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Mortality of Professional Chemists in England and Wales, 1965–1989

W.J. Hunter, FFOM, MB, BS, LRCP, MRCS, B.A. Henman, CChem, FRSC, D.M. Bartlett, BSc, and I.P. Le Geyt, BA

Several studies on the mortality of chemists have revealed a lower overall mortality but an excess of deaths from certain diseases, in particular, cancers. This study determined the causes of mortality of 4,012 chemists among 14,884 members of The Royal Society of Chemistry who were followed for a period of 25 years. The results demonstrated consistency with other studies. There was an overall low mortality rate, with fewer deaths than expected from cancers, but an excess mortality from lymphatic and hematopoietic cancers, in particular leukemias. There was an excess of deaths from certain gastrointestinal cancers. There was reduced mortality from respiratory diseases, including lung cancers, and from cardiovascular disease. New findings reported in this study are increased mortality from cancers of the duodenum and kidney, certain skin cancers, mental disorders, and diseases of the nervous system.

Key words: occupational diseases, mortality, chemists cancer, chemical exposures, presenile dementia, mesothelioma

INTRODUCTION

Several studies on the mortality of chemists, while reporting low overall mortality, have revealed an excess of deaths from certain diseases, in particular, cancers. A mortality study among members of the American Chemical Society [Li et al., 1969] found an excess of cancer deaths, in particular, from malignant lymphomas and pancreatic cancers, and from leukemia and intestinal cancer. In studies on Swedish chemists [Olin, 1976, 1978; Olin and Ahlbom, 1980, 1982], there were significantly more cancer deaths than expected, in particular, from lymphatic and hematopoietic cancers, and from Hodgkin's disease. Olin also found an excess of deaths from genitourinary tumors, including prostatic cancer, and from brain tumors.

A study of chemists employed by Du Pont in the United States [Hoar and Pell, 1981a] showed excess deaths from cancers of the large intestine, prostate, and kidney, and from cancers of the lymphatic and hematopoietic tissue, in particular, Hodgkin's disease. Another American study on chemical researchers [Maher and Defonso, 1986] revealed an excess of deaths from digestive, lymphatic, and he-

Commission of the European Communities, Health and Safety Directorate, Luxembourg (W.J.H.), The Royal Society of Chemistry, London, England (B.A.H., D.M.B., I.P.L.G.).
Address reprint requests to Mr. B.A. Henman, Registrar, The Royal Society of Chemistry, Burlington House, Piccadilly, London W1V 0BN, UK.
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records, we obtained details of full name and address, and the date and place of birth. Wherever possible, we also obtained the date and place of death from membership records for those known to have died.

For the purpose of comparison, we used mortality data from England and Wales for males aged 15 and over, taken from the Registrar General's Decennial Supplement on Occupational Mortality, 1970–1972 [OPCS, 1978]. (The period 1970–1972 was chosen because detailed data were available for comparison purposes.) We selected Social Classes I and II (professional, technical, and managerial classes) as the closest match to that of the deceased chemists.

We gave information on the RSC chemists to the National Health Service Central Register (NHSCR) of the Office of Population Censuses and Surveys (OPCS). We asked the NHSCR to trace each individual. The NHSCR provided death certificates for decedents and coded the underlying causes of death according to the International Classification of Diseases (ICD) (8th Revision) [WHO, 1967]. We were able to trace all but 20 of the individuals in the study.

We were unable to determine the cause of death of 34 of the 4,012 decedents, who were found to have died while resident in England and Wales in the period from January 1, 1965 to December 31, 1989. These were included in our analyses under "other unknown and unspecified causes of morbidity and mortality."

Population at Risk: Chemists and Their Comparison Group

The population at risk for the RSC chemists was the male membership in 1971, taken from the RSC membership records. For comparison purposes, the population was the male population aged 15 and over in Social Classes I and II (professional, technical, and managerial classes) in England and Wales, taken from the OPCS Census 1971 [OPCS, 1975].

We calculated SMRs for each cause with three or more deaths. Confidence Intervals were calculated using the British Medical Journal's Confidence Interval Analysis Programme.

RESULTS

Of the 14,884 male chemists who comprised the entry group for the study, 4,012 were identified as having died during the 25-year period 1965–1989. This study has revealed an overall reduction in mortality from all causes and from all cancers but an excess mortality from certain cancers and other diseases.

The SMRs for the main causes of death for male chemists in England and Wales are given in Table I.

Cancers

There were fewer deaths than expected from cancer. There were reductions in deaths from cancers of the buccal cavity and pharynx, cancers of the gastrointestinal system (in particular, the stomach, sigmoid colon, rectum, and head of the pancreas), cancers of the respiratory system (in particular, cancer of the bronchus and lung), and Hodgkin's disease.

There were more deaths than expected from cancers of the duodenum and unspecified parts of the large intestine, and from unspecified parts of the pancreas; cancer of the pleura and benign neoplasms of the bronchus and lung; unspecified

TABLE I. Main Causes of Death: Standardized Mortality Ratios for Male Chemists in England and Wales: 1965–1989

ICD cause of death (8th revision)	Standardized mortality ratios			
	OBS	EXP	SMR	95% CI
All causes (000–999)	4012	5473.26	73*	71.1–75.6
I. Infective and parasitic diseases (000–136)	20	20.86	96	58.6–148.0
II. Neoplasms (140–239)	934	1211.83	77*	72.2–82.2
Malignant neoplasms (140–209)	918	1195.77	77*	71.9–81.9
Benign neoplasms (210–228)	5	6.59	76	24.6–177.0
Unspecified neoplasms (230–239)	11	7.56	146	72.6–260.0
III. Endocrine, nutritional, and metabolic diseases (240–279)	34	56.38	60*	41.8–84.3
IV. Diseases of blood and blood-forming organs (280–289)	6	13.29	45*	16.6–98.3
V. Mental disorders (290–315)	16	7.05	227*	130.0–369.0
VI. Diseases of the nervous system and sense organs (320–389)	72	45.58	158*	124.0–199.0
VII. Diseases of the circulatory system (390–458)	2199	3026.01	73*	69.7–75.8
VIII. Diseases of the respiratory system (460–519)	357	615.41	58*	52.1–64.4
IX. Diseases of the digestive system (520–577)	100	119.84	83	67.9–101.0
X. Diseases of the genitourinary system (580–607)	57	77.24	74*	55.9–95.6
XII. Diseases of the skin and subcutaneous tissue (680–709)[a]	2			
XIII. Diseases of the musculoskeletal system and connective tissue (710–738)	9	12.45	72	33.1–137.0
XIV. Congenital anomalies (740–759)	9	3.72	242*	111.0–459.0
XVI. Symptoms and ill-defined conditions (780–796)	48	33.26	N/A	
XVII. Accidents, poisonings, and violence (external cause)[a] (E800–999)	149	190.87	78*	66.0–91.7

[a]Not analyzed.
*Significance level between $p < 0.01$ and $p < 0.0005$.

malignant melanoma and skin cancer of the trunk; cancer of the kidney; cancer of other unspecified parts of the nervous system and secondary cancer of the brain; cancers without specification of site; and neoplasms of the lymphatic and hematopoietic tissue (in particular, from other primary malignant neoplasms of lymphoid tissue and from both lymphatic and myeloid leukemia).

The SMRs for selected deaths from cancers among male chemists in England and Wales are given in Table II.

Diseases Other Than Cancer

There were fewer deaths than expected from endocrine, nutritional, and metabolic diseases (in particular, diabetes mellitus); diseases of the blood and blood-forming organs; cardiovascular disease (in particular, hypertensive disease, ischemic heart disease, other forms of heart disease, cerebrovascular disease, and diseases of arteries, arterioles, and capillaries); diseases of the respiratory system (in particular, acute respiratory infections, influenza, pneumonia; "bronchitis, emphysema, and asthma"; and bronchiectasis); diseases of the digestive system (in particular, hernia of the abdominal cavity); diseases of the genitourinary system; and accidents, poisonings, and violence.

There were more deaths than expected from mental disorders (in particular, from senile and presenile dementia); diseases of the nervous system (in particular, paralysis agitans and "other diseases of the brain"); diseases of the mitral and aortic

TABLE II. Deaths From Neoplasms: Standardized Mortality Ratios for Male Chemists in England and Wales: 1965–1989

ICD cause of death (8th revision)	Standardized mortality ratios			
	OBS	EXP	SMR	95% CI
II. Neoplasms (140–239)	934	1211.83	77*	72.2–82.2
Malignant neoplasms (140–209)	918	1195.77	77*	71.9–81.9
Buccal cavity and pharynx (140–149)	9	28.17	32*	14.6–60.6
Digestive organs and peritoneum (150–159)	303	433.33	70*	62.3–78.3
Stomach (151)	53	121.66	44*	32.6–57.0
Small intestine, including duodenum (152)	5	2.29	219	70.9–510.0
Duodenum (152.0)	3	0.58	517*	107.0–1510.0
Large intestine, except rectum (153)	101	113.65	89	72.4–108.0
Sigmoid colon (153.3)	15	41.43	36*	20.3–59.7
Large intestine including colon, part unspecified (153.8)	44	20.35	216*	157.0–290.0
Rectum and rectosigmoid junction (154)	38	68.78	55*	39.1–75.8
Rectum (154.1)	36	64.65	56*	39.0–77.1
Pancreas (157)	50	61.84	81	60.0–107.0
Head of Pancreas (157.0)	18	39.82	45*	26.8–71.4
Pancreas, unspecified (157.9)	28	15.15	185*	123.0–267.0
Respiratory system (160–163)	211	394.27	54*	46.5–61.3
Trachea, bronchus and lung (162)	193	381.73	51*	43.7–58.2
Bronchus and lung (162.1)	193	381.15	51*	43.7–58.3
Other and unspecified respiratory organs (163)	11	1.55	709*	354.0–1270.0
Pleura (163.0)	11	1.04	1059*	528.0–1890.0
Bone, connective tissue, skin, and breast (170–174)	22	22.34	98	61.7–149.0
Malignant melanoma of skin (172)	8	5.29	151	65.3–298.0
Malignant melanoma of skin, site unspecified (172.9)	4	1.00	398*	109.0–1020.0
Other malignant neoplasms of skin (173)	7	6.48	108	43.4–223.0
Skin, trunk except scrotum (173.6)	3	0.98	305*	63.1–895.0
Genitourinary organs (185–189)	185	185.14	100	86.0–115.0
Other and unspecified urinary organs (189)	30	17.91	167*	113.0–239.0
Kidney (189.0)	28	17.15	163*	108.0–236.0
Other and unspecified sites (190–199)	91	71.07	128*	103.0–157.0
Other parts of nervous system (192)	11	1.49	736*	369.0–1320.0
Other parts of nervous system, site unspecified (192.9)	11	0.88	1255*	624.0–2240.0
Other secondary malignant neoplasm (198)	5	3.15	159	51.5–370.0
Brain, specified as secondary (198.3)	3	0.99	303*	62.5–886.0
Malignant neoplasm without specification of site (199)	39	22.19	176*	125.0–240.0
Lymphatic and hematopoietic tissue (200–209)	97	72.74	133*	108.0–163.0
Hodgkin's disease (201)	8	15.82	51*	21.8–99.6
Other neoplasms of lymphoid tissue (202)	12	2.78	431*	223.0–754.0
Other primary neoplasms of lymphoid tissue (202.2)	12	2.25	533*	276.0–932.0
Lymphatic leukemia (204)	17	10.28	165*	96.3–265.0
Chronic lymphatic leukemia (204.1)	15	8.38	179*	100.0–295.0
Myeloid leukemia (205)	25	13.60	184*	119.0–271.0
Acute myeloid leukemia (205.0)	17	8.85	192*	112.0–308.0
Benign neoplasms (210–228)	5	6.59	76	24.6–177.0
Benign neoplasm of respiratory system (212)	3	0.25	1203*	247.0–3510.0
Benign neoplasm of bronchus and lung (212.3)	3	0.15	1980*	412.0–5840.0

*Significance level between $p < 0.01$ and $p < 0.0005$.

valves; empyema and "other diseases of the respiratory system"; acute appendicitis; and congenital anomalies (in particular, congenital anomalies of the heart).

The SMRs for selected deaths from diseases other than neoplasms among male chemists in England and Wales are given in Table III.

DISCUSSION

Studies on the mortality of chemists that have employed different techniques of analysis have shown a certain consistency in findings. There has been excess mortality due to lymphatic and hematopoietic cancers, and lesser mortality due to cancer of the lung, respiratory diseases, diseases of the cardiovascular system, and accidents (Table IV).

In the case of RSC chemists, the reduction in mortality from cancer of the lung and from diseases of the respiratory system is more likely to be a reflection of their smoking habits than of any other factor, as is evidenced from the results of a survey by questionnaire carried out by the RSC in 1980 (RSC unpublished data, 1982). The smoking habits of 13,342 RSC chemists compared with Social Classes I and II in 1980 [OPCS, 1981] are analyzed in Table V.

The proportion of nonsmokers (ex-smokers and those who had never smoked) among RSC chemists was substantially greater (79%) than among their counterparts in Social Classes I and II (69%). Of the RSC chemists, 21% were current smokers, compared with 31% in Social Classes I and II. These differences would account for the reduction in mortality due to respiratory diseases, including cancer of the trachea, bronchus, and lung.

The reduction in overall mortality of RSC chemists from diseases of the circulatory system may also be a reflection of the lower percentage of RSC chemists who have smoked. Of 216 RSC chemists who had participated in the questionnaire-based surveys and had subsequently died of myocardial infarction, 66 (31%) had been smokers at the time of the survey (compared with the overall 21% among all RSC chemists in the survey.)

With the exception of a reduction in mortality from Hodgkin's disease, not found in other studies of chemists, the consistent finding of an increased mortality in chemists from lymphatic and hematopoietic cancers suggests that there may be one or more chemical substances involved as etiological factors. However, other factors are known to play a part in the etiology of these cancers, including immune impairments, viral infections, and irradiation [Alderson, 1986].

There are several chemical substances which have been associated with cancers of the lymphatic and hematopoietic system. The most well known of these is benzene, considered by the International Agency for Research on Cancer (IARC) to cause leukemias [IARC, 1987]. Furthermore, the agent responsible for the increased risk of cancers of the lymphatic and hematopoietic system in the rubber and leather industries is considered by the IARC to be benzene [IARC 1981, 1982a]. Since all RSC decedents had worked for all or part of their careers as chemists, and all had studied chemistry to degree level, it is possible that the excess mortality found in RSC chemists caused by cancers of the lymphatic and hematopoietic tissue is due in part to exposure to certain chemicals, in particular to benzene, which was commonly used in laboratories in the past. Other chemicals may be involved in the causation of leukemias [Wongsrichanalai et al., 1989]. These include carbon tetrachloride and

TABLE III. Deaths From Diseases Other Than Neoplasms: Standardized Mortality Ratios for Male Chemists in England and Wales: 1965–1989

ICD cause of death (8th revision)	Standardized mortality ratios			
	OBS	EXP	SMR	95% CI
I. Infective and parasitic diseases (000–136)	20	20.86	96	58.6–148.0
Tuberculosis (010–019)	5	12.79	39*	12.7–91.2
Other bacterial diseases (030–039)	6	1.67	358*	132.0–782.0
Septicemia (038)	6	1.24	486*	178.0–1050.0
III. Endocrine, nutritional, and metabolic diseases (240–279)	34	56.38	60*	41.8–84.3
Diseases of other endocrine glands (250–258)	27	44.20	61*	40.3–88.9
Diabetes mellitus (250)	26	42.38	61*	40.0–89.9
IV. Diseases of blood and blood-forming organs (280–289)	6	13.29	45*	16.6–98.3
V. Mental disorders (290–315)	16	7.05	227*	130.0–369.0
Psychoses (290–299)	16	6.53	245*	140.0–398.0
Senile and presenile dementia (290)	15	5.93	253*	142.0–417.0
VI. Diseases of nervous system and sense organs (320–389)	72	45.58	158*	124.0–199.0
Other diseases of central nervous system (340–349)	68	42.04	162*	126.0–205.0
Paralysis agitans (342)	38	18.46	206*	146.0–283.0
Other diseases of brain (347)	5	1.72	291*	94.4–678.0
VII. Diseases of circulatory system (390–458)	2199	3026.01	73*	69.7–75.8
Chronic rheumatic heart disease (393–398)	26	35.31	74	48.1–108.0
Diseases of mitral and aortic valves (396)	8	3.07	260*	113.0–513.0
Hypertensive disease (400–404)	32	85.41	37*	25.6–52.9
Ischemic heart disease (410–414)	1417	1719.70	82*	78.2–86.8
Acute myocardial infarction (410)	1027	1237.69	83*	78.0–88.2
Chronic ischemic heart disease (412)	372	457.91	81*	73.2–89.9
Other forms of heart disease (420–429)	108	238.95	45*	37.1–54.6
Cerebrovascular disease (430–438)	463	672.25	69*	62.7–75.4
Diseases of arteries, arterioles, and capillaries (440–448)	120	195.87	61*	50.8–73.3
Arteriosclerosis (440)	38	96.50	39*	27.9–54.0
VIII. Diseases of the respiratory system (460–519)	357	615.41	58*	52.1–64.4
Acute respiratory infections (except influenza) (460–466)	4	10.53	38*	10.4–97.3
Influenza (470–474)	10	25.74	39*	18.6–71.4
Pneumonia (480–486)	207	280.98	74*	64.0–84.4
Bronchitis, emphysema, and asthma (490–493)	94	304.67	31*	24.9–37.8
Other diseases of respiratory system (510–519)	42	25.20	167*	120.0–225.0
Empyema (510)	3	0.47	636*	132.0–1870.0
Bronchiectasis (518)	3	8.84	34*	7.0–99.2
Other diseases of respiratory system (519)	30	6.06	495*	334.0–707.0
IX. Diseases of the digestive system (520–577)	100	119.84	83	67.9–101.0
Appendicitis (540–543)	5	2.38	210	68.2–490.0
Acute appendicitis (540)	5	2.03	246*	80.0–575.0
Hernia of abdominal cavity (550–553)	3	8.87	34*	7.0–98.8
X. Diseases of the genitourinary system (580–607)	57	77.24	74*	55.9–95.6
Diseases of male genital organs (600–607)	14	26.82	52*	28.5–87.6
Hyperplasia of prostate (600)	13	26.52	49*	26.1–83.8
XIV. Congenital anomalies (740–759)	9	3.72	242*	111.0–459.0
Congenital anomalies of heart (746)	4	1.31	306*	83.2–782.0
XVII. Accidents, poisonings, and violence (external cause) (E800–999)	149	190.87	78*	66.0–91.7
All accidents (E800–949)	91	114.17	80*	64.2–97.9
Poisonings and violence (E950–999)	58	79.36	73*	55.5–94.5
Motor vehicle traffic accidents (E810–819)	42	53.07	79	57.0–107.0
Motor vehicle traffic accident of unspecified nature (E819)	3	0.88	343*	70.3–996.0
Air and space transport accidents (E840–845)	5	0.61	819*	266.0–1910.0
Accident to powered aircraft, other and unspecified (E841)	5	0.49	1013*	331.0–2380.0
Other accidents (E910–929)	13	7.98	163	86.7–279.0
Other and unspecified accident (E929)	5	0.54	920*	301.0–2160.0
Injury undetermined whether accidentally or purposely inflicted (E980–989)	10	12.59	79	38.1–146.0
Falling from a high place (undetermined whether accidentally or purposely inflicted) (E987)	3	0.94	321*	65.8–933.0

*Significance level between $p < 0.01$ and $p < 0.0005$.

TABLE IV. Comparison of Findings on Causes of Death Among Male Chemists

ICD cause of death (8th revision)	RSC	Li et al. (1969)		Olin (1978, 1980)	Hoar & Pell (1981)	Maher & Defonso (1986)	Milham (1976)	Registrar General (1986)
		<65 years	65+ years					
All causes (000–999)	–							
II. Neoplasms (140–239)	–	+	+	–				
Buccal cavity and pharynx (140–149)				+				
Digestive organs and peritoneum (150–159)								
Stomach (151)	–							
Duodenum (152.0)	–							
Large intestine (or parts thereof) (153)	+			–		+		+
Rectum (154.1)	+							
Pancreas (or parts thereof) (157)	–			+				
Respiratory system (160–163)	+	+			+			+
Bronchus and lung (162.1)	–			+				+
Pleura (163.0)	–			–			+	
Malignant melanoma of skin (or parts thereof) (172)	++					–		–
Other malignant neoplasm of skin (or pa thereof) (173)	+							
Genitourinary organs (185–189)	+							
Prostate (185)				+				
Kidney (189.0)				+	+			
Brain (191)	+			+				
Other parts of nervous system (192)								
Lymphatic and hematopoietic tissue (200–209)	+			+				+
Hodgkin's disease (201)	+	H	+	+	+	+		
Lymphosarcoma, other lymphoid tissue (200–202)	–			+				
Leukemias (204, 205)	+		+	+				
Benign neoplasm of bronchus and lung (212.3)	+							
Diseases other than neoplasms	+							
Endocrine, nutritional and metabolic diseases (240–279)								
Diabetes mellitus (250)	–							
Diseases of the blood and blood-forming organs (280–289)	–							
Mental disorders (290–315)								
Diseases of the nervous system (320–389)	+							
Diseases of the circulatory system (390–458)	+							
Ischemic heart disease (410–414)	–							
Cerebrovascular disease (430–438)	–							
Diseases of the respiratory system (460–519)								
Cirrhosis of liver (or parts thereof) (571)	–	–	–					
Diseases of the genitourinary system (580–607)	–			–				
Congenital anomalies (740–759)	–							
Accidents (E800–949)	+							
Suicides (E950–959)	–							
							+	+

+ = excess mortality; – = reduced mortality.

The above studies used differing statistical analyses a pr f their data: RSC/Li: Olin, Registrar General: all findings listed above have ... significan ... findings = "PMRs over 200"; Hoar/Maher: findings not necessarily significant (sometime "slight excesses" listed), some findings refer to subgroups such as pensioners or specific levels of exp ure.

TABLE V. Comparison of Smoking Habits Between RSC Chemists and Social Classes I + II: 1980

Smoking habits	RSC Chemists	Social Classes I + II
Current smokers	21%	31%
Ex-smokers	31%	33%
Never smoked	48%	36%
Total	100%	100%

carbon disulfide [Checkoway et al., 1984], formaldehyde and herbicides [Alderson, 1986], vinyl chloride [Smulevich et al., 1988], and chemicals in a chlorohydrin unit [Ott et al., 1989].

Our finding of excess mortality from cancer of the duodenum is new. Excesses in deaths from other digestive cancers show consistency with other studies (see Table IV).

There may be chemical factors involved in the findings of excess mortality of cancer of the colon in this and other studies. There is evidence linking ethylene bromide [ILO, 1983a], soots, tars, mineral oils [IARC, 1982b], and asbestos [Schottenfeld and Winawer, 1982; Alderson, 1986] with cancers of the digestive system. Other chemicals, such as *n*-nitroso compounds and hydrazines, may also play a role, but this has not been established [Maher and Defonso, 1986].

All the studies so far carried out on chemists have revealed an excess of pancreatic cancer or parts thereof. Little is known about the etiology of pancreatic cancer, but several epidemiological studies have indicated excess risks of this disease in various other occupational groups, including the printing industry (printing and commercial pressmen), rubber manufacturing [see references in Pietri et al., 1990], metal industries and aluminum milling, and oil refining and exposure to petroleum products [see references in Norell et al., 1986]. Associations with specific exposures include beta-naphthylamine and benzidine [Mancuso and El-Attar, 1967]; paint thinners, paint and varnish, detergents, floor and window cleaning agents, polish, and exposure to refuse, as well as work in refuse disposal plants [Norell et al., 1986].

Other excesses in cancer mortality found among RSC chemists were of the pleura, skin, and kidney. Eleven RSC chemists were reported as dying of cancer of the pleura, 8 of whom died from pleural mesothelioma (3 from exposure to asbestos, 3 from "industrial disease," and in the case of the remaining 2 there were no details). The link between mesothelioma and asbestos is well known [IARC, 1987; Alderson, 1986]. Skin cancer has been linked with soots, tars, and mineral oils [ILO, 1988; Tomatis et al., 1989]. Mortality from malignant melanoma has been linked with the petrochemical industry [Alderson, 1986; Savitz and Moure, 1984] and the chemical industry [Teta et al., 1990]. There was a higher incidence of melanoma among the Du Pont chemists than expected [Hoar and Pell, 1981a], and among chemical workers [O'Berg et al., 1987] and chemists exposed to organic chemicals [Wright et al., 1983]. Nonmelanotic skin cancers have been reported in chemical workers and paper and printing workers [Alderson, 1986]. Excess skin cancer has also been reported in rubber workers and workers exposed to arsenic [Alderson, 1986], as well as being a known risk to workers exposed to ultraviolet light.

Excess kidney cancers have been observed in Du Pont active chemists [Hoar and Pell, 1981a], in chemical plant workers [Bond et al., 1985], and in workers

exposed to hydrocarbons [Kadama
McLaughlin and Schuman, 1983]
among petrochemical workers, pr
balmers exposed to formaldehyde
gasoline and jet fuel [Siemiatycki

The findings of excess morta
in particular senile dementia, and
question of the existence of a chro
to paint solvents has been raised.
remains sufficient evidence, taken
abuse, to conclude that the occurr
RSC, 1990]. Psychoses and demen
carbon disulfide and toluene [CE
excess in mental disorders in their
research, development, and engine

The effects of solvent abuse o
long-term overexposure to dichloro
tem [IARC, 1979; CEC/RSC, 19
phenolic compounds are known t
exposure [Thomas and Waxweiler,
to carbon disulfide [ILO, 1983b]
containing glues [Pezzoli et al., 19

Although there was no excess
chemists, as had been observed a
1986] and among laboratory worke
tality from cancers of other parts o
incidence among male and female
excess of brain and nervous system
as among physical/biological scien
1991].

CONCLUSIONS

Although the overall mortality
members of The Royal Society of C
among chemists from lymphatic a
num, colon, pancreas, kidney, skin
system, and mental disorders. In vie
25-year study, we shall continue to

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