obtained from the 1970 census as well as from the 1975 census. Among the bus drivers 90 cases were identified. Urban drivers had a relative risk of a first myocardial infarction of 1.6 (95% c.i. 1.1-1.9).

In the third substudy cause specific mortality, as well as incidence of myocardial infarction, were investigated among urban bus drivers, employed a the Stockholm Transport. An increased incidence, as well as mortality from myocardial infarction among the bus drivers, compared to other men in Stockholm county was observed, particularly among the middle-aged drivers. For drivers older than 65 years of age no excess risk was observed.

The findings of the present study suggest that factors in the work environment of urban bus drivers may contribute to an increased risk of myocardial infarction. Factors of possible importance are job strain, irregular working hours, automobile exhausts, and noise.

SHEEP - STOCKHOLM HEART EPIDEMIOLOGY PROGRAM: STUDY DESIGN

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The incidence of myocardial infarction (MI) has been shown to vary across different occupational, social, and ethnical groups, between geographic regions, and over time; those variations, however, can only partly be explained by differences in the established risk factors hypertension, hyperlipidemia, and smoking. A large number of other risk factors have also been suggested. Several of these factors are related to the work environment, such as exposure to dynamite, carbon disulphide, or combustion products, shift work, and/or work under high performance demands but with small decision latitude. We have started a **case-referent study** to test several hypotheses concerning risk factors for MI, such as exposures to chemicals and/or psychosocial factors, social and environmental factors, smoking and dietary habits, and biological/medical factors. Special attention is given to potential interaction between the various factors and to sex differences in risk factor patterns. The study will comprise approximately 3000 cases of acute MI (first episode only) occurring in the Stockholm county area during January 1992 - December 1993 among men and women aged 45-69 years. Non-fatal as well as fatal cases are included, and one referent/case is chosen from the general population. Exposure information is obtained through questionnaires to non-fatal cases and to all referents; the non-fatal cases and their referents are also subjected to certain biomedical examination. For fatal cases, the exposure information is collected from close relatives or persons with correspondingly good knowledge of the case's habits. The quality of exposure information obtained from spouses of MI patients has been evaluated in a pre-test of the questionnaires we use in the study. The number of case-referent studies on MI is small, and the advantages and problems versus prospective cohort studies shall be discussed.

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THE RELATIONSHIP BETWEEN JOB STRAIN, AMBULATORY BLOOD PRESSURE AND HYPERTENSION

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'Job strain' (defined as high psychological workload demands combined with low control on the job), has been previously reported to be associated with increased risk of coronary heart disease (CHD). This study was designed to test the hypothesis that this increased risk can be explained by the impact of 'job strain' on CHD risk factors, specifically blood pressure and left ventricular mass index (LVMI). A cohort study of healthy employed men and women in New York City, aged 30-60, was begun. A nested case-control study design, which included 264 men from 8 worksites, was implemented as part of the first wave of data collection. Eligible cases (N=88) has diastolic blood pressure (DBP) above 85 mm Hg at both screening and recruitment, or were taking antihypertensive medication, while controls (N=176) had DBP less than or equal to 85 mm Hg at both screening and recruitment. After three years of follow-up, preliminary data is also now available for 191 of these 264 men. All subjects wore a 24-hour ambulatory blood pressure monitor, completed detailed psychosocial and health questionnaires (including the Karasek Job Content Questionnaire), received a medical examination, and provided blood and urine samples. Other known risk factors for hypertension were evaluated. In the first wave of the study, subjects exposed to 'job strain' (21% of the sample) were at significantly increased risk of hypertension with an odds ratio, OR=2.7 (95% CI: 1.2-6.0), controlling for age, race, body mass index, Type A behavior, alcohol use, smoking, worksite, 24-hour urine sodium, education, and physical demands of the job. Using ANCOVA, 'job strain' was associated with an increase in work systolic blood pressure (SBP) of 6.8 mm Hg (p=.002) and in work DBP of 2.8 mm Hg (p=.03) after adjusting for the same potential confounders. This effect persisted to home and sleep blood pressures. 'Job strain' was also associated with increased LVMI of 9.7 g/m^2 (p=.001). Analysis of cohort data (for 191 men) displayed a pattern of blood pressure change consistent with the initial cross-sectional findings. Workers exposed to 'Job strain' at both waves of data collection (N=14) had significantly higher wave 2 work DBP (87 mm Hg), controlling for wave 1 work DBP and the covariates listed above, than the reference group (no exposure at either wave, N=136, DBP=82 mm Hg), or groups that changed exposure status. A similar pattern emerged for work SBP. Therefore, previous research that suggests that 'job strain' is a risk factor for CHD may now be partly explained as a consequence of elevation of blood pressure and structural changes in the heart.

SURVEILLANCE

SURVEILLANCE OF OCCUPATIONAL SKIN DISEASE IN THE UNITED KINGDOM THE OCC-DERM PROJECT

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Occupational dermatoses and skin neoplasia are probably the most frequent and debilitating work-related conditions, accounting for over half of compensated working days lost in Britain up to 1983 when statutory sick pay reporting was abolished; however there have been few attempts to develop a systematic method for assessing frequency, type of disease and agent responsible. In 1989 a voluntary reporting scheme was initiated, on a pilot scale, in the United Kingdom by the Contact Dermatitis Group of the British Dermalogical Society. This scheme has much in common with the SWORD project for occupational respiratory disease and was also funded by the Health and Safety Executive. Sixteen centres, located in the major cities, agreed to report, at three month intervals, new cases thought to be due to occupational exposure. These were classified by the dermatologist under 16 diagnostic headings together with brief information on age, sex, type of work and suspect agent. During the twelve month period to August 1991 1543 new cases were reported, 1466 of occupational dermatoses and 77 of other skin disorders. The participating centers are broadly representative of the main urban areas of the United Kingdom but probably do not reflect the incidence of occupational skin disease for more than perhaps 20% of the population. Analysis by 48 occupational categories indicated that by far the largest umber of cases were reported from employees in metal work and machine assembly and repair (226) in catering (185) in hairdressers and beauty (143) and cleaning (123). However no attempt has yet been made to relate reported cases to denominators of the working population by age, sex, region, industry or agent, although this can be done, as in SWORD. This pilot project on skin disease has demonstrated the feasibility and usefulness of a reporting scheme based on the voluntary participation of consultant dermatologists and it has rapidly identified factory outbreaks of both dermatitis and neoplasia, as well as previously unreported dermatitic hazards. Plans are now being finalized to extend the project to all specialist skin physicians throughout the United Kingdom and to put it on a stronger epidemiological basis.

EPIDEMIOLOGIC SURVEILLANCE FOR OCCUPATIONAL LEAD POISONING IN WASHINGTON STATE USING WORKERS' COMPENSATION AND OTHER SOURCES OF DATA: ANALYSIS AND RECOMMENDATIONS

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Lead poisoning of workers continues to occur despite a large body of literature on its prevention. Improved surveillance of the problem can lead to needed prevention activities. We tested the usefulness of workers' compensation data for surveillance of lead poisoning in Washington State using a sentinel event model, and investigated the feasibility of using several other data sources for surveillance.

We performed a detailed record review of the 146 claims filed for lead poisoning or related procedures between 1983-1990; of these only 45 were actually associated with lead. Only 10 claims filed in 1989-90 were identified with blood lead levels (BLLs) at least 40 μg/dl or zinc protoporphyrin levels greater than 100 μg/100ml, and we determined the work location of each case (six of the claims were related to transient construction operations). Worksite air sampling and biomonitoring at the four remaining locations demonstrated significant exposure in other workers. We compared these worksites to similar operations in which no claims had been filed and found even greater exposures/BLLs at these referent worksites. It is apparent that while workers' compensation records may contribute sentinel events, they give a very incomplete picture of the extent of occupational lead poisoning.

We also tested the feasibility of surveillance using clinical laboratory reporting, hospital discharge records, mandated toxic substance use records, and industrial hygiene laboratory records. Each of these potentially contribute additional cases of lead poisoning or worksites with the potential for poisoning, but each source also had significant drawbacks. The major problem found was the lack of biomonitoring performed by employers exposing workers to lead, with the result that over-exposed workers are not captured by any existing surveillance system.

We conclude that a successful epidemiologic surveillance system for occupational lead poisoning must have three components: 1) Laboratory reporting of all elevated BLLs to a central tracking center; 2) Maintenance of a list of all employers who potentially expose workers to lead ("lead users list"); 3) Mandated biomonitoring by all employers on the lead users list. Existing data sources can be used to supplement this system and improve the quality of the lead users list. This surveillance loop, linked with case follow-up and intervention activities, should enable a marked reduction in the occurrence of occupational lead poisoning.

OCCUPATIONAL MORTALITY IN ITALY: A RECORD-LINKAGE BASED SURVEILLANCE SYSTEM

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A National surveillance program of occupational mortality is being implemented in Italy. It is based on record-linkage procedures among databases containing individual information about work histories and health outcomes. Such surveillance systems represent a major improvement in terms of efficiency and validity, in comparison with more traditional occupational mortality analyses based only on death certificates. On the other hand, the feasibility of record-linkage depends on the availability of suitable keys for linkage and on the confidentiality rules into effect in a given country.

This paper describes the main features of the available databases and of the record-linkage procedures, along with some examples of finding from an occupational mortality analysis based on a linkage between census records and death certificates.

The databases providing information on the occupational history of a person include: census (every 10 years, economically active population, 258 job titles and 545 industry codes), pension fund (complete work history back to 1974, employees in the private industry, 12 titles, 545 industry codes), tax return (yearly back to 1978, economically active population, 9 professional titles, 280 industry titles), workers' compensation (occupational diseases and work injuries back to 1937, economically active population, 473 job titles, 240 industry codes, 51 occupational exposures). Information on causes of death (ICD 8th and 9th) is available from the National Death Index (created in 1969, anonymous data) and from the Regional Death Indexes (implemented in a few Regions since 1985, covering 50% of Italian deaths with individual identification data).

Three different sets of variables are needed for the record linkage. A first set consists of the personal identification number, which is available in the tax return file and may be automatically created on the basis of the personal identificators available in the Regional Death Indexes. A second set of variables, consisting of the household number and the date of birth, allows one to link census and mortality records (both at the National and at the Regional level). The third set of key-variables consists of surname, name, date and place of birth, and allows one to match both the pension fund and the workers' compensation records with the Regional Death Indexes.

Two databases are ready for an epidemiologic analysis of mortality among economically active individuals at 1981 census: the Torino Longitudinal Study - TLS - (10,798 deaths, follow-up 1981-89, Standardized Mortality Ratio analysis), and the National Mortality Cross-sectional Study - NMCS - (15, 734 deaths, 6 month follow-up 1981-82, Mortality Odds Ratio analysis). Two examples of results are illustrated.

The mortality pattern among male drives of motor vehicles shows significant excess for lung cancer (NMCS: MOR 1.28, 95% CL 1.02-1.61; TLS: SMR 1.43, 95% CL 0.95-2.09) and for traffic accidents (NMCS: MOR 1.54, 95% CL 1.22-1.96; TLS: SMR 1.46, 95% CL 0.52-3.09); and the mortality pattern for male agriculture workers in NMCS includes significant decreases of mortality for lung cancer (MOR 0.74, 95% CL 0.62-0.88) and ischemic hearth diseases (MOR 0.83, 95% CL 0.71-0.96); while significant excess for stomach cancer (MOR 1.38, 95% CL 1.08-1.77), work injuries (MOR 2.11, 95% CL 1.66-2.68) and suicides (MOR 1.96, 95% CL 1.50-2.56).

ADJUSTMENT FOR SMOKING, ALCOHOL CONSUMPTION, AND SOCIOECONOMIC STATUS IN THE CALIFORNIA OCCUPATIONAL MORTALITY STUDY

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This paper presents methods for adjusting for smoking, alcohol, and socioeconomic status in death certificate-based occupational mortality surveillance. The methods were applied in the California Occupational Mortality Study, a statewide study of rates based on 180,000 deaths and census estimates of occupations. For each occupation, levels of smoking, alcohol consumption, and socioeconomic status were estimated using National Health Interview Survey and U.S. Census data and an empirical Bayes procedure to improve the stability of smoking and alcohol estimates for small occupations. Expected death rates for occupations were calculated by modeling rates as a function of age, smoking, alcohol, and socioeconomic status with Poisson regression.

The effects of adjustments were usually moderate and in the expected direction, with the adjusted relative risks (RR) being generally closer to 1.0 than the unadjusted estimates. After adjustment, elevated risks were identified in several occupations, including agricultural occupations in which there was excess mortality from injury in all agricultural occupations combined (RR = 1.60, $p < 0.05$) and excess mortality from chronic obstructive pulmonary disease in farmers (RR=1.65, $p < 0.05$). Physicians and dentists had very high rates of suicide (adjusted RR=2.12, $p < .0.05$).

Many occupations were identified that had high levels of smoking or drinking and correspondingly high unadjusted mortality from diseases related to these factors. Such occupations could be considered in the targeting of preventive intervention programs. The following male occupations had high estimated levels of smoking and significant excess mortality from respiratory and cardiovascular diseases: construction workers, truck drivers, roofers, operating engineers, bartenders, and waiters. Occupations with high estimated levels of alcohol consumption and significant excess mortality from cirrhosis and other liver diseases or cancer of the lip, oral cavity, or pharynx were: bartenders, cooks, helpers and laborers, performing artists, stone masons, roofers, and waiters.

ORGANIZATIONAL CORRELATES OF WORK-RELATED DISABILITY

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We have conducted a study of organizational factors in relation to Workers' Compensation Lost Time Frequency Rates (LTFR). We selected nearly 1000 workplaces in eight "Rate Groups" (industrial groupings), stratified by size (50-99, >100 employees) and LTFR (3 categories). Each was sent a survey: 3 booklets to management, aimed at the senior manager, human resources manager, and management co-chair of the Joint Health and Safety Committee (JHSC), and one booklet for the worker co-chair of the JHSC. Some questions were identical in both the management and worker questionnaires.

Questions explored several areas: basic data on the workplace; management organization, culture and philosophy; management approaches and attitudes to occupational health and safety (OHS); labour approaches to the workplace and OHS; labour-management relations and joint approaches to OHS; indicators and perceptions of physical risk; and financial performance.

In a second phase of the study we conducted several detailed interviews at a small number of workplaces in our sample. We wanted to explore areas that could not be addressed in a mail questionnaire and examine other questions arising from the survey.

Overall, we received at least one completed booklet from 54% of our sample and all 4 booklets from 44% an excellent response in this type of survey. A brief telephone interview with a sample non-responders obtained a 75% response from management and answers were very similar to those from the mail survey. It was more difficult to contact the worker co-chair by telephone and differences from the mail responses are attributed to this. The mail survey response was similar for each of the LTFR categories, and we believe comparisons between them are valid.

Variables significantly associated with higher LTFR included employee turnover, unionization, grievance rate, low training of labour members of JHSC, work refusals in the last 3 years. Lower LTFR were related to delegation of authority by management, a high degree of worker autonomy/participation, encouragement of career commitment, OHS defined in managers' job descriptions and included in their annual appraisals, and the provision of group safety incentives.

The study is discussed in the context of some limitations, including the use of compensation claim rates as measures of safety performance. Interpretations are assisted by the broader understanding of some issues that we gained in the Phase II interviews.

Friday, September 25, 1992
Plenary Presentations

VARIABILITY OF EXPOSURE TO POSTURAL LOAD ON THE BACK IN OCCUPATIONAL GROUPS

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Most epidemiologic studies on low-back-pain characterize exposure to postural load on the back by monitoring a random sample of workers of the occupational groups under study. The occupational groups are defined by their occupation or job title. To avoid misclassification of exposure, this approach warrants that the occupational group have distinguishable levels of exposure. Unfortunately, this assumption has been evaluated seldomly.

A survey was conducted to investigate the components of variability of exposure to postural load on the back. Bending and rotation of the trunk were chosen as parameters of exposure, since these nonneutral postures increase postural load on the back and are frequently observed in working situations. Five occupational title groups were selected of which a number of workers were randomly selected. Each worker was observed for two periods of 30 minutes during his shift, while classifying his posture every 20 seconds. The estimated percentage of time spent in trunk flexion and rotation were the principal measures of exposure. Simple log-transformations were performed to allow the use of statistical methods based upon normally distributed data. A two-way analysis of variance with repeated measurements was performed to estimate between-group variance, between-worker variance and within-shift variance.

The overall results are presented in Table 1. Within each occupational group considerable differences between workers were found, expressed by the geometric standard deviation. Most groups were lacking homogeneity, as can be seen by the presented range ratios of the 97.5th percentile to the 2.5th percentile of the distribution of worker's mean exposure. The variance ratio, the ratio of the within-shift variance to the between-worker variance, shows that the impact of variability of exposure within each individual worker on unbiased exposure assessment can exceed the between-worker variance. However, inhomogeneous groups are acceptable in epidemiologic studies unless they have overlapping exposure distributions. The partitioning of the total exposure variability showed that the between-group variance was the principal source of variance in this study, accounting for the variability of exposure to trunk flexion and rotation for 47% and 72%, respectively. The corresponding percentages for the between-worker variance and the within-shift variance were 24% and 29% for trunk flexion, and 12% and 16% for trunk rotation.

This type of analysis of the components of variability of exposure may guide towards appropriate measurement strategies for exposure to postural load on the back in epidemiologic studies on low-back pain.

Table 1   Between-worker variance $GSD_{b,w}$ range ratio $R_{0.95}$ and variance ratio λ for log-transformed distribution of trunk flexion and trunk rotation by occupational title group

Occupational title group	Number of measurements	Trunk flexion			Trunk rotation		
		$GSD_{b,w}$	$R_{0.95}$	λ	$GSD_{b,w}$	$R_{0.95}$	λ
Straddle-carrier drivers	42	2.0	14.7	3.0	1.5	5.1	0.2
Crane operators	40	2.1	16.9	0.3	1.7	7.4	3.6
Office workers	20	1.5	4.6	1.0	2.1	17.7	0.5
Woodworking machinists	28	2.5	35.9	0.5	2.1	18.8	0.8
Packers	24	1.3	2.5	2.8	1.2	1.8	7.1
Total	154	2.9	66.8	0.5	3.7	168.2	0.2

$GSD_{b,w}$ = Geometric Standard Deviation of the between-worker variance ($expSD_{L,w}$)
λ = variance ratio (σ_v^2/σ_w^2)
$R_{0.95}$ = ratio of 97.5th percentile to the 2.5 percentile ($exp(3.92*SD_{L,w})$)

CASE-COHORT STUDY DESIGNS IN OCCUPATIONAL EPIDEMIOLOGY

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In a case-cohort study, researchers obtain exposure and confounder histories for all cases occurring in a cohort over a follow-up period, and for a random sample ("sub-cohort") of the cohort. The random sample will include some persons who become cases, and many who do not. Like the "nested" case-control design ("case-control within cohort"), this provides an inexpensive way to obtain relative risk estimates with more detailed exposure and confounder information than would be possible for the whole cohort. Our experience and a review of the small literature on the case-cohort design suggests the following advantages over the nested case-control design for occupational studies: (i) from the person years at risk in the random sample we can obtain approximate SMRs using external rates, as well as "internal" rate ratio estimates; (ii) we may study more than one disease using the same random sample; (iii) we may select and collect data on the random sample prior to identifying cases; (iv) if cases can be identified by other means, such as linkage to a cancer registry, we need ascertain mortality only for the random sample, rather than the entire cohort; and (v) under some circumstances relative risk estimates are more precise for the same sample size. However, there are also disadvantages: (i) the analysis is more complicated, especially for correct confidence intervals, which are slow to compute, and only currently available from one software package (EPICURE); (ii) for efficiency, we must usually stratify the random sample, choosing separate sampling fractions to provide a similar ratio of cases: sample in each stratum; (iii) we must calculate indices (e.g., cumulative) of exposure for each year during which a sampled subject was in the cohort, not just up to the age of diagnosis of the matched case, as in a nested case-control study; and (iv) likelihood ratio significance tests are not strictly valid. We illustrated these conclusions with reference to two occupational case-cohort studies currently nearing completion.

PHYSICAL JOB DEMANDS, JOB CONTROL AND PREGNANCY OUTCOME

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Strenuous working conditions have been associated with preterm delivery and low birth weight, but studies are inconsistent. For preventive intervention in the antenatal clinic, it is important to identify self-reported factors which alone or in combination are risk indicators. Several studies support the view that lack of job control combined with stressful job demands can have negative effects on health.

To analyze the combined effects of physical workload and lack of job control on pregnancy outcome, we employed the Demand-Control Model (Karasek and Theorell 1989). Data were collected through a national survey with a self-administered questionnaire to all women giving birth in Norway during a six weeks period in 1989. Of 6235 women registered by the Central Bureau of Statistics in Norway as giving birth in the actual period, 5438 (87.2%) responded. We report some results on low birth weight and preterm birth in nonsmoking Nordic primipara with single births, age 20-34, employed beyond the first trimester.

For low birth weight relative risk (RR) was 1.8 (95% CI 0.9, 3.6) in jobs requiring daily standing with back bent forward. When this strenuous posture was combined with lack of control with work pace, RR increased to 5.6 (1.6, 19.3). In jobs requiring daily twisting or bending several times per hour, RR was 2.5 (1.1, 5.6). When these physical demands were combined with lack of control with work pace, RR increased to 6.2 (1.9, 20.6). For lack of control alone, RR was 5.6 (1.7, 18.2). For preterm delivery, corresponding RRs were for standing, back bent forward 1.3 (0.8, 2.2) plus lack of control 2.1 (1.0, 4.3); for twisting and bending 1.7 (1.0, 2.8) plus lack of control 1.8 (0.9, 3.5), and for lack of control alone 1.6 (0.9, 2.8).

Our findings support the hypothesis that effects of physical workload on LBW and possibly also preterm delivery, are modified by job control. Lack of job control alone, defined here as control with work pace, may be a reliable risk indicator.

CANCER 5

AN EXPOSURE-RESPONSE ANALYSIS OF CANCER MORTALITY AMONG A COHORT OF WORKERS EXPOSED TO ETHYLENE OXIDE

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Ethylene Oxide (EtO) is widely used in the production of chemicals, and in the sterilization of medical devices and pharmaceuticals. An excess in leukemia, lymphoma and other cancers has been observed in experimental studies of animals exposed to EtO. Excess leukemia mortality has also been reported in some studies of workers exposed to EtO. We previously reported the results from the largest cohort mortality study of EtO-exposed workers conducted to date. Here we extend our previous work by quantitatively examining the relationship between cancer mortality and EtO exposure estimated by an industrial hygiene based model. Historical exposures to EtO were estimated for all cohort members based on a regression model. Standard life-table analysis was used to examine the cancer mortality in three categories of cumulative exposure to EtO. The Cox proportional hazards model was also used to examine cumulative and other measures of EtO exposure as continuous predictors of cancer mortality. A weak positive trend in all lymphatic and hematopoietic cancer mortality with cumulative EtO exposure was observed in the life-table analysis. This trend was only evident for males with SMRs of 95 (95%CI=26-243) in the lowest exposure category (<1200 ppm-days) and 143 (95% CI=62-283) in the middle exposure category (1200-8500 ppm-days) and 196 (95% CI=101-343) in the highest exposure category (>8500 ppm-days). A significant exposure - response relationship with cumulative EtO exposure ($\beta=1.1 \times 10^{-5}$, $x^2=4.96$, $p=0.03$) was observed for all lymphatic and hematopoietic neoplasms when exposures were lagged 10 years in the Cox model. The most pronounced relationship was observed for cumulative EtO exposure lagged 5 years with a model combining lymphocytic leukemia and non-Hodgkin's lymphoma ($\beta=1.2 \times 10^{-5}$, $x^2=8.44$, $p=0.004$). Duration, average and maximum exposure were not found to significantly predict mortality from all lymphatic and hematopoietic neoplasms in the Cox model. Mortality from all leukemias, stomach, pancreatic, kidney and brain cancers were not found to have a significant positive association with any of the exposure measures. We believe our findings provide some support for the hypothesis that exposure to EtO increases the risk of mortality from lymphatic and hematopoietic neoplasms.

CANCER INCIDENCE IN THE POLYURETHANE FOAMING INDUSTRY

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During the last decades the industrial use of diisocyanates has increased rapidly, especially of toluenediisocyanate (TDI) and methylenediphenyldiisocyanate (MDI). Their main use is in the polyurethane foaming industry. Both TDI and MDI are mutagenic. TDI is carcinogenic to rodents, probably due to *in vivo information* of the carcinogen diaminotoluene. Moreover, occupational exposure to MDI may cause formation of the carcinogen methylenedianiline. We have conducted a cancer incidence study of workers from nine Swedish polyurethane foaming plants. Name, date of birth, address, and date of start and end of employment were obtained through the company records. Workers who had left employment or died before the year the company registers were complete were not included in the cohort. The year when polyurethane foaming started varied between 1958 and 1974 for the different plants. Information on tumors as well as incidence rates were obtained from the National Swedish Tumor Register. Date of tumor diagnosis, death, emigration or a persons 80th birthday, were used as individual endpoints, whichever occurred first. Altogether 4,167 workers employed for at least one year, were followed-up 1958-1987. The average length of exposure was 6.5 years, the average first year of exposure was 1976, and the average length of follow-up was 10.6 years. The SMR for overall cancer incidence was 0.79 (95% CI 0.62-1.00, 72 observed), indicating a "healthy worker effect". We found no profound excess of any tumors. The SMR was 0.50 (0.14-1.27) for lung cancer, 0.89 (0.24-2..29) for bladder cancer, and 1.36 (0.44-3.18) for malignant lymphomas (5 observed). Excluding the first 10 years since onset of exposure did not change the SMR for all cancer (0.80, 0.58-1.10, 41 observed). The SMR for malignant lymphomas increased, however, to 2.68 (0.89-6.38). Each workplace in the nine plants has been classified by an occupational hygienist with regard to "low" or "high" exposure levels of TDI and MDI, respectively. This classification will be used in further cohort analyses. Moreover, a "nested" case-referent study within the cohort is presently conducted, using a more specific and detailed assessment of the chemical exposure. The workers comprising the cohort are still young, the start of isocyanate exposure was relatively recent and subsequently the follow-up time for many subjects was short. Thus, the study is presently limited by small numbers for the cancers of interest.

ACUTE MYELOID LEUKEMIA AMONG PETROL STATION ATTENDANTS

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Acute myeloid leukemia(AML) may be caused by environmental exposure to benzene and ionizing radiation. We have studied the risk of AML within different occupations to identify occupations with a previously unknown increased risk and to generate hypotheses on unknown environmental etiologies of AML. The study population was the gainfully employed Swedish population, 20-64 years in 1970. The census information was linked to the information on incident cancer cases in the National Swedish Cancer Register during the period 1971-1984. The observed number of AML cases within an occupation was compared to the expected number. The only occupational group showing a substantially elevated risk of AML based on at least five cases was male "petrol station attendants and demonstrators". Ten cases of AML occurred versus 2.8 expected, yielding an observed/expected ratio of 3.6 (95% CI 1.7-6.6). For several decades Swedish petrol has contained 2-5% of benzene. Thus a hypothesis was that benzene had contributed to the excess risk. The work histories of the 10 cases were recontracted through interviews with surviving relatives and were compatible with the hypothesis. However, since the air benzene exposures at petrol stations always have been lower than benzene exposures previously associated with an increased risk of AML, the leukemogenic effect of benzene may have been potentiated by other petrol or vehicle exhaust components.

COHORT MORTALITY STUDY OF FILLING STATION ATTENDANTS

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Gasoline vapors and exhausts contain chemicals which are known human carcinogens, such as benzene. Several surveillance systems reported increased risks for various neoplasms (bladder, kidney, pancreas, respiratory system and lymphohaemopoietic tissue) among filling station attendants. We have conducted a cohort mortality study of 1,446 gas station workers (1,312 men and 134 women), who were in service in Rome during 1980 and still alive on January 1st, 1981. The cohort was enrolled through the 1980 regional census of gas stations; only managers who where clearly identifiable as individuals (not commercial houses) were considered eligible for the study (1,446/1,713=84%). At entry in the study they had worked for 15 years on average, were mainly (69%) full-time employees, and 71% of them worked in small size stations where annual sales of gasoline per full-time employee were around 300 thousand liters. Vital status of cohort members was ascertained through July 31, 1991. At the end of the study, 1,214 subjects were still alive (84%), 141 had died (132 men and 9 women), and 91 had not been traced (6%). The whole cohort experienced a low overall mortality compared to the Regional population (SMR all causes=0.83; 90% C.I. 0.72-0.95), mainly because of a deficit in mortality from cardiovascular diseases (SMR=0.65, 90% C.I. 0.50-0.83). Fifty-seven cancer deaths were observed vs 56 expected. No kidney cancer death was recorded (one expected). Among men, the overall cancer mortality was slightly lower than expected (SMR=0.95, 90% C.I. 0.75-1.20). However, increased risks were found for cancer of the oesophagus (SMR=3.45, 90% C.I. 0.94-8.91, based on 3 observed deaths) and for non-Hodgkin's lymphomas (SMR=3.57, 90% C.I. 0.97-9.23, based on 3 cases). All the oesophagus cancer cases had at lease 25 years of length of employment at entry and were full-time employees in small filling stations. Two out of three cases of non-Hodgkin's lymphoma had length of employment at entry of 20 and 25 years respectively, while one had reported just two years of "exposure". One case of soft tissue sarcoma was observed (0.07 exp). Slightly elevated risks were found for colon cancer (5 obs vs 3.2 exp), bladder cancer (4 obs vs 2.5 exp) and leukemia (2 obs vs 1.7 exp). Mortality from tobacco-and alcohol-related causes was not raised: 19 lung cancers were observed vs 18 expected, 8 respiratory diseases vs 11 expected, and 5 cirrhosis of the liver vs 8.4 expected. Out of the five cancer deaths observed among women, one was due to colon cancer (vs 0.3 exp), one to cancer of the pancreas (vs 0.1 exp), two to breast cancer (vs 0.7 exp) and one to cancer of the uterine body (vs 0.2 exp). Our findings, in spite of the low power of the study, support the hypothesis that occupational exposure to gasoline fuel and exhausts might entail an increased risk of cancer, particularly of lymphohaemopoietic malignancies.

CANCER INCIDENCE IN A COHORT OF SEWAGE WORKERS

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Sewage workers are exposed to a multitude of potentially harmful agents. Several reports have described various pathogenic microorganisms and toxic chemicals. Among the identified chemicals are also known carcinogens. Sewage workers are found to have an increased risk for urinary mutagens. One Swedish case-control study found an increased risk for astrocytoma among people living near waste water processing plants. In a US cohort study presented recently a slight elevation in total cancer mortality was seen among sewage workers. There was also an elevated mortality in some specific cancers, e.g. larynx, lungs, stomach and kidneys.

We have conducted a retrospective analysis of cancer incidence in a cohort of 656 male sewage workers recruited from 17 municipal sewage plants in Sweden. The inclusion criterion was employment for at least one year at one of these plants during the years 1965-1987. Four exposure levels were defined by job classification, where the assumed degree of exposure to waste water and aerosols was the main determinant. The mortality and cancer incidence data for the cohort were collected from national registers. The study period was 1965-1987. In the cohort analysis we used a computer program calculating the person year of observation matrix, expected values, SMRs and 95% CIs. Exposure-response relations were studied by logistic regression.

In the analysis we found lower than expected total mortality (SMR=0.75, 95% CI 0.58-0.97), and cardiovascular mortality (SMR=0.61, 95% CI 0.39-0.91). This is interpreted as a healthy worker effect. No increase in total cancer incidence was found. The incidences for brain tumors, gastric cancers and renal cancer were higher than expected. The number of person-years at observation were 9443.

	SMR	95% CI	observed number of cases
All cancer	1.02	0.72-1.38	37
Brain tumor	2.19	0.45-6.39	3
Gastric cancer	2.73	1.00-5.94	6
Renal caner	1.68	0.35-4.90	3

When a 10 years latency period was introduced in the calculations there were no dramatic changes in the results. The person-years at observation were reduced to 4331. The most notable change was an increase of the SMR for renal cancer (SMR=2.39, 95% CI 0.49-6.99).

In the logistic modelling we found a positive relation for renal cancer to a weighted sum of employment times (p=0.051). The weights were chosen arbitrarily to describe the assumed exposure relations. Age was forced in as a regression variable in the model. The other cancers showed no such relations to either total time of employment or the weighted sum of employment times.

The results are based on small numbers of cases, why they should be interpreted with caution. However, for renal cancer there is more than just one indication on an overrisk. The elevated SMR increased with the introduction of the latency period in the person years calculation. In the logistic regression we found an almost significant relation to the weighted sum of employment times, while the fitting of total employment time was less successful. These findings point toward a possible effect of the exposure. The power of this study is still low, why a future follow-up with increased person-years at observation is needed. The exposures in waste water work need further study to allow for better exposure-response analysis.

CANCER 6

EVALUATING THE EFFICACY OF COLORECTAL CANCER SCREENING IN PATTERN AND MODEL MAKERS

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Pattern and Model Making is a highly skilled occupational trade responsible for constructing prototypes and patterns used for mass production. This occupation has numerous exposures that include various woods, metals, solvents, cutting oils, plastics, fiberglass, epoxy resins, and dusty work environments. Epidemiologic studies have identified members of this occupation as being at increased risk for colorectal neoplasia with two-fold and greater excesses in both incidence and mortality. The focus of this investigation is to evaluate the impact of an ongoing, union-sponsored colorectal cancer screening program initiated in 1981. Our study population consisted of 1,641 white male pattern and model makers employed in shops located in southeast Michigan. Over the course of ten years and four screening programs, 59.4% of this cohort have voluntarily participated on at least one occasion. The typical examination included digital rectal examination, stool occult blood tests, and 60-cm flexible sigmoidoscopy. Patients with suspicious mucosal lesions (usually on adenomatous appearing polyps) were referred to specialists for biopsy and appropriate management. The mean age for eligible study participants in 1981 was 41.6 years. Follow-up of study subjects was accomplished through linkage with the Metropolitan Detroit Cancer Surveillance System (MDCSS) and the Michigan Death Tape. Expected cancers were computer generated, and stratified by age and screening participation using southeast Michigan population-based invasive cancer incidence rates. With a total of 14,513 person-years of observation (8,748 screened, 5,765 unscreened), 68 invasive primary incident cancer cases were identified (SIR = 0.88, N.S.). Eight invasive colorectal cancers were observed vs. 9.00 expected (SIR = 0.89, N.S.). Seven incident invasive colorectal cancers were diagnosed in the unscreened cohort vs. 4.33 expected (SIR = 1.62, N.S.), with the remaining incident case diagnosed in the screened cohort vs. 4.67 expected (SIR = 0.21, N.S.). Mantel-Haenszel rate ratio comparisons controlling for age revealed the unscreened cohort exceeded a statistically significant ten-fold greater risk for developing invasive colorectal cancer ($RR_{MH} = 10.39$, $P < 0.01$). When two in-situ colorectal cancers diagnosed in the unscreened cohort are included, this rate ratio becomes greater than a thirteen-fold ($RR_{MH} = 13.35$, $P < 0.01$). This investigation is a preliminary report of a twenty year study containing quantifiable evidence supporting periodic colorectal cancer screening toward the reduction of colorectal cancer incidence.

COLORECTAL CANCER AND PHYSICAL ACTIVITY

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Many studies performed in the 1980s on colon cancer and occupational exposures have shown a negative association between physically active work (PAW) and colon cancer with a decreasing risk from right to left. The situation regarding rectal cancer and PAW is, however, less clear since no effect or an increased effect has been found with regard to rectal cancer.

This study included 99 cases of colon cancer and 78 cases of rectal cancer, diagnosed 1984-86. The referents were residents in the same area as the cases and consisted of two different sets. One set of referents was sampled from the population register, 430 persons, and the other set consisted of patients from the surgery departments in the area, that is, patients with hernia, hemorrhoids, fissures or fistulas, in total 371 persons. All cases and referents were alive.

Exposure information was collected by a questionnaire mailed to the subjects (after treatment of cases and hospital referents). The occupations were assigned to different classes depending on the level of physical activity. The years spent in PAW were then used as the exposure variable (0 years = level 1, 1-20 years = level 2 and > 20 years = level 3).

The results, for level 3 compared with level 1, obtained by stratification on age and sex was no clear preventive effect from PAW for colon cancer at all sites from PAW (OR=1.0, CI_{90}=0.6-1.6) but with a strong preventive effect for cancer in the left side of colon (OR=0.4, CI_{90}=0.1-0.9). For rectal cancer there was an increased risk (OR=1.7, CI_{90}=1.0-3.0).

When the material was divided according to sex and stratified on age, there was a preventive effect from PAW (OR-0.8, CI_{90}=0.4-1.6) for colon cancer and for rectal cancer there was a risk from PAW (OR=1.6, CI_{90}=0.8-3.2). The results for females were contradictory since there was an increased risk both for colon cancer (OR=1.4, CI_{90}=0.4-4.1) and rectal cancer (OR=1.9, CI_{90}=0.6-5.5). It may be noted that the majority of women in these ages have worked most of there lives as housewives coded as an intermediate between PAW and sedentary work so most women were therefore allocated to level 1 of PAW.

The results of this study are consistent with previous findings for PAW and colon cancer, perhaps with the exception of women alone. They are also consistent with findings in some studies of rectal cancer. This experience suggests that there may be a need for separate analyses for colon and rectal cancer when a study concerns physical activity.

COLON AND STOMACH CANCER MORTALITY AMONG AUTOMOTIVE WOOD MODEL MAKERS

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Automotive wood model makers have been reported to be at excess risk for colon and other cancers in recent epidemiologic studies. To further explore these risks, we conducted a retrospective cohort mortality study, with follow-up from 1940 through 1984, of 2294 white male wood model makers employed at any time until 1980 by three U.S. auto makers. Using U.S. mortality rates for comparison, we found elevated standardized mortality ratios (SMR) of 1.2 (95% C.I., 0.8-1.9) for colon cancer and 1.6 (95% C.I., 0.9-2.6) for stomach cancer. Neither SMR was statistically significant nor was any other cause of death significantly elevated. However, the SMR for stomach cancer approached significance and remained elevated even when we controlled for ethnicity. To examine possible relationships between colon and stomach cancer mortality and plant exposures from wood model making, we conducted nested case-control studies for 20 colon and 17 stomach cancer cases and 543 age-matched controls. To determine the plant exposures from wood model making, we coded detailed work histories for all jobs held by the cases and controls from company records. This allowed us to remove time spent laid off, on leave or working in jobs with exposures other than wood model making. We used duration employed in jobs with exposure to wood model making (years) as one of our exposure variables. To determine the specific exposures from wood dust, we multiplied the geometric means for wood dust exposure, which had been assigned to each job, by the duration employed in that job. The geometric means for wood dust exposure were assigned to each job based on industrial hygiene surveys of the three study plants. We used weighted wood dust exposure (mg/m^3-years) as our other exposure variable. We used logistic regression to model mortality on the plant exposures while adjusting for prior employment in wood model making and other possible confounders. We found no trend of increased risk for colon or stomach cancer mortality with increased exposure to wood dust or to duration employed in wood model making.

MORTALITY OF URBAN FIREFIGHTERS IN ALBERTA: 1927 - 1987

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The mortality experience of firefighters has been an active topic of investigation. Collateral toxicological evidence suggests that certain causes of death are likely to be associated with firefighting: lung cancer, heart disease, and obstructive pulmonary disease. To date there has not been a clear and consistent demonstration of excess risk due to occupational exposure for these outcomes but certain uncommon cancers, including genitourinary, leukemias, lymphomas and myeloma, appear to be consistently elevated. A major unproven hypothesis is that risk increased following the introduction in the 1950's of combustible plastic furnishing and building materials known to generate toxic combustion products. Mortality by cause of death was examined for two cohorts totalling 3,328 firefighters active from 1927 to 1987 in Edmonton and Calgary, the two major urban centers in the province of Alberta, Canada, examining associations with cohort (before and after the 1950's) and years of service weighted by exposure opportunity. The study attained 96% follow-up of vital status and over 64, 983 person-years of observation yielding 370 deaths. Mortality from all causes was close to the expected standardized mortality ratio (96; 95% confidence limits (CL) 87,107) as was that for heart disease (110; 95% CL 92,131), and neither was statistically significant at the $p < 0.05$ level (N.S.). Excesses were observed for all malignant neoplasms (127; 95% CL 102, 155, $p < 0.05$) and for cancer of lung (142; 95% CL 91,211, N.S.), bladder (315; 95% CL 86, 808, N.S.), kidney and ureter (414; 95% CL 166, 853, $p < 0.05$), colon and rectum (161; 95% CL 88,271, N.S.), pancreas (155; 95% CL 50, 362, N.S.) and leukemia, lymphoma, and myeloma (127; 95% CL 61, 233, N.S.); obstructive pulmonary diseases (157; 95% CL 79, 281, N.S.). Fire-related causes showed a marked excess (486; 95% CL 233, 895, $p < 0.01$) but external causes overall showed a significant deficit (66; 95% CL 49, 87, $p < 0.05$). The lung cancer excess was confined to Edmonton; there was no consistent association with duration of employment, exposure opportunity, or cohort of entry (before or after the 1950's). The excess of cancers of the urinary tract was observed mostly among firefighters entering service after 1950, appeared to increase with length of service and exposure opportunity, and was observed in both cities. An occupational association with lung cancer, heart disease, and chronic pulmonary disease is not supported in this population, although a weak effect for lung cancer confounded by stronger effects cannot be ruled out; associations of firefighting with cancers at genitourinary sites and with fire-related injury are strongly suggested.

20-YEAR FOLLOW-UP OF MORTALITY OF COKE WORKERS IN BRITAIN

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A 12 or 13-year follow-up of men employed by two companies in 1967 as coke workers at 27 plants throughout Britain had shown less lung cancer than in American studies. A 20-year follow-up aimed to examine further if lung cancer, and other causes of death, were work-related. Vital status was established for all but 153 (2%) of the 6673 men studied. Detailed job-names from work histories up to 1976 were allocated to 10 groups, according to broad area of work and results from 1630 measurements of benzene soluble materials (BSMs) from routine monitoring at 19 plants 1971-88, showing geometric mean levels of 1.5-2.0 mg.m-3 BSM in ovens tops jobs. Cumulative exposures to BSMs up to 1967 assumed that earlier concentrations were similar to those in the 1970s. Data on smoking habits were available from surveys 1968-73 for 1767 men. The all-cause SMR, based on 2208 deaths, was 92 relative to the local (regional) population. The 319 lung cancer deaths (SMR 126) were a statistically significant excess. Cox regression analyses showed a positive association between lung cancer mortality and estimated exposure to BSMs in data from one company, with an indication of a positive interaction between exposure and cigarette smoking. BSM data from the other company were sparse. Excess laryngeal cancer (SMR 260, 9 deaths) was not associated with estimated BSM exposures. Stomach cancer mortality in the second company (SMR 130, 95% CI 89-183) was related to time worked in the by-product plants These results are broadly consistent with those from other studies. A negative trend with age in IHD SMRs remains unexplained.

INJURY AND MUSCULOSKELETAL DISORDERS

EPIDEMIOLOGY OF INJURIES IN THE WOOD PRODUCTS INDUSTRY IN MAINE

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Lumber and wood products processing (SIC 24) accounts for about 13% of the manufacturing workforce in the state of Maine, employing 9,701 workers in 1987. It is a highly hazardous industry; the rates both of all OSHA recordable injuries and of lost workday cases were more than twice the state average in that year. A study of acute and musculoskeletal injury has been conducted in wood products manufacturing facilities in Maine, using available data from several state agencies and other sources. All employers' First Reports of Injury to the Workers' Compensation Commission were obtained for the period, 1985-1989. The injury reports were linked by employer identifier to supplementary databases that provided biannual updates on SIC code, the size of the work force, whether or not each company was unionized, type of wood processed, specific types of equipment in use, type of product, and annual production output. Estimating stratum-specific denominators for each of these categories, incidence rates were calculated for various injury types, body parts, and levels of severity. A total of 14,192 injuries were reported to occur on employers' premises in Maine from 1985 through 1989, for an overall rate of 29.3 cases per 100 workers; about 40% were lost-time injuries and seven were fatalities. Almost one-third were injuries to the musculoskeletal system, particularly the trunk and upper extremity. In relation to work force size, injury rates showed an inverted "U"-shaped curve, with the highest rates in moderate-size plants of 51-100 workers (42.0 injuries of all types per 100 workers, or roughly double the rates in both the smallest and largest plants). No trend was observed with production output (board feet processed or gross sales). Rates were 1.6 times higher in plants that processed hard rather than soft woods (32.2 vs 20.5 per 100 workers). Injuries were also more frequent in plants with saw mills (21.5 vs 13.7 per 100 workers, RR = 1.6) or bolter mills (21.1 vs 16.3 per 100 workers, RR = 1.3) in use. These relationships held when disabling and non-disabling injuries were examined separately, as well as for various subgroups by body part, nature and type of injury. Rates were markedly lower in unionized plants (17.5 vs 24.0 per 100 workers, RR = 0.7) compared with unorganized workplaces, but this finding was inherently confounded by workforce size, since the nonunionized plants were much smaller on average (250 vs 75 employees). The substantial variation in injury rate by SIC (242-249) similarly appeared to be confounded by plant size. A nested case-control study is underway to investigate risk factors in more detail.

SELF-REPORT WORK INJURY EXPERIENCE OF MINNESOTA HIGH SCHOOL STUDENTS

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The purpose of this study was to describe the incidence and severity of work-related injuries to adolescents. A self-administered questionnaire was completed by 3,054 tenth through twelfth grade students representing public school districts throughout Minnesota. The questionnaire referenced work experience from August 1990 through May 1991. The percentage of working students (57% to 93% of boys and 51% to 92% of girls) was found to increase as grade level increased from tenth through twelfth grade, and varied depending on school district size. Individuals were asked to list up to three activities that described their job. As a group girls most frequently reported working as cashiers (39%, baby-sitters (23%), fast food and short order cooks (17%), and sales clerks (13%). Boys most frequently reported working as fast food and short order cooks (21%), non-construction laborers (20%), farm-agricultural workers (20%), cashiers (17%), and janitors (16%). Comparing responses of working teens from tenth through twelfth grades, report of at lease one work-related injury during the ten month reference period decreased from 25/100 to 12/100 for girls and 22/100 to 18/100 for boys. Approximately 5/100 girls and 7/100 boys indicated having restricted their normal activities for more than one day. The most frequently reported injuries were burns, sprains, cuts, and bruises. The cumulative incidence ratio was computed as the incidence of injury among those performing a specific job activity compared to the incidence among those not performing the activity. The highest cumulative incidence ratios in girls were associated with fast food cook, 3.4 (95% C.I.: 1.2, 9.1) in urban and 2.1 (95% C.I.: 1.3, 3.6) in nonurban settings; carhop, 2.2 (95% C.I.: 0.9, 5.1) in urban and 1.9 (95% C.I.: 1.2, 3.1) in nonurban settings; and dishwasher, 1.8 (95% C.I.: 1.1, 3.0) in nonurban settings. In the urban setting, boys appeared to be at equal injury risk regardless of job type. However, nonurban boys reported somewhat greater risk of injury working as a short order cook, 1.5 (95% C.I. 0.9, 2.4), dishwasher, 1.5 (95% C.I.: 0.9, 2.4), and fast food cook 1.4 (95% C.I.: 0.8, 2.5). The results suggest that modification of the work environment in restaurants could substantially reduce injuries to working teens.

A CASE-CONTROL STUDY OF RISK FACTORS FOR INDUSTRIAL LOW BACK INJURY: THE UTILITY OF PREPLACEMENT SCREENING IN DEFINING HIGH RISK GROUPS

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Industrial low back injuries are common, painful, and costly. Because industry in the United States spends upwards of 11 billion dollars a year for compensable low back injuries, considerable efforts have been directed at preventing industrial back pain. In industry, personnel departments often hope that preplacement physical examinations will reduce the risk of injuries. However, the literature has not provided much support for this hope. Working from a cohort of 8,183 postal workers hired between 1980 and 1987, we carried out a case-control study to evaluate the efficacy of preplacement medical examinations in defining high risk groups. From this cohort, we identified 154 cases who had filed workers' compensation claims for low back injuries between 1983 and 1988, and an additional 942 controls who did not have low back injuries. Starting with the variables - job classification, history of a back injury, gender, age at preplacement screening, Quetelet Index, history of disability, history of work related injury, history of psychiatric disorder, and history of substance abuse, we constructed a multiple logistic regression model. Disabilities included all conditions listed by applicants as disabilities on their preplacement questionnaire. We found that a history of a prior disability, odds ratio 2.90 (95% CI 1.88-4.48), and a heavy lifting job, odds ratio 1.91 (1.32-2.76) were associated with occupational low back injuries. However, a history of previous back injury on preplacement examination was not associated with subsequent occupational injury. Separate analyses looking at different types of disabilities found a pattern of elevation throughout: back, odds ratio 4.16; lower extremity, odds ratio 2.48; upper extremity, odds ratio 2.07; psychiatric, odds ratio 2.53; and other, odds ratio, 1.93. This association between a history of disability and occupational low back injury has not been previously noted and would warrant further research. The lack of an association between a history of previous back injury and subsequent occupational back injury contradicts previous suggestions from the literature and would argue against denying an applicant employment solely on the basis of a history of a previous back injury.

PREDICTORS OF SCIATICA IN A FOUR-YEAR FOLLOW-UP AMONG ELDERLY MUNICIPAL EMPLOYEES

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Predictors of four-year cumulative incidence of sciatica were studied in a sample of elderly municipal employees. The subjects of this study consisted of 4863 employees who answered a postal questionnaire in 1981 and 1985 and who reported in 1981 not having had sciatica. All subjects were 44-58 years of age and active workers with at least five years experience in their current occupations at the baseline. The four year cumulative incidence of sciatica was 8.7%. The questionnaire comprised items on physical and mental work demands, job satisfaction, work environment, and lifestyle and life events. A total of 121 variables were considered in the analysis. In the first phase of the analysis, F-statistics with respective probability values (p-values) were estimated for each of the potential predictors using canonical discriminant analysis. In the second phase, separate backward step-wise discriminant analyses were performed including all statistically significant variables ($p<.05$) from the group of work-related variables and from the group of lifestyle variables. The significant variables obtained from these two separate analyses were then included in a further discriminant analysis. The number of significant predictors was reduced to 13: difficult and uncomfortable work postures; heavy work at the age of 30-39, dry, humid or wet environment; repetitive motions; heavy work younger than 20 years; haste and tight schedule; satisfaction to breaks; starting time for regular work; risk for accidents; need for vocational training; active member in societies and foundations; severe illness of a family member during the past 6 months; and mentally heavy work. In addition to these 13 variables, age, social class and smoking were included as potential confounders in the canonical discriminant analyses but they had no notable effect. In the last phase of the analysis, logistic regression modeling was performed using the reduced set of predictors for men and women separately. For women the significant predictors were heavy physical work younger than 20 years, difficult work postures, and repetitive movements. If all these risk factors were present, the relative risk (RR) of sciatica was 2.5 (95% confidence interval, CI, 1.8-3.3) in reference to all factors being absent. For men the significant predictors were difficult postures and mental heaviness of work. RR for sciatica was 1.5 (95% CI 1.1-2.0) for those with high strain from difficult postures and mentally heavy work. The results of this study emphasize the role of physical stressors as predictors of sciatica, but also mental stress seems to be of importance.

OSTEOARTHRITIS OF THE HIP IN FARMERS

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Evidence is emerging that farming is associated with an increased risk of hip osteoarthritis. However, most studies to date have been based on surgically treated cases, and associations may have been exaggerated if farmers have a lower threshold for obtaining treatment than other occupational groups. To obtain a less biased estimate of risk, and to try and identify the aspects of work responsible for the association, we have carried out a population based cross sectional survey of farmers and of controls with mainly sedentary jobs.

Subjects were identified by a screening occupational questionnaire which we sent to a random sample of 1,231 men aged 60-76, selected from the lists of five rural general practices. They comprised all current and ex-farmers and also those men who reported having worked all their lives in offices. Detailed occupational histories were elicited at interview, and subjects who had not undergone previous hip replacement were invited to have a plain A-P pelvic radiograph. Hip osteoarthritis was defined as a verified history of joint replacement for the disease, or a minimal joint space $\leq$ 1.5 mm in at least one hip. Assessment of osteoarthritis was possible in 250 men (61% of those originally selected), with similar response rates for the farmers and controls.

Among 167 current and ex-farmers there were 28 cases of hip osteoarthritis (including 20 with hip replacement) as compared with 2 (1 hip replacement) among 83 controls. After adjustment for age, the odds ratio for hip osteoarthritis was 5.8 (95% CI 1.1 - 31.5) in those who had farmed for 1-9 years and 10.1 (95% CI 2.2 - 45.9) in those who had farmed for 10 or more years. The excess could not be attributed to any single type of farming. All but one of the cases among the farmers reported regularly lifting weights in excess of 25 kg, but 8 had never driven tractors, and only 10 had regularly driven tractors for at least 4 hours per day.

On current evidence, manual handling seems the most likely explanation for the hazard.

RESPIRATORY DISEASE 2

OCCUPATIONAL DUST EXPOSURE AND LUNG DISEASE AMONG SHEET METAL WORKERS

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A previous large medical survey of active and retired sheet metal workers with 20 or more years in the trade revealed an unexpectedly high prevalence of obstructive pulmonary disease among both smokers and non-smokers. A cross-sectional interview study was nested in this group to explore occupational risk factors for lung disease. Four hundred and seven workers were selected from this group on the basis of their potential for exposure to fiberglass and asbestos. Selection was independent of health status, and excluded welders. A detailed occupational exposure history, focusing on task-specific percent-time exposures to fiberglass and asbestos, was obtained by telephone interview for 333 of these workers. Exposure data were analyzed in relationship to previously collected data on respiratory health and personal characteristics.

Assessment of the effects of fiberglass exposure as distinct from the effects of asbestos exposure has been difficult in previous studies of construction workers. This cross-section of experienced workers has performed a diversity of jobs involving exposure to many different types of materials, and we were able to evaluate each dust exposure independently. Occupational risk factors were identified for chronic bronchitis, defined symptomatically at the time of the previous medical survey. Smoking sharply increased the risk of chronic bronchitis; fiberglass and asbestos exposures were also associated with increased risk. Multiple logistic regression odds ratios (OR) and 95% confidence limits (in parentheses) for chronic bronchitis risk factors were: 1-59 packyears compared to zero packyears, OR=5.2 (1.2 - 23.2); >60 packyears compared to zero packyears, OR=10.5 (1.9 - 59.5); current smoker, OR=2.1 (1.0 - 4.5); a history of high-level exposure to fiberglass, OR=2.3 (1.1 - 4.9); and years of exposure to asbestos. Years of asbestos exposure was treated as a continuous variable and yielded an odds ratio of 1.04 for each year of exposure, which may be extrapolated to OR=2.3 (1.2 - 4.4) for 20 years of asbestos exposure. Only two other studies have found fiberglass exposure to be associated with chronic bronchitis; we are not aware of studies linking asbestos to this condition.

Obstructive disease, defined by pulmonary function test results at the medical survey, was also found to be related to both smoking occupational risk factors. In the interviewed population, risk factors for obstructive disease varied depending on packyears' smoked. Sheet metal work exposure to asbestos did, however, increase the risk of obstructive disease among all packyear categories. Fiberglass exposure was not associated with obstructive disease.

CORRELATION BETWEEN RESPIRATORY SYMPTOMS AND ACCELERATED LOSS OF VENTILATORY FUNCTION IN ASBESTOS-EXPOSED WORKERS: A LONGITUDINAL ANALYSIS

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Cross-sectional studies assessing respiratory questionnaire validity have demonstrated an association between respiratory symptoms and diminished ventilatory function. Few studies, however, have assessed the association between respiratory symptoms and change in ventilatory function over time. To determine whether respiratory symptoms are associated with accelerated loss of ventilatory capacity, reported symptoms of cough, phlegm, wheeze, and dyspnea on the American Thoracic Society (ATS-DLD-78A) questionnaire were correlated with longitudinal changes in forced vital capacity (FVC) and forced expiratory volume, one second (FEV1) in 446 asbestos exposed workers.   Subjects were enrolled in the randomized prospective Seattle Asbestos Chemoprevention Trial (1985-1988), with questionnaire and spirometry data from randomization and after three to five years follow-up. All had worked in specified construction and ship-building trades with high risk for asbestos exposure, with more than 15 years from first exposure to randomization. Symptom prevalence ranged from 23% for wheeze to 45% for phlegm. As a whole, the cohort experienced an accelerated loss in ventilatory function of 49ml/yr in FVC, and 50ml/yr in FEV1. Reported respiratory symptoms on initial exam was not predictive of accelerated loss in FVC or FEV1. However, the development of any respiratory symptom between initial and follow-up exam was associated with accelerated decline in both FVC and FEV1:

Annual Change in FVC and FEV1 (ml/yr)[a]
Compared to Asymptomatic Individuals
FVCFEV1

	Group A[b]	Group B	Group C	Group A	Group B	Group C
Cough	+5	-32	-8	+1	-39**	-22*
Phlegm	-2	-50**	-18	-12	-32**	-12
Wheeze	+5	-67**	-29	-4	-38**	-16
Dyspnea	-7	-34*	-26	+3	-28*	-5

[a]from MLR model, with covariates: baseline FVC, age, smoking status
[b]Group A-resolution of symptom between initial and follow-up exam
Group B-development of symptom between initial and follow-up exam
Group C-persistence of symptom between initial and follow-up exam
*$p < 0.05$, **$p < 0.01$

In summary, these results indicate that development of respiratory symptoms was associated with accelerated decline in ventilatory function. The presence of symptoms per se was not predictive of significant decline. We conclude that serial administration of respiratory questionnaires to asbestos exposed worker may effectively identify groups at risk for progressive ventilatory impairment.

PREVALENCE AND INCIDENCE OF COALWORKER'S PNEUMOCONIOSIS IN U.S. UNDERGROUND MINERS

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The 1969 Federal Coal Mine Health and Safety Act (FCMHSA) mandated that dust exposures in underground coal mines be reduced substantially from 1970 onwards (3 mg/m^3, reduced to 2 mg/m^3 in 1972 in the absence of excessive silica in the dust). To investigate whether this action has led to a reduction in occupational lung disease in coal miners, the National Institute for Occupational Safety and Health (NIOSH) has been conducting periodic epidemiologic studies. In the most recent investigation, prevalence and incidence of coalworkers' pneumoconiosis (CWP) was studies in a group (n=3, 182) of U.S. underground miners and ex-miners previously examined by NIOSH between 1970 and 1975. Chest radiographs taken between 1985 and 1988 were read by three B readers using the 1980 ILO classification of the pneumoconioses. Based on median determinations of the three readings, overall prevalence of CWP (defined for this analysis as radiologic profusion category 1/0 or greater small opacities) was 6.8%. There was a distinctly lower prevalence of CWP among miners with 15 - 19 years of underground tenure (approximately the interval between mandated reduction in dust levels and date of examination) compared to those with 20 - 24 years (who would have experienced conditions before the mandated reduction) (3.4% versus 11.7%). Consistent with findings elsewhere, greater levels of CWP were seen in high rank coal regions (10.2% for high rank versus 5.8% for other coal fields). Furthermore, miners who said they left work for health-related reasons had a CWP prevalence about twice that seen among working coal miners. Examination of incidence of CWP over the approximately 15 years of follow-up (during which time they had apparently been exposed to an average dust concentration of just over 1 mg/m^3 indicated that most (about 70%) of the CWP identified in the 1985 to 1988 survey had developed after 1970. Moreover, nine cases of severe CWP (category 2/1 or greater rounded opacities) were found to have developed over the study period from an apparently normal initial film (median determination = category 0/0. Overall, the results suggest that while federal limitation of dust may have led to a reduction in the prevalence of CWP in underground coal miners, it has not prevented all CWP from occurring.

SURVEILLANCE OF ASBESTOSIS DEATHS IN THE UNITED STATES USING MULTIPLE CAUSE OF DEATH DATA, 1968-1988

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Asbestosis is an occupational lung disease targeted by the Public Health Service Year 2000 National Health Promotion and Disease Prevention Objectives. Trends in asbestosis mortality provide one criterion for evaluating progress toward preventing asbestosis. Most occupational mortality studies have been based on underlying cause of death only. Data tapes listing both underlying and contributing causes of death for all deaths in the United States are prepared annually by the National Cancer for Health Statistics (NCHS). These data are especially attractive for the analysis of chronic conditions such as asbestosis, which may often be listed as contributing rather than underlying cause of death.

For years 1968-1988, we analyzed temporal trends, geographic patterns at state and county levels, and years working life lost (i.e., prior to age 65) in decedents with any death certificate mention of asbestosis. Deaths with asbestosis were identified by International Classification of Diseases (ICD) Version 8 code 515.2 from 1968-1978 and by ICD Version 9 code 501 from 1979-1988. Sex- and race-specific rates were calculated. State-specific rates were developed for the 1968-1978 and 1979-1988 periods. Data on usual industry and occupation of decedents, available from NCHS since 1985 for selected states, were also analyzed.

From 1968 to 1988, the national annual age-standardized rates for deaths with asbestosis increased from 1 per million to 6 per million in white males. The proportion of deaths with asbestosis occurring in white males over 65 years increased from 50% in 1968-1978 to 76% in 1979-1988. Despite the increased proportion of asbestosis deaths over age 65, years working life lost generally increased from 1968-1988. By state, New Jersey and Washington had the highest rates in both the 1968-1978 and the 1979-1988 periods. County level mapping identified more detailed geographic patterns of deaths with asbestosis within these states. Construction was the most frequently listed industry, and plumbing, pipefitting, and steamfitting were the most frequently listed occupations among decedents with coded industry and occupation.

Although the use of asbestos has declined in the United States, continued exposure to asbestos indicates the need for an occupational mortality surveillance system for asbestosis. The NCHS multiple cause of death tapes provide data for such a system.

TRENDS IN CLASSIFICATION OF SMALL OPACITY TYPE IN THE COAL WORKER'S X-RAY SURVEILLANCE PROGRAM, 1970-1989

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The objective of this study was to examine trends in the classification of small radiographic opacities in the Coalworkers' X-ray Surveillance Program (CWXSP), a NIOSH-administered medical monitoring program for underground coal miners. Data were restricted to classifications of 15,403 chest radiographs classified as category 1 CWP by 88 B-readers from 1970 to 1989. For films classified under the 1971 ILO U/C system, the predominant type of small opacity was taken as the type with the highest profusion. For films classified under the 1980 ILO system, the predominant type of small opacity was assigned by G-readers. The most striking classification trend observed was a general decrease over time in the proportion of films with a predominance of type p opacities. This decrease occurred largely between 1979 and 1982. Before that time the proportion of category 1 films with predominant type p opacities was fairly stable and averaging above 30%, while after that time the proportion was very stable at about 10%. Type t opacities were the major beneficiary of the reduction in p type opacities, although type q opacities also showed a slight increase over the study period. Proportions of films with a predominance of one of the other three types of small opacities (i.e., r, s, and u) varied little over time. The trend toward a predominance of irregular opacities at the expense of rounded opacities may, in part, relate to a change in the ILO system for classifying radiographs for pneumoconioses, but the trend appears to have begun before the CWXSP adopted the 1980 ILO Classification scheme. The observed trend held when each minor profusion category (1/0, 1/1, and 1/2) was examined separately, when miner tenure was controlled for, and after excluding readings from the seven B-readers who had read the largest numbers of films. The trend also remained evident when the data set was restricted to films from a subset of miners who worked with high volatile bituminous A coals. In conclusion, a general trend over time for category 1 radiographs from the CWXSP to be classified by B-readers as having a predominance of irregular small opacities at the expense of rounded (especially p) types was noted. Although the change in ILO classification system have played a role, no definite explanation for the observed trend was found.

CANCER 7

CAUSE OF DEATH AND CANCER INCIDENCE AMONG NURSES

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Nurses endure emotional and physical effects of stress at the job. They are exposed to potential cancerogens such as ionizing radiation, cytostatic drugs, anesthetic waste gases, infectious agents and variety of chemicals. Former studies have found an increased risk of suicides and have demonstrated increased cancer risk at all sites, breast, corpus uteri, colon, rectum, nervous system, kidney and stomach among nurses.

The objective of this study was to describe the mortality pattern and the cancer morbidity among a cohort of Icelandic nurses with a special focus on suicides and breast cancer. They are compared with the female general population. Information on the nurses was obtained from the Nurses Associations membership rolls, which included all registered nurses in Iceland, who worked and lived in Iceland. The cohort comprised 2168 female nurses. Altogether 1265 (58%) graduated 1970 or later, 389 (18%) 1960-69, 246 (11%) 1950-59, 268 (12%) before 1949. No valid information was available on job categories or work tasks of the individual women. Through the membership rolls it was possible to identify each individual and register their ten-digit personal identification number. These numbers were used to link the cohort with the files of the National Register, the Register of Deceased and the Cancer Register. Standardized mortality ratio (SMR) and standardized incidence ratio (SIR) were calculated on basis of person-years and mortality and cancer incidence rates for the general female population in Ireland.

A healthy worker effect was observed in the total cohort (SMR 0.75, CI 95% 0.64-0.88) mainly explained by significant deficit of mortality from ischemic heart disease (SMR 0.56, 0.35-0.85). An excess was seen from cancer of intestine, uterus, kidney, bladder, nervous system and leukemia, all based on few cases. Suicide was in excess. When analyzing the mortality data with requirement of 20, 30, 40 and 50 years latency a significant increase in SMRs was seen for all causes, all cancers and bladder cancer.

The SIR for all cancers was 1.07 (0.89-1.29). SIR was elevated for cancer of liver, lung, breast, kidney, bladder, brain, thyroid, and lymphosarcoma and leukemia. When analyzed with latency there was a gradient in SIR for most cancer sites, a significant tread was found for all sites, cancer of lung, breast and bladder.

In conclusion: The data show an excess of incidence of cancers particularly breast cancer, but also lung cancer and kidney cancer. The mortality from lung and breast cancer was not as high, although elevated, which could indicate that nurses benefit from their profession, getting diagnosis and treatment early in the course of their disease. Excess of suicides was only seen in the total cohort. The cohort is small and relatively young, thus leaving us with small numbers.

CANCER RISKS AMONG FEMALE AGRICULTURAL WORKERS IN SWEDEN

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In our studies on cancer risks among Swedish male agriculture workers we found that the overall cancer risk and the risk for many individual sites were significantly decreased, especially for cancers of the respiratory organs. Cancer sites with elevated relative risks were lip, malignant melanoma and skin carcinoma of the head and neck region, multiple myeloma and stomach cancer. Other Swedish studies have found increased risk for soft tissue sarcomas and malignant lymphoma after exposure to phenoxy acid herbicides. In Sweden, women have traditionally been working with the not physically demanding or technically advanced tasks on the farm and have thus not to the same extent as males come in contact with potentially hazardous agents as e.g. solvents. Few women have license for pesticide application and have not handled pesticides to the same extent as men. However, they are likely to have experienced passive exposure to pesticides and other agricultural chemicals to a larger extent than the general population. We have conducted a cohort study of cancer risk among 50,682 women occupied in agriculture in the 1970 census. Special attention was paid on female genital organs and breast cancer. The cohort was followed-up in the nationwide population-based Swedish Cancer Register from January 1, 1971 until death or until December 31, 1984. Expected number of cases was based on annual cancer incidence in five-year age groups. The standardized incidence ratio (SIR) was computed as the ratio between observed and expected number of cases. Totally 3,458 cases of cancer were observed in the cohort from 1971 until 1984 versus 4,060 expected, resulting in a significantly decreased SIR of 0.85 (0.82-0.88). SIR for breast cancer was significantly decreased 0.83 (0.77-0.88), as were SIR for cervix uteri 0.43 (0.34-0.55). For the other female genital organs SIR was close to unity. SIR for phenoxy acid associated cancer sites were 0.67 (0.39-1.07), 0.78 (0.60-0.98) and 1.31 (0.84-1.94), for soft tissue sarcoma, non-Hodgkin's lymphoma and Hodgkins disease. Other sites with significantly decreased SIRs were colon 0.87 (0.76-0.98), lung 0.41 (0.32-0.53) and urinary bladder 0.61 (0.46-0.79). The main explanation to the low risks in respiratory organs found in this study is favourable smoking habits. This is also one of the explanation to the low risk for cancer in cervix uteri. The low risk for breast cancer could be due to lower age at first full term pregnancy, longer lactation periods and more children. High intake of fat has been associated with higher incidence of breast cancer. It is therefore interesting that despite higher consumption of fat, female farmers have a decreased risk of breast cancer. The passive exposure to phenoxy acids and other agricultural chemicals, have not resulted in any increased risk for soft tissue sarcoma and non-hodgkin's lymphoma. The not-significantly increased risk for Hodgkin's disease could be due to phenoxy acid exposure. Other possible explanations are exposure to animals, which have been suggested in other studies.

CANCER RISK AMONG URBAN POLICEMAN IN ROME

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Exposure to exhausts from both diesel and gasoline-fuelled vehicles has been suggested to be carcinogenic. Increased risks of lung cancer, bladder cancer and lymphomas have been reported among professional drivers but other studies on exposed groups have been negative. Most policemen are exposed to engine exhausts in the urban environment during traffic control. Therefore, the mortality pattern of urban policemen in Rome was investigated through a historical cohort study. A total of 3,876 male subjects, first employed between 1946 and 1975, was followed-up from January 1973 to July 1991. Vital status was ascertained for 98.2% cohort members. Regional death rates were used to calculate standardized mortality ratios (SMRs). The overall mortality was lower than expected (556 deaths, SMR-0.82, 90% CI, 0.76-0.88), whereas the number of recorded deaths for all neoplasms was as expected (234 deaths, SMR = 1.01, 90% CI, 0.91-1.12). Mortality from circulatory (SMR=0.74), respiratory (SMR=0.40), digestive diseases (SMR=0.60) and accidents (SMR=0.35) was significantly lower than expected. No excess was found for lung cancer (SMR = 1.04, 81 deaths). Increased mortality was found for cancers of colon (SMR=1.30, 18 deaths), kidney (SMR=1.33, 6 deaths), bladder (SMR=1.21, 13 deaths), melanoma (SMR=2.14, 4 deaths) and non-Hodgkin lymphoma (SMR=1.67, 6 deaths), although none of the excesses was statistically significant. Noteworthy, two male breast cancer cases were found vs 0.19 expected (SMR=10.3,90%CI=1.87-32.44). Nested case-control studies were conducted to evaluate cancer risk among job categories entailing exposure to engine exhausts (traffic guards, drivers and motorcyclists) in comparison with non-exposed (clerks, bailiffs and general services operators). Five controls were matched to each lung cancer case (81 deaths) on year of birth ($\pm$ 2), year of hire ($\pm$ 2) and year of termination of employment ($\pm$ 2.). Similarly, 20 controls were matched for each case of urinary cancer (19 deaths) and lymphohaemopoietic cancer (16 deaths). A conditional logistic regression analysis was performed. Lung cancer risk did not differ among job categories and did not increase with duration of outdoor exposure. Bladder cancer was significantly increased among car drivers (OR=3.68,90%CI=1.3-10.6); a slight excess was present for kidney cancer among motorcyclists; non-Hodgkin lymphoma clearly clustered among motorcyclists (OR=12.49,90%CI=1.80-86.87). The study, in line with other observations, indicates an increased risk for bladder cancer among drivers, it also suggests that motorcyclists are a group at risk of renal cancer and lymphoma. The excess risk found for rare cancers such as melanoma and breast cancer deserve further insight.

SOLVENTS AND NOISE

MORTALITY OF PAINT PRODUCTION WORKERS, RE-ANALYSIS AFTER ASSESSMENT OF EXPOSURE TO SOLVENTS

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A cohort mortality study of employees at one of the largest coatings and paint industry in Italy has been re-examined. 1614 male workers employed for at least four months since the beginning of operations were followed-up during the period 1948-1987 (vital status ascertainment was 96.4% complete; 287 deaths occurred). Individual job histories were available for all but 81 workers. Exposure was complex, involving hundreds of different chemicals and particularly solvents (toluene, xylene and technical hydrocarbons, mainly). Workers were first classified on a qualitative scale (not exposed; solvents only; solvents & resins; solvents, resins & pigments), after examining individual job histories and technological changes in production processes. Suggestive increased of hematologic neoplasms and cirrhosis were noted among solvents exposed workers, and a significant excess of oesophagus cancer (2 cases only, however) was seen among those exposed to solvents and resins. Data on measurements of solvents air concentrations during the period 1978-1987 were recently made available, both on department in specific job basis. Using mathematical models and environmental hygiene considerations exposure was quantitatively estimated for the total follow-up period and sub-periods. Cumulative exposure to mixtures of solvents was computed for each worker. Department and job specific cumulative exposures were correlated (r=0.70), and department data were used in analysis given their larger representativeness of exposure conditions in the plant. Workers were categorized into quartiles of solvents cumulative exposure values. Standard SMR (local rates as reference) and Poisson regression methods (both internal and external) were used for effect estimation (controlling for age, calendar period, latency). The only statistically significant excess regarded cirrhosis of the liver in the second quartile of cumulative exposure (Obs=8, SMR=225). The only trend for increasing cumulative exposure to solvents was noted for bladder cancer (4 cases observed; statistically nonsignificant). Five cases of oesophagus cancer were observed vs. 2 expected, a clear but nonsignificant increase; no monotonic trend according to solvents exposure was visible. Cardiovascular mortality was lower than expected, whereas mortality owing to nonmalignant respiratory and digestive diseases showed a slight nonsignificant increase.

GLOMERULONEPHRITIS AND SOLVENT EXPOSURE: A CASE-CONTROL STUDY OF 298 BIOPSY PROVED CASES

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During the past fifteen years, twelve case-control studies on glomerulonephritis (GN) and solvent exposure have been published among which nine showed an excess risk among exposed subjects and three were negative. However, most of these studies have been criticized, mainly for their lack of specificity both in histological types and exposure assessment. This study was undertaken to confirm or not this excess of risk and to determine groups at risk.

A case-control study of 298 biopsy proved cases were carried out between 1989 and 1991 in five hospitals of the Paris area: 82 membranous GN, 100 nephrotic syndromes with focal and segmental glomerulosclerosis and hyalinosis or minimal change nephropathies (MCN) and 116 Berger's diseases were included. 298 controls were selected through hospitals admission lists and matched for age, sex, ethnic group and place of residence. Subjects were interviewed about social habits, medical and drug history and occupational history. For each job, a detailed list of tasks involving solvent exposure was systematically submitted to the subjects and accurate information was recorded concerning type of solvent, the handling and working conditions and the exposure time. Solvent exposure was assessed blindly by two experienced chemists/occupational hygienists and translated into level and frequency of exposure by chemical categories of solvents.

At least one exposure during working life to:	Controls N=298 % exposed	Risk (OR) of GN according to solvent exposure			
		All GN N=298	Membr- andous GN N=82	MCN N=100	Berger's disease N=116
- Halogenated solvent	12%	1.06	0.76	0.93	1.49
- Oxygenated solvent	19%	1.02	0.92	1.00	1.12
- Aliphatic or aromatic solvent	22%	1.02	0.80	1.06	0.93
- At least one solvent (95% CI)	31%	1.15 (0.81- 1.62)	0.84 (0.43- 1.64)	1.37 (0.76- 2.47)	1.22 (0.70- 2.11)
- At least one high or medium exposure level (95% CI)	16%	1.23 (0.81- 1.88)	0.92 (0.42- 2.02)	1.17 (0.54- 2.55)	1.57 (0.81- 3.06)

First analysis of the data did not show any statistically significant relationship between solvent exposure and GN. Highest exposed jobs such as painters, machineryfitters and mechanics or printers were not in excess among the cases (OR=0.72, 0.95, 0.79, respectively). Analysis by histological type of GN and by chemical family of solvents did not show any significant excess of risk either. Considering only high or medium exposures, the odds ratios slightly increased but none of them reached the statistical significance. Detailed analysis of the GN risk is necessary by sex, type of solvents, level, frequency, duration and period of exposures, before interpreting the results as definitely negative. This will be presented and discussed in comparison with exposures and histological types of GN considered in the literature.

LIVER AND KIDNEY FUNCTION IN HOUSE PAINTERS WITH LONG-TERM EXPOSURE TO ORGANIC SOLVENTS

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Cross-sectional studies of active workers have indicated an effect of organic solvent exposure on urinary albumin levels, serum bile acids, and rarely, on serum liver enzymes. The objective of this study was to determine if tests of liver and kidney damage were affected among house painters with long-term, previously heavy, solvent exposure.

The study group was selected from the painters and carpenters who had been members in their respective trade unions for at least 10 years before 1970 and who were born 1925 or later.

148 painters and 85 carpenter who had performed psychometric conscription tests were invited to a clinical examination, regardless of their current exposure status. 135 painters and 71 carpenters participated. Blood and urine samples were obtained in the morning after one nights fasting. Serum activities, or levels, of aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase (ALP), gamma-glutamyl transpeptidase (GGT), bilirubin, cholic acid, chenodeoxy cholic acid, and the fraction of total transferrin with isoelectric pint 5.7 were used as tests of liver function. Urinary albumin was used as an index of glomerular function.

The participants were interviewed concerning their solvent exposure and potential confounding factors (age, alcohol consumption, obesity, drugs affecting liver function). Cumulative solvent exposure, frequency of episodes feeling high, and the solvent exposure during the last year were considered as exposure estimates. The data was analyzed with multiple linear regression and logistic regression with the results adjusted for potential confounders.

There was a significant relationship between cumulative solvent exposure and ALP serum activities (p=0.03). There was no relationship between any exposure estimate and any of the other outcome variables.

The increasing ALP activities with increasing cumulative solvent exposure may indicate minor changes in liver function due to solvent exposure since ALP previously has been suggested a useful indicator of mild hepatic injury due to environmental agents. However, all other outcome variables were unaffected by solvent exposure and it seems that long-term, heavy exposure to paint solvents, in most workers, has a low potential to cause chronic liver damage or glomerular damage in the kidneys.

OCCUPATIONAL NOISE EXPOSURE AND NOISE-INDUCED HEARING LOSS: AN EPIDEMIOLOGICAL STUDY IN CHINA COAL MINES

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A cross-sectional study of noise-induced hearing loss in China coal mines is presented in this paper. 670 miners (exposure group, more than 5-year underground worklife length) and 102 controls (control group, non-miner) from three China coal mines were surveyed for clinical examination, audiogram tests and a standardized questionnaire concerning health, occupational history, smoking habits and alcohol intake. The average noise level is 98.5 dBA in coal mine underground and is less than 80 dBA in control workplaces. Using SAS program, the obtained data were analyzed by Liogest regression and the Stepwise regression. The results of analysis show that incidence rate of severe noise-induced hearing loss is markedly higher in coal miners, compared with controls (68.2% versus 17.4%). It is found that the severe noise-induced hearing loss is related with underground worklife length. There was significantly difference in hearing levels between two groups after age-adjusted (p < 0.001), especially at high frequencies (3000, 4000 and 6000 HZ). There was approximately 15 dBA difference in mean hearing levels at 500, 1000, and 2000 HZ (P < 0.01), and more than 25 dBA difference at 3000, 4000, 6000 and 8000 HZ (P < 0.001) between two groups. It suggested that change of hearing threshold at each frequencies has the relationship with duration of exposure to noise in coal mines. The findings reveal that noise exposure is one of severe occupational in China coal mines. It is necessary to perform medical survey of audiometric testing in China coal mines, and to set preventive measures including noise control and hearing protection in China coal mines.

PHYSICIAL AND MENTAL STRESSORS

WORK COMPLAINTS AND PHYSICAL WORKLOAD DURING PREGNANCY

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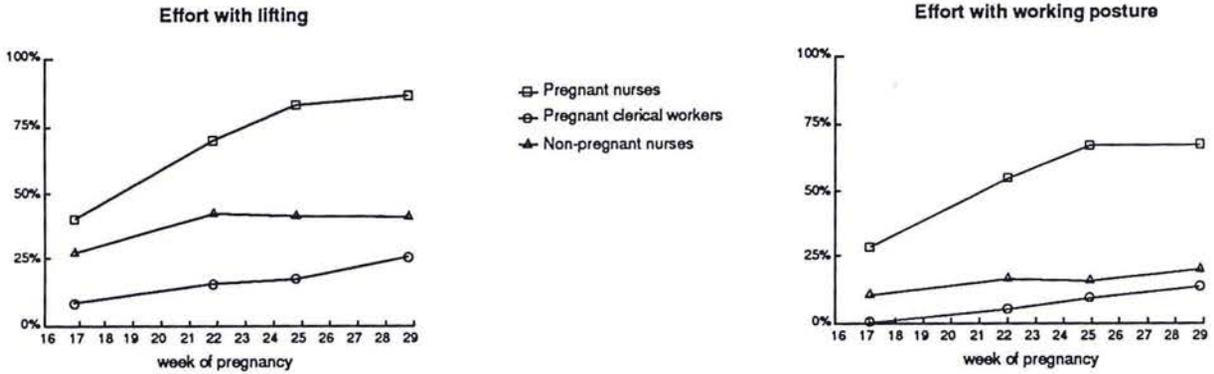
A five month follow-up study was conducted on a sample of 117 pregnant nurses, 122 non-pregnant nurses and 81 pregnant clerical workers. The relationship between physical workload during pregnancy and health effects, labour participation, complaints with work environment and pregnancy outcome was examined. From the 4th month of pregnancy until delivery each pregnant woman and at the same time each non-pregnant woman answered each month a questionnaire about health complaints and sickness leave. She also returned a list with number of minutes stooping/squatting and lifting during that day. By interviews with each woman and by observations of the work-place we got comprehensive data about workload, ergonomic working conditions and lifting weights.

The upper figures show the result after matching for age, working hours, number of children and educational level of two work complaints: lifting and working posture. The pregnant nurses had a significant (p<0.001) increase during their pregnancy for these two complaints: Lifting was at the end of pregnancy two times more difficult for them than for the non-pregnant nurses at that time and four times more than for the pregnant clerical workers. Complaints about working posture occurred to them four times more often than to the non-pregnant nurses and six times more often than to the pregnant clerical workers.

The lower figures present the number of employees in the group of pregnant nurses and in the group of pregnant clerical workers that changed their job tasks during pregnancy. At the 25th week of pregnancy one of three pregnant nurses were working as usual against three of four pregnant clerical workers (p<0.0001). At the 33th week of pregnancy significantly more pregnant nurses had stopped working all together. This suggests that the adaptations at the workplace normally obtained are not sufficient enough to prevent early withdrawal from labour.
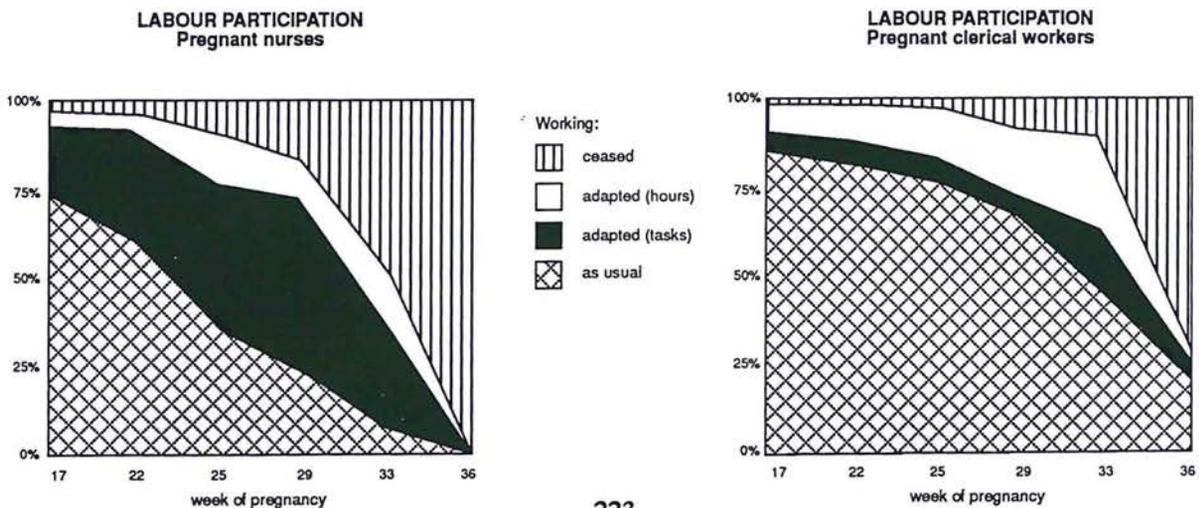
PSYCHOSOCIAL STRESSORS AT WORK AND MUSCULOSKELETAL PROBLEMS: A STUDY ON A REPRESENTATIVE SAMPLE OF THE DUTCH WORKING POPULATION

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It is widely accepted that psychosocial stressors can cause depressive symptoms and psychological dysfunctioning and that they may play an exacerbating role in cardiovascular pathology. It is, however, only recent that epidemiological research pays attention to the relationship between psychosocial stressors and musculoskeletal problems. A recent review* on this topic shows that studies on this relationship are very heterogeneous, both with respect to the independent variable and the outcome variable. No clear picture exists as to what are the causal psychosocial stressors, and how specific the relationship is with respect to the type of musculoskeletal problem: back pain or other musculoskeletal problem, chronic or acute effects and if non-work activities like sports participation confound the relationship.

In the present study, a cross-sectional analysis was performed on a representative sample of the Dutch working population, consisting of 7388 employees, who participated in a National Work and Living Condition Survey in the period of 1977 to 1986. In this survey structured interviews were conducted by the Central Bureau of Statistics. Information was gathered on the employees work (occupation and stressors), health and several personal characteristics(e.g. sex, age, sports participation).

A factor analysis on the stressors resulted in 3 independent factors: (1) work pace, (2) skill discretion (consisting of four variables: monotonous work, poor possibilities for personal development, poor fit between the actual work and education or experience level and poor promotion prospects) and (3) physical stressors (amongst which heavy physical work).

By way of multiple logistic regression the Odds Ratios were estimated from the regressions of the first two psychosocial stressors and of heavy physical work on different outcome measures: (chronic) back pain disorders, back pain complaints, musculoskeletal problems of the limbs or joints and psychological health. Age, sex and sports participation were studied as potentially confounding factors.

The regressions indicate that, independent of the confounders studied, psychosocial factors which are indicative of skill discretion are consistently associated with all types of musculoskeletal problems (Table 1; OR's of the confounders are not shown). Although the confounders are significantly related to almost all health problems, they do not affect the OR's of the stressors.

Table 1. Estimated Odds Ratios of work pace, skill discretion and heavy physical work on musculoskeletal problems and psychological health, adjusted for age, sex and sports participation the reference category is the group of subjects who report the stressor to be absent.

stressor	(chronic)	back pain	problems	psychological
work place	1.01	1.03	1.03	1.17
skill discretion	.71*	.76*	.79*	.75*
1 stressor	1.04	.96	.98	.96
2 stressors	1.11	1.13	1.09	1.12
3 stressors	1.85*	1.42*	1.60*	1.97*
4 stressors				
	1.30*	1.37*	1.33*	1.20*
heavy physical work				

* a p < .005

A CROSS-NATIONAL COMPARISON OF THE OPERATING CHARACTERISTICS OF JOB STRESS AND MENTAL HEALTH MEASURES BETWEEN JAPAN AND THE UNITED STATES

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The purpose of this research was to serve as a pilot study to validate research methodologies and the measures for a larger cross-national study on job stress between Japan and the U.S. The objective of the larger study will be to test various models of the role of job control in the relationship between job stressors and indicators of emotional and behavioral dysfunction after controlling for individual and psychosocial factors that also might play a role in the relationship. The samples for the pilot study were from Japanese-owned semiconductor factories located in the U.S. (n=184; males=81%; mean age=33 yrs) and in Japan (n=473; males=82%; mean age=30 yrs). The research follows closely the NIOSH model and guidelines for studying job stress. The measures include: job control (i.e., the NIOSH measure modified to reflect a sense of control at both an individual and collective level); other sources of job stress (i.e., quantitative job overload, job future ambiguity, under-utilization of abilities, job role ambiguity, and job/non-job role conflict); individual and psychosocial factors (e.g., sociodemographic factors, sense of mastery, centrality of one's job, social support, and life stress other than job); job characteristics (e.g., job status, environmental exposure, and type of shift work); and dependent measures of well-being and dysfunctional behavior (i.e., health conditions, sick days, use of medical care, alcohol and tobacco usage, life satisfaction including job, family and leisure satisfaction, depression, and anxiety). Detailed item analyses of all items in the questionnaire were performed which included cross-national comparisons of: missing data, response tendencies, and internal consistency reliability of composite indexes. Higher rates of missing data (i.e., about double) on a majority of the job stress and mental health measures were observed among the Japanese compared to the U.S. Workers. Inspection of individual items identified differences that may signal culturally sensitive items, e.g., on an item inquiring about "being a failure in life" in the depression scale, there was 16 times the rate of missing data among the Japanese compared to the U.S. workers. As to response tendencies, the data did not show that the Japanese tended to express emotional distress somatically as has been suggested in the literature. While the pattern of responses on the mental health measures were similar between the Japanese and U.S. Workers, there was a tendency among the Japanese to choose the exact midrange response choice on the items forming the job stress measures. The internal consistency reliability of the composite measures of job stress and mental health indicated that the measures tended to be somewhat more reliable among the U.S. workers. While many of differences on Cronbach's alpha were negligible, several of the scales showed differences of between 11 to 24 points. Measures of job future ambiguity, job overload, social support (boss/marital or live-in partner/and friend support), job satisfaction, and alcoholism were substantially less reliable among the Japanese compared to the U.S. workers.

HEARING THRESHOLD LEVELS IN A NIGERIAN IRON AND STEEL FACTORY: THE IMPACT OF NOISE

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A study of 132 male subjects exposed to various levels of continuous noise, ranging from 63 to 111dBA in an iron and steel factory was undertaken to assess:
i. how varying levels of noise impact on the hearing thresholds of subjects who work, without protection, 12 hours a day for 6 days a week
ii. the contribution of prior exposure to the hearing threshold

The study was conducted with the use of air-conductance audiometer. Audiograms were obtained for both ears but analysis was based on left ear audiograms. At every test frequency the production subjects had significantly (p 0.001) higher hearing thresholds than the non-production subjects. The production subgroup that had mean noise exposure of between 90 and 103dB had a significantly higher threshold at 4kHz than the subgroup with a mean exposure level of 85dB.

In the production group the hearing threshold was stable at about 30dB in the first decade of employment and increased by 1.62dB/year and 3.4dB/year for the next two half decades respectively. This rate of increase was markedly smaller than that (2.2-117dB per year) reported earlier for a demographically similar group exposed to textile factory noise of between 90 and 115dBA.

Prior noise exposure did not add to the hearing threshold of the production subjects. Rather, duration of employment alone accounted for 21.1 of the 25 percent variation in hearing threshold contributed by the regressed variables, age and duration of employment. The longer the Nigeria worker labours in the unregulated environment the more severe will be his health impairment and attendant consequence on production.

METALS

IMPACT OF UNLEADED GASOLINE REGULATION ON BLOOD LEAD LEVELS OF WORKERS IN MUFFLER SHOPS

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In 1986, a survey was conducted in 9 muffler shops employing 49 workers in order to evaluate their exposure to lead. Lead concentrations in the environment (air, fumes and dusts) as well as blood lead levels of workers were measured using standardized procedures. 77.6% of the workers (n=38) agreed to participate to the survey. Taking into account their potential of exposure, the workers were divided into two groups: installers (n=27) and non-installers (mechanics and administration n=11). The results showed that the mean blood lead level of the installers was significantly higher than that of the non-installers (36.4 $\pm$ 8.3 mcg/dl compared to 23.6 $\pm$ 7.3 mcg/dl for the non-installers; $p < 0.0001$). No difference in blood lead levels was recorded between smokers and nonsmokers, or between those who ate their lunch in the shop and those who did not. The major source of lead contamination in the environment was the oxyacetylene torch used to cut the exhaust systems of vehicles which burned leaded gasoline. The mean concentration of lead in the fumes was 163.0 mg/m^3 for leaded gasoline compared to 4.5 mg/m^3 for unleaded gasoline. During the fall of 1990, a second survey was conducted in the same shops. . 29 workers (25 installers and 4 non-installers) were surveyed. The participation rate of this second survey was 63.0%. The results showed that the mean blood lead level had dropped significantly ($p < 0.001$) to 15.6 $\pm$ 6.3 mcg/dl for the installers. For the non-installers, the mean blood lead level had dropped to 13.9 $\pm$ 6.3 mcg/dl ($p = 0.05$). 6 installers participated to both surveys. Their mean blood lead levels dropped from 40.7 $\pm$ 12.9 mcg/dl to 21.2 $\pm$ 9.9 mcg/dl. The difference was statistically significant ($p < 0.001$). The decrease in blood lead levels was attributed to the September 1990 regulation which banished leaded gasoline use.

Presented by Michel Rossignol

NASAL SEPTUM LESIONS CAUSED BY CHROMIUM EXPOSURE AMONG CHROMIUM ELECTROPLATING WORKERS

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One case of nasal septum perforation was found on a chromium electroplating worker who suffered from epistaxis during this work. To determine the etiology and prevalence of nasal septum lesions we conducted a survey of 7 chromium electroplating factories and examined 79 workers. 40 workers from 3 aluminum electroplating factories were also enrolled as the reference group. Every worker was thoroughly examined by an otorhinolaryngologist. A questionnaire interview regarding symptoms of upper respiratory tract, past medical history, life style, and work history was also conducted 118 out of 119 workers received blood tests of alanine aminotransferase (ALT, aspartate aminotransferase (AST), albumin/globulin (A/G) ratio, blood urea nitrogen (BUN), creatinine (Cr), urine test of n-acetyl--d-glucosaminindase (NAG), and venereal disease research laboratory test. Urine samples of these workers were taken at end-of-shift at end-of-workweek. Air chromium concentrations were measured by taking area sampling for 4-6 hours. Concentrations of urine chromium and air chromium were determined by graphite furnace atomic absorption spectrometry. After field observation and chromium measurements, we divided chromium electroplating into 3 different exposure zones: workers directly dealing with electroplating tanks (n=31), other processes workers (n=29), office workers and drivers (n=19). Among the 79 chromium electroplating workers, there were 16 cases with nasal septum perforation, 4 with scar formation, and 31 with ulceration. No worker from aluminum electroplating factories had any nasal septum abnormalities. Air and urine concentrations of chromium for the three exposure zones were 0.7-168.3 ug/m3 and 3.1-36.3 ug/gm creatinine, 0.5-39.7 ug/m3 and 0.7-6.4 ug/gm creatinine, 0.3-4.4 ug/m3 and 0.3-6.1 ug/gm creatinine respectively; while those of the reference group were 0.04-0.2 ug/m3 and 0.08-0.4 ug/gm creatinine. There were no statistical differences among different groups of workers for ALT, AST, A/G ratio, BUN, Cr, and urine NAG. All tests of VDRL were negative for all surveyed workers. There was a consistent trend between the degree of chromium exposure and signs and symptoms related to nose, throat, and skin. The severity of nasal septum lesions was associated with lifetime index of chromium exposures (air concentration x duration of work). We conclude that signs and symptoms of nasal septum among chromium electroplating workers were caused by the exposure of chromium, and immediate improvement of occupational hygiene should be started.

INCREASED LEAD ABSORPTION CAUSED BY WORKING NEXT TO A LEAD RECYCLING FACTORY

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Our series of studies found out that workers at a lead recycling plant in Taiwan suffered from lead poisoning. Air and soil outside the plant were seriously contaminated by lead. The objective of this study was to determine whether workers at a factory adjacent to the lead recycling plant were affected by lead contamination. 41 out of 45 workers of a forging factory next to the lead recycling plant were enrolled as the exposed group. A comparison group of 51 workers were selected from another forging factory about 20 km away. Each subject was interviewed regarding his life style, work history and residence, and was drawn blood for lead measurement by graphite furnace atomic absorption spectrometry. The results showed that the two groups were compatible for age, sex and smoking patterns. Blood lead of the exposed group was significantly higher than that of the comparison group (Mean $\pm$ SD:20.4 $\pm$ 9.4ug/dl vs. 5.9 $\pm$ 2.9ug/dl). The difference persisted after stratification control by sex and working zones. Blood lead levels were lower among exposed workers who were employed less than 2 months than those employed longer. There was no difference among exposed workers at different outdoor working zones. 5 months after the improvement of pollution control and decrease of production volume in the lead factory, 31 exposed workers were retested for blood lead. The blood lead of outdoor workers had an average decrease of 4.2 ug/dl while that of indoor workers showed no significant difference. We concluded that the changes of blood lead level among exposed workers were caused by lead contamination generated by its neighboring lead recycling plant.

POSTER PRESENTATIONS

"BACKGROUND" LEAD LEVELS IN CONSTRUCTION WORKERS

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Construction workers who demolish metal structure are at high risk for episodic lead exposure and overt poisoning, usually without chronic ongoing exposure. We screened construction workers not currently performing lead work at four union halls in Maryland, the only state which has a lead construction standard comparable to the OSHA lead standard for fixed industry. Two hundred sixty-four active or retired union members participated, including 198 ironworkers and 66 laborers. There were 262 men and 2 women, with a mean age of 43 years, ranging from 18-79 years. Whole blood lead levels were skewed towards lower levels, with a median of 7 mcg/dl, a mean of 8.0 mcg/dl, and a range of 0 to 30. Participants who had "ever" worked in demolition (N=125) had higher blood lead levels than those who had not (8.65 mcg/dl vs. 7.18 mcg/dl, p = .006). Those who had ever burned paint and metal and who had welded outdoors (N=79) had higher levels than those who had done none of these activities (N=48) 8.56 mcg/dl vs. 6.83 mcg/dl). Forty-nine workers had workplace lead monitoring performed; as a whole, they had higher lead levels (9.12 mcg/dl), but levels did not correlate with recalled results ("high", "normal", etc.). Ten workers had been told they were lead poisoned, with mean lead previously treated, lead levels were indistinguishable from the group as a whole (8.00 vs. 7.83 mcg/dl, p=.91). Lead levels did not correlate with age. Blacks (N=69) had higher lead levels than whites (N=187) (8.93 mcg/dl vs. 7.46 mcg/dl, p=0.15). Pack-years of cigarettes smoked correlated with lead levels (r=.17, p=.006), although cigar and pipe smoking did not. There were only two women enrolled, and their lead levels were 7 mcg/dl and 21 mcg/dl, giving them an average level higher than the men (14 mcg/dl vs. 7.8 mcg/dl, p=0.44). Lead levels increased with increased moonshine consumption, to a high of 10.2 mcg/dl among the 25 in the highest exposure category. Mean lead level decreased for those who had completed high school (N=157, lead level = 7.3 mcg/dl). Lead levels were also higher in those who had ever been struck by a bullet (N=32, lead level =9.25 mcg/dl).
Population differences in blood lead levels reflect past contributions of demolition work as well as other specific exposures.

ASBESTOS RELATED DISEASES IN CONSTRUCTION CARPENTERS

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A clinical survey was conducted in 632 workers from the International Brotherhood of Carpenters and Joiners union in eastern Massachusetts, during 1987-1988. Eighty percent worked mainly as carpenters and 9% as millwrights. Eleven percent worked in other construction trades. Chest radiographs, spirometry, and a modified ATS occupational respiratory questionnaire were obtained from each subject. Chest x-ray were interpreted according to the ILO International Classification of Radiograph of Pneumoconiosis. One hundred ninety-one (30.4%) had never smoked cigarettes, 199 (31.6%) were current smokers, and 239 (38%) were ex-smokers. Four hundred and fifty eight (72.5%) had no evidence of radiographic abnormalities, 43 (6.8%) had parenchymal abnormalities, and 67 (10.6%) had only pleural abnormalities. Most (97.5%) of the subjects reported having worked with asbestos-containing products (manufacture/use, replacement, or asbestos mining/milling). In addition, the carpenters were exposed to wood dust. Workers with parenchymal abnormalities had significant decreases in the percent predicted value for FVC; from 104.4 ± 12.5 to 95.7 ± 14.8, $p < 0.001$; and FEV_1; from 101.3 ± 14.6 to 86.4 ± 20.3, $p < 0.001$; when compared to workers with normal chest x-ray. On the other hand, those with only pleural abnormalities had no significant decrease in their percent predicted value for FVC, but they did have a significant decrease in the percent predicted value for FEV1; from 101.3 ± 14.6 to 94.8 ± 17.9, $p < 0.001$. Significant increases in the prevalences of both parenchymal ($p < 0.001$) and pleural abnormalities ($p < 0.005$) were found when comparing non-smokers to smokers. The results of this study show a relatively high prevalence of radiographic evidence of asbestos-related diseases. Workers with parenchymal abnormalities had significantly lower ventilatory function (FVC and FEV1) consistent with a restrictive pattern, while workers with pleural abnormalities only had significantly lower FEV1 consistent with obstructive pattern. Further analysis of relevant exposures and confounders for respiratory disease (e.g., asbestos and wood dust exposure, and smoking habits) is currently underway. Supported in part by ES-00002.

USES OF SURVEILLANCE DATA FOR IDENTIFYING TRENDS AND CLUSTERS IN OCCUPATIONAL INJURY RATES IN THE CONSTRUCTION INDUSTRY IN THE U.S., 1972-1991

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Occupational injury rates in the construction industry in the U.S. are among the highest of any industry. The U.S. Bureau of Labor Statistics maintains an injury surveillance system with an annual survey of a sample of employers. The object of this investigation is, based on these surveillance data, to describe lost workday and total non-fatal and fatal injury incidence rates in the construction industry by year and by three digit SIC codes for 20 subclasses of the industry and to determine whether there are significant differences by year and by SIC code.

We obtained estimates of annual injury incidence rates from the U.S. Bureau of Labor Statistics survey of employers with 11 or more employees for the years 1972-1991. We conducted a simple linear regression of incidence rates by years for each industry subclass. We also performed a one-way analysis of variance of incidence rates classified by SIC code to determine sources of variation in these rates.

Both fatal and nonfatal injury rates show a slight decline over this study period for the three major subdivisions (two digit SIC codes) of the industry with remarkably similar regression lines. Significant differences exist ($p < 0.05$) when incidence rates were classified by SIC code but not when classified by year. The highest non fatal injury incidence rate occurred in the roofing and sheet metal industry for all years examined. (SIC = 176).

These are crude incidence rates, unadjusted for the age and experience of the labor force, expansion or contraction of the industry, or employer size distribution, all of which are associated with injury incidence rates. It is possible that any association with these confounders is obscured. These surveillance data are useful for identifying trends and clusters of excess injury rates and suggest additional more intensive investigation of injury rates in this industry.

INEFFECTIVE MEDICAL SURVEILLANCE IN A STEEL FOUNDRY, CONNECTICUT, 1990-1991

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In October 1991, separate community sources reported two cases of lung disease among air arc operators in a Connecticut foundry to the Connecticut Department of Health Services. In 1979, the Centers for Disease Control had investigated the foundry, recognized undiagnosed silicosis cases, and recommended routine medical surveillance, which began in 1984. While investigating the two sentinel cases from 1991, we assessed the usefulness of this surveillance program for detecting occupational lung disease. Initially, we reviewed the most readily available surveillance data: annual screening chest radiographs (CXRs) for 1984-1986 and 1989-1990. An abnormal CXR was defined as one with lung parenchymal round and/or irregular opacities in any or all lung lobes with a profusion of 1/0 or greater by International Labour Office criteria. The incidence of workers with a newly abnormal screening CXR was < 5% for 1984-1986 and 1989 compared to 41.6% (32/75) in 1990. For 1990, workers $\geq$ 40 years old were at higher risk for abnormal CXRs than those aged < 40 years (52.4% [22/42] vs. 28.6% [10/35]; relative risk [RR]=1.8; 95% confidence interval [CI]=1.0-3.3; in addition, workers with $\geq$ 10 years of employment at the foundry were at higher risk than those with $\leq$ 10 years (60.6% [20/33] vs. 21.9% [7/32]; RR=2.8; 95% CI=1.4-5.6). The rate of abnormal CXRs was significantly higher for chippers/grinders than for all other workers (68.4% [13/19] vs. 35.2% [19/54]; RR=1.9; 95% CI=1.2-3.1] and was independent of age or duration of foundry employment. Ethnicity, smoking history, and history of respiratory disease were not associated with abnormal CXRs. The single index patient screened during this period had a normal CXR by our criteria. Summary data collected in the surveillance program had not been reviewed, analyzed, and reported prior to our investigation. The surveillance program failed to identify both the reported lung disease in the screened air arc operator and the increasing incidence of abnormal CXRs among chipper/grinders. Additional investigation is required to determine whether occupational lung disease exists among workers in this foundry.

OCCUPATIONAL IMPAIRMENT AND DISABILITY AMONG APPLICANTS FOR SOCIAL SECURITY DISABILITY BENEFITS IN PENNSYLVANIA

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Public health officials have used many data systems for occupational disease and injury surveillance purposes, including workers' compensation, sentinel provider, hospital discharge, pension and life insurance and other records. Each system provides information that contributes to an understanding of the burden of disease in a country that lacks an active surveillance system. For many workers with occupationally-related disorders, the federal Social Security Disability Insurance (SSDI) benefit program serves as an alternative or back-up benefit system to workers' compensation and is a potentially important data base for surveillance purposes. We studied a convenience sample of 240 SSDI applicants to the Pennsylvania Bureau of Disability Determination (BDD) to assess the extent of work-related disorders. We considered a case to have a work-related component if there was a clear statement of a workplace illness or injury associated with the impairment, or if the applicant had worked at an occupation with a high likelihood of exposures know or suspected to contribute to the condition of interest. Of the 240 applicants, 166 (69%) were awarded SSDI benefits; a total of 27 (11%) had work-related conditions. These included 14 of the 166 (8%) found to be disabled. Eleven of the 27 (40%) applicants had a disorder that was musculoskeletal in origin. The age distribution of our sample did not differ from the age distribution of a quality assurance sample done at the time of the study. However, the distribution of cases by organ system differed from the cancer cases and deficits of musculoskeletal and respiratory cases. Of the 59 disability applicants with cancer, we estimated that six (10.2%) had some work-related etiologic component. This proportion is consistent with other estimates of the annual incidence of work-related cancers. Our occupation was abstracted from a disability application form that does not elicit a full occupational history. When we extrapolated our results to an estimated 71,680 SSDI applicants in Pennsylvania in 1990 (excluding disabled children, psychiatric patients and widows) we projected 5,076 new SSDI beneficiaries with an occupationally-related disability. The study results indicate a substantial number of applicants for SSDI benefits are likely to be suffering from an impairment caused or exacerbated by prior workplace exposures. These findings have implications for surveillance, notification and follow-up purposes, including worksite evaluation, medical screening of similarly exposed workers and education of the employer and employees, and creating incentives for employers to reduce occupational risks.

NESTED CASE-CONTROL STUDY OF RECTAL CANCER IN AUTOMOTIVE WORKERS EXPOSED TO MACHINING FLUIDS

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Several studies have previously reported excesses of rectal cancer among workers exposed to machining fluids, agents used to cool and lubricate metals during machining and grinding operations. We have recently completed a large cohort mortality study of automotive workers in which we noted an association of exposure to one of the major types of machining fluids--straight oils--with rectal cancer risk. To investigate this finding further, a case-control study nested within the cohort was undertaken. In the case-control analysis, it was possible to make full use of the extensive exposure data that have been assembled, allowing control for other exposures and development of evidence implicating specific etiologic agents within the fluids. For each of the 57 deaths attributed to rectal cancer in the cohort, 20 controls were selected from subjects at risk of dying at the age of the death of the case, matched on year of birth (in 5-year categories), plant, gender, and race. Exposure data available for analysis included duration and intensity of exposure to each of the three major types of machining fluids (straight oils, soluble oils, and synthetic fluids) and duration of exposure to a number of additives and contaminants of machining fluids. In a conditional logistic regression model containing terms for all three of the major fluid types, a dose-response trend was evident for straight oils, with an odds ratio for the highest cumulative exposure category (exposure to more than 2.5 mg/m^3 - years) of 3.3 (95% confidence interval: 1.6-6.9). Models are currently being fitted that incorporate terms for specific components of straight oils, including PAHs, sulfur additives, chlorine additives, and certain metal contaminants. The case-control analysis provides strong evidence that exposure to straight oil is associated with risk of rectal cancer.

LUNG CANCER MORTALITY IN THE SWEDISH MINERAL WOOL PRODUCTION INDUSTRY-A FOLLOW UP STUDY

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Since 1938 Man-Made Vitrous Fibres (MMVF) have been produced in Sweden. Two rock wool plants and one fibre glass plant were investigated regarding cancer incidence and mortality as a part of a collaboration in a multi-national European cohort study of 24609 subjects, organized by IARC (International Agency for Research on Cancer), Lyon. The Swedish cohort, earlier followed up to 1982 has now been followed up to 1990.

Lung cancer incidence was followed 1958-1987 and mortality 1952-1990. Subjects not exposed to MMVF were executed from the cohort now comprising 3539 subjects identified by company records, and contributing 58229 person years of observation. The eligibility criteria was at least one year of employment fibrewith exposure since the start of MMVF production.

Historical MMVF exposure profiles were estimated for each individual from plant data using a model for historical exposure estimation based on a plant model of past MMMF exposure. Retrospective exposures to combustion gases and curing fumes were estimated on a job title level.

Lung cancer mortality subdivided by fibre type (expected number were based on national death rates):

Plant	Obs	1983-1990 SMR	95% CI	Obs	1952-1990 SMR	95% CI	Obs	30 ysfe[*] (1952-1990) SMR	95% CI
FG	6	140.0	(52-306)	14	119.7	(65-201)	8	204.1	(88-402)
RW	5	99.2	(32-232)	12	98.2	(51-172)	5	131.9	(43-308)
Total	11	118.2	(59-211)	26	109.0	(71-159)	13	169.0	(90-288)

RW Rock wool   FG=Fibre glass   [*]=years since first exposure

The number of observed cases of lung cancer was close to the expected number, based on national statistics. However, there was a tendency to an increased SMR for lung cancer after a latency of 30 years.

The mean cumulative MMFV exposure in the Swedish rock wool cohort was estimated to be 0.9 f/ml·year. There was no dose-response relationship for estimated MMVF exposure and lung cancer mortality. For the other exposures there were too few cases to draw any conclusions.

The number of lung cancer cases in the Swedish sub-cohort is relatively small. The large IARC study will probably allow more precise conclusions. So far this study supports the results from the last Swedish follow-up study with a slight excess risk for lung cancer after a latency of > 30ysfe.

CANCER IN WELDERS AND OTHER WORKERS IN A NORWEGIAN SHIPYARD

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This study is conducted to investigate a possible relation between exposure to welding fumes and cancer, especially lung cancer. 4.571 male shipyard workers, including 623 welders, were followed in a historical cohort study.

The workers had their first employment at the shipyard between January 1, 1940 and December 31, 1979. The incidence of cancer was observed from January 1953 through 1990. The mean length of follow-up was 24.0 years for the total cohort and 21.5 years for the welders. Loss to follow-up was 1.1%.

The shipyard was established in 1900 as a local service yard and expanded after World War II due to repair and rebuilding works. Shipbuilding on a larger scale began in the 1950's. Until 1977, when the yard started constructing for the offshore oil-industry, the welding was mainly performed on mild steel.

There were 408 cases of cancer in the total cohort vs. 361 cases expected based on the Norwegian national age adjusted rates for men. Among the welders 38 cases of cancer were observed vs. 26 expected. An increased incidence of lung cancer with 9 cases compared with 3.5 expected were observed among the welders.

Smoking and exposure to asbestos are possible confounders in this study. Smoking data from the work-force in 1984 showed more smokers among the workers as compared with the Norwegian male population. A difference in smoking habits are likely to account for a fraction of the elevated lung cancer rates. There were 4 cases of mesotheliomas in the cohort vs. 1.2 expected. Asbestos was used in the yard until the early 1970's. No cases were found among the welders (0.1 expected).

In the present study a cohort of shipyard workers including welders was followed for up to 50 years since first exposure. The results show a possible relationship between exposure to mild steel welding fumes and lung cancer; even when considering the effect of smoking and asbestos as confounders in the material.

A RETROSPECTIVE COHORT STUDY ON THE RELATIONSHIPS BETWEEN METHYLMERCURY EXPOSURE AND HEALTH INDICES OF THE INHABITANTS IN JAPAN

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There have been two outbreaks of methylmercury poisoning in Japan, caused by intake of fish and shellfish contaminated by methylmercury compounds discharged from chemical plants: the first case was found in 1965 in Minamata City, facing the Yatsushiro Sea, and therefore the disease was designated as Minamata Disease; the second outbreak was seen in 1965 along the Agano River in Niigata.

To clarify a dose-response relationship between methylmercury exposure and health indices of inhabitants, a retrospective cohort study was conducted. Hair was used for assessing the dose of methylmercury taken through the diet. The mercury concentration levels in the hair, collected from the subjects in Minamata (1960-1963) and Niigata (1965), were measured by a dithizone procedure.

Effects of the mercury levels on the mortality of the recognized patients in Minamata was examined by Cox's proportional hazards regression analysis adopting sex and age as covariates. The total number of subjects was 902, among which 178 died. Results indicate that the mortality rate increased with the mercury level. For example, among subjects with same sex and age, the relative risk of subjects with mercury level over 100 ppm to those with 5-20 ppm was estimated to be 1.3, which suggests that the exposure to methylmercury may have increased the risk of death.

Among the 1,191 subjects whose hair mercury concentration was determined in 1965 in Niigata, a total of 134 cases developed the typical symptom and officially diagnosed as Minamata Disease patients by the end of 1990. The results of dose-response analysis on this data indicated that the threshold dose is estimated to be 40 - 70 ppm by the hockey-stick model. It is also suggested that the dose-response may be modified by age at exposure.

EVALUATION OF THE HEALTH STATUS OF WORKERS EXPOSED TO ALYPHATIC AND AROMATIC HYDROCARBONS IN LIGNITS GASIFICATION

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The authors present the conclusions reached following medical examinations and certain standard investigations concerning the influence of alyphatic and aromatic hydrocarbons (AH, PAH) from the lignits gasifications on the health of the exposed workers.

The workplace monitoring reveals a high level of air pollution with PAH. Evaluation of the PAH exposure (marker: 3, 4 Benz/a/Pyren) was performed by the spectrofluorimetric method; mean yearly value of 3, 4 - B/a/P was 419.91 ± 9.32 ng/m^3. The AH air level in the workplaces was evidenced as three times higher compared to MAC.

The effects of exposure to AH and PAH on health are reported: respiratory, cardio-vascular and neurological. Chronic bronchitis was significantly higher in workers compared to population leaving around the investigated factory. There was also found cardiac troubles of ischemic, ritm and conductance type ($p < 0.05$). Health effects evidenced neurological disorders-sensitive polyneuropathy, significantly higher in workers exposed to AH and PAH. As long term effects on health, PAH-exposure could be responsible for carcinogenic risk in workers. The carcinogenic risk factors in workers and in non-occupational population of polluted area were evaluated with a comparative scar method.

There was also studied the morbidity prevalence of workers exposed to AH and PAH. The causes of morbidity were coded according to the International Classification of Disease. Disease of Respiratory system, Heart diseases and Diseases of Nervous system were placed within the seven first picks of morbidity. There were no morbidity events for cancer of the respiratory system.

OCCUPATIONAL ASTHMA IN HARD CHROME ELECTROPLATERS

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This Paper is designed to find the prevalence of occupational asthma in hard chrome plating, and is a cross-sectional study of symptoms and lung function in a hard chrome electroplating factory where there have already been two confirmed cases of occupational asthma. 49 workers comprised the Study Population, randomly selected, out of a total of 70 workers, and these 49 workers were divided into two groups: Group 1-23 hard chrome male workers, and Group 2-22 other male workers, who were to act as controls.

Investigation included administration of a modified Medical Research Council respiratory questionnaire, a dry wedge spirometer followed by serial peak flow measurements, skin tests, urinary chrome measurements, and static and personal dust sampling.

RESULTS: Number of workers with symptoms

	Group 1	Group 2	95% Confidence Intervals
Wheeze	6	8	(-0.229 to 0.285)
Cough	5	6	(-0.247 to 0.220)
Dyspnoea	1	14	(0.546 to 0.136) * $p < 0.05$
Skin irritation (itch)	8	9	(-0.0265 to 0.269)
Rhinitis	6	6	(-0.212 to 0.272)
Lung Function Results (mean % predicted)			
FEV1	99.5	95.8	(-4.50 to 11.9)
FVC	106.9	105.2	(-6.97 to 10.4)
FEF 25/75	71.4	76.8	(-19.5 to 8.7)
Peak Flow	94.9	90.8	(-10.7 to 18.9)
Urinary Chrome	17.9	9.9	(-3.05 to 19.1)
(nmol/mmol creatinine - mean levels)	0.0066	0.0027	(-0.000113 to -0.00769)
Air Chrome/mean levels			
(MEL/Chromium VI 0.05 mg/m³)			

Subsequent to the aforementioned results, the interpretation of serial peak expiratory flow (PEF) records is as follows: Only 40 workers were studied, of which there were 3 cases of asthma in Group 1 with 2 being occupational, and in Group 2 there were 7 cases of asthma, of which 4 were occupational. This therefore is the nub of the survey, where 10 out of 40 workers (25%) had asthma, 15% being work-related.

Despite Groups 1 and 2 having significantly different exposures to chrome based on urinary chrome levels, no statistically significant increase in symptoms or decrease in lung function could be found between the Groups, and in fact the control group has significantly more dyspnoeic workers, $p < 0.05$ (95%).

Confounding factors could include: (a) smoking - 11 smokers in Group 1 and 22 smokers in Group 2. (b) good control of air levels of Chromium VI. (c) ingestion of chromic acid dust, rather than inhalation of fume. (d) a healthy worker effect. (e) the small numbers studied.

GLUTATHIONE-S-TRANSFERASE MU PHENOTYPE AND GENOTYPE IN WORKERS WITH ASBESTOS-RELATED LUNG DISEASE

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While asbestos-related disorders are among the most well-studied occupational diseases, little is known about factors which affect individual susceptibility to these conditions. A considerable recent literature has implicated the production of oxygen-free radicals in the pathogenesis of asbestos-related diseases. Several workers have recently proposed that the ability of asbestos minerals to induce fibrogenic lung disease is mediated by their known ability to catalyze a Fenton-type reaction, producing cytotoxic and genotoxic electrophilic compounds.

Many of these electrophilic products of free radical generation could either interact with Phase I metabolic reactions or be detoxified by Phase II enzymatic conjugation reactions. Hydroxyalkenes, for example, are major products of lipid peroxidation and their efficient detoxification by glutathione-S-transferase is likely essential for normal cellular survival. The induction of significant radical formation by asbestos would, hence, be expected to be accompanied by increased activity of catalyzed conjugation of glutathione to potentially toxic electrophilic compounds like the hydroxyalkenes. To investigate whether the known genetic polymorphism in glutathione-S-transferase mu (GST-1) is associated with susceptibility to the induction of asbestos-related lung disease, we studied 77 workers with either asbestos-related pleural disease, (N=40), asbestosis (N=37), or both. We measured GST-mu activity phenotypically in 48 individuals using tritiated trans-stilbene oxide as a substrate. All of the subjects were genotyped using established PCR-based techniques. There was an excellent correlation between phenotype and genotype with only one discrepancy. The prevalence of GST-1 deleted genotype in individuals with asbestos-related disease was 57%. In controls, the prevalence is 47%. Analysis controlling for duration of exposure and type of asbestos-related disease revealed a non-significant trend toward an over-representation of GST-1 deleted genotype in those with asbestos-induced disease. Smoking, age and other lifestyle factors had no significant effect on this analysis.

ASSESSING EFFECT OF EXPOSURE TO DUST ON LUNG FUNCTION IN CHINA COAL MINES

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In this paper, the results are presented from a cross-sectional epidemiological study for assessing the situation of occupational lung impairment and giving more epidemiological evidence to the relationship between lung function change and exposure to dust in China coal mines. 2925 miners (observed group) with 5-year underground worklife length and 803 controls (control group) who are never exposed to dust or had worked underground for less than 2 years and left for more than 5 years were surveyed for the lung function tests including FVC, FEV_1, FEV_1/FVC %, $FEF_{25-75\%}$, $FEF_{75-85\%}$, V_{75}, V_{50}, V_{25}, MTT, MTT_p, RV and RT. More, the data concerning respiratory symptoms, occupation history and smoking habits were obtained by a standardized questionnaire. Using SAS program, the obtained materials were analyzed by the covariance analysis and the stepwise regression. The results reveal that exposure to coal mine dusts can result in a severe impairment of lung function, that the incidence of lung function abnormality is 45.23% in observed group in compared with 12.2% in control group ($p < 0.001$), that all measurements of lung function tests are markedly lower in observed group than in control group ($P < 0.001$), and that the lung function change is inversely related with underground worklife length. Additionally, the stepwise regression equations are got to forecast lung function impairment for China coal miners based on underground worklife length. The authors suggested that lung function tests should be included in medical surveillance for China coal miners. The lung function tests are important and necessary for assessing the dust occupational hazard and for determining the disability of Coal Workers' Pneumoconiosis.

RELATIONSHIP BETWEEN BIRTHWEIGHT AND OCCUPATIONAL EXPOSURE TO CYTOSTATIC DRUGS DURING PREGNANCY

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Objectives: The study we carried out aimed at comparing the outcomes of pregnancies between one group of nurses who handled cytostatic drugs during and/or before pregnancy and one group who did not. Results presented here concern birthweight of the babies.

Method: The study was performed in four French hospitals. Departments involved in cancer chemotherapy were selected if each nurse prepared at least 10 perfusions a week. Control units involved departments in which no such perfusions were used. All the female daytime staff, up to 45 years, were asked to participate. Data on previous pregnancies and occupational exposure to cytostatic drug at the time of the study and in previous departments were obtained by interview.

Results: The present results concern the 420 single live births on the 534 pregnancies described by the 466 nurses who agreed to participate (response rate = 87%). Mean birthweight for the 413 babies whose data on birthweight were available was 3265 ± 483 g. Among the 405 pregnancies for whom data enabled us to determine cytostatic exposure, 90 were exposed before and during pregnancy, 17 were before only, and 298 were not. Using a model of multiple regression that included gestational age, Body Mass Index (BMI), age of the mother at birth, parity, sex of the baby and cigarette consumption, we tested the relationship between birthweight and cytostatic exposure. Results did not display any significant relationship between birthweight and cytostatic exposure.

Relationship between birthweight and selected variables adjusted for the different risk factors considered simultaneously[*]

Risk Factors (N=384)	Estimate βi*	95% CI of βi
Gestational age (weeks)	131.4	97.4 to 165.3
(Gestational age)^2	-22.1	-33.7 to -10.5
(Gestational age)^3	-2.8	5.5 to -0.1
BMI (kg/cm^2)x 10^{-4}	3.5	-7.4 to 14.4
Age of the mother at the baby's	3.6	-7.9 to 15.1
birth (years)		-240.8 to 25.4
Smoking during pregnancy	-107.7	23.4 to 145.5
Parity	84.5	-216.8 to -51.9
Sex of the baby[**]	-134.3	-155.1 to 43.1
Cytostatic exposure	-56.0	

[*]Slopes are given in g/unit of risk factors; [**] 1=male, 2=female

Conclusion: This study does not show any statistically significant relationship between the handling of cytostatic drugs during and/or before pregnancy and birthweight, at the observed level of exposure of 18 perfusions/week/nurse on the average. Although this result does not seem to be explained, either by confounding factors or selection bias, we believe that further investigation are needed before finally concluding that handling of cytostatic drugs during and/or pregnancy does not have any effect on fetal growth. On the other hand, we previously found that this level of exposure resulted in a frequency of spontaneous abortion twice as high for the exposed as for the non exposed pregnancies (Stücker 1990), a result which argues in favor of a reduction of the exposure level.

ANNUAL INCIDENCE AND RISK FACTORS OF NEEDLE-STICK INJURIES AMONG NURSES IN A UNIVERSITY HOSPITAL

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The objective of this study was to determine the annual incidence rate and risk factors of needle stick injuries among nurses. In May of 1991, 998 nurses of a university hospital were asked to fill out a structured questionnaire regarding the annual frequencies and mechanisms of their needle stick injuries. 863 (86.5%) responded, and a random sample of 85 of them were asked to refill the same questionnaire. The reliability calculated by Kappa value was 66.7%. The results showed that the annual incidence rate of needle stick injuries was 75.2% in the previous year. If only considering contaminated needles, there were 44.4% during the previous year. The annual incidence rates of needle stick were higher during the preparation of medication (59.8%), cardiopulmonary resuscitation (34.9%), and cleaning the table (33.5%); while mechanisms of such injuries showed that 58.6% happened during the recapping of needles, 36.5% happened during the removing of needles. Only 17 nurses with needle stick injuries went for HBIG (hepatitis-B immune globulin) injection. We concluded that the needle and its cap need to be redesigned to avoid such injuries, and that nurses should be provided with adequate education and training to prevent adverse effects from needle sticks.

THE EFFECT OF WORK-RELATED PSYCHOSOCIAL STRESSORS ON MUSCULOSKELETAL COMPLAINTS OF FEMALE HEALTH CARE EMPLOYEES

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It is widely recognized that musculoskeletal disorders of employees may be caused by a large variety of factors, of which physical work load, non-work activities and constitutional aspects of the employee (age, sex, physical condition) are the most accepted. The impact of work-related psychosocial stressors on musculoskeletal problems, however, has not received much attention in epidemiological research. To elucidate this relation a study was carried out among employees of 34 health care institutions in the Netherlands.

Information on the employees of four types of institutions (8 general hospitals, 7 mental hospitals, 5 homes for mentally retarded and 14 nursing homes) was available with respect to their age, length of working week, level of education and as to whether they worked in shifts or not. Also, the employees completed a questionnaire with questions (with dichotomous answer-categories: yes v. no) on their work and health. Two questions were used to operationalize Physical Work Load: do you often have to work standing-up for a prolonged period? do you often have to walk during your work for a prolonged period? There were four questions included on (psychosocial) Job Demands. Two examples are: Are you working regularly under time pressure? Is there a shortage of personnel in your department? Finally, there were seven questions asked on Job Autonomy; for example. Do you have work with sufficient autonomy? Are you sufficiently informed about what is going on in your institution? Does management consider your opinions? For the dependent variable, Musculoskeletal Complaints, two questions were combined in a sum-score: do you regularly have low backpain? do you regularly have complaints about your legs and/or feet? The correlations among the questions within these clusters were relatively high. To get a more powerful design, in the regression analyses not the separate questions, but the four clusters of added questions were used, next to the four personal/demographic variables. To exclude the influence of sex and profession, the analyses were carried out separately for the five largest professional groups of female employees (nurses, nursing aides, household personnel, kitchen personnel and ergotherapists). The results of the multiple linear regression analyses per professional group - with Musculoskeletal Complaints as the dependent factor - are shown below in beta's (standardized regression coefficients; * = p <.05 and ** = p<.01).

	Nurses (n=1044)	Nursing aides (n=534)	Household personnel (n=252)	Kitchen personnel (n=170)	Ergo therapists (n=194)
Age	.01	.00	.09	.21**	.11
Length working week	.8**	.02	.06	-.06	-.04
Level of education	-.04	-.03	-.07	-.02	.12
Shift work	.00	.04	-.13*	-.04	.10
Physical work load	.24**	.12**	.13*	.18**	.20**
Job demands	.10**	.19**	.18**	.18*	.17*
Job autonomy	-.09**	-.14**	-.17**	-.16*	-.10
Multiple R	.32	.32	.40	.40	.38

The results clearly showed that Physical Work Load and psychosocial Job Demands in all five samples have a significant impact on Musculoskeletal Complaints of female health care workers. In addition, it is shown that a high level of Job Autonomy has a lowering effect on Musculoskeletal Complaints. Some theoretical explanations of the relations will be suggested.

A HIERARCHICAL CODING SYSTEM FOR CHEMICALS AND OTHER OCCUPATIONAL EXPOSURES

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As part of a research program aimed at identifying occupational cancer risk factors and workplace carcinogens, we are developing a job exposure matrix (JEM) for the main industries of British Columbia. An important consideration in the establishment of a JEM is the coding of occupational exposure. Specifically, the coding method should be systematic and permit analysis of highly specific compounds, similar classes or broad groups of compounds. Since such a system is not available, we have developed a comprehensive, hierarchical approach to the coding of chemicals found in the occupational environment. Each substance is categorized by its chemical nature, subclassified and chemicals in such a manner offers two major advantages; 1) information concerning a substance's structure, properties and chemical family affiliations can be readily retrieved; 2) classes of similar compounds may be grouped for analysis. For example, a list of nitrogen-containing compounds could be initially classified into broad categories (eg. inorganic versus organic) and then further subdivided into classes of agents (eg. inorganic nitrates, organic aliphatic amines versus aromatic amines).

Ten digits are used to classify substances according to their structures, chemical and physical natures. The first digit denotes chemical nature, differentiating between: simple inorganic substances; complex inorganic salts; organic compounds; inorganic/organic substances (eg. organometallics); complex mixtures (a comprehensive categorization of trade name products and industrial chemical formulations); physical hazards; and biological agents (includes biomolecules, organisms and pharmaceuticals). The significance of digits 2 through 2 differs depending on chemical nature. For inorganic, organic and inorganic/organic combinations, digits 2-9 are determined using the nomenclature rules of the International Union of Pure and Applied Chemists. Digits 2-9 for complex mixtures and physical hazards are assigned based on physical properties and methods of industrial use. Codes for biological substances are dependent on biological classification and biological origin and are determined using the nomenclature rules of the International Union of Biochemistry. The tenth digit identifies the physical nature of a substance.

This coding system is unique in that it is hierarchical, enabling codes to be analyzed on a variety of levels, and it codes substances in a manner reflecting their structural relationships and chemical families. Although our coding system was primarily developed to assist in the identification of potential carcinogens in occupational studies using JEMs, it has wider applications; specifically, it could be used by industry to comprehensively catalogue chemicals and to facilitate monitoring of health hazards in the occupational environment.

JOB EXPOSURE PROFILES: A SYSTEM FOR MANAGING EXPOSURE INFORMATION FOR EPIDEMIOLOGIC STUDIES AND SURVEILLANCE

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Assessing exposures in industry-based epidemiologic studies often requires the collection of large amounts of data. These data are in a variety of formats and often cover multiple departments and jobs so that organization of these data in a system to allow easy reference when assessing exposures can be somewhat difficult. In addition, investigators often do not identify what information was known and what information was assumed when estimating exposure levels, creating the industrial hygienist's "black box". We are conducting an epidemiologic study of 27,000 workers exposed to acrylonitrile since the 1950's in eight worksites. In this study, 270,000 job entries were abstracted from the work history records and collapsed into 150 to 600 jobs in each of the plants in the study for a total of about 3000 job titles. Exposure information was collected from the employers and from other sources by interviewing long-term workers, taking walk-through surveys of the facilities, conducting air monitoring of about ten jobs over a week's period and collecting historical records. Over 400 pages of documents per plant were collected and, in addition, over 15,000 monitoring results were obtained which had been collected by the companies since the 1960's. To handwrite out all of the information describing the exposure characteristics and idiosyncracies of each job was determined to be impractical, so an interactive computerized program was developed which files all the exposure information by job title. In this system, the 3000 job titles were incorporated into a data base. The user then entered information for 17 exposure variables, e.g., process description, frequency of exposure, use of personal protective equipment, etc. which describes the exposure environment experienced by each particular job throughout the duration of the manufacturing process under study. Identification was made as to where the information could be found in the collected documents or, if the information was based on judgement, what the basis of that judgement was. Various reports were developed which summarized the entered information. This data management system is described. This electronic data base allowed easy reference to all the exposure information available on each job. The uniqueness of this system is that the data are fed into a second program, which when linked to the air monitoring results available on each job, can be used to estimate historical exposures. The system, therefore, also provided documentation as to what information was available to the industrial hygienist when assessing exposures. The system can be used for other retrospective epidemiologic studies, for prospective studies or for hazard and/or medical surveillance systems.

THE SEMICONDUCTOR HEALTH STUDY: AN OVERVIEW OF THE EXPOSURE ASSESSMENT STRATEGY

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The Semiconductor Health Study included three component epidemiologic investigations of adverse health effects that may be associated with working in silicon based wafer fabricating clean rooms. The study was conducted at 14 companies across the U.S. The exposure assessment for these studies was complicated by several factors: chemical exposures are quite low by normal occupational standards; exposure assessment also needed to consider many physical and ergonomic exposures in semiconductor manufacturing, the industry is rapidly changing and over 50 highly variable fabrication rooms had to be evaluated, and there was no specific a-priori agent identified for adverse reproductive effects Three levels of exposure assessment, of increasing specificity, were developed. The simplest categorization was based on whether or not a subject worked in the fabrication rooms for a minimum period of time. A better separation of qualitatively different exposures was based on an analysis of the work structure, which led to assigning subjects to work groups, which were formulated as a part of this research. Finally, potential exposure to several chemical and physical agents and ergonomic stressors were estimated based on the tasks each subject performed. Questionnaires to evaluate exposures were developed and administered to each subject. These included questions about job description as well as the tasks performed. Site visits were made to each of the 50 fabrication rooms by study industrial hygienists, who used a standardized notebook to collect data on work structure and stability, process equipment, chemicals used, and work practices or engineering controls which might increase or decrease exposure. A limited number of measurements, for magnetic fields, fluoride, and solvents, were made for each fab as well. Based on an analysis of the work structure at each of the 50 fabs, a study wide definition of 8 work groups was developed. Subjects were assigned to work groups based on a four tiered evaluation of their questionnaire responses. Potential exposure scores were developed from which subjects were classified into 3 or 4 exposure categories. The scores were generated from algorithms which combined each individual's questionnaire responses with fabrication room specific information gathered by study industrial hygienists. The fab status of each subject was determined, a work group assigned, and a category of exposure to each of approximately a dozen chemical agents calculated. These three levels of exposure assessment thus provided classification with large numbers in each category (with fab/non-fab having the maximum power) and as well as two levels of specificity: work groups, which included sets of exposures common to most members, and agent analyses, which were most specific.

ASSESSING JOINT EFFECTS OF MULTIPLE TIME-DEPENDENT EXPOSURES

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The U.S. historical cohort of man-made vitreous fiber (MMVF) production workers includes employees at one or more of eleven plants which produced fibrous glass filament and/or fibrous glass wool. As part of the current update on this cohort sponsored by the Thermal Insulation Manufacturer's Association, exposure data for several agents (asbestos, asphalt, formaldehyde, phenolics, polycyclic aromatic hydrocarbon compounds and silica) are being obtained in addition to quantitative fiber measurements. Several statistical considerations arise in the formulation of risk models involving correlated time-dependent exposures in multiple plants. These include characterizing the multi-exposure environment in a manner that is relevant to the analysis, accounting for plant effects either as confounders or as exposures of interest, and assessing model stability. An important aspect of model stability is the extent to which collinearities in the data may degrade parameter estimation. Simple methods of assessing correlations among variables are inadequate in the typical occupational setting because they neither identify the contributions of individual variables to a collinearity nor assess the impact of a collinearity on parameter estimation.

A collinearity diagnostic without these shortcomings has been proposed by Belsley, Kuh and Welsch (1980) for multiple linear regression, and has been extended by Weissfeld (1989) to relative risk regression models. This diagnostic, based on the singular value decomposition of the variance-covariance matrix of the parameter estimates, provides a measure of the numerical stability of the estimates. In the setting of multiple time-dependent covariates, the diagnostic can be applied to identify those exposures and combinations of exposures whose effects can be well-estimated within a plant. Because the exposures occur at various levels in various combinations in different plants, this approach is generalized to identify constellations of exposure effects that can be distinguished statistically from more general plant effects.

These methods are illustrated using preliminary exposure data for four of the fiberglass plants in the updated MMVF study. This paper outlines our exploratory analysis of the new exposure data, focusing on the identification of problematic near-dependencies among the exposure variables.

A JOB EXPOSURE MATRIX FOR IDENTIFICATION OF POTENTIAL EXPOSURES IN OCCUPATIONAL SETTINGS

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In studying occupational health, a knowledge of occupation-specific exposures is useful. Because exposures vary for occupations and industries, several approaches have been used to identify occupation-specific exposure information. Direct quantitative exposure measurements, if available, have been used. However, many studies of mortality or morbidity are conducted by using vital statistics or other record systems where the only exposure data recorded are the decedent's or respondent's occupation or industry. For analysis of such studies, a classification system or matrix linking industry, occupation, and exposure would be useful. A job exposure matrix has been developed based on data collected during the 1981-1983 National Occupational Exposure Survey (NOES). Potential exposures to 14,000 chemical, physical, or biological agents observed across 377 occupations and 521 industries were recorded in the NOES if certain minimum guidelines for exposure were met. The survey sample was representative of all U.S. non-agricultural businesses covered under the OSHAct and employing eight or more employees. Potential exposure data collected during the NOES is cross-classified by industry and occupation in the job exposure matrix. Data on the number of employees observed to be potentially exposed to the agent, the number of employees exposed full time, presence of engineering controls over exposure, and presence of the agent in a trade-named product are included in the job exposure matrix. Data is included for each agent observed in each industry and occupation classification in the NOES. All data is given by gender and by size of facility from which it was collected: small (8-99 employees), medium (100-499 employees), or large (500 or more employees). Data included in the job exposure matrix are based on field observations. Other sources of exposure information, such as the literature or panels of chemists or industrial hygienists, were not used.

The job exposure matrix may be used to profile potential exposures to specific agents in occupational settings. For example, occupational settings where potential exposure to inorganic lead or metal ore occurs may be determined. Using the matrix, more than 50 employees in each of 53 occupations across 73 industries had potential exposure to inorganic lead or metal ore. All assemblers engaged in manufacturing wire telephone and telegraph equipment (1903 observed) were found to be potentially exposed, while less than 1% of assemblers engaged in manufacturing motor vehicles and passenger car bodies (87 observed) were potentially exposed. Seventy-seven percent of the telephone equipment assemblers (1459 observed) were females, while none of the motor vehicle assemblers were. Potential exposure data from the job exposure matrix may be used to determine occupational groups for studies of exposure. Such data may also be used for an objective measure of exposure in occupational health research studies.

MISCLASSIFICATION OF A POLYCHOTOMOUS EXPOSURE VARIABLE, ADJUSTING FOR MULTIPLE CONFOUNDERS

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Many occupational epidemiology studies are carried out under the assumption that the amount of exposure to an agent of interest is known without error. However, such information is often not available, and some other easily measured datum is used as a surrogate for the exposure level. The effects of the resulting misclassification on estimates of relative risk are described in a rich literature when the exposure variable is dichotomous; very little is known about the case involving multiple exposure levels. In this paper we examine the problem of estimating the true relative risk in the context of an imprecisely measured polychotomous exposure variable, simultaneously adjusting for an arbitrary number of confounding or nuisance variables. Our results show that unlike the dichotomous case, misclassification of a polychotomous exposure variable may introduce bias of the estimated risk away from the null value. The true relative risks may be obtained as the solution to a set of simultaneous linear equations involving the observed relative risks and a matrix of (possibly unknown) misclassification probabilities.

EVALUATION OF METHODS TO CONTROL THE HEALTHY WORKER SURVIVOR EFFECT: AN EXAMPLE USING ARSENIC EXPOSURE AND RESPIRATORY CANCER

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The healthy worker survivor effect (HWSE) is a component of the healthy worker effect whereby those individuals who remain employed are healthier than those individuals who leave employment. The HWSE attenuates any true effect of an occupational exposure. In a reanalysis of an occupational cohort from Tacoma, Washington (N=2802), Poisson regression, using the lowest dose category as an internal referent, was used to derive rate ratios (RR) in a reanalysis of arsenic exposure and respiratory cancer. This paper compares results from an unadjusted analysis with results obtained using each of four methods, and from a combination of these methods, to control the HWSE.

From the lowest to the highest dose category, the "unadjusted" RR's were 1.3, 1.4, 1.5, 1.7, and 2.2. Lagging cumulative exposure demonstrated greater RR's at each does category than an unlagged analysis. For example, at a 5 year lag the RR's by increasing dose categories were 1.5, 1.9, 1.7, 2.1, 2.8 and at a 15 year lag the RR's were 1.7, 1.8, 2.0, 2.6, 3.2. Restriction to those employees who survived at least 5 years demonstrated results similar to an unrestricted analysis; the RR's were 1.3, 1.2, 1.5, 1.5, and 2.1. However, a 15 year restriction period demonstrated greater RR's at each dose category; the RR's were 1.9, 2.0, 2.6, 2.3, and 2.8. A third method incorporates a covariate representing work status: (Currently employed versus retired or otherwise not employed). Inclusion of work status yielded a higher RR than its exclusion. Without work status, the RR's were identical to the unadjusted analysis; with work status, the RR's were 1.3, 1.5, 1.7, 2.0, and 2.6. The combination of lagging exposure and including work status resulted in RR's of even greater magnitude. For example, including work status with a 15 year lag resulted in RR's of 1.7, 1.8, 2.0, 2.7, and 3.2. A fourth method, Robins' G-Null estimation procedure is operationally different. The G-Null method uses a matched, nested case-control strategy to run multiple "clinical trials." With the lowest dose as an internal referent, odds ratios (OR) are calculated for the other exposure levels. However, these exposure levels are not comparable to those of the previous methods as exposure is not considered in a cumulative or average manner. From lowest to highest exposure category, the G-Null algorithm produced OR's of 1.2, 1.5, 2.3, 1.5, and 3.3. The results were similar when exposure was lagged at 5 and 10 years.

To some extent, each method was successful in controlling the HWSE. However, restricting the cohort reduces the generalizability of the results in addition to the loss of information. Lagging exposure imposes a latency period on the exposure-response relationship. The inclusion of a work status covariate considers an employee's off-work and on-work time to be independent of each other. The G-Null method has two important advantages: one, exposure is not a function of follow-up time; two, the off-work experiences of an employee are not independent of past exposures.

The general shape of the dose-response curve was similar for all methods with a relatively greater increase in risk at the lower levels of exposures. The inclusion of a covariate for work status resulted in larger risk estimates than the lagged or restricted analyses; the shape was also modified with an indication of a greater increase in risk at higher exposure levels than when the covariate was excluded. As the G-Null method handles exposure in a different manner, its results are not directly comparable. From the G-Null analyses, the overall shape of the dose-response curve was similar to the other methods; however, these results implied an even greater risk at lower levels of exposure. Lagging the G-Null analysis did not alter these findings; this agrees with a current hypothesis that arsenic is a late-stage carcinogen. The assumptions underlying each method need to be considered in their application.

INTERVENTION IN OCCUPATIONAL MEDICINE AS BASED ON INDIVIDUAL A PRIORI DISEASE RISK

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There is ample evidence that work-related exposure result in numerous disease cases and that it contributes to a great number of other cases. Exposure at work is rarely the only cause of an illness, though, with some exceptions, e.g. mesotheliomas among asbestos-exposed subjects for whom asbestos exposure generally contributes 50-90% of all new mesotheliomas. Epidemiologists who commit themselves to causalities between work-related exposure and disease are generally less preoccupied with using this knowledge in actual prevention of such illnesses.

The purpose of this presentation is to address the question of whether it is possible to use the currently available knowledge on causal relations between work-exposure and disease to prevent the diseases that otherwise would occur in the population at risk.

Individual disease risk is determined by those host and environmental factors which characterize the subject. The term "risk" may be used for the experienced (a posteriori) risk, as well as for projected (a priori) risk. Disease risk is frequently affected by interaction between the determinants of concern. In such situations the total absolute risk of a given illness is greater than the sum of the absolute risk resulting directly from each separate environmental disease determinant. Hence, interaction should be accounted for when using individual a priori risk as basis for prevention.

A model for risk determined intervention (=RDI) permitting individual risk estimation will be presented, as well as a proposal for the practical use of this model in populations of limited size. Estimation of a priori lung cancer risk will be used as practical example. It will be shown how the etiologic fraction can be used for practical intervention against asbestos-related cancers among subjects with asbestos exposure and tobacco smoking.

To gain measurable results when choosing these two lung cancer determinants as targets for intervention it is considered preferable to carry out intervention in a population with an a priori lung cancer risk which is much higher than that of the general population. This can be achieved by choosing subjects who are heavily exposed to both determinants. As disease risks resulting from host factors are frequently unknown, it is chosen not to attempt to identify these determinants.

In the chosen example, subjects with an a priori risk of lung cancer, as projected to any time in future, exceeding the national absolute age-adjusted lung cancer risk significantly, e.g. by a factor of five, are enrolled for individual RDI counseling. If the available resources for RDI permit only small numbers of participants, projected absolute disease risk exceeding national averages by seven, eight, or 10 times, can alternatively be chosen as criterion for participation. Actually, once the individual a priori risk is determined, any risk level or risk interval can be chosen as criterion for participation and exclusion, respectively, in both RDI and screening. Further details of the method (RDI) will be presented and discussed at the presentation.

How RDI can be combined with other methods of prevention, e.g., lung cancer screening among high risk groups, will also be discussed. Lung cancer screening could be performed as four-monthly or six-monthly two-angle chest x-rays, alone or along with yearly three-day exfoliative cytology examination.

SELECTION BIAS IN A CASE-CONTROL STUDY OF PSYCHIATRIC DISEASE AND OCCUPATIONAL SOLVENT EXPOSURE

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A case-control study of psychiatric disease and occupational solvent exposure carried out in eight automobile and truck assembly plants included 273 cases with psychiatric disease (selected psychoses, chemical dependencies, and affective, anxiety, and personality disorders) who were granted medical disability retirement in 1980-88. Two control groups were selected, the first from those granted retirement in the same time period because of medical disability from causes unrelated to solvent exposure. The second included hourly employees from the plant population. Cases were individually matched to controls on plant, gender, race, birth date, hire date, and employment duration (the last three to within three years). Solvent exposure was expressed continuously and categorically in many ways, including total years exposed, years of dermal exposure, and years of high or low exposure. Regardless of how it was expressed, exposure appeared to be protective, more so for the population control group than the disabled control group. Results could not be explained by conventional confounding exposures or characteristics nor by the Healthy Worker Effect, as even in the first year of employment cases had less exposure than either control group. Cases, and to a lesser extent, the disabled control group, appeared to be selected into jobs with low solvent exposure immediately upon or soon after hire. Possible explanations are discussed.

MODELLING THE EFFECT OF DIFFERENT TIME VARIABLES ON THE RISK OF DEVELOPING COALWORKERS' PNEUMOCONIOSIS

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Time is a fundamental concept in the epidemiological analysis of a disease, especially if the disease process can be broken down into a sequence of multiple spells and/or stages. Coalworkers' pneumoconiosis (CWP), defined by the 12 distinct profusion categories of ILO 1980, forms such a multi-state multi-episode process which can be described on different time scales: time underground (= time since first exposure), calendar time, age and the duration of disease episodes may be used in a description of the disease dynamics.

The aim of this study is to analyze the development of CWP in 472 miners of a mine in German hard coal mining, who left the mine in 1974 - 1977, 1980 or 1985 and who worked at least 20 years underground. Total observation time comprises 13877 person-years. 5701 chest radiographs were evaluated independently by at least two physicians according to ILO 1980. Rate and risk of developing different stages of CWP are analyzed in dependence on individual time data. Cox models are used to incorporate different time scales as time independent and/or time dependent covariables. Process time is chosen as time underground (Markov approach) or sojourn time in a specified state of disease (Semi-Markov approach).

Focusing on the occurrence of the important 1/1 category some results of a comparison of the intensity for the 1/0 → 1/1 transition with the intensity for the 1/1 → 1/2 transition are given as an example: On the one hand elementary log-rank tests give non-significant results ($p \geq 0.05$) for both the Markov and Semi-Markov approach; on the other hand Cox modelling of the data using time underground as study time (Markov approach) show a significant decrease of incidence rate ($p < 0.01$) after adjustment for age, calendar time and sojourn time in a time dependent manner. A strong influence of sojourn time independent of time underground can be seen generally, so the process appears to be a Semi-Markov one.

In epidemiological studies time often can be expressed in different ways and the choice of the time concept may influence the outcome of an analysis substantially. In such a situation sophisticated modelling is necessary to carry out an adequate analysis.

POTENTIAL OF BIOLOGICAL MARKERS TO IMPROVE VALIDITY OF OCCUPATIONAL EPIDEMIOLOGY STUDIES: IMPLICATIONS FOR OCCUPATIONAL SURVEILLANCE AND EPIDEMIOLOGY

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Job classification is frequently used as a surrogate measure of exposure in occupational epidemiology or surveillance studies. It is well known that misclassification arising from use of surrogate exposure measures frequently biases the effect measure toward the null, but the potential magnitude of this attenuation in strength of association has not been widely discussed. As biological markers slowly become more available, the opportunities to use these tools to improve the validity of studies have become more frequent.

To illustrate the potential magnitude of the increase in strength of association when a dichotomous biological marker is unused in place of the dichotomous surrogate exposure measure, a simple example of a hypothetical tumor registry-based care control study of Primary Hepatocellular Carcinoma (PHC) is presented. Job classification as a Health Care Worker (HCW) (0/1) is the surrogate measure of exposure, and the biological marker of interest is Hepatitis B Virus carrier (0/1), whose association with PHC has been well studied. If the exposure is defined as HBV carrier, we assume the Odds Ratio (OR) will be around 200, as was found in the Taiwan cohort study of PHC and HBV carrier status. Assuming realistic incidences of PHC and population prevalences of HBV carrier status in the general population and among HCW's we show that the observed OR for the association between the surrogate exposure HCW and the disease outcome PHC is 2. The use of the biological marker has produced a hundredfold increase in the strength of association.

The general relationships between the parameters of interest will be demonstrated graphically and algebraically. The implications of this example for surveillance of hypothesis generating studies of diseases and occupations which have no biological marker readily available will be discussed.

IS CANCER AFFECTED BY THE HEALTHY WORKER EFFECT?

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The process by which cancers are produced is not thought to depend on the general health of an individual. Therefore, there should be no particular reason why chronic cancer mortality should be affected by the Healthy Worker Effect (HWE).

A sample of occupational health studies published over a six year period were selected from a number of leading American and British journals that usually carry reports of occupational health studies. Studies selected had to meet these requirements (1) they investigated effects of suspected carcinogens (specifically: dioxins and furans, metals, organic chemicals and solvents, polyaromatic miscellaneous hydrocarbons, petrochemicals, PVC, radon and rubber), (2) they reported a standard mortality ratio of < 1.00 for <u>all-causes,</u> and (3) they contained data and/or presented computations for standardized mortality ratios for <u>all-cancers.</u>

59 studies met these criteria. Of these 59 studies 39 had SMRs of <1.00 for <u>all-cancers.</u> Of these 39, 14 had SMRs that were significantly smaller than 1.00 with $p \leq .05$. Only five studies had SMRs for <u>all-cancers</u> significantly greater than 1.00 (with $p \leq .05$).

Thus, a Healthy Worker Effect for cancer can be seen even in occupations that expose workers to carcinogens. The observation of an SMR of < 1.00 for all cancers has also been reported in a number studies of U.S. veteran groups.

The demonstration of Healthy Worker Effect for all cancer not only may have important consequences for the design and analysis of occupational health studies, but might be an important observation for future studies of cancer etiology.

OMNI NETHERLAND PLAZA

CINCINNATI, OHIO
FOURTH FLOOR LEVEL

SOUTH HALL

BANQUET KITCHEN

STAGE

PAVILLION

HALL OF MIRRORS
ENTRANCE ON THIRD FLOOR

BALCONY

FOURTH FLOOR FOYER

WOMEN

COAT CHECK

CAPRICE 1&4

ELEVATOR LOBBY

2   3

NORTH HALL

SALON M

HOTEL STORAGE

CONFERENCE SERVICES

MEN

HALL OF NATIONS

SALON I | SALON H | SALON G | SALON F | SALON E | SALON D | SALON C | SALON B | SALON A

FOURTH FLOOR LEVEL

CINCINNATI

NEWPORT

COVINGTON

MAINSTRASSE

OHIO RIVER

EDEN PARK

MOUNT ADAMS
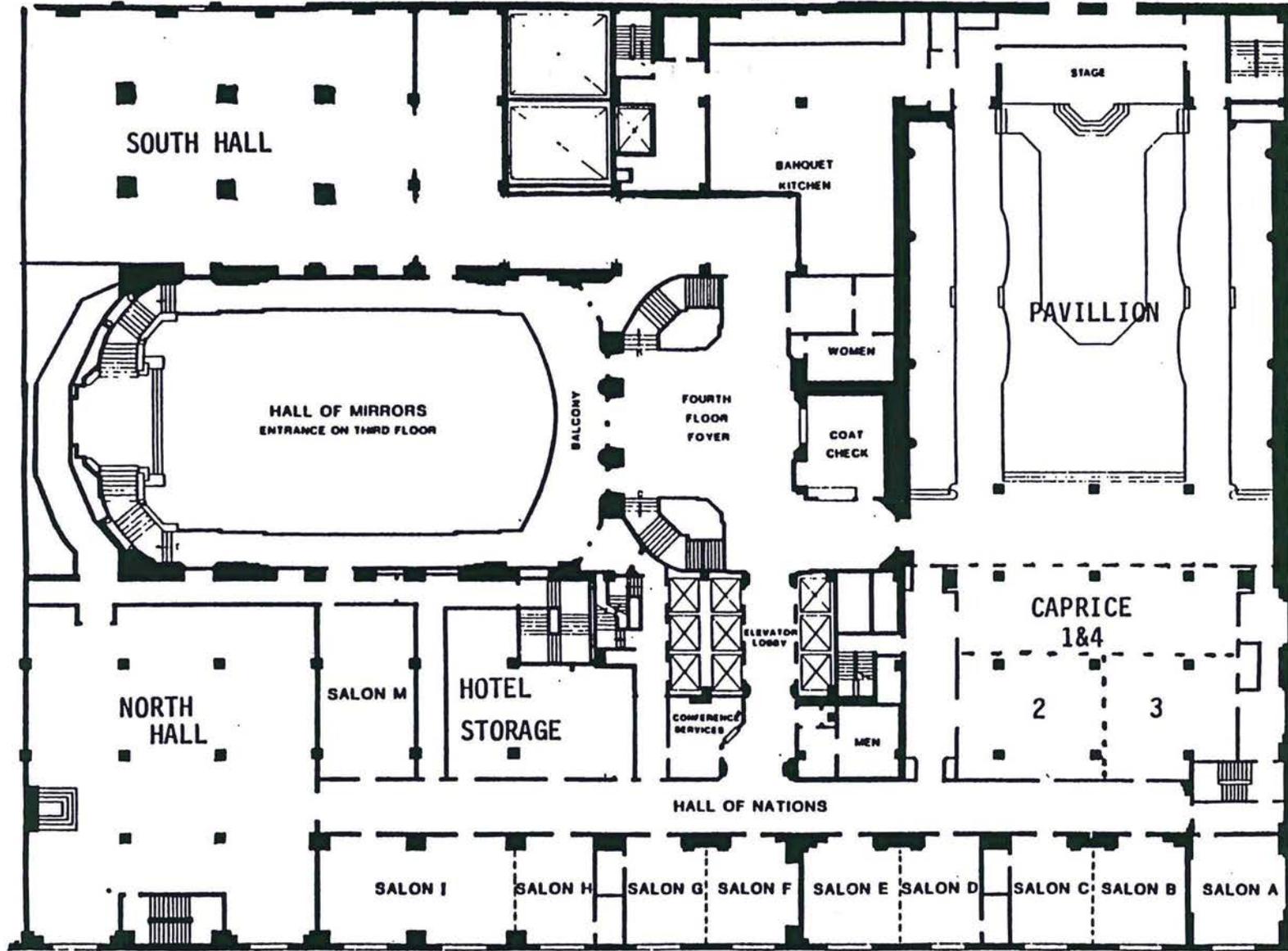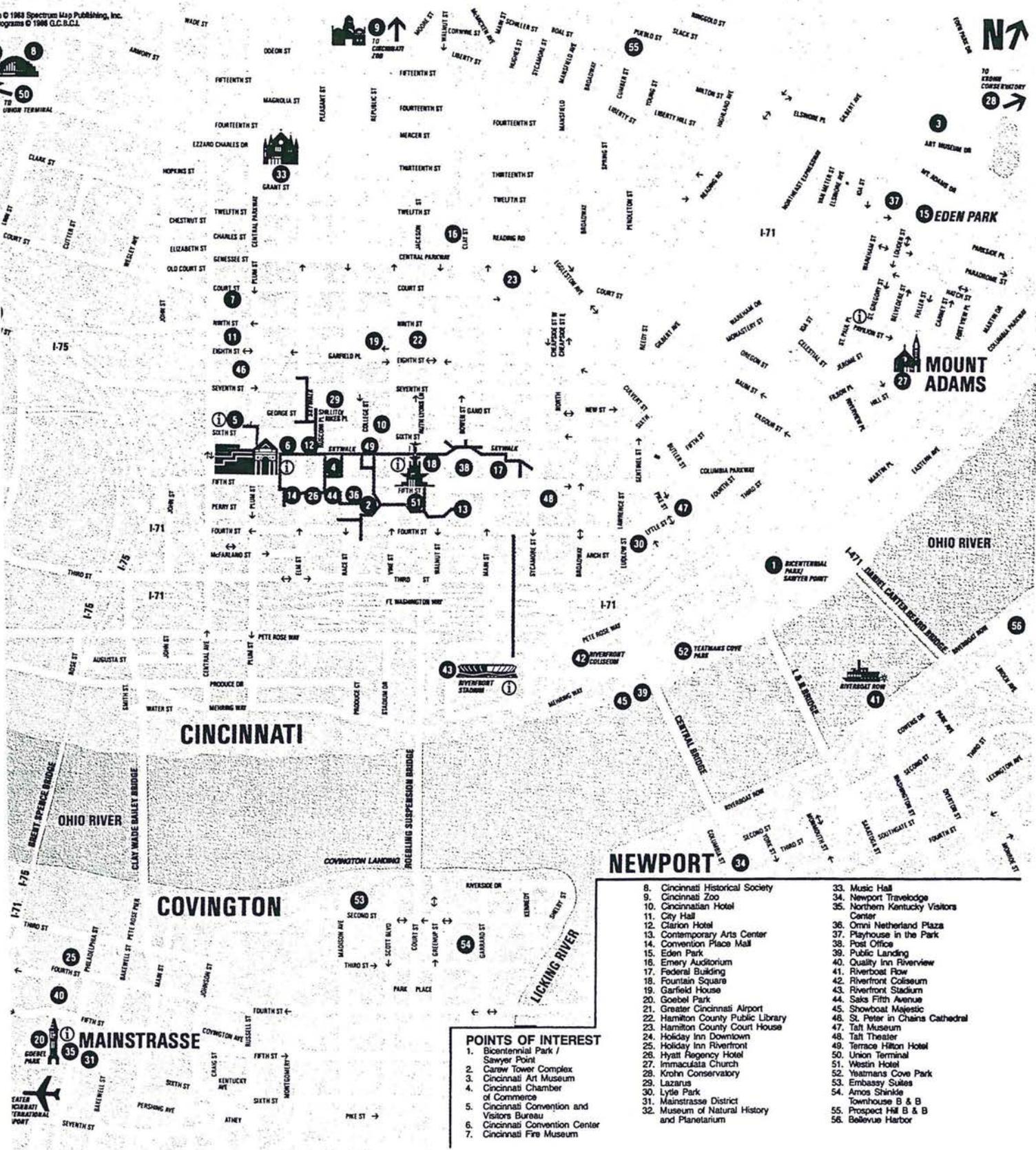
POINTS OF INTEREST

1. Bicentennial Park / Sawyer Point
2. Carew Tower Complex
3. Cincinnati Art Museum
4. Cincinnati Chamber of Commerce
5. Cincinnati Convention and Visitors Bureau
6. Cincinnati Convention Center
7. Cincinnati Fire Museum
8. Cincinnati Historical Society
9. Cincinnati Zoo
10. Cincinnatian Hotel
11. City Hall
12. Clarion Hotel
13. Contemporary Arts Center
14. Convention Place Mall
15. Eden Park
16. Emery Auditorium
17. Federal Building
18. Fountain Square
19. Garfield House
20. Goebel Park
21. Greater Cincinnati Airport
22. Hamilton County Public Library
23. Hamilton County Court House
24. Holiday Inn Downtown
25. Holiday Inn Riverfront
26. Hyatt Regency Hotel
27. Immaculata Church
28. Krohn Conservatory
29. Lazarus
30. Lytle Park
31. Mainstrasse District
32. Museum of Natural History and Planetarium
33. Music Hall
34. Newport Travelodge
35. Northern Kentucky Visitors Center
36. Omni Netherland Plaza
37. Playhouse in the Park
38. Post Office
39. Public Landing
40. Quality Inn Riverview
41. Riverboat Row
42. Riverfront Coliseum
43. Riverfront Stadium
44. Saks Fifth Avenue
45. Showboat Majestic
46. St. Peter in Chains Cathedral
47. Taft Museum
48. Taft Theater
49. Terrace Hilton Hotel
50. Union Terminal
51. Westin Hotel
52. Yeatmans Cove Park
53. Embassy Suites
54. Amos Shinkle Townhouse B & B
55. Prospect Hill B & B
56. Bellevue Harbor

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