

A FOLLOW-UP STUDY OF WOMEN IN THE SYNTHETIC RUBBER INDUSTRY

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ABSTRACT

This is the first retrospective follow-up study of mortality among women in the synthetic rubber industry. Previous studies of over 17,000 male synthetic rubber workers found an excess of leukemia that was possibly due to exposure to 1,3-butadiene (BD) or to BD plus other chemicals. Experimental studies have shown that BD produces mammary tumors in female mice and rats and ovarian tumors in female mice.

The present study included 4,863 women employed at eight North American plants that made styrene-butadiene rubber (SBR) and related products. The main objectives were to evaluate mortality patterns and to determine if certain employment factors and quantitative exposure to certain chemicals, were associated with the cancers of *a priori* interest or other with other diseases. Based on the epidemiologic studies of men and on toxicological data, cancers of *a priori* interest included leukemia, non-Hodgkin lymphoma (NHL), other forms of lymphohematopoietic cancer (LHC), breast cancer and ovarian cancer.

The study included women who had worked at any one of the plants for at least one day during the period of 1943 through 2002. Identifying and work history information came from plant records. Data on jobs held by subjects were used to classify subjects according to three main work areas (SBR-related operations, administration and residual operations). The SBR-related operations area was subdivided further into five major subgroups (production, maintenance, labor, laboratories and other operations) and seven additional subgroups (production subgroups: polymerization, coagulation and finishing; maintenance subgroups: shop and field; labor subgroups: production and maintenance). Computation of cumulative exposure estimates involved multiplying the calendar year-specific amount of time a worker spent in each work area by the exposure estimate for that work area and calendar year category, and summing over all work areas and years covered by a subject's employment history. The main cumulative exposure indices were: BD ppm-years; styrene ppm-

years; BD ppm -years due to exposure to intensities >100 ppm; and DMDTC total mg-years/cm.

Vital status as of January 1, 2003, was determined for 97% of the cohort. Employees' mortality rates were compared with state and provincial general population rates, using the standardized mortality ratio (SMR) as the measure of association. Poisson regression analyses examined site-specific cancer rates in relation to BD, styrene and DMDTC. Models provided maximum likelihood estimates of the relative rate (RR) for each exposure quartile of an agent compared to no exposure to the agent, adjusting for other agents and for additional potential confounders.

Employees had a total of 181,831 and an average of 37 person-years of follow-up during the 1943-2002 study period. Employees' median duration of employment as 1.6 years, and 30% were ever hourly. In total, there were 1,198 observed compared to 1,383 expected deaths (SMR=87, 95% confidence interval (CI)=82-92). SMRs for all causes were 94 for ever-hourly women and 82 for never-hourly women. Employees with relatively long potential induction time (20+ years since hire) and relatively long duration of years of employment (5+ years) had SMRs for all causes of death combined and for all cancers that were somewhat lower than those of the total study group. Mortality was below or close to expectation for leukemia (total cohort: 10 observed/13 expected, SMR=79, CI=38-145; ever-hourly: 2/4.3; never-hourly: 8/8.4) and multiple myeloma (total cohort: 7/7.9, SMR=88, CI=35-182; ever-hourly: 3/3.3; never-hourly: 4/4.6). For NHL, the total cohort had 15 observed compared to 14 expected deaths (SMR=108, CI=61-178; ever-hourly: 7/4.4; never-hourly: 8/9.5). No increases in deaths from cancers of the breast were seen in the total cohort (72/74, SMR=97, CI=76-123) or in ever-hourly employees (18/23, SMR=77, CI=46-121); never-hourly employees had 54 observed and 51 expected breast cancer deaths (SMR=107, CI=80-139). For the total cohort and for the ever-hourly and never-hourly subgroups, ovarian cancer deaths were close to expectation (total cohort: 21/22, SMR=94, CI=58-143; ever-hourly, 7/7.2; never-hourly, 14/15).

Employees had an excess of lung (106/83, SMR=127, CI=104-154) and bladder cancer deaths (8/4.3, SMR=186, CI=80-366). Both excesses were concentrated among ever-hourly employees (lung cancer: 47/26, SMR=182, CI=133-242; bladder cancer: 6/1.7, SMR=353, CI=130-768) and among ever-hourly employees with 20+ years since hire, but neither cancer displayed a pattern of increasing SMRs with increasing duration of employment.

Analyses by work area did not detect any strong or statistically significant associations for leukemia, NHL or other forms of LHC. Ever-hourly women in SBR-related operations had a two-fold increase in deaths from lung cancer (34/17, SMR=198, CI=137-276); never-hourly women in this work area also had a slight increase in deaths from this cancer (12/9.8, SMR=123, CI=63-214). Among subgroups within SBR-related operations, the lung cancer excess was concentrated in laboratory workers (25/11, SMR=235, CI=152-346), was limited to those with 20+ years since starting in the area but was not concentrated among those with long-term employment in laboratories.

Never-hourly employees in administration had fewer than expected lung cancer deaths (36/42, SMR=86, CI=60-119) and had small increases in deaths from breast cancer (40/36, SMR=110, CI=78-149) and bladder cancer (3/1.9, SMR=154, CI=32-451). In residual operations, ever-hourly employees had an increase in deaths from lung cancer (15/8.7, SMR=173, CI=97-285) and had more observed than expected deaths from bladder cancer (4/0.7, SMR=540, CI=147-1382). The latter increase was limited to women with 1-4 years of employment and 20+ years since hire (3/0.39, SMR=770, CI=159-2250).

For leukemia, other LHCs, breast cancer and ovarian cancer, differences in observed and expected numbers of deaths were small both among women exposed, and among women unexposed, to each agent. Women exposed to BD had a statistically significant increase in lung cancer deaths (42/19, SMR=223, CI=161-302), whereas the unexposed group had no excess (56/57, SMR=99, CI=75-129). Results were similar for groups exposed to styrene (43/22, SMR=197, CI=143-266) or

to DMDTC (16/8.0, SMR=199, CI=114-324). Results were unremarkable for the groups unexposed to styrene or DMDTC.

Analyses of cumulative exposure indices were done for lung cancer and breast cancer but not for other forms of cancer because numbers of exposed cases were too small numbers. Results for lung cancer indicated a moderately positive association with each agent, without exposure-response. RRs were 1.0, 2.8, 1.9, 2.3, and 2.1, respectively, for exposures of 0, >0-<1.9, 1.9-<12.8, 12.8-<56.3 and 56.3+ BD ppm-years; 1.0, 1.7, 1.5, 2.9, and 2.0, respectively, for exposures of 0, >0-<0.8, 0.8-<6.0, 6.0-<21.6 and 21.6+ styrene ppm-years; and 1.0, 1.9, 2.0, 1.9 and 1.6, respectively, for 0, >0-<8.9, 8.9-<71.7, 71.7-<673.6 and 673.6+ DMDTC mg-years/cm. Adjusting for DMDTC had little impact on the relation between BD ppm-years and lung cancer or between styrene ppm-years and lung cancer. After adjustment for BD ppm-years or styrene ppm-years, DMDTC was not associated with lung cancer.

For BD and styrene, the RR for breast cancer was 2.0 or higher in one or more exposure quartiles in single agent models. However, most of these results were not statistically significant, and/or there was no evidence of a consistent exposure-response relation. DMDTC was not analyzed for breast cancer because only seven women with breast cancer were exposed to this agent.

In summary, our results indicated that women employed in the synthetic rubber industry had death rates for all causes combined and all cancers that were slightly lower than the rates of general population. Ever-hourly employees had higher SMRs than never-hourly employees, possibly due to differences in socioeconomic status that affect health. We did not find any strong, consistent or statistically significant association between occupational factors and any of the cancers of *a priori* interest. The present results do not provide any support for the hypothesis that employment in the synthetic rubber industry in general or exposure to BD or other chemicals cause leukemia or other LHCs. The absence of any association between employment factors and leukemia or other LHCs in

this study may reflect the fact that the numbers of women and of person-years with relatively high exposure to BD and other chemicals were quite small. Employees had an excess of lung cancer and bladder cancer deaths. For these two cancers, the absence of any trend of increasing SMRs with increasing duration of employment, the lack of any exposure-response trend for cumulative exposure to BD, styrene or DMDTC and the absence of positive results in studies of male employees indicate that these occupational exposures may not have been responsible for the observed excesses of lung and bladder cancers among women in the industry. We did not have any information on cigarette smoking, a known cause both of lung cancer and of bladder cancer, or other lifestyle factors and, thus, were not able to determine if such nonoccupational factors contributed to associations observed for these two cancers.

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INTRODUCTION

This is the first of two reports that describe a retrospective follow-up study of women employed in the synthetic rubber industry at one of eight plants in the United States (US) and Canada. Herein, we present results pertaining to mortality patterns by pay status, years since hire, years worked and work area within the industry. The second report will contain results pertaining to quantitative exposure estimates and cancers of interest.

Workers in the synthetic rubber industry are exposed to a number of chemicals with concern about toxic effects focusing on several chemicals used in making styrene-butadiene rubber (SBR), including 1,3-butadiene (BD) and styrene, monomers used to produce styrene-butadiene rubber, and the shortstop dimethyldithiocarbamate (DMDTC). Previously, we assembled and analyzed epidemiologic data on over 17,000 men, many of whom were potentially exposed to BD, styrene and DMDTC in the synthetic rubber industry. Epidemiologic analyses of the data indicated that these men had an excess of leukemia that was likely to have been due to exposure to BD or BD plus other chemicals (Cheng, 2007; Delzell, 2001; Delzell, 2006; Delzell, 1996; Graff, 2005; Macaluso, 1996; Macaluso, 2004; Sathiakumar, 2007; Sathiakumar, 1998; Sathiakumar, 2005). There are no previous epidemiologic studies of women in the synthetic rubber industry. At some of the plants, women accounted for a proportion of laboratory staff, with potentially high exposure to BD. Also, experimental studies have shown that BD produces mammary tumors in female mice and rat and ovarian tumors in female mice. The broad objective of the research described in this report was to determine if employment factors had any impact on the mortality of women synthetic rubber workers.

BACKGROUND AND SIGNIFICANCE

Synthetic rubber manufacturing started in the US and Canada in the early 1940s, when 15 plants began operations. These plants were sold to private companies between 1946 and 1955. An estimated number of 70,000 people have worked in production jobs at some time in the industry in the US (US Industry & Trade Outlook, 1998). SBR, a copolymer of BD and styrene, has been the most important type of synthetic rubber manufactured at most of these plants.

Exposures in the synthetic rubber industry

Potential exposure to chemicals used in making synthetic rubber varies by production process and by job (Macaluso, 2004). Synthetic rubber production involves several major processes, including polymerization, recovery, coagulation and finishing. SBR may be produced by an emulsion or a solution process, the former being considerably more common. All SBR plants also have tank farm, warehouse, laboratory, utilities and maintenance operations.

Synthetic rubber production workers are exposed to many chemicals, including BD and styrene monomers, shortstops (including DMDTC in the past), emulsifiers, activators, modifiers, catalysts, dilute acids, antioxidants, oils, carbon black and solvents. In the past, benzene was used in small quantities at most plants, primarily in certain laboratory procedures and maintenance operations. Benzene also has been used in some solution polymerization operations.

Concern about the possible toxic effects of workplace exposures in the synthetic rubber industry has centered mainly on the monomers used to make SBR rubber, BD and styrene. More recently, a possible carcinogenic role of DMDTC, an immune system depressant, has been

suggested (Irons, 1998). Benzene exposure in the industry appears to have been quite low (Macaluso, 1996).

In 1992 the International Agency for Research on Cancer (IARC) classified BD as a probable human carcinogen (group 2A), judging the evidence on carcinogenicity to be sufficient in animals but limited in humans (IARC, 1992). In 1998 the IARC reviewed all new and previous information on BD and retained the classification of BD as a probable human carcinogen. Again, the evidence on carcinogenicity was deemed to be inconclusive (limited) in humans. The IARC has classified styrene as possibly carcinogenic to humans (Group 2B) based on limited evidence of carcinogenicity in experimental animals and on inadequate evidence in humans (IARC, 1994). A metabolite of styrene, styrene epoxide, is regarded as carcinogenic in animals (IARC, 1994), but the human cancer-causing potential of this metabolite remains uncertain. The National Toxicology Program's Report on Carcinogens, Ninth Edition, listed BD, but not styrene, as known to be carcinogenic in humans (NTP, 2000). Benzene is a known human leukemogen (IARC group 1, sufficient evidence of carcinogenicity in humans and animals). No epidemiologic information is available on the human health effects of DMDTC. In 1991 IARC judged the available information on certain dithiocarbamates inadequate for an evaluation of carcinogenicity (IARC, 1991).

1,3-Butadiene (BD)

BD has been used extensively since 1943 to make synthetic rubbers and other polymers and copolymers. Before the mid-1980s, some jobs in the synthetic rubber industry in the US entailed BD exposure above 25 parts per million (ppm) (eight-hour time weighted average, TWA), with exposures of several hundred ppm being reported for some jobs (Fajen, 1993; Macaluso, 1996; Macaluso, 2004; Sathiakumar, 2007). Low-level environmental exposure to

BD occurs via emissions from facilities making or using BD, from motor vehicle exhaust and from sidestream cigarette smoke.

Experimental studies have established that certain monoepoxide and diepoxide metabolites of BD are genotoxic and that BD is an animal carcinogen (Anderson, 1997; Anderson, 1998; Anderson D, 1993; Himmelstein, 1997; Huff, 1985; Irons, 1989; Irons, 1986; Irons, 1986; Irons, 1987; Melnick, 1990; Melnick, 1988; Melnick RL, 1989; Owen, 1987; USDHHS, 1998). In mice BD or its metabolites cause malignant lymphoma/leukemia, hemangiosarcoma of the heart and tumors of the lung, forestomach and possibly other organs. Both female and male mice have identical somatic cell tumors. In addition, female mice have an increased incidence of mammary and ovarian tumors, and male mice had preputial gland tumors. In rats, BD causes mammary gland tumors and other tumors related to endocrine function. BD appears to be a considerably more potent carcinogen in mice than in rats, and research has shown species differences in the formation of genotoxic epoxide metabolites.

In addition to the established carcinogenic effects of BD in experimental animals, various reports have led to concern about the potential reproductive and developmental effects of exposure to BD (Anderson, 1997; Anderson, 1998; Anderson D, 1993; Bevan, 1996; IARC, 1992). Animal inhalation studies report an increased incidence of testicular or ovarian atrophy and of fetal abnormalities. However, most of these studies had serious methodological limitations. Thus, there is no convincing evidence that exposure to BD causes adverse effects on the germ cell in animals.

Epidemiologic studies of persons exposed to BD in occupational settings have yielded somewhat incoherent results (Cheng, 2007; Cowles, 1994; Delzell, 2001; Delzell, 2006; Delzell, 1996; Divine, 1993; Divine and Hartman, 1996; Divine and Hartman, 2001; Downs, 1987; Graff,

2005; Macaluso, 1996; Matanoski, 1997; Matanoski G, 1993; Matanoski, 1990; Matanoski and Schwartz, 1987; Meinhardt, 1982; Santos-Burgoa, 1992; Sathiakumar, 1998; Sathiakumar, 2005; Ward, 1995; Ward, 1996). Investigations of BD monomer production workers, who are potentially exposed to BD but not to styrene, have not consistently reported a positive association between BD and leukemia (Divine, 1993; Divine and Hartman, 1996; Divine and Hartman, 2001; Ward, 1995). However, two of these studies reported that workers had an elevated rate of deaths from lymphosarcoma, a form of non-Hodgkin lymphoma (NHL) (Divine, 1993; Divine and Hartman, 1996; Divine and Hartman, 2001; Ward, 1995; Ward, 1996), and a recent update of the largest available study of butadiene monomer production workers reported a slight excess of deaths both from leukemia and from NHL (Divine and Hartman, 2001). The interpretation of these results is unclear because quantitative estimates of exposure to BD were not developed.

The results of studies of workers in the sector of the synthetic rubber industry that uses monomers to make SBR and other rubbers differ from the findings of studies of BD monomer workers. SBR worker investigations have reported an excess of leukemia among certain subgroups of workers specified on the basis of work area within the industry (Delzell, 1996; Divine and Hartman, 1996; Matanoski G, 1993; Matanoski, 1990; Matanoski and Schwartz, 1987; Santos-Burgoa, 1992; Sathiakumar, 1998; Sathiakumar, 2005). The largest and most recent study of SBR industry workers reported a positive association between quantitative measures of BD exposure and leukemia but no consistent association between BD and NHL or multiple myeloma (Cheng, 2007; Delzell, 2006; Graff, 2005). Matanoski et al. examined essentially the same cohort, but during an earlier follow-up period and using a different exposure estimation approach, and reported that BD was positively associated in a dose dependent manner

with leukemia and with Hodgkin lymphoma but not with NHL (Matanoski, 1997). Irons and Pyatt have suggested that DMDTC may have confounded the apparent association between BD and leukemia seen in studies of synthetic rubber industry workers (Irons, 1998).

The results of the occupational mortality studies of SBR and BD monomer workers prompted concerns that students in the neighborhood of SBR plants may be at an increased risk of certain forms of lymphohematopoietic cancer (LHC). To address this concern, Loughlin et al. (Loughlin, 1999) identified 15,403 students, who attended high school in the eastern TX area adjacent to SBR plants, from school records and TX Department of Health records for 1963/1964 to 1992/1993 school years. Both men and women had lower than expected mortality from all causes combined compared to the corresponding US general population. An excess of LHC and of leukemia mortality noted among men was concentrated in the subgroup with less than two years of schooling in the area. Women had a deficit of deaths from leukemia. These results suggest that schooling in the area adjacent to SBR plants did not appear to increase the risk of subsequent mortality from LHC.

Studies of Czech Republic rubber polymer and monomer workers with relatively low exposure to BD have found that BD is not associated with gene mutations or structural changes in chromosomes (Albertini, 2003). A recent report examined differences in exposure concentrations and in levels of urinary metabolites between women and men employed in the Czech synthetic rubber industry (Albertini, 2007). BD exposure was lower for women than for men, and the concentration of urinary metabolites of BD per unit of BD exposure was lower for women than for men.

Styrene

Styrene, like BD, is produced by the petrochemical industry. It is used more widely than BD, in making other petrochemicals, synthetic elastomers and plastics and polyester paints. Generally, workers are exposed to relatively low styrene levels (TWA, <10 ppm) in styrene monomer and polymer production; SBR, latex and paint production; and styrene polymer fabrication operations. Much higher exposures have been documented in reinforced plastics production (IARC, 1994; Pfaffli, 1993).

Studies of humans exposed to styrene have found no clear evidence of carcinogenicity (Coggon, 1994). In their investigation of synthetic rubber workers, Matanoski et al. reported that styrene was positively associated with NHL and with multiple myeloma but not with leukemia or Hodgkin lymphoma (Matanoski, 1997). Additional information on the health effects of styrene comes from studies of workers in the reinforced plastics manufacturing industry (Kogevinas, 1994; Kogovenas M, 1993; Kolstad, 1995; Kolstad, 1994; Wong, 1994), from studies of workers in styrene monomer and polymerization facilities (Hodgson and Jones, 1985; Nicholson, 1978) and from a study of workers employed in the development and manufacturing of styrene-based products (Bond, 1992). These investigations observed increases in leukemia, NHL and/or other LHC in some subgroups of workers, but the pertinent results were difficult to interpret because of small numbers of observed and expected deaths, because of a lack of consistent duration-response patterns and because of methodologic limitations pertaining to exposure assessment and control of confounding by other chemicals present in the occupational settings that were studied. Several analyses of data from a large investigation of reinforced plastics workers in Europe have focused on diseases other than LHC. These studies have reported that styrene may be associated with nonmalignant genitourinary system disease (Welp, 1996), chronic diseases of the central

nervous system (Welp, 1996) and pancreas cancer (Kogovenas M, 1993). Women were included in some of the above studies, but the numbers of women generally were small and the numbers of women exposed to styrene were even smaller.

Benzene

Benzene has been used in the synthetic rubber industry in laboratory testing (small volume use) and as a solvent carrier in solution polymerizations, primarily to make polybutadiene rubber (relatively large volume use). Benzene is an established cause of acute myelogenous leukemia and may increase the risk of other forms of leukemia as well (IARC, 1987; Savitz and Andrews, 1997). Evidence for an effect of benzene on forms of LHC other than leukemia is inconclusive, although positive associations have been reported for NHL and for multiple myeloma.

Although benzene was used in some synthetic rubber production facilities, this agent does not appear to have had any major impact on the occurrence of leukemia in the industry (Macaluso, 1996). This implies that exposure to benzene was too low or occurred in too few workers to produce a statistically detectable increase in leukemia risk.

Dimethyldithiocarbamate (DMDTC)

DMDTC is a water-soluble chemical that was used in the synthetic rubber industry as a shortstop in the polymerization process, beginning in the late 1940s to early 1950s. Irons and Pyatt have proposed that DMDTC exposure explains the leukemia excess seen among SBR workers and the apparently contradictory results of studies of synthetic rubber workers and BD monomer workers (Irons, 1998). The hypothesis is founded partly on observations concerning the pharmacological effects of dithiocarbamates (DTCs), a broad category of chemicals related to DMDTC. Several DTCs, including diethyldithiocarbamate and disulfiram display bone

marrow depressant effects leading to reduced counts of peripheral leukocytes and platelets. Recent studies have highlighted the potential mechanistic importance of the inhibitory activity that DTCs exert on the activity of a transcriptional regulatory protein that has an important role in T-lymphocyte activation. Pyatt, Irons and coworkers reported that DMDTC inhibits T-lymphocyte activation and the clonogenic response of CD4+ bone marrow cells (Pyatt, 1998) . The biological significance of these findings with respect to carcinogenicity is not conclusive but is sufficiently compelling to warrant an epidemiologic evaluation of the hypothesis. In 1991, IARC reviewed several metal salts of DMDTC, forms of DMDTC used in industry. IARC found no information on carcinogenicity in human and at most, limited evidence in experimental animals and classified these DMDTCs as group 3 (not classifiable as to its carcinogenicity in humans) (IARC, 1991).

Previous investigations of workers at the study plants

We previously assembled a cohort of 17,964 North American male synthetic rubber industry workers, about 75% of whom were exposed to BD and 83% to styrene (Cheng, 2007; Delzell, 2001; Delzell, 2006; Delzell, 1996; Graff, 2005; Macaluso, 1996; Macaluso, 2004; Sathiakumar, 2007; Sathiakumar, 1998; Sathiakumar, 2005). Recent studies of these workers evaluated mortality patterns during the period 1944 through the end of 1998 (Cheng, 2007; Delzell, 2006; Graff, 2005; Sathiakumar, 2005). Workers had a total of 6,237 deaths, compared to 7,242 expected on the basis of general population rates, a 14% deficit. Observed/expected numbers of deaths were 1,608/1,741 for all cancers combined, 71/61 for leukemia, 53/53 for NHL, and 26/27 for multiple myeloma. The 16% leukemia increase was concentrated in ever-hourly employees with 20-29 years since hire and 10 or more years of employment in the industry and in subgroups employed in polymerization, coagulation, maintenance labor, and

laboratory operations. Cumulative exposure to BD was associated positively with leukemia. These results and most biological information from other research support an interpretation that BD causes leukemia in humans. Styrene and DMDTC also were associated positively with leukemia. Exposures to these two agents were correlated with BD, data on the independent effect of each chemical on leukemia were inadequate, and external support for a leukemogenic role is lacking for styrene and is limited for DMDTC. Thus, the interpretation of observed associations of styrene and DMDTC with leukemia remained uncertain. The study did not find any clear relation between exposure to BD, styrene, or DMDTC and NHL or multiple myeloma. Some subgroups of subjects had more than expected deaths from colorectal cancer and prostate cancer. These increases did not appear to be related to occupational exposure in the industry.

Study rationale

BD and styrene are commercially important chemicals that are used in a variety of industries. Exposure to these chemicals occurs in diverse occupational and nonoccupational settings. The potential carcinogenicity of BD and styrene has been investigated, but unanswered questions remain.

In general, there is a paucity of investigations of occupational cancer among women (Blair, 1999), and all previous epidemiologic investigations of synthetic rubber workers have been limited to men. Women in the synthetic rubber industry are of interest because at some of the plants they accounted for a proportion of laboratory staff, with potentially high exposure to BD and other chemicals, and because they worked in production jobs at most of the plants during some years of operation. In addition to the information from our updated study of male synthetic rubber workers, information from this study of female synthetic rubber workers may be useful for risk assessment and regulatory actions by state and federal agencies in the US and by

agencies in other countries. It also will be useful in evaluating further the role of styrene and DMDTC in human carcinogenesis.

OBJECTIVES

The research objectives addressed in the present report were:

- to evaluate the overall and cause-specific mortality experience of female synthetic rubber workers relative to that of the state female general populations; and
- to determine if the overall and cause-specific mortality patterns of the subjects are associated with characteristics such as duration of employment, time since hire, pay status (ever hourly or never hourly) and work area.
- to evaluate the relation between quantitative estimates of exposure to BD and leukemia, NHL, other LHC and cancers of the breast and ovary;
- to evaluate the relation between quantitative estimates of exposure to styrene and leukemia, NHL, other LHC and cancers of the breast and ovary; and
- to evaluate the relation between quantitative estimates of exposure to DMDTC and leukemia, NHL, other LHC and cancers of the breast and ovary.

METHODS

Overview of the study design

The investigation was a retrospective follow-up study of 4,863 women employed for at least one day at one of eight synthetic rubber manufacturing plants in the US and Canada. These subjects experienced a total of 1,198 deaths during the study period of 1943 through 2002. Cause-specific mortality was evaluated for subjects from all eight plants. Work area analyses evaluated mortality among women in three major categories: SBR-related operations,

administration and residual operations, the latter comprised of women who were not in SBR-related operations or in administration.

The study plants

Table 1 describes the location, main products and operating dates of the eight study plants. The eight study plants were located in Kentucky (plant 1), Texas (plants 2, 5, 6 and 8), Louisiana (plants 3 and 4) and Ontario (plant 7). Plant 8 consists of two facilities, referred to as plants 8A and 8B.

Throughout much of the history of these plants emulsion SBR was a major product, but it is now made in large amounts (>200 million pounds per year) only at plants 3, 5, 6, and 8. Plants 1-4, 7 and 8 were similar with respect to their original design. All began by using a batch emulsion process to make SBR. Major improvements at the six plants occurred in the mid-1950s and included changes from a hot to a cold production process and from a bath to a continuous process. Plant 5, which opened in 1957, was constructed as a continuous, rather than batch, polymerization process. Plant 7 originally made SBR using an emulsion process similar to that of the US plants that opened in the early 1940s. However, plant 7 also had butyl rubber and various petrochemical operations.

Beginning primarily in the 1960s, the product lines of some of the plants expanded (table 2). Plants 1, 4, and 7 produced solution process polybutadiene rubber using various solvent systems, including toluene at plant 1; hexane at plant 4; and benzene, cyclohexane and 1-butene at plant 7. Plant 8 made small amounts of emulsion process polybutadiene rubber. Plants 3, 6, and 7 made nitrile rubber using an emulsion process. Plants 6, 7 and 8 made a styrene-butadiene latex using an emulsion process. Plant 4 made solution SBR using hexane. Plant 1 made various liquid polymers, including various copolymers of styrene, BD, acrylonitrile and acrylic acid, in

addition to polybutadiene rubber. Both plants 3 and 7 made BD, and plant 7 also made STY. Only plant 7 has commercially produced butyl and halobutyl rubber. Neoprene, polyisoprene and ethylene propylene rubbers were not produced commercially at any of the plants.

Subject eligibility and follow-up period

A woman was eligible if she was employed for at least one day before the closing date of our study of male synthetic rubber workers at the same plants (December 31, 1991) and having been at work during the period when her plant systematically retained the personnel records of former workers. The specific eligibility criteria were:

- employment duration of at least one day between 1943 and the closing date of the study of male synthetic rubber workers, December 31, 1991
- active employment between 1943 and 1991 at plants 2, 3, 4, 6 and 8A; active employment between 1950 and 1991 at plants 7 and 8B; or active employment between 1960 and 1991 at plant 5; or active employment between 1965 and 1991 at plant 1.
- personnel records of acceptable quality, containing at a minimum information on birth date, Social Security number, hire date and termination date.

The maximum follow-up was 60 years, from January 1, 1943, to January 1, 2003, for women from plants 2, 3, 4, 6 and 8A. The earliest follow-up differed for other subcohorts as follows: January 1, 1950 for plants 7 and 8B; January 1, 1960 for plant 5; and January 1, 1965 for plant 1.

We did not include women hired after January 1, 1991. These subjects would have contributed little information to the present study by virtue of the short duration between their hire date and the study end date and because exposures in the workplace are known to be

considerably lower in the recent years (Macaluso, 2004; Sathiakumar, 2007). Recently hired workers were not included in the study of male synthetic rubber workers.

Our previous study of men in the synthetic rubber industry imposed a one-year minimum duration of employment criterion for eligibility. The main reason for this restriction was to limit research resources expended on studying short-term employees, whose risk of health effects from occupational exposures was assumed to be relatively low: there was a large turnover of employees in the synthetic rubber industry, with about 50% of the total workforce having under one year of employment. For the present study, we included all women ever employed at the study plants, irrespective of the duration of employment. However, we carried out analyses of subgroups of women that allowed us to examine mortality patterns separately among those employed for <1 year and those employed longer.

Study group identification

During our previous investigations (Delzell, 1996; Macaluso, 1996; Sathiakumar, 1998), we assembled data on men and women who had worked at one of the eight study plants. Using this data source as a starting point, we identified a preliminary cohort of 3,225 women. We evaluated the completeness of the preliminary cohort using sources other than personnel records that were collected during the previous study. For the US plants, we used seniority rosters, Internal Revenue Service (IRS) earnings reports (for plants 1, 3, 4 and 8A), lists of newly hired, terminated and retired employees; pre-employment medical evaluation forms; and organizational charts. For the Canadian plant, we used data from archived paper and microfiche personnel and benefits records. From each of these sources we developed a computer file containing subject identifiers. We crosschecked these files with the preliminary cohort file to identify cohort omissions. We then visited the study plants to obtain these subjects' personnel records and to

systematically review and identify additional records. Consequently, we identified a total of 6,796 potentially eligible subjects. After completing preliminary cohort identification and verification, we reviewed all hard copy data on each subject to determine if the eligibility criteria were met.

The final study group included 4,863 eligible women. Women were excluded because of missing crucial information (surname, Social Security Number (SSN), date of birth or employment dates (N=938); termination before the beginning of follow-up (N=505); not employed at the study plant (N=315); or male gender (N=175).

The following general information was abstracted for each eligible subject: plant, surname(s), first name, middle initial, SSN, race, birth date, first hire date, most recent termination date, employment status (active, retired, terminated), death date, most recent address and spouse's name. Women are typically more difficult to trace than men because of surname changes. Hence, we recorded all surname changes mentioned for subjects in their plant records.

Information on race was not included in the personnel records for 28% of subjects. Interviews with long-term plant personnel in human resources and pre-employment application photographs were used as supplemental sources to obtain information on race. Final race assignments were based on plant personnel records for 72% of the cohort, on plant ancillary information (plant interviews and pre-employment information) for 14% cohort and on death certificates for 0.1% (N=5). The remaining 14%, all of whom were Canadian subjects, were classified as white reflecting the race distribution of employees at that plant.

Work histories

Personnel records were the primary source of work history information. We used these to obtain information on each of an employee's job changes, including the start date, work area,

job title, end date and pay status. We also recorded gaps in employment due to layoffs or other absences. We classified the jobs of women employees into three main work areas: 1) SBR-related operations, 2) administration and 3) residual operations, a group consisting of jobs not included in SBR-related operations or administration (table 2). SBR-related operations comprised the same jobs as in our study of men. We further categorized jobs in SBR-related operations into five large subgroups (production, maintenance, labor, laboratories and other operations) and seven smaller subgroups (production: polymerization, coagulation and finishing; maintenance: shop and field; labor: production labor and maintenance labor).

As in our previous study of men in synthetic rubber industry, we used the work histories to develop for each plant a list of unique combinations of work area and job title. The number of unique work area/job combinations was 1,129 for US subjects and 2,528 for Canadian subjects. Using information obtained from plants on both SBR and non-SBR operations and on jobs and tasks within each type of operation, we specified a total of 133 work area/job groups for the overall study group. A group was comprised of operations and jobs considered to be similar. SBR-related operations consisted of 51 work area/job groups. Administration consisted of one work area/job group. Residual operations consisted of 81 work area/job groups. Appendix B lists the 133 work area/job group codes and their corresponding translations organized by major groups (SBR-related operations, administration and residual) and by pay status.

The Administration group was comprised predominantly of salaried women in clerical and other administrative positions. The residual operations group was comprised of women employed in general services, in safety, in design engineering and, at the Canadian plant, in maintenance, technical and other operations that could not be identified as related to SBR production.

Exposure estimation

We have described historical exposure estimation procedures in detail elsewhere (Macaluso, 1996; Macaluso, 2004). In brief, estimation procedures included, for each agent: 1) identifying at each plant a series of work area/job groups, each of which was homogeneous with respect to its component tasks and exposure potential, 2) identifying for each plant-specific work area/job group its component tasks that entailed exposure and documenting historical changes in those tasks, 3) calculating plant-, work area/job group- and time-specific average exposure intensities (ppm) and compiling these into job-exposure matrices (JEM), and 4) linking the monomer intensity estimates in the JEMs with each subject's work history to obtain cumulative exposure estimates. While carrying out the above steps, we found eight work area/job groups that were not among those found for men. Three groups were unexposed to the agents of interest. To each of the remaining five work area/job groups, involving work histories of 23 subjects, we assigned the agent exposure values estimated for the work area/job group combination at the same plant that came closest in task composition to that of the problematic work area/job group.

Computation of cumulative exposure estimates involved multiplying the calendar year-specific amount of time a worker spent in each work area/job group by the exposure estimate for that work area/job group and calendar year category, and summing over all work area/job group title groups and years covered by a subject's employment history. The cumulative exposure indices were: 1) BD ppm-years; 2) styrene ppm-years; 3) BD ppm years due to exposure to intensities ≤ 100 ppm; 4) BD ppm -years due to exposure to intensities > 100 ppm; 5) total number of high-BD-intensity tasks; 6) total number of high-styrene-intensity tasks; and 7) DMDTC total mg-years/cm. Macaluso et al. (Macaluso, 2004) have described these indices in further detail.

We recently completed an investigation aimed at validating exposure estimates (Sathiakumar, 2007). We compared estimates of exposure to BD developed for the Canadian plant with personal BD measurements that came from an exposure monitoring program. Estimates were correlated with measurements for work area/job title combinations pertaining both to well-defined and to poorly-defined jobs typically found in SBR plants, and correlated to a lesser extent for well-defined jobs not typically found in SBR plants. Estimates were not correlated with measurements for poorly-defined jobs not typically found in SBR plants. For well-defined typical SBR jobs with measurement means that were over 7.0 ppm, estimates were consistently lower than measurements.

Vital status

For US subjects, we used plant records to obtain surname changes during the employment period and LexisNexis records for post-separation surname changes. LexisNexis is a nationwide person locator database. For Canadian subjects, we obtained all surname changes during employment at the study plant from plant records. Procedures for obtaining vital status information differed for US and Canadian subjects.

US subjects: We used plant records, the Social Security Administration (SSA), the National Death Index (NDI), Cambridge Statistical Research Associates (CSRA), Centers for Medicare and Medicaid services (CMS) and individual tracing to determine the vital status of 3,175 US subjects as of January 1, 2003. We began vital status tracing by using plant personnel and benefits records to identify currently active (N=70) and living pensioners (N=36). Both of these groups were classified as alive. To determine the vital status of employees who had terminated or retired, we first submitted a list of their names and SSNs for linkage with the SSA, with the NDI records and with the CSRA. These sources identified a total of 1,057 deaths. Of

these, 972 had died on or before December 31, 2002, and were classified as deceased, and 85 had died later and were classified as alive at the end of the study.

Of the remaining 2,012 subjects, 1,878 were classified as alive because of SSA's IRS data (N=1,459) or because they were receiving Medicare or Medicaid benefits (N=252) or because they were contacted by project staff (N=34). We also classified as alive subjects who terminated in or after 1979 and who did not have an NDI record (N=133). The NDI identifies a high proportion of deaths occurring in 1979 or later, about 98% among whites and 95% among blacks. We considered as lost to follow-up 134 subjects (6.7% of the US cohort) who terminated employment before 1979 and for whom we had no current vital status information.

Canadian subjects: Statistics Canada conducted linkages with the CMDDB to determine the vital status information of 1,688 Canadian subjects as of January 1, 2003, and identified 226 deaths. All of these 226 subjects died before the study closing date and were classified as deceased. Annual tax files, without income information, were also used internally by Statistics Canada to assist with the linkages and to verify the number of subjects who were alive at the close of the study. Of the residual 1,462, Statistics Canada identified 1,187 as confirmed alive and 287 as lost to follow-up. Because data were provided in the aggregate as a summary table for the residual group, we assigned the end of follow-up as the study closing date for all Canadian subjects without a CMDDB death record.

Cause of death

For US subjects identified as having died before 1979, we obtained death certificates from the state bureau of vital records. Two nosologists independently reviewed all death certificates and coded the underlying cause of death using codes from the International Classification of Diseases in effect at the time of death. The nosologists also coded any cancer

listed on the death certificate as a condition other than the underlying cause of death. For subjects identified as having died in or after 1979, we obtained their cause of death codes from the NDI *Plus* (Sathiakumar, 1998). We also obtained death certificates of all subjects whose NDI *Plus* codes indicate an LHC cancer or any other blood disorder as a cause of death.

Cause of death codes for Canadian subjects came from the CMDB. All codes Canadian decedents also were based on the revision of the ICD in effect at the time of death.

SMR analyses

The overall and cause-specific mortality experience of the study groups was assessed by comparing their rates with female general population rates of the states or the province where the plants are located (US: Kentucky, Louisiana and Texas; Canada: Ontario), using the standardized mortality ratio (SMR) as the measure of association.

We computed SMRs for the overall group of female synthetic rubber workers and for subgroups specified on the basis of selected employment factors, including plant, pay status (ever-hourly and never-hourly), work area, duration of employment, time since hire and cross-classifications of some of these variables. The effect of duration of employment on specific forms of cancer and other diseases was examined within categories of time since hire (<20 and 20+ years). In these analyses, time since hire served as a surrogate for induction time.

We computed the SMR for a particular cause of death as the ratio (x 100) of the number of deaths observed among the overall cohort or a subgroup to the number expected based on the cause-, race-, age- and calendar time-specific mortality rates of state or provincial general populations. To compute expected numbers of deaths, we first accumulated person-years of observation for each subject into race-specific five-year age and calendar time categories. Person-year accumulation begin on the date when the subject accumulated a day of employment,

on the date of entry into a particular cohort subgroup or on the date when personnel records at the subject's plant were considered complete, whichever was latest. Person-year accumulation ended on the date of death, on the date of loss to follow-up (the termination date for lost subjects) or on the study end date (December 31, 2002), whichever was earliest. Next, we multiplied the race-, age- and calendar time-specific person-years by the corresponding state mortality rates and summed the resulting quantities to obtain expected numbers. We estimated 95% CIs of the SMRs under the assumption that the observed numbers of deaths follow a Poisson distribution.

Further SMR analyses computed observed and expected numbers of deaths for various agent exposure categories (ever exposed to each agent, unexposed to each agent, quantiles of exposure to BD ppm-years, styrene ppm-years, and DMDTC mg-years/cm. To facilitate comparison of the results of the present study with those of our previous study of male synthetic rubber industry workers, we also estimated expected numbers of leukemia deaths for the same categories of BD ppm-years used in our study of men (i.e., quartile 1, <33.7 ppm-years; quartile 2, 33.7 – <184.7 ppm-years; quartile 3, 184.7 – <425.0 ppm-years; and quartile 4, 425.0+ ppm-years).

We used the software, the Occupational Cohort Mortality Analysis Program (OCMAP), for data analyses (Marsh, 1998). State-specific general population rates were available as part of OCMAP for 1950-1998 for cancers and for 1962-1998 for noncancers. For 1960-1964 noncancer rates, we used 1962-1964 OCMAP state-specific rates. For 1944-1949 general population cancer rates and for 1944-1959 general population noncancer rates, we used US population rates provided by the United States Death Rate (USDR) program developed by Monson (Monson, 1974), instead of state rates. USDR rates for NHL and multiple myeloma

were not available for the 1944-1949 period. Therefore, we used OCMAP population rates for the 1950-1954 time period to calculate expected numbers of deaths for these two categories during the 1944-1949 period. Statistics Canada provided the rates for Ontario general population.

Internal analyses

Internal analyses were conducted when there were at least 10 exposed decedents for a form of cancer of interest. These analyses used Poisson regression models to examine selected cancers in relation to BD, styrene, and DMDTC exposure, within the six-plant study group and without reference to an external comparison population (Breslow, 1987; Callas, 1998). These models provided maximum likelihood estimates of the relative rate for one agent, adjusting for other agents and for additional potential confounders. All models used indicator terms for the agent exposure categories, rather than continuous exposure variables. Thus, the RR for a particular category is interpreted as the rate in that category divided by the rate in the referent (zero or low exposure) category. Internal analyses included all decedents from a specific forms of cancer coded either as the underlying or as a contributing cause of death.

We used the Statistical Analysis System procedure GENMOD (SAS Inst Inc 1993) to obtain maximum likelihood estimates of rate ratios (RRs) for categories of the three main exposure indices, BD ppm-years, styrene ppm-years and DMDTC mg-years/cm, and for two other indices (number of high-BD- or high-styrene-intensity tasks). We specified exposure categories based on the distribution of cumulative exposure among cases of each form of cancer, using quartiles of cumulative exposure among those decedents with nonzero exposure (Greenland, 1995). Exploratory modeling considered age, years since hire, calendar period and race as potential confounders. Final models included only age and years since hire, in addition to the agents of interest, because dropping race and calendar period from the models had little

impact on agent-specific RRs but enhanced the precision of the analyses. The models for the Poisson regression analyses included indicator terms for all agents and covariates being considered.

RESULTS

Characteristics of the cohort

Of the total of 4,863 women, 4,498 (92%) were white and 365 (8%) were nonwhite (table 3). About one-third of the subjects worked at the Canadian plant. White women were mainly never-hourly (75%), whereas nonwhite women were mainly ever-hourly (82%). About 50% of subjects were hired before 1960 (median hire year, 1959), 41% worked for less than one year at the plants (median, 1.6 years), and 67% had at least 30 years since hire (median, 39 years). Of the total 4,863 subjects, 3,531 (72%) were alive, 1,198 (25%) were deceased, and 134 (3%) were lost to follow-up. At the close of follow-up, 69% were at least 70 years of age. The number of person-years of follow-up was 181,831 (average, 37.4 years per woman) overall, 170,464 (average, 37.9) for whites and 11,366 (average, 31.1) for nonwhites.

As seen in table 4, 34% of the women in the study had worked in SBR-related operations, 50% in administration and 27% in residual operations. The distribution of subjects by pay status differed by work area. Women in SBR-related operations had a greater proportion of ever hourly subjects (61%) compared to administration (2%) and the residual group (34%). Of the 1,641 subjects in SBR-related operations, 18% had worked in production, 2% in maintenance, 22% in labor, 26% in laboratories and 38% in other SBR operations. In the SBR production group, most (91%) had worked in finishing. The SBR-related operations subgroups (polymerization, coagulation, maintenance, production labor and maintenance labor) had small numbers of subjects and deaths. Analyses of mortality by work area were limited to categories with at least

250 subjects and at least 50 deaths, including SBR-related operations and certain subgroups (production, production finishing, labor, laboratories and other operations); administration; and residual operations.

General mortality patterns

Among all subjects, the SMR for all causes combined was 87 (95% CI=82-92), based on 1,198 deaths and 1,383 expected deaths (table 5, third data column). For all cancers, the SMR was 96 (374 observed/392 expected; CI=86-106). With the exception of lung cancer and bladder cancer, SMRs were close to or below the null value of 100. There was a statistically significant excess of deaths from lung cancer (106 observed/83 expected, SMR=127, CI=104-154). There were more than expected deaths from bladder cancer (8/4.3, SMR=186, CI=80-366); this result was based on small numbers and was not statistically significant. Leukemia, Hodgkin lymphoma and multiple myeloma deaths were fewer than expected (leukemia: 10/13, SMR=79, CI=38-145; Hodgkin lymphoma: 1/1.3; multiple myeloma: 7/7.9, SMR=88, CI=35-182), and observed and expected numbers of deaths were approximately equal for NHL (15/14, SMR=108, CI=61-178). Observed and expected numbers of deaths were approximately equal for cancer of the breast (72/74, SMR=97, CI=76-123) and ovary (21/22, SMR=94, CI=58-143). SMRs for most other major causes of death were close to or below the null value of 100. Observed and expected deaths from nonmalignant respiratory disease were equal (102/102, SMR=100, CI=82-122).

Results for ever-hourly women were similar to results for the overall study group. SMRs for ever-hourly employees were 182 (47/26, CI=133-242) for lung cancer and 353 (6/1.7, CI=130-768) for bladder cancer. This group did not have any excess of deaths from breast cancer (18/23, SMR=77, CI=46-121), ovarian cancer (7/7.2, SMR=97, CI=39-200), leukemia (2/4.3),

Hodgkin lymphoma (0/0.5) or multiple myeloma (3/3.3) and had an SMR of 159 (7/4.4, CI=64-327) for NHL.

Never-hourly women had lower than expected mortality from most causes of death. Their SMRs were lower than those of ever-hourly subjects for many causes of death. Exceptions included those for breast cancer (54/51, SMR=107, CI=80-139) and leukemia (8/8.4, SMR=96, CI=41-189).

Appendix C presents plant-specific results. The SMR for all causes combined was lower than or close to the null value of 100 for employees at all of the eight plants. With the exception of a slightly elevated SMR for all cancer in plant 6, all other plants had SMRs that were below or close to 100. Among all ever-hourly subjects, there were more than expected lung cancer deaths at seven of the eight plants.

Appendix D presents detailed results for the cohort subgroup with at least one year of employment. In brief, this group had mortality rates that were 20% lower than those of the general population comparison groups. For most causes of death, the SMRs of ever hourly women were higher than the SMRs of never hourly women. There was no strong association with cancers of *a priori* interest. The most notable result was a statistically significant excess of lung cancer among ever-hourly women.

Years since hire and years worked

The cohort subgroup having both a relatively long potential induction time (20+ years since hire) and long duration of employment (5+ years) had SMRs for all causes (SMR=84) and for all cancer (SMR=85) (table 6) that were lower than those the corresponding SMRs for the overall cohort. This subgroup had increased mortality from lung cancer (27/17, SMR=156, CI=103-228): however, an excess of this cancer also was present in the subgroup with 20+ years

since hire and <1 year of work (51/37, SMR=137, CI=102-181). Small, statistically nonsignificant increases were present for bladder cancer both in those with 20+ years since hire and <1 year worked (5/1.9, SMR=259, CI=84-605) and those with 20+ years since hire and 5+ years worked (3/1.0, SMR=302, CI=62-883). No increase was seen for breast or ovarian cancer in women with 20+ years since hire and 5+ years work, and this subgroup had 0/2.4 deaths from leukemia, 2/2.9 deaths from NHL, 0/0.1 death from Hodgkin lymphoma and 3/1.4 deaths from multiple myeloma.

Among ever-hourly women, analyses by years since hire and years worked indicated that the excess of lung cancer was concentrated among those with 20+ years since hire; within that subgroup there was no marked variation in SMRs by years worked (<1 year worked: 24/14, SMR=178, CI=114-264; 1-4 years: 13/6.1, SMR=212, CI=113-363; 5+ years: 8/4.1, SMR=197, CI=85-389) (table 7). Bladder cancer deaths occurred only among those with 20+ years since hire; within this subgroup, increases occurred both among women with <1 year of employment (4/0.9, SMR=449, CI= 122-1149) and those with 5+ years of employment (2/0.3, not statistically significant). NHL and multiple myeloma deaths also occurred only in the subgroup of ever-hourly women with 20+ years since hire, without any marked excesses or any pattern of increasing SMRs with increasing duration of employment. There was only one death from leukemia among ever-hourly women with 20+ years since hire, and this occurred in the group with <1 year of employment.

Work area

Among subjects in ever-hourly SBR-related operations (table 8, first data column), SMRs were 90 (293/324, CI=80-101) for all causes, 104 (86/83, CI=83-128) for all cancers, 198 (34/17, CI=137-276) for lung cancer and 75 (11/15, CI=37-134) for breast cancer. Results for other

forms of cancer were based on small numbers and did not include any large or statistically significant excesses. Never-hourly women in SBR-related operations also had a slight increase in lung cancer deaths (12/9.8, SMR=123, 63-214). They had an SMR of 94 for breast cancer (8/8.5), and their results for other cancers were based on very small numbers.

Further analyses of the ever-hourly women in SBR-related operations (table 9) indicated that the increase in lung cancer was concentrated among the subgroup with 20+ years since starting in SBR-related operations; within this category, an increase occurred in all duration of employment groups (<1 year: 19/10, SMR=191, CI=115-298; 1-4 years: 10/4.3, SMR=232, CI=111-427; 5+ years: 3/1.7, SMR=180, CI=37-526). Appendix D presents results for work area subgroups within SBR-related operations. The lung cancer excess was concentrated among women in laboratories (25/11, SMR=235, CI=152-346) (table D2). Among laboratory workers, the lung cancer excess was restricted to those with 20+ years since starting in laboratories; within this group, lung cancer increases occurred in each category of duration of employment but were statistically significant only among shorter-term employees (<1 year in laboratories: 13/5.5, SMR=238, CI=127-407; 1-4 years: 10/3.4, SMR=297, CI=143-547; 5+ years: 2/1.5). Modest increases in lung cancer, based on small numbers, were present for all other SBR-related subgroups analyzed. Results for LHC and for breast and ovarian cancers were unremarkable for women in SBR-related operations.

Never-hourly employees in administration had a deficit of observed deaths from all causes combined (517/625, SMR=83, CI=76-90) and all cancers (167/189, SMR=89, CI=76-189) (table 10). They had fewer than expected lung cancer deaths (36/42, SMR=86, CI=60-119) and approximately equal numbers of observed and expected ovarian cancer deaths (10/11,

SMR=91, CI=43-167). Small increases occurred for breast cancer (40/36, SMR=110, CI=78-149) and bladder cancer (3/1.9, SMR=154, CI=32-451).

Ever-hourly women in residual operations had SMRs of 102 (222/217, CI=89-117) for all causes and 112 (56/50, CI=84-145) for all cancers and had an increase in deaths from lung cancer (15/8.7, SMR=173, CI=97-285) (table 11, first data column). They also had more observed than expected deaths from bladder cancer (4/0.7, SMR=540, CI=147-1382). The latter increase was limited to women with 1-4 years of employment and 20+ years since hire (3/0.39, SMR=770, CI=159-2250) (table 12). Never-hourly women in residual operations had SMRs of 74 (141/190, CI=62-87) for all causes and 77 (46/60, CI=56-102) for all cancers. Their SMR was 122 (16/13, CI=69-197) for lung cancer.

SMRs for employees unexposed or exposed to agents

Both employees unexposed to BD and those exposed to BD had fewer observed deaths from leukemia than expected (unexposed: 7/8.7; exposed: 2/2.7) (table 13). Examination of leukemia mortality among women by categories of BD ppm-years used in our study of male synthetic rubber industry workers (Graff, 2005) indicated the following observed and expected numbers of deaths: 1/1.7 in quartile 1 (<33.7 ppm-years); 1/0.5 in quartile 2 (33.7 – <184.7 ppm-years); 0/0.2 in quartile 3 (184.7 – <425.0 ppm-years); and 0/0.1 in quartile 4 (425.0+ ppm-years) (data not displayed in a table).

For LHCs other than leukemia, differences in observed and expected numbers of deaths were small both among women exposed and among women unexposed to each agent (table 13). For NHL, observed/expected numbers among the exposed were 2/3.0 for BD, 5/3.5 for styrene and 1/1.3 for DMDTC. For breast cancer, observed/expected numbers among the exposed were

14/17 for BD, 15/19 for styrene and 7/7.2 for DMDTC. For ovarian cancer, observed/expected numbers among the exposed were 8/4.9 for BD, 8/5.7 for styrene and 2/2.1 for DMDTC.

Employees ever exposed to BD, styrene or DMDTC had statistically significant increases in observed compared to expected deaths from lung cancer (BD ppm-years >0: 42/19, SMR=223, CI=161-302; styrene ppm-years >0: 43/22, SMR=197, CI=143-266; DMDTC mg-years/cm >0: 16/8.0, SMR=199, CI=114-324). The lung cancer SMR was close to the null value for those unexposed to BD (SMR=99) and for those unexposed to styrene (SMR=103) and was elevated slightly for those unexposed to DMDTC (SMR=122, CI=97-151). Results for bladder cancer were unremarkable and were based on at most two observed deaths among women exposed to each agent.

Internal analyses

Internal analyses of the relation between cumulative exposure to agents of interest among women from six of the eight study plants included 4,511 subjects. The decedents with specific forms of cancer for whom we developed summary exposure data included 10 with leukemia, 14 with NHL, five with multiple myeloma, one with Hodgkin lymphoma, 104 with lung cancer, eight with bladder cancer, 67 with breast cancer and 22 with ovarian cancer. These groups of decedents consisted of the subjects who had worked at one of the six plants and who had the specific cancer listed as the underlying cause of death (UCD) or as a contributing cause of death (CCD) on their death certificates: leukemia (UCD, 9; CCD, 1); NHL (UCD, 13; CCD, 1); multiple myeloma (UCD, 5); Hodgkin lymphoma (UCD, 1); lung cancer (UCD, 98; CCD, 6); bladder cancer (UCD, 6; CCD, 2); breast cancer (UCD, 60; CCD, 7); and ovarian cancer (UCD, 19; CCD, 3).

For all subjects, proportions ever exposed to the agents of interest were 26% for BD ppm-years, 31% for styrene ppm-years and 13% for DMDTC mg-years/cm (table 14). Proportions of all decedents exposed were similar to those for all subjects (BD ppm-years, 26%; styrene ppm-years, 31%; DMDTC mg-years/cm, 9%). Median cumulative exposure values were 8.0 BD ppm-years, 1.7 for styrene ppm-years and 15.7 for DMDTC mg-years/cm for all subjects and were 19.9 for BD ppm-years, 3.0 for styrene ppm-years and 121.9 for DMDTC mg-years/cm for all decedents.

For each of the LHCs, the number of subjects exposed to the agents was small, and there was considerable overlap in exposure to the three agents. Of 10 leukemia decedents, two were exposed both to BD and to styrene, and one of these two subjects also was exposed to DMDTC. Of 14 NHL decedents, two were exposed to BD and styrene, and one of these subjects was also exposed to DMDTC; another three women with NHL were exposed to styrene alone. Of five decedents with multiple myeloma, one decedent was exposed to BD, styrene and DMDTC. The one Hodgkin lymphoma decedent was unexposed. Cumulative exposure levels were unremarkable among the two exposed women with leukemia in comparison with levels found among all subjects and all decedents. Because the number of cases exposed to agents of interest was small, we did not carry out further analyses of exposure in relation to leukemia, other LHCs, bladder cancer or ovarian cancer. Further analyses pertain to lung cancer and breast cancer.

Compared to all decedents, lung cancer decedents had lower median BD ppm-years, 1.7 times higher median styrene ppm-years and lower median DMDTC mg-years/cm (table 14) and had median exposure values that were about 25% lower for BD ppm-years due to intensities \leq 100, 36% lower for BD ppm-years due to intensities >100 , similar for high-BD intensity tasks, and 1.8 times higher for high-styrene intensity tasks (table 15). Breast cancer decedents,

compared to all decedents, had similar median BD ppm-years, 1.8 times higher median styrene ppm-years, 7.2 times higher DMDTC mg-years/cm, about 1.3 times higher for BD ppm-years due to intensities ≤ 100 , 1.4 times higher for BD ppm-years due to intensities >100 , similar for high-BD intensity tasks, and 73% lower for high-styrene intensity tasks.

The three main exposure variables were correlated for all subjects and for lung and breast cancer decedents (data not displayed in a table). Spearman rank correlation coefficients were 0.96 for BD ppm-years and styrene ppm-years, 0.55 for BD ppm-years and DMDTC, and 0.52 for styrene ppm-years and DMDTC for the 104 lung cancer decedents and were 0.95 for BD ppm-years and styrene ppm-years, 0.65 for BD ppm-years and DMDTC, and 0.64 for styrene ppm-years and DMDTC for the 67 breast cancer decedents. Because of the high correlation between BD ppm-years and styrene ppm-years, we did not examine them concurrently in models for lung and breast cancers.

For lung cancer, single-agent Poisson regression analyses adjusting for age and years since hire indicated a positive association with any exposure to each of the three agents, but there was no evidence of a consistently increasing exposure-response relationship for any of the agents (table 16). RRs were 1.0, 2.8, 1.9, 2.3, and 2.1, respectively, for exposures of 0, >0 - <1.9 , 1.9 - <12.8 , 12.8 - <56.3 , and 56.3 + BD ppm-years (Model 1); 1.0, 1.7, 1.5, 2.9, and 2.0, respectively, for exposures of 0, >0 - <0.8 , 0.8 - <6.0 , 6.0 - <21.6 , and 21.6 + styrene ppm-years (Model 2); and 1.0, 1.9, 2.0, 1.9, and 1.6, respectively, for 0, >0 - <8.9 , 8.9 - <71.7 , 71.7 - <673.6 , and 673.6 + DMDTC mg-years/cm (Model 3).

Adjusting for DMDTC had very little impact on the magnitude of the association between BD ppm-years and lung cancer (table 16, Model 4) or between styrene ppm-years and lung cancer (Model 5). Adjustment for BD ppm-years or styrene ppm-years removed the positive

association between DMDTC and lung cancer (Models 4 and 5). Most of the RRs for BD ppm-years and styrene ppm-years and all of the RRs for DMDTC were statistically imprecise, with CIs that included the null value. Similar patterns were found for the relationship between other indices of BD and styrene exposure and lung cancer (table 17).

A positive association, noted both for BD ppm-years and styrene ppm-years, and breast cancer was limited to the highest BD ppm-years and styrene ppm-years categories (table 18, Models 1 and 2). We did not analyze the relation between DMDTC and breast cancer because only seven women with breast cancer were exposed to this agent.

DISCUSSION

We conducted a retrospective follow-up study of 4,863 women employed at eight North American plants that made SBR and related products. This is the first study of long-term mortality patterns among women employed in the synthetic rubber industry. Of particular *a priori* interest were results for leukemia, NHL and other LHCs, based on toxicologic studies and epidemiologic investigations of male synthetic rubber workers. Also of *a priori* interest, based on toxicologic studies, were results for cancers of the breast and ovary.

The women studied had a total of 181,831 person-years of follow-up, an average of 37 years per woman, and experienced 1,198 deaths during the period 1943-2002. They had death rates for all causes combined and all cancers that were slightly lower than the rates of general population comparison groups. As is typical in occupational cohorts, ever-hourly employees had higher SMRs than those of never-hourly employees, probably due to differences in socioeconomic status that affect health. We did not find any strong or consistent association with any of the cancers of *a priori* interest. However, we noted excesses of lung and bladder cancer.

The study's main strengths were its long follow-up period, its use of objective procedures for classifying subjects according to various indices of employment and to cause of death and its evaluation of mortality patterns by a number of employment factors, including pay status, duration of employment, time since hire and work area.

Limitations of the research included the relatively small number of subjects, overall and, particularly, in some of the SBR-related operations subgroups; lack of medical records confirming leukemia and other cancer deaths; and lack of information on lifestyle factors, most importantly cigarette smoking, that could have been responsible for associations seen in this study. Misclassification by cause of death, work area and other employment variables is another potential problem. However, we used data collection and work area classification procedures that were objective, ensuring that any misclassification was nondifferential. Vital status and cause of death ascertainment were carried out without knowledge of subjects' detailed work histories.

Leukemia

We did not observe any observed excess of leukemia among women in the industry. Also, there was no observed death from leukemia in polymerization, coagulation, maintenance labor or laboratory jobs, areas where the potential for exposure to agents of interest was relatively high. Most of the leukemia decedents had worked in administration and were never-hourly. The results for women do not provide any support for the hypothesis that employment in the synthetic rubber industry in general or exposure to BD or other chemicals cause leukemia. The absence of an excess of leukemia deaths in SBR-related operations and among those exposed to BD or other agents may reflect the very small number of women and person-years with relatively high exposure in the present study.

NHL and other LHCs

Overall, the study group had rates of NHL and of other LHCs that were similar to general population rates. Although slight increases in these cancers were present in some subgroups, there were no patterns by duration of employment, work area or exposure category that would suggest a causal link. Among the work area subgroups with potential high exposure to monomers, only laborers and laboratory workers had an increase in NHL, and these results were based on only 2 observed and 0.6 expected deaths and 2 observed compared to 1.1 expected deaths, respectively. There was no increase in NHL deaths among women exposed to BD.

Our study detected only one death from Hodgkin lymphoma, in the never-hourly administration group. The seven subjects with multiple myeloma were distributed across SBR-related operations, administration and residual operations and across pay status, and there was no notable increase in multiple myeloma deaths among women exposed to the agents of interest. These patterns are not indicative of a causal association between employment factors and multiple myeloma.

Breast and ovarian cancers

Never-hourly women had a small increase in deaths from breast cancer, but deficits were seen for ever-hourly women in general, in SBR-related operations, in residual operations and in subgroups exposed to each agent. Internal analyses indicated a positive association between highest-level exposure to BD ppm-years and styrene ppm-years and breast cancer. These associations were not statistically significant, and evidence of a consistent exposure-response relation was not clear. Results were largely null for ovarian cancer.

Lung cancer

The overall cohort, as well as women in SBR-related and residual operations, had an excess of lung cancer that was higher among the ever-hourly subjects compared to the never-hourly subjects. Among ever-hourly subjects in SBR-related and residual operations, the increases in lung cancer were concentrated in the subgroup with 20+ years since starting, but an excess occurred both in short-term and longer-term duration of employment categories. Further detailed analysis of subgroups of SBR-related operations indicated that the lung cancer excess was concentrated among women in laboratory jobs. Never-hourly women in administration had a deficit of deaths from lung cancer.

Analyses of cumulative exposure indices to BD (RRs ranging from 1.8-2.8) and styrene (RRs ranging from 1.4-2.7) indicated a moderately positive association between each agent and lung cancer, regardless of exposure level. The absence of any trend of increasing RRs with increasing cumulative exposure to BD or styrene suggests that these occupational exposures may not have been responsible for the excess of lung cancer among hourly employees. There was no evidence of an association between DMDTC and lung cancer.

In our updated study of male synthetic rubber workers, lung cancer SMRs were close to the null value for ever-hourly subjects and for most of the work areas. A meta-analysis of mortality among workers in the synthetic rubber-producing industry reported a pooled lung cancer SMR that was close to the null value (Alder, 2006). Although some early studies suggested a possible association between styrene and lung cancer, most recent studies do not substantiate this finding (IARC, 2002).

Smoking is a strong risk factor for lung cancer, both among men and among women. In a case-control study of lung cancer among Iowa women, smokers had approximately a 14-fold

increase in lung cancer risk compared to nonsmokers after adjustment for age, education and radon exposure (Neuberger, 2006). We did not have data on employees' smoking habits and thus cannot determine if differences in smoking between the women employed in the synthetic rubber industry and the general population comparison groups could have been large enough to completely explain the association seen in the present study for lung cancer. Blair et al.(2007) have suggested that differences in smoking between occupational groups and general populations are rarely large enough to cause substantial confounding. However, their conclusion is based on data that pertain largely to men, and the issue has not been examined adequately for occupational groups comprised of women.

Bladder cancer

Bladder cancer was increased overall, among ever-hourly women in SBR-related and residual operations and in the never-hourly administration group. The deaths were not clearly associated with any subgroup of SBR-related operations, and results for groups exposed to each of the agents of interest were unremarkable. All results for bladder cancer were based on small numbers. Workers in some rubber products manufacturing plants have an increased risk of bladder cancer because of their exposure to aromatic amines. To our knowledge, such exposure did not occur in the synthetic rubber industry. Cigarette smoking is an established cause of bladder cancer and is responsible for nearly one-third of bladder cancer deaths in women. The association that we observed could be due at least in part to uncontrolled confounding by smoking, but we do not have data to support or refute this possibility.

Summary

Women employed in the synthetic rubber industry had death rates for all causes combined and all cancers that were slightly lower than the rates of general population. Ever-

hourly employees had higher SMRs than never-hourly employees, probably due to differences in socioeconomic status that affect health. We did not find a strong, consistent or statistically significant association between occupational factors and any of the cancers of *a priori* interest. In particular, no large or statistically significant excess of leukemia or any other form of LHC was observed for women ever exposed to BD, styrene or DMDTC. Because of small numbers of exposed decedents with LHCs and ovarian cancer, we were not able to evaluate exposure-response relationships between the agents of interest and these cancers. Employees had increased mortality from lung and bladder cancers. For these two cancers, several observations suggest that occupational exposures may not have been responsible for the excesses seen in some analyses in the present study. For both cancers, there was no trend of increasing SMRs with increasing duration of employment, overall or in work areas where excesses were observed; for lung cancer, there also was no trend of increasing RRs with increasing cumulative exposure to BD, styrene or DMDTC; and among men, neither lung cancer nor bladder cancer has been associated with employment in the synthetic rubber industry. We did not have any information on cigarette smoking or other lifestyle factors and, thus, were not able to determine if such nonoccupational factors contributed to observed increases in deaths from lung and bladder cancers.

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Table 1. Study plant operating dates and major products

Plant – Location		Operating dates	Major products
1	Kentucky	1943 – 1947, 1950 – 1981 1960 – present 1962 – present 1988 – present	Styrene-butadiene rubber (SBR) Solution polybutadiene Liquid polymers Solution SBR
2	Texas	1943 – 1977	SBR
3	Louisiana	1943 – present 1965 – present	SBR Nitrile rubber
4	Louisiana	1943 – 1983 1969 – present	SBR Solution SBR
5	Texas	1957 – present	SBR
6	Texas	1943 – present 1948 – present 1979 – present	SBR Nitrile rubber Styrene-butadiene latex
7	Ontario	1943 – present 1947 – present 1944 – present 1971 – present 1958 – 1992 1963 – present 1943 – 1990 1962 – 1974	SBR Nitrile rubber Butyl rubber Halobutyl rubber Styrene-butadiene latex Solution polybutadiene Styrene Acrylonitrile-butadiene-styrene plastic
8	Texas	1943 – present 1978 – present 1959 – 1965	SBR Emulsion polybutadiene Polyethylene

Table 2. Work area classification

Group

SBR-related operations

Subgroups

SBR/Solution polymer/Latex production

Polymerization

Coagulation

Finishing

SBR Maintenance

Maintenance shop

Maintenance field

SBR Labor

Production labor

Maintenance

SBR Laboratories

SBR Other operations

Administration

Residual operations

Table 3. Number of subjects by selected characteristics for white and nonwhite women and all subjects combined

	White		Nonwhite		Total	
	N	(%)	N	(%)	N	(%)
Total	4,498	(100)	365	(100)	4,863	(100)
Plant, location, follow-up start year						
1, Kentucky, 1965	164	(4)	9	(2)	173	(4)
2, Texas, 1943	237	(5)	44	(12)	281	(6)
3, Louisiana, 1943	398	(9)	77	(21)	475	(10)
4, Louisiana, 1943	670	(15)	95	(26)	765	(16)
5, Texas, 1960	70	(2)	1	(0)	71	(1)
6, Texas, 1943	514	(11)	89	(25)	603	(12)
7, Ontario, 1950	1,688	(37)	--	--	1,688	(35)
8, Texas, 1943	757	(17)	50	(14)	807	(16)
Payroll status						
Ever hourly	1,143	(25)	301	(82)	1,444	(30)
Never hourly	3,355	(75)	64	(16)	3,419	(70)
Year of hire						
< 1950	1,328	(30)	159	(43)	1,487	(31)
1950-1959	1,022	(23)	7	(2)	1,029	(21)
1960-1969	914	(20)	7	(2)	921	(19)
1970+	1,234	(27)	192	(53)	1,426	(29)
Median	1959		1972		1959	
Years worked as of the end of 1991						
< 1	1,779	(39)	215	(59)	1,994	(41)
1-4	1,471	(33)	90	(25)	1,561	(32)
5-9	481	(11)	20	(5)	501	(10)
10+	767	(7)	40	(11)	807	(17)
Median	1.7		0.6		1.6	
Years since hire						
< 20	458	(10)	63	(17)	521	(11)
20-29	903	(20)	155	(43)	1,058	(22)
30+	3,137	(70)	147	(40)	3,284	(67)
Median	39		27		39	
Vital Status						
Alive	3,301	(73)	230	(63)	3,531	(72)
Deceased	1,098	(25)	100	(27)	1,198	(25)
Unknown	99	(2)	35	(10)	134	(3)
Age at end of study						
<60	1,364	(30)	160	(45)	1,524	(31)
60-69	914	(20)	35	(9)	949	(20)
70-79	1,103	(25)	35	(9)	1,138	(23)
80+	1,117	(25)	135	(37)	1,252	(26)
Median	69		64		69	

Table 4. Number of subjects and number of deaths by work area*

Group	Number of subjects	Number of deaths
SBR-related operations, total	1,641	401
By payroll status		
Ever-hourly	1,004	293
Never-hourly	637	108
SBR-related subgroups		
SBR/SP/Latex production	288	63
Polymerization	11	1
Coagulation	17	2
Finishing	262	57
SBR Maintenance	27	6
Maintenance shop	11	1
Maintenance field	16	5
SBR Labor	368	87
Production labor	84	4
Maintenance	157	24
SBR Laboratories	420	159
SBR Other operations	640	94
Administration, total	2,447	522
Ever-hourly	55	5
Never-hourly	2,392	517
Residual operations, total	1,305	129
Ever-hourly	444	58
Never-hourly	861	71

*Nonmutually exclusive groups.

Table 5. Observed/expected number of deaths, SMR and 95% CI by pay status, all subjects

Cause of death		Ever-hourly	Never-hourly	Total
		(PY=51,306)	(PY=130,524)	(PY=181,831)
All causes	Obs/Exp	506/539	692/845	1,198/1,383
	SMR	94	82	87
	95% CI	86-103	76-88	82-92
All cancer	Obs/Exp	139/132	235/259	374/392
	SMR	105	91	96
	95% CI	88-124	79-103	86-106
Buccal cavity & pharynx	Obs/Exp	0/1.7	5/3.2	5/4.9
	SMR	0	156	103
	95% CI	0-222	51-365	33-240
Esophagus	Obs/Exp	0/1.5	3/2.5	3/3.9
	SMR	0	121	76
	95% CI	0-253	25-354	16-223
Stomach	Obs/Exp	3/3.9	2/5.8	5/9.7
	SMR	78	34	52
	95% CI	16-228	4-124	17-121
Colorectum	Obs/Exp	9/14	19/25	28/39
	SMR	63	77	72
	95% CI	29-119	46-120	48-104
Liver	Obs/Exp	4/3.3	3/6.0	7/9.3
	SMR	120	50	75
	95% CI	33-307	10-147	30-155
Pancreas	Obs/Exp	6/7.1	8/12	14/20
	SMR	84	65	72
	95% CI	31-183	28-127	39-120
Larynx	Obs/Exp	0/0.5	0/0.9	0/1.3
	SMR	0	0	0
	95% CI	0-815	0-432	0-282
Lung	Obs/Exp	47/26	59/57	106/83
	SMR	182	103	127
	95% CI	133-242	78-133	104-154
Breast	Obs/Exp	18/23	54/51	72/74
	SMR	77	107	97
	95% CI	46-121	80-139	76-123
Uterus*	Obs/Exp	6/8.9	3/13	9/22
	SMR	68	23	41
	95% CI	25-148	5-66	19-78
Ovary	Obs/Exp	7/7.2	14/15	21/22
	SMR	97	92	94
	95% CI	39-200	50-154	58-143

Table 5. Observed/expected number of deaths, SMR and 95% CI by pay status, all subjects

Cause of death		Ever-hourly	Never-hourly	Total
		(PY=51,306)	(PY=130,524)	(PY=181,831)
Bladder	Obs/Exp	6/1.7	2/2.6	8/4.3
	SMR	353	77	186
	95% CI	130-768	9-277	80-366
Kidney	Obs/Exp	0/2.3	2/4.5	2/6.8
	SMR	0	44	30
	95% CI	0-163	5-160	4-107
Brain	Obs/Exp	1/2.8	5/6.6	6/9.4
	SMR	36	76	64
	95% CI	1-201	25-176	23-139
LHC	Obs/Exp	12/12	22/23	34/35
	SMR	101	95	97
	95% CI	52-177	59-143	67-135
NHL	Obs/Exp	7/4.4	8/9.5	15/14
	SMR	159	85	108
	95% CI	64-327	37-167	61-178
Hodgkin lymphoma	Obs/Exp	0/0.5	1/0.8	1/1.3
	SMR	0	126	77
	95% CI	0-735	3-703	2-430
Leukemia	Obs/Exp	2/4.3	8/8.4	10/13
	SMR	46	96	79
	95% CI	6-167	41-189	38-145
Multiple myeloma	Obs/Exp	3/3.3	4/4.6	7/7.9
	SMR	91	86	88
	95% CI	19-265	24-221	35-182
Other cancer	Obs/Exp	20/16	34/31	54/47
	SMR	124	110	114
	95% CI	76-192	76-154	86-149
Benign neoplasms	Obs/Exp	0/2.1	1/2.7	1/4.8
	SMR	0	37	21
	95% CI	0-179	1-203	1-116
Blood disorders	Obs/Exp	2/2.4	2/3.7	4/6.1
	SMR	83	55	66
	95% CI	10-299	7-198	18-169
Mental disorders	Obs/Exp	4/6.3	7/10	11/16
	SMR	63	69	67
	95% CI	17-162	28-143	34-120
Allergic, endocrine & metabolic disease	Obs/Exp	15/24	15/34	30/59
	SMR	61	44	51
	95% CI	34-101	24-72	34-73

Table 5. Observed/expected number of deaths, SMR and 95% CI by pay status, all subjects

Cause of death		Ever-hourly	Never-hourly	Total
		(PY=51,306)	(PY=130,524)	(PY=181,831)
Nervous system disease	Obs/Exp	14/25	22/28	36/53
	SMR	56	78	68
	95% CI	31-94	49-119	48-94
Circulatory disease	Obs/Exp	214/229	253/309	467/539
	SMR	93	82	87
	95% CI	81-107	72-93	79-95
Nonmalignant respiratory disease	Obs/Exp	37/38	65/64	102/102
	SMR	98	101	100
	95% CI	69-136	78-129	82-122
Digestive disease	Obs/Exp	19/21	23/36	42/56
	SMR	91	65	74
	95% CI	55-142	41-97	54-101
Genitourinary disease	Obs/Exp	13/13	11/16	24/29
	SMR	101	68	83
	95% CI	54-173	34-122	53-123
External causes	Obs/Exp	25/22	30/46	55/68
	SMR	113	66	81
	95% CI	73-167	44-94	61-106
Other known	Obs/Exp	15/24	20/37	35/58
	SMR	62	55	60
	95% CI	35-102	33-84	42-84
Unknown		9	8	17

* Uterus including cervix.

¶Other cancer (N=54) includes: ileum (N=1), gall bladder (N=1), peritoneum/retroperitoneum (N=4), intestinal tract unspecified (N=3), maxillary sinus (N=1), connective and other soft tissue (N=5), malignant melanoma of skin (N=1), unspecified skin (N=1), vagina/vulva (N=4), eye (N=2), endocrine unspecified (N=1), ill-defined head/face/neck (N=2), ill-defined digestive tract (N=2), secondary neoplasm of respiratory tract (N=1), secondary neoplasm of the urinary tract (N=1), secondary neoplasm of the brain (N=1), unspecified site (N=23).

Table 6. Observed/expected number of deaths, SMR and 95% CI by years since hire and years worked, all employees

Cause of death		<20 years since hire			20+ years since hire		
		<1 years worked	1-4 years worked	5 + years worked	<1 years worked	1-4 years worked	5 + years worked
		(PY=41,748)	(PY=32,838)	(PY=17,635)	(PY=41,180)	(PY=28,372)	(PY=20,058)
All causes	Obs/Exp	37/89	23/55	27/46	609/600	268/313	234/280
	SMR	42	42	58	102	86	84
	95% CI	29-58	26-63	39-85	94-110	76-97	73-95
All cancer	Obs/Exp	12/24	6/16	16/17	184/161	89/95	67/79
	SMR	50	37	95	114	94	85
	95% CI	26-88	13-79	54-155	98-132	75-115	66-108
Buccal cavity & pharynx	Obs/Exp	0/0.3	0/0.2	0/0.2	2/2.1	2/1.2	1/1.0
	SMR	0	0	0	97	170	102
	95% CI	0-1367	0-2058	0-1816	12-352	21-615	3-568
Esophagus	Obs/Exp	0/0.2	0/0.1	0/0.1	0/1.7	2/1.0	1/0.9
	SMR	0	0	0	0	209	113
	95% CI	0-2330	0-3519	0-2714	0-217	25-756	3-632
Stomach	Obs/Exp	0/0.8	0/0.5	0/0.5	1/3.9	3/2.1	1/1.9
	SMR	0	0	0	26	146	52
	95% CI	0-449	0-730	0-744	1-144	30-426	1-288
Colorectum	Obs/Exp	0/2.0	1/1.3	2/1.3	13/17	8/9.2	4/8.5
	SMR	0	80	151	77	87	47
	95% CI	0-189	2-446	18-544	41-132	37-171	13-121
Liver	Obs/Exp	1/0.4	0/0.3	0/0.3	2/4.1	4/2.3	0/1.9
	SMR	254	0	0	48	173	0
	95% CI	6-1417	0-1419	0-1262	6-175	47-444	0-192
Pancreas	Obs/Exp	1/0.7	0/0.4	2/0.6	10/8.9	1/4.8	0/4.2
	SMR	150	0	359	113	21	0
	95% CI	4-835	0-848	43-1297	54-207	1-115	0-88
Larynx	Obs/Exp	0/0.1	0/0.0	0/0.0	0/0.6	0/0.3	0/0.3
	SMR	0	-	-	0	0	0
	95% CI	0-7415	-	-	0-635	0-1114	0-1382
Lung	Obs/Exp	2/2.2	1/1.7	2/2.2	51/37	23/23	27/17
	SMR	92	58	89	137	101	156
	95% CI	11-331	2-326	11-323	102-181	64-151	103-228
Breast	Obs/Exp	2/5.9	3/4.2	3/4.5	33/28	22/17	9/14
	SMR	34	71	67	119	126	63
	95% CI	4-123	15-208	14-197	82-167	79-190	29-120
Uterus	Obs/Exp	1/3.3	0/2.0	1/1.5	5/7.7	1/4.2	1/3.4
	SMR	30	0	65	65	24	30
	95% CI	1-167	0-188	2-362	21-152	1-134	1-165

Table 6. Observed/expected number of deaths, SMR and 95% CI by years since hire and years worked, all employees

Cause of death		<20 years since hire			20+ years since hire		
		<1 years worked	1-4 years worked	5 + years worked	<1 years worked	1-4 years worked	5 + years worked
		(PY=41,748)	(PY=32,838)	(PY=17,635)	(PY=41,180)	(PY=28,372)	(PY=20,058)
Ovary	Obs/Exp	0/1.6	0/1.0	1/1.1	10/8.8	7/5.4	3/4.5
	SMR	0	0	88	113	129	67
	95% CI	0-239	0-358	2-488	54-208	52-265	14-197
Bladder	Obs/Exp	0/0.2	0/0.1	0/0.1	5/1.9	0/1.0	3/1.0
	SMR	0	0	0	259	0	302
	95% CI	0-2158	0-3665	0-3115	84-605	0-369	62-883
Kidney	Obs/Exp	0/0.3	0/0.2	0/0.2	1/2.9	1/1.7	0/1.4
	SMR	0	0	0	34	58	0
	95% CI	0-1239	0-1767	0-1603	1-190	2-324	0-266
Brain	Obs/Exp	0/0.9	0/0.6	0/0.5	3/3.4	2/2.2	1/1.8
	SMR	0	0	0	88	90	57
	95% CI	0-436	0-591	0-705	18-256	11-325	1-318
LHC	Obs/Exp	2/2.2	0/1.6	1/1.4	20/15	6/8.3	5/7.1
	SMR	91	0	73	138	72	71
	95% CI	11-328	0-230	2-409	84-212	27-157	23-165
NHL	Obs/Exp	0/0.6	0/0.5	1/0.5	8/5.9	4/3.5	2/2.9
	SMR	0	0	216	136	114	68
	95% CI	0-595	0-821	5-1201	59-268	31-291	8-246
Hodgkin lymphoma	Obs/Exp	1/0.3	0/0.2	0/0.1	0/0.4	0/0.2	0/0.1
	SMR	336	0	0	0	0	0
	95% CI	8-1870	0-2153	0-5231	0-859	0-1801	0-3072
Leukemia	Obs/Exp	1/1.0	0/0.8	0/0.6	7/5.0	2/2.9	0/2.4
	SMR	97	0	0	139	70	0
	95% CI	2-538	0-483	0-643	56-287	9-254	0-151
Multiple myeloma	Obs/Exp	0/1.0	0/0.5	0/0.3	4/3.1	0/1.7	3/1.4
	SMR	0	0	0	130	0	208
	95% CI	0-369	0-796	0-1321	35-332	0-221	43-608
Other cancer	Obs/Exp	3/2.9	1/1.8	4/2.5	28/18	7/11	11/10
	SMR	103	56	160	156	62	109
	95% CI	21-302	1-310	44-410	103-225	25-128	54-195
Benign neoplasms	Obs/Exp	0/0.8	0/0.4	0/0.2	1/1.9	0/0.9	0/0.6
	SMR	0	0	0	53	0	0
	95% CI	0-477	0-920	0-1706	1-295	0-412	0-587
Blood disorders	Obs/Exp	0/0.5	0/0.3	0/0.2	1/2.6	1/1.3	2/1.2
	SMR	0	0	0	39	76	172
	95% CI	0-713	0-1194	0-1967	1-216	2-425	21-622

Table 6. Observed/expected number of deaths, SMR and 95% CI by years since hire and years worked, all employees

Cause of death		<20 years since hire			20+ years since hire		
		<1 years worked	1-4 years worked	5 + years worked	<1 years worked	1-4 years worked	5 + years worked
		(PY=41,748)	(PY=32,838)	(PY=17,635)	(PY=41,180)	(PY=28,372)	(PY=20,058)
Mental disorders	Obs/Exp	0/1.0	0/0.6	0/0.3	4/6.6	3/3.5	4/4.4
	SMR	0	0	0	61	85	91
	95% CI	0-372	0-649	0-1077	17-156	18-247	25-233
Allergic, endocrine & metabolic disease	Obs/Exp	0/2.2	1/1.4	1/1.4	20/28	5/14	3/12
	SMR	0	71	73	71	35	26
	95% CI	0-171	2-395	2-408	43-109	12-83	5-75
Nervous system disease	Obs/Exp	0/13	0/5.6	0/2.7	19/16	15/8.4	2/7.9
	SMR	0	0	0	120	180	25
	95% CI	0-29	0-66	0-138	72-187	101-296	3-91
Circulatory disease	Obs/Exp	7/17	2/11	4/12	254/258	100/122	100/117
	SMR	40	19	32	98	82	85
	95% CI	16-83	2-67	9-82	87-111	67-99	69-104
Nonmalignant respiratory disease	Obs/Exp	0/3.7	1/2.3	1/1.9	51/47	23/25	26/22
	SMR	0	43	52	110	93	116
	95% CI	0-100	1-241	1-288	82-144	59-139	76-170
Digestive disease	Obs/Exp	5/4.5	0/2.8	0/2.3	22/23	8/13	7/11
	SMR	111	0	0	95	63	64
	95% CI	36-259	0-132	0-160	59-143	27-125	26-132
Genitourinary disease	Obs/Exp	0/2.1	0/1.2	0/0.8	9/13	6/6.2	9/5.4
	SMR	0	0	0	67	98	166
	95% CI	0-179	0-316	0-468	31-128	36-212	76-314
External causes	Obs/Exp	11/13	6/9.6	3/5.3	19/20	8/12	8/9.1
	SMR	86	63	57	97	69	88
	95% CI	43-154	23-137	12-166	59-152	30-136	38-173
Other known	Obs/Exp	1/7.2	2/3.8	2/1.9	18/23	7/12	5/10
	SMR	14	53	105	79	60	48
	95% CI	0-77	6-190	13-380	47-124	24-123	16-112
Unknown		1	5	0	7	3	1

Table 7. Observed/expected number of deaths, SMR and 95% CI by years since hire and years worked, ever-hourly employees

Cause of death		<20 years since hire			20+ years since hire		
		<1 years worked	1-4 years worked	5 + years worked	<1 years worked	1-4 years worked	5 + years worked
		(PY=15,075)	(PY=7,273)	(PY=3,983)	(PY=14,625)	(PY=6,571)	(PY=3,780)
All causes	Obs/Exp	15/44	6/20	10/15	288/272	113/112	74/76
	SMR	34	30	68	106	101	97
	95% CI	19-57	11-66	32-124	94-119	83-121	77-122
All cancer	Obs/Exp	4/10	0/5.4	6/5.5	79/64	30/28	20/19
	SMR	38	0	110	123	108	105
	95% CI	11-98	0-69	40-239	97-153	73-155	64-163
Buccal cavity & pharynx	Obs/Exp	0/0.1	0/0.1	0/0.1	0/0.8	0/0.4	0/0.2
	SMR	0	0	0	0	0	0
	95% CI	0-3152	0-5995	0-5269	0-450	0-1049	0-1523
Esophagus	Obs/Exp	0/0.1	0/0.1	0/0.1	0/0.8	0/0.3	0/0.2
	SMR	0	0	0	0	0	0
	95% CI	0-4670	0-7984	0-6817	0-484	0-1253	0-1670
Stomach	Obs/Exp	0/0.4	0/0.2	0/0.2	1/1.9	2/0.7	0/0.5
	SMR	0	0	0	54	280	0
	95% CI	0-886	0-1876	0-2248	1-298	34-1013	0-748
Colorectum	Obs/Exp	0/0.9	0/0.5	1/0.5	5/7.3	2/3.0	1/2.2
	SMR	0	0	217	68	66	46
	95% CI	0-409	0-798	5-1207	22-160	8-240	1-254
Liver	Obs/Exp	0/0.2	0/0.1	0/0.1	1/1.7	3/0.8	0/0.5
	SMR	0	0	0	58	401	0
	95% CI	0-2010	0-3754	0-3695	2-325	83-1173	0-749
Pancreas	Obs/Exp	1/0.3	0/0.2	0/0.2	4/3.8	1/1.6	0/1.1
	SMR	336	0	0	105	64	0
	95% CI	8-1874	0-2320	0-1878	29-268	2-355	0-340
Larynx	Obs/Exp	0/0.0	0/0.0	0/0.0	0/0.2	0/0.1	0/0.1
	SMR	-	-	-	0	0	0
	95% CI	-	-	-	0-1535	0-3880	0-5774
Lung	Obs/Exp	1/0.9	0/0.5	1/0.8	24/14	13/6.1	8/4.1
	SMR	117	0	128	178	212	197
	95% CI	3-653	0-685	3-711	114-264	113-363	85-389
Breast	Obs/Exp	1/2.4	0/1.3	2/1.4	10/11	3/4.6	2/3.2
	SMR	41	0	140	95	65	63
	95% CI	1-231	0-283	17-506	46-175	13-190	8-227
Uterus	Obs/Exp	0/1.7	0/0.7	1/0.5	4/3.7	1/1.4	0/0.8
	SMR	0	0	207	107	72	0
	95% CI	0-218	0-503	5-1154	29-275	2-404	0-443

Table 7. Observed/expected number of deaths, SMR and 95% CI by years since hire and years worked, ever-hourly employees

Cause of death		<20 years since hire			20+ years since hire		
		<1 years worked	1-4 years worked	5 + years worked	<1 years worked	1-4 years worked	5 + years worked
		(PY=15,075)	(PY=7,273)	(PY=3,983)	(PY=14,625)	(PY=6,571)	(PY=3,780)
Ovary	Obs/Exp	0/0.6	0/0.3	1/0.4	3/3.3	3/1.5	0/1.0
	SMR	0	0	269	90	199	0
	95% CI	0-580	0-1130	7-1501	19-263	41-580	0-358
Bladder	Obs/Exp	0/0.1	0/0.0	0/0.0	4/0.9	0/0.4	2/0.3
	SMR	0	-	-	449	0	734
	95% CI	0-3934	-	-	122-1149	0-1037	89-2653
Kidney	Obs/Exp	0/0.1	0/0.1	0/0.1	0/1.1	0/0.5	0/0.3
	SMR	0	0	0	0	0	0
	95% CI	0-2897	0-5135	0-4869	0-324	0-734	0-1083
Brain	Obs/Exp	0/0.3	0/0.2	0/0.2	0/1.2	0/0.6	1/0.4
	SMR	0	0	0	0	0	258
	95% CI	0-1204	0-2305	0-2394	0-310	0-642	7-1438
LHC	Obs/Exp	1/0.9	0/0.4	0/0.4	7/5.8	2/2.6	2/1.8
	SMR	117	0	0	120	79	113
	95% CI	3-651	0-834	0-908	48-247	10-284	14-406
NHL	Obs/Exp	0/0.2	0/0.1	0/0.1	4/2.2	2/1.0	1/0.7
	SMR	0	0	0	185	198	138
	95% CI	0-1515	0-2863	0-2578	50-473	24-715	3-768
Hodgkin lymphoma	Obs/Exp	0/0.1	0/0.1	0/0.0	0/0.2	0/0.1	0/0.0
	SMR	0	0	-	0	0	-
	95% CI	0-2918	0-6635	-	0-1946	0-4735	-
Leukemia	Obs/Exp	1/0.4	0/0.2	0/0.2	1/2.1	0/0.9	0/0.6
	SMR	248	0	0	49	0	0
	95% CI	6-1382	0-1779	0-2289	1-272	0-413	0-599
Multiple myeloma	Obs/Exp	0/0.6	0/0.3	0/0.1	2/1.4	0/0.6	1/0.4
	SMR	0	0	0	144	0	264
	95% CI	0-591	0-1436	0-3475	17-519	0-674	7-1471
Other cancer	Obs/Exp	0/1.0	0/0.7	0/0.5	16/6.5	0/3.4	4/2.3
	SMR	0	0	0	246	0	174
	95% CI	0-369	0-527	0-738	141-400	0-109	47-445
Benign neoplasms	Obs/Exp	0/0.4	0/0.2	0/0.1	0/0.9	0/0.3	0/0.2
	SMR	0	0	0	0	0	0
	95% CI	0-885	0-2264	0-5711	0-412	0-1081	0-2033
Blood disorders	Obs/Exp	0/0.3	0/0.1	0/0.1	1/1.2	1/0.5	0/0.3
	SMR	0	0	0	86	207	0
	95% CI	0-1430	0-3120	0-6053	2-477	5-1151	0-1135

Table 7. Observed/expected number of deaths, SMR and 95% CI by years since hire and years worked, ever-hourly employees

Cause of death		<20 years since hire			20+ years since hire		
		<1 years worked	1-4 years worked	5 + years worked	<1 years worked	1-4 years worked	5 + years worked
		(PY=15,075)	(PY=7,273)	(PY=3,983)	(PY=14,625)	(PY=6,571)	(PY=3,780)
Mental disorders	Obs/Exp	0/0.5	0/0.2	0/0.1	2/2.8	2/1.4	0/1.3
	SMR	0	0	0	71	143	0
	95% CI	0-770	0-1764	0-3378	9-255	17-517	0-289
Allergic, endocrine & metabolic disease	Obs/Exp	0/1.1	0/0.5	0/0.5	11/14	2/5.3	2/3.2
	SMR	0	0	0	80	38	62
	95% CI	0-334	0-694	0-771	40-142	5-138	8-223
Nervous system disease	Obs/Exp	0/8.6	0/3.4	0/0.9	9/6.9	5/3.0	0/2.2
	SMR	0	0	0	131	167	0
	95% CI	0-43	0-109	0-409	60-248	54-390	0-165
Circulatory disease	Obs/Exp	3/8.6	0/4.2	2/4.3	125/128	52/51	32/34
	SMR	35	0	47	98	103	94
	95% CI	7-103	0-89	6-169	81-116	77-135	65-133
Nonmalignant respiratory disease	Obs/Exp	0/1.8	0/0.8	1/0.6	20/19	9/8.8	7/6.2
	SMR	0	0	160	104	102	112
	95% CI	0-205	0-452	4-894	63-160	47-194	45-231
Digestive disease	Obs/Exp	4/2.1	0/1.0	0/0.7	11/10	3/4.3	1/2.8
	SMR	187	0	0	110	70	35
	95% CI	51-479	0-389	0-517	55-198	14-204	1-196
Genitourinary disease	Obs/Exp	0/1.1	0/0.5	0/0.3	7/6.9	2/2.6	4/1.6
	SMR	0	0	0	102	79	246
	95% CI	0-337	0-818	0-1448	41-210	10-284	67-630
External causes	Obs/Exp	4/5.0	2/2.3	1/1.3	10/8.0	5/3.5	3/2.1
	SMR	80	87	80	125	144	141
	95% CI	22-205	11-313	2-444	60-230	47-336	29-411
Other known	Obs/Exp	0/4.5	1/1.4	0/0.6	9/10	1/3.3	4/3.1
	SMR	0	71	0	87	30	129
	95% CI	0-82	2-398	0-615	40-166	1-169	35-330
Unknown		0/0.0	3	0	4	1	1

Table 8. Observed/expected number of deaths, SMR and 95% CI among employees in SBR-related operations, by pay status

Cause of death		Ever-hourly PY=(35,483)	Never-hourly PY=(23,387)
All causes	Obs/Exp	293/324	108/135
	SMR	90	80
	95% CI	80-101	66-96
All cancer	Obs/Exp	86/83	44/43
	SMR	104	103
	95% CI	83-128	75-139
Buccal cavity & pharynx	Obs/Exp	0/1.0	1/0.5
	SMR	0	194
	95% CI	0-361	5-1080
Esophagus	Obs/Exp	0/0.9	1/0.4
	SMR	0	258
	95% CI	0-406	7-1438
Stomach	Obs/Exp	2/2.3	0/0.9
	SMR	86	0
	95% CI	11-312	0-412
Colorectum	Obs/Exp	4/8.5	7/3.9
	SMR	47	181
	95% CI	13-121	73-372
Liver	Obs/Exp	1/2.1	1/1.0
	SMR	48	102
	95% CI	1-267	3-569
Pancreas	Obs/Exp	5/4.4	1/2.0
	SMR	115	51
	95% CI	37-267	1-284
Larynx	Obs/Exp	0/0.3	0/0.1
	SMR	0	0
	95% CI	0-1243	0-2625
Lung	Obs/Exp	34/17	12/9.8
	SMR	198	123
	95% CI	137-276	63-214
Breast	Obs/Exp	11/15	8/8.5
	SMR	75	94
	95% CI	37-134	41-186
Uterus	Obs/Exp	5/5.7	1/2.1
	SMR	87	47
	95% CI	28-204	1-263

Table 8. Observed/expected number of deaths, SMR and 95% CI among employees in SBR-related operations, by pay status

Cause of death		Ever-hourly PY=(35,483)	Never-hourly PY=(23,387)
Ovary	Obs/Exp	5/4.5	2/2.5
	SMR	112	80
	95% CI	36-262	10-287
Bladder	Obs/Exp	2/1.0	0/0.4
	SMR	206	0
	95% CI	25-742	0-945
Kidney	Obs/Exp	0/1.4	0/0.8
	SMR	0	0
	95% CI	0-261	0-487
Brain	Obs/Exp	1/1.8	2/1.1
	SMR	57	177
	95% CI	1-316	21-638
LHC	Obs/Exp	6/7.3	3/3.8
	SMR	82	79
	95% CI	30-179	16-232
NHL	Obs/Exp	4/2.7	1/1.6
	SMR	149	65
	95% CI	41-381	2-359
Hodgkin lymphoma	Obs/Exp	0/0.3	0/0.1
	SMR	0	0
	95% CI	0-1095	0-2629
Leukemia	Obs/Exp	0/2.6	1/1.4
	SMR	0	73
	95% CI	0-140	2-408
Multiple myeloma	Obs/Exp	2/2.1	1/0.7
	SMR	97	139
	95% CI	12-350	4-773
Other cancer	Obs/Exp	10/9.8	5/5.2
	SMR	102	96
	95% CI	49-188	31-224
Benign neoplasms	Obs/Exp	0/1.3	0/0.4
	SMR	0	0
	95% CI	0-275	0-838
Blood disorders	Obs/Exp	2/1.5	1/0.6
	SMR	133	169
	95% CI	16-480	4-943

Table 8. Observed/expected number of deaths, SMR and 95% CI among employees in SBR-related operations, by pay status

Cause of death		Ever-hourly PY=(35,483)	Never-hourly PY=(23,387)
Mental disorders	Obs/Exp	3/3.4	1/1.6
	SMR	87	63
	95% CI	18-255	2-351
Allergic, endocrine & metabolic disease	Obs/Exp	10/16	0/5.7
	SMR	62	0
	95% CI	30-114	0-65
Nervous system disease	Obs/Exp	7/14	2/4.2
	SMR	49	48
	95% CI	20-101	6-172
Circulatory disease	Obs/Exp	117/132	33/47
	SMR	89	70
	95% CI	73-106	48-98
Nonmalignant respiratory disease	Obs/Exp	18/23	10/10
	SMR	80	97
	95% CI	47-126	47-178
Digestive disease	Obs/Exp	13/13	4/5.8
	SMR	101	69
	95% CI	54-173	19-176
Genitourinary disease	Obs/Exp	9/7.9	1/2.5
	SMR	114	40
	95% CI	52-216	1-222
External causes	Obs/Exp	15/15	4/8.0
	SMR	103	50
	95% CI	58-170	14-128
Other known	Obs/Exp	8/14	5/6.2
	SMR	58	81
	95% CI	25-113	26-188
Unknown		5	3

Table 9. SBR Observed/expected number of deaths, SMR and 95% CI among ever-hourly employees in SBR-related operations, years since hire and years worked

Cause of death		<20 years since hire			20+ years since hire		
		<1 years worked PY=(11,411)	1-4 years worked PY=(5,212)	5+ years worked PY=(1,583)	<1 years worked PY=(10,942)	1-4 years worked PY=(4,671)	5+ years worked PY=(1,663)
All causes	Obs/Exp	12/30	4/11	4/4.5	189/183	64/66	20/28
	SMR	40	35	88	103	96	71
	95% CI	20-69	10-90	24-226	89-119	74-123	43-109
All cancer	Obs/Exp	3/7.0	1/3.2	2/1.4	54/46	20/18	6/7.0
	SMR	43	31	141	118	110	85
	95% CI	9-125	1-173	17-510	88-153	68-171	31-186
Buccal cavity & pharynx	Obs/Exp	0/0.1	0/0.0	0/0.0	0/0.6	0/0.2	0/0.1
	SMR	0	-	-	0	0	0
	95% CI	0-4869	-	-	0-639	0-1619	0-4160
Esophagus	Obs/Exp	0/0.1	0/0.0	0/0.0	0/0.6	0/0.2	0/0.1
	SMR	0	-	-	0	0	0
	95% CI	0-6878	-	-	0-665	0-1985	0-5348
Stomach	Obs/Exp	0/0.3	0/0.1	0/0.0	1/1.3	1/0.4	0/0.2
	SMR	0	0	-	75	237	0
	95% CI	0-1397	0-3942	-	2-416	6-1319	0-2329
Colorectum	Obs/Exp	0/0.6	0/0.3	0/0.1	4/5.0	0/1.8	0/0.8
	SMR	0	0	0	81	0	0
	95% CI	0-655	0-1458	0-3180	22-207	0-202	0-493
Liver	Obs/Exp	0/0.1	0/0.1	0/0.0	0/1.2	1/0.5	0/0.2
	SMR	0	0	-	0	207	0
	95% CI	0-3283	0-7141	-	0-302	5-1152	0-1904
Pancreas	Obs/Exp	1/0.2	0/0.1	0/0.0	4/2.7	0/1.0	0/0.4
	SMR	550	0	-	150	0	0
	95% CI	14-3066	0-4347	-	41-383	0-373	0-943
Larynx	Obs/Exp	0/0.0	0/0.0	0/0.0	0/0.2	0/0.1	0/0.0
	SMR	-	-	-	0	0	-
	95% CI	-	-	-	0-2067	0-5711	-
Lung	Obs/Exp	1/0.7	1/0.4	0/0.2	19/10	10/4.3	3/1.7
	SMR	154	248	0	191	232	180
	95% CI	4-860	6-1382	0-1807	115-298	111-427	37-526
Breast	Obs/Exp	1/1.7	0/0.8	0/0.4	8/7.6	2/3.1	0/1.2
	SMR	60	0	0	106	65	0
	95% CI	2-335	0-445	0-972	46-208	8-234	0-315
Uterus	Obs/Exp	0/1.2	0/0.4	1/0.2	3/2.8	1/0.9	0/0.3
	SMR	0	0	631	108	113	0
	95% CI	0-315	0-896	16-3514	22-315	3-631	0-1162

Table 9. SBR Observed/expected number of deaths, SMR and 95% CI among ever-hourly employees in SBR-related operations, years since hire and years worked

Cause of death		<20 years since hire			20+ years since hire		
		<1 years worked PY=(11,411)	1-4 years worked PY=(5,212)	5+ years worked PY=(1,583)	<1 years worked PY=(10,942)	1-4 years worked PY=(4,671)	5+ years worked PY=(1,663)
Ovary	Obs/Exp	0/0.4	0/0.2	1/0.1	2/2.4	2/1.0	0/0.4
	SMR	0	0	1245	83	198	0
	95% CI	0-923	0-2053	31-6936	10-300	24-716	0-965
Bladder	Obs/Exp	0/0.1	0/0.0	0/0.0	1/0.6	1/0.2	0/0.1
	SMR	0	-	-	169	491	0
	95% CI	0-6084	-	-	4-942	12-2735	0-4147
Kidney	Obs/Exp	0/0.1	0/0.0	0/0.0	0/0.8	0/0.3	0/0.1
	SMR	0	-	-	0	0	0
	95% CI	0-4456	-	-	0-462	0-1102	0-2765
Brain	Obs/Exp	0/0.2	0/0.1	0/0.0	0/0.9	0/0.4	1/0.2
	SMR	0	0	-	0	0	676
	95% CI	0-1731	0-3579	-	0-427	0-933	17-3766
LHC	Obs/Exp	0/0.6	0/0.3	0/0.1	3/4.0	2/1.6	1/0.7
	SMR	0	0	0	74	122	152
	95% CI	0-627	0-1335	0-3392	15-217	15-441	4-849
NHL	Obs/Exp	0/0.2	0/0.1	0/0.0	2/1.5	2/0.7	0/0.3
	SMR	0	0	-	136	303	0
	95% CI	0-2216	0-4559	-	16-490	37-1093	0-1360
Hodgkin lymphoma	Obs/Exp	0/0.1	0/0.0	0/0.0	0/0.1	0/0.1	0/0.0
	SMR	0	-	-	0	0	-
	95% CI	0-4164	-	-	0-2849	0-7100	-
Leukemia	Obs/Exp	0/0.3	0/0.1	0/0.1	0/1.4	0/0.6	0/0.2
	SMR	0	0	0	0	0	0
	95% CI	0-1325	0-2876	0-7861	0-265	0-658	0-1651
Multiple myeloma	Obs/Exp	0/0.4	0/0.1	0/0.0	1/1.0	0/0.4	1/0.1
	SMR	0	0	-	98	0	716
	95% CI	0-922	0-3187	-	3-548	0-1043	18-3990
Other cancer	Obs/Exp	0/0.6	0/0.4	0/0.3	9/5.3	0/2.0	1/0.5
	SMR	0	0	0	170	0	200
	95% CI	0-615	0-922	0-1230	78-322	0-184	5-1114
Benign neoplasms	Obs/Exp	0/0.3	0/0.1	0/0.0	0/0.6	0/0.2	0/0.1
	SMR	0	0	-	0	0	0
	95% CI	0-1240	0-3822	-	0-593	0-1727	0-4379
Blood disorders	Obs/Exp	0/0.2	0/0.1	0/0.0	2/0.8	0/0.3	0/0.1
	SMR	0	0	-	253	0	0
	95% CI	0-1952	0-4771	-	31-914	0-1260	0-2863

Table 9. SBR Observed/expected number of deaths, SMR and 95% CI among ever-hourly employees in SBR-related operations, years since hire and years worked

Cause of death		<20 years since hire			20+ years since hire		
		<1 years worked PY=(11,411)	1-4 years worked PY=(5,212)	5+ years worked PY=(1,583)	<1 years worked PY=(10,942)	1-4 years worked PY=(4,671)	5+ years worked PY=(1,663)
Mental disorders	Obs/Exp	0/0.3	0/0.1	0/0.0	1/1.8	2/0.7	0/0.4
	SMR	0	0	-	56	277	0
	95% CI	0-1087	0-2762	-	1-311	34-1002	0-873
Allergic, endocrine & metabolic disease	Obs/Exp	0/0.8	0/0.4	0/0.2	9/10	1/3.3	0/1.3
	SMR	0	0	0	89	31	0
	95% CI	0-438	0-996	0-2048	41-169	1-170	0-277
Nervous system disease	Obs/Exp	0/5.5	0/1.3	0/0.4	4/4.6	3/1.7	0/0.9
	SMR	0	0	0	88	172	0
	95% CI	0-67	0-286	0-878	24-225	36-503	0-432
Circulatory disease	Obs/Exp	1/5.9	0/2.3	2/1.2	80/82	26/28	8/12
	SMR	17	0	175	97	94	65
	95% CI	0-94	0-158	21-630	77-121	61-137	28-128
Nonmalignant respiratory disease	Obs/Exp	1/1.3	0/0.5	0/0.2	10/13	5/5.3	2/2.4
	SMR	77	0	0	78	94	83
	95% CI	2-428	0-762	0-1935	37-143	31-219	10-299
Digestive disease	Obs/Exp	3/1.5	0/0.6	0/0.2	8/6.8	2/2.7	0/1.1
	SMR	198	0	0	118	75	0
	95% CI	41-579	0-656	0-1686	51-232	9-272	0-342
Genitourinary disease	Obs/Exp	0/0.8	0/0.3	0/0.1	5/4.7	2/1.5	2/0.6
	SMR	0	0	0	107	138	311
	95% CI	0-465	0-1361	0-3857	35-251	17-498	38-1122
External causes	Obs/Exp	4/3.8	1/1.6	0/0.5	6/5.6	3/2.2	1/0.9
	SMR	106	63	0	107	134	117
	95% CI	29-272	2-349	0-729	39-233	28-392	3-654
Other known	Obs/Exp	0/2.6	0/0.5	0/0.3	7/7.1	0/2.1	1/1.2
	SMR	0	0	0	99	0	83
	95% CI	0-142	0-738	0-1230	40-203	0-176	2-464
Unknown		0/0.0	2	0	3	0	0/0.0

Table 10. Observed/expected number of deaths, SMR, and 95% CI among never-hourly employees in administration

Cause of death		Never hourly PY=(91,475)
All causes	Obs/Exp	517/625
	SMR	83
	95% CI	76-90
All cancer	Obs/Exp	167/189
	SMR	89
	95% CI	76-103
Buccal cavity & pharynx	Obs/Exp	2/2.3
	SMR	86
	95% CI	10-310
Esophagus	Obs/Exp	2/1.8
	SMR	111
	95% CI	13-399
Stomach	Obs/Exp	2/4.3
	SMR	47
	95% CI	6-170
Colorectum	Obs/Exp	13/18
	SMR	72
	95% CI	38-123
Liver	Obs/Exp	2/4.4
	SMR	46
	95% CI	6-165
Pancreas	Obs/Exp	6/9.1
	SMR	66
	95% CI	24-143
Larynx	Obs/Exp	0/0.6
	SMR	0
	95% CI	0-596
Lung	Obs/Exp	36/42
	SMR	86
	95% CI	60-119
Breast	Obs/Exp	40/36
	SMR	110
	95% CI	78-149
Uterus	Obs/Exp	3/9.6
	SMR	31
	95% CI	7-91
Ovary	Obs/Exp	10/11

Table 10. Observed/expected number of deaths, SMR, and 95% CI among never-hourly employees in administration

Cause of death		Never hourly PY=(91,475)
	SMR	91
	95% CI	43-167
Bladder	Obs/Exp	3/1.9
	SMR	154
	95% CI	32-451
Kidney	Obs/Exp	2/3.3
	SMR	60
	95% CI	7-218
Brain	Obs/Exp	3/4.8
	SMR	63
	95% CI	13-184
LHC	Obs/Exp	19/17
	SMR	112
	95% CI	67-175
NHL	Obs/Exp	7/6.9
	SMR	101
	95% CI	41-209
Hodgkin lymphoma	Obs/Exp	1/0.6
	SMR	170
	95% CI	4-945
Leukemia	Obs/Exp	7/6.1
	SMR	115
	95% CI	46-237
Multiple myeloma	Obs/Exp	3/3.4
	SMR	88
	95% CI	18-257
Other cancer	Obs/Exp	24/23
	SMR	105
	95% CI	67-156
Benign neoplasms	Obs/Exp	1/2.0
	SMR	49
	95% CI	1-274
Blood disorders	Obs/Exp	2/2.7
	SMR	74
	95% CI	9-266
Mental disorders	Obs/Exp	5/7.6
	SMR	66

Table 10. Observed/expected number of deaths, SMR, and 95% CI among never-hourly employees in administration

Cause of death		Never hourly PY=(91,475)
	95% CI	21-153
Allergic, endocrine & metabolic disease	Obs/Exp	12/26
	SMR	47
	95% CI	24-82
Nervous system disease	Obs/Exp	14/21
	SMR	68
	95% CI	37-113
Circulatory disease	Obs/Exp	197/232
	SMR	85
	95% CI	73-98
Nonmalignant respiratory disease	Obs/Exp	44/48
	SMR	92
	95% CI	67-124
Digestive disease	Obs/Exp	21/26
	SMR	80
	95% CI	50-123
Genitourinary disease	Obs/Exp	9/12
	SMR	75
	95% CI	34-142
External causes	Obs/Exp	24/33
	SMR	73
	95% CI	47-109
Other known	Obs/Exp	16/26
	SMR	62
	95% CI	36-101
Unknown		5

Table 11. Observed/expected number of deaths, SMR and 95% CI among employees in residual operations, by pay status

Cause of death		Ever- hourly (PY=15,653)	Never-hourly (PY=31,574)
All causes	Obs/Exp	222/217	141/190
	SMR	102	74
	95% CI	89-117	62-87
All cancer	Obs/Exp	56/50	46/60
	SMR	112	77
	95% CI	84-145	56-102
Buccal cavity & pharynx	Obs/Exp	0/0.6	3/0.7
	SMR	0	403
	95% CI	0-573	83-1177
Esophagus	Obs/Exp	0/0.6	1/0.6
	SMR	0	169
	95% CI	0-652	4-942
Stomach	Obs/Exp	1/1.6	0/1.4
	SMR	63	0
	95% CI	2-353	0-269
Colorectum	Obs/Exp	5/6.0	2/5.7
	SMR	84	35
	95% CI	27-196	4-126
Liver	Obs/Exp	3/1.3	1/1.3
	SMR	238	75
	95% CI	49-695	2-416
Pancreas	Obs/Exp	1/2.8	2/2.8
	SMR	35	70
	95% CI	1-197	9-254
Larynx	Obs/Exp	0/0.2	0/0.2
	SMR	0	0
	95% CI	0-2335	0-1839
Lung	Obs/Exp	15/8.7	16/13
	SMR	173	122
	95% CI	97-285	69-197
Breast	Obs/Exp	7/8.9	9/12
	SMR	79	75
	95% CI	32-163	34-143
Uterus	Obs/Exp	1/3.3	0/3.1
	SMR	31	0
	95% CI	1-171	0-121

Table 11. Observed/expected number of deaths, SMR and 95% CI among employees in residual operations, by pay status

Cause of death		Ever- hourly (PY=15,653)	Never-hourly (PY=31,574)
Ovary	Obs/Exp	2/2.8	5/3.6
	SMR	72	141
	95% CI	9-260	46-328
Bladder	Obs/Exp	4/0.7	0/0.6
	SMR	540	0
	95% CI	147-1382	0-615
Kidney	Obs/Exp	0/0.9	0/1.0
	SMR	0	0
	95% CI	0-435	0-360
Brain	Obs/Exp	0/1.0	0/1.5
	SMR	0	0
	95% CI	0-366	0-239
LHC	Obs/Exp	7/4.6	2/5.4
	SMR	152	37
	95% CI	61-314	5-135
NHL	Obs/Exp	4/1.7	1/2.2
	SMR	232	46
	95% CI	63-594	1-256
Hodgkin lymphoma	Obs/Exp	0/0.2	0/0.2
	SMR	0	0
	95% CI	0-2294	0-2373
Leukemia	Obs/Exp	2/1.7	0/1.9
	SMR	117	0
	95% CI	14-422	0-191
Multiple myeloma	Obs/Exp	1/1.3	1/1.1
	SMR	78	95
	95% CI	2-435	2-527
Other cancer	Obs/Exp	10/6.0	5/7.1
	SMR	167	70
	95% CI	80-307	23-164
Benign neoplasms	Obs/Exp	0/0.7	0/0.6
	SMR	0	0
	95% CI	0-503	0-633
Blood disorders	Obs/Exp	0/0.9	0/0.8
	SMR	0	0
	95% CI	0-402	0-460
Mental disorders	Obs/Exp	1/2.9	1/2.2

Table 11. Observed/expected number of deaths, SMR and 95% CI among employees in residual operations, by pay status

Cause of death		Ever- hourly (PY=15,653)	Never-hourly (PY=31,574)
	SMR	35	45
	95% CI	1-192	1-248
Allergic, endocrine & metabolic disease	Obs/Exp	5/8.5	3/7.6
	SMR	59	40
	95% CI	19-137	8-116
Nervous system disease	Obs/Exp	5/11	7/6.4
	SMR	46	109
	95% CI	15-107	44-224
Circulatory disease	Obs/Exp	104/99	53/68
	SMR	105	77
	95% CI	86-127	58-101
Nonmalignant respiratory disease	Obs/Exp	20/15	19/14
	SMR	133	135
	95% CI	82-206	81-211
Digestive disease	Obs/Exp	6/8.2	2/7.9
	SMR	73	25
	95% CI	27-160	3-91
Genitourinary disease	Obs/Exp	5/5.1	3/3.5
	SMR	99	85
	95% CI	32-231	18-249
External causes	Obs/Exp	9/7.5	6/11
	SMR	120	57
	95% CI	55-228	21-123
Other known	Obs/Exp	7/8.2	1/8.0
	SMR	85	13
	95% CI	34-176	0-70
Unknown		4	0

Table 12. Observed/expected number of deaths, SMR and 95% CI among ever hourly employees in residual operations, by years since hire and years worked

Cause of death		<20 years since hire			20+ years since hire		
		<1 years worked PY=(4,128)	1-4 years worked PY=(1,921)	5+ years worked PY=(2,124)	<1 years worked PY=(4,342)	1-4 years worked PY=(1,285)	5+ years worked PY=(1,853)
All causes	Obs/Exp	4/15	3/8.3	6/9.8	117/104	42/36	50/44
	SMR	26	36	61	113	116	115
	95% CI	7-67	8-106	23-134	93-135	83-157	85-151
All cancer	Obs/Exp	1/4.0	0/2.4	4/3.9	29/22	10/7.1	12/11
	SMR	25	0	103	132	142	110
	95% CI	1-140	0-155	28-263	88-189	68-261	57-192
Buccal cavity & pharynx	Obs/Exp	0/0.1	0/0.0	0/0.1	0/0.3	0/0.1	0/0.1
	SMR	0	-	0	0	0	0
	95% CI	0-7689	-	0-7288	0-1294	0-4026	0-2642
Esophagus	Obs/Exp	0/0.0	0/0.0	0/0.0	0/0.3	0/0.1	0/0.1
	SMR	-	-	-	0	0	0
	95% CI	-	-	-	0-1446	0-4504	0-2608
Stomach	Obs/Exp	0/0.2	0/0.1	0/0.1	0/0.6	1/0.2	0/0.3
	SMR	0	0	0	0	446	0
	95% CI	0-2113	0-3590	0-3075	0-573	11-2485	0-1184
Colorectum	Obs/Exp	0/0.4	0/0.2	1/0.3	1/2.8	2/0.9	1/1.3
	SMR	0	0	300	36	215	75
	95% CI	0-958	0-1606	8-1670	1-202	26-775	2-420
Liver	Obs/Exp	0/0.1	0/0.1	0/0.1	1/0.6	2/0.2	0/0.3
	SMR	0	0	0	170	1010	0
	95% CI	0-4655	0-7253	0-5089	4-947	122-3647	0-1351
Pancreas	Obs/Exp	0/0.1	0/0.1	0/0.2	0/1.4	1/0.4	0/0.6
	SMR	0	0	0	0	226	0
	95% CI	0-2781	0-4251	0-2476	0-268	6-1258	0-580
Larynx	Obs/Exp	0/0.0	0/0.0	0/0.0	0/0.1	0/0.0	0/0.0
	SMR	-	-	-	0	-	-
	95% CI	-	-	-	0-4922	-	-
Lung	Obs/Exp	0/0.3	0/0.2	1/0.6	7/4.2	2/1.2	5/2.2
	SMR	0	0	178	166	162	231
	95% CI	0-1396	0-1699	4-991	67-341	20-585	75-540
Breast	Obs/Exp	0/0.9	0/0.6	2/1.0	2/3.5	1/1.1	2/1.8
	SMR	0	0	199	57	89	109
	95% CI	0-415	0-676	24-720	7-208	2-496	13-394
Uterus	Obs/Exp	0/0.6	0/0.3	0/0.3	1/1.2	0/0.4	0/0.5
	SMR	0	0	0	85	0	0
	95% CI	0-593	0-1230	0-1211	2-471	0-996	0-783

Table 12. Observed/expected number of deaths, SMR and 95% CI among ever hourly employees in residual operations, by years since hire and years worked

Cause of death		<20 years since hire			20+ years since hire		
		<1 years worked PY=(4,128)	1-4 years worked PY=(1,921)	5+ years worked PY=(2,124)	<1 years worked PY=(4,342)	1-4 years worked PY=(1,285)	5+ years worked PY=(1,853)
Ovary	Obs/Exp	0/0.3	0/0.2	0/0.3	1/1.1	1/0.4	0/0.6
	SMR	0	0	0	91	273	0
	95% CI	0-1343	0-2273	0-1318	2-505	7-1519	0-623
Bladder	Obs/Exp	0/0.0	0/0.0	0/0.0	3/0.4	0/0.1	1/0.2
	SMR	-	-	-	855	0	586
	95% CI	-	-	-	176-2499	0-3015	15-3265
Kidney	Obs/Exp	0/0.1	0/0.0	0/0.1	0/0.4	0/0.1	0/0.2
	SMR	0	-	0	0	0	0
	95% CI	0-7129	-	0-6715	0-928	0-2996	0-1974
Brain	Obs/Exp	0/0.1	0/0.1	0/0.1	0/0.4	0/0.1	0/0.2
	SMR	0	0	0	0	0	0
	95% CI	0-3419	0-5876	0-3408	0-957	0-2932	0-1699
LHC	Obs/Exp	1/0.3	0/0.2	0/0.3	5/2.1	0/0.7	1/1.0
	SMR	324	0	0	236	0	98
	95% CI	8-1806	0-2044	0-1302	77-551	0-537	2-544
NHL	Obs/Exp	0/0.1	0/0.1	0/0.1	3/0.8	0/0.3	1/0.4
	SMR	0	0	0	377	0	241
	95% CI	0-4079	0-6353	0-3514	78-1102	0-1413	6-1343
Hodgkin lymphoma	Obs/Exp	0/0.0	0/0.0	0/0.0	0/0.1	0/0.0	0/0.0
	SMR	-	-	-	0	-	-
	95% CI	-	-	-	0-5387	-	-
Leukemia	Obs/Exp	1/0.1	0/0.1	0/0.1	1/0.8	0/0.3	0/0.4
	SMR	703	0	0	130	0	0
	95% CI	18-3917	0-4552	0-3412	3-726	0-1457	0-1030
Multiple myeloma	Obs/Exp	0/0.3	0/0.1	0/0.1	1/0.5	0/0.1	0/0.2
	SMR	0	0	0	215	0	0
	95% CI	0-1430	0-2806	0-5940	5-1200	0-2551	0-1676
Other cancer	Obs/Exp	0/0.5	0/0.3	0/0.4	8/2.6	0/1.1	2/1.6
	SMR	0	0	0	308	0	125
	95% CI	0-738	0-1230	0-922	133-606	0-335	15-452
Benign neoplasms	Obs/Exp	0/0.1	0/0.1	0/0.0	0/0.3	0/0.1	0/0.1
	SMR	0	0	-	0	0	0
	95% CI	0-2571	0-6669	-	0-1149	0-3885	0-4377
Blood disorders	Obs/Exp	0/0.1	0/0.0	0/0.0	0/0.4	0/0.2	0/0.2
	SMR	0	-	-	0	0	0
	95% CI	0-4630	-	-	0-842	0-2443	0-2068

Table 12. Observed/expected number of deaths, SMR and 95% CI among ever hourly employees in residual operations, by years since hire and years worked

Cause of death		<20 years since hire			20+ years since hire		
		<1 years worked PY=(4,128)	1-4 years worked PY=(1,921)	5+ years worked PY=(2,124)	<1 years worked PY=(4,342)	1-4 years worked PY=(1,285)	5+ years worked PY=(1,853)
Mental disorders	Obs/Exp	0/0.2	0/0.1	0/0.1	1/1.2	0/0.6	0/0.8
	SMR	0	0	0	83	0	0
	95% CI	0-2271	0-5325	0-5494	2-460	0-629	0-460
Allergic, endocrine & metabolic disease	Obs/Exp	0/0.3	0/0.2	0/0.3	2/4.6	1/1.5	2/1.7
	SMR	0	0	0	44	68	116
	95% CI	0-1191	0-2160	0-1289	5-158	2-378	14-417
Nervous system Disease	Obs/Exp	0/3.6	0/1.9	0/0.4	4/2.7	1/1.0	0/1.3
	SMR	0	0	0	148	99	0
	95% CI	0-103	0-194	0-855	40-378	3-554	0-290
Circulatory disease	Obs/Exp	2/3.0	0/1.9	0/3.0	58/53	22/19	22/20
	SMR	66	0	0	110	117	111
	95% CI	8-238	0-200	0-121	84-142	73-177	69-168
Nonmalignant respiratory disease	Obs/Exp	0/0.6	0/0.3	1/0.4	10/7.4	4/2.7	5/3.5
	SMR	0	0	240	135	146	143
	95% CI	0-623	0-1130	6-1339	65-248	40-374	46-333
Digestive disease	Obs/Exp	1/0.7	0/0.4	0/0.5	4/3.7	0/1.3	1/1.6
	SMR	135	0	0	108	0	62
	95% CI	3-752	0-1001	0-782	30-278	0-287	2-345
Genitourinary Disease	Obs/Exp	0/0.4	0/0.2	0/0.2	2/2.6	1/0.9	2/0.9
	SMR	0	0	0	77	113	225
	95% CI	0-1006	0-2261	0-2471	9-278	3-631	27-814
External causes	Obs/Exp	0/1.3	1/0.6	1/0.7	4/2.8	1/0.9	2/1.2
	SMR	0	160	147	144	108	173
	95% CI	0-276	4-892	4-819	39-368	3-603	21-626
Other known	Obs/Exp	0/0.7	1/0.2	0/0.3	2/3.3	1/0.7	3/1.7
	SMR	0	500	0	61	143	176
	95% CI	0-527	13-2786	0-1230	7-219	4-796	36-516
Unknown		0/0.0	1	0	1	1	1

Table 13. Observed/expected number of deaths, SMR and 95% CI by exposed/unexposed status, six plants

Cause of death		BD ppm-years		STY ppm-years		DMDTC mg-years/cm	
		0	>0	0	>0	0	>0
Leukemia	Obs/Exp	7/8.7	2/2.7	7/8.2	2/3.2	8/10	1/1.1
	SMR	81	74	85	63	78	89
	95% CI	32-166	9-266	34-175	8-229	34-154	2-498
NHL	Obs/Exp	11/10	2/3.0	8/9.0	5/3.5	12/11	1/1.3
	SMR	116	67	89	143	107	80
	95% CI	58-207	8-240	38-175	47-335	55-186	2-446
Multiple Myeloma	Obs/Exp	4/5.3	1/1.7	4/5.0	1/1.9	4/6.3	1/0.6
	SMR	76	60	80	52	63	166
	95% CI	21-194	2-335	22-205	1-288	17-162	4-924
Hodgkin Lymphoma	Obs/Exp	1/0.9	0/0.3	1/0.8	0/0.3	1/1.0	0/0.1
	SMR	115	0	124	0	97	0
	95% CI	3-639	0-1417	3-691	0-1129	2-538	0-3767
Lung	Obs/Exp	56/57	42/19	55/54	43/22	82/67	16/8.0
	SMR	99	223	103	197	122	199
	95% CI	75-129	161-302	77-134	143-266	97-151	114-324
Bladder	Obs/Exp	5/2.9	1/1.0	4/2.8	2/1.0	5/3.5	1/0.4
	SMR	171	110	143	193	144	277
	95% CI	56-399	3-610	39-366	23-696	47-336	7-1541
Breast	Obs/Exp	46/51	14/17	45/48	15/19	53/60	7/7.2
	SMR	91	84	94	78	88	97
	95% CI	67-121	46-140	69-126	43-128	66-115	39-199
Ovary	Obs/Exp	11/15	8/4.9	11/14	8/5.7	17/18	2/2.1
	SMR	72	163	76	140	94	96
	95% CI	36-129	70-320	38-136	61-276	55-151	12-346

Table 14. Number (%) exposed and median exposure values for butadiene (BD) ppm-years, styrene (STY) ppm-years, and dimethyldithiocarbamate mg-years/cm, for all subjects, all decedents, lymphohematopoietic, lung, bladder, breast and ovarian cancer decedents

Group (median values, years of age, hire year and years worked)	Total N	BD ppm-years		STY ppm-years		DMDTC mg-years/cm	
		N>0 (%)	Median	N>0 (%)	Median	N>0 (%)	Median
All subjects (64, 1960, 1.7)	4,511	1,191 (26)	8.0	1,417 (31)	1.7	571 (13)	15.7
All decedents (72, 1946, 0.9)	1,051	269 (26)	19.9	325 (31)	3.0	99 (9)	121.9
All leukemias (72, 1953, 0.6)	10	2 (14)	19.2	2 (36)	5.3	1 (7)	131.8
Non-Hodgkin lymphoma (66, 1951, 1.2)	14	2 (14)	306.8	5 (36)	6.0	1 (7)	23.4
Multiple myeloma (69, 1944, 0.4)	5	1 (20)	8.3	1 (20)	2.8	1 (20)	7.8
Hodgkin lymphoma (31, 1965, 0.4)	1	0 (0)	-	0 (0)	-	0 (0)	-
Lung cancer (68, 1949, 1.0)	104	43 (41)	12.8	44 (42)	5.0	17 (16)	71.7
Bladder cancer (73, 1945, 0.5)	8	1 (13)	468.9	3 (38)	0.4	1 (13)	1,780.9
Breast cancer (65, 1953, 0.9)	67	17 (25)	19.9	17 (25)	5.5	7 (10)	883.2
Ovarian cancer (67, 1946, 1.1)	22	8 (36)	13.0	9 (41)	1.1	2 (9)	31.9

Table 15. Number (%) exposed and median exposure values for butadiene (BD) ppm-years due to intensities ≤ 100 ppm, (BD) ppm-years due to intensities > 100 ppm, number of high-BD intensity tasks, and number of high-styrene (STY) intensity tasks, for all subjects, all decedents, lymphohematopoietic, lung, bladder, breast and ovarian cancer decedents

Group	BD ppm-years ≤ 100 ppm		BD ppm-years > 100 ppm		High BD- intensity tasks		High STY- intensity tasks	
	N>0 (%)	Median	N>0 (%)	Median	N>0 (%)	Median	N>0 (%)	Median
All subjects	1,191 (26)	3.1	966 (21)	7.5	966 (21)	187.4	825 (18)	150.6
All decedents	269 (26)	5.7	237 (23)	16.9	237 (23)	367.1	226 (22)	493.7
All leukemias	2 (20)	3.2	2 (20)	16.0	2 (20)	45.0	2 (20)	46.9
Non-Hodgkin Lymphoma	2 (14)	82	2 (14)	224.2	2 (14)	331.7	2 (14)	49.0
Multiple myeloma	1 (20)	1.0	1 (20)	7.3	1 (20)	126.8	1 (20)	172.3
Hodgkin lymphoma	0 (0)	-	0 (0)	-	0 (0)	-	0 (0)	-
Lung cancer	43 (41)	4.3	37 (36)	10.8	37 (36)	387.2	33 (32)	897.5
Bladder cancer	1 (13)	79.4	1 (13)	388.9	1 (13)	347.5	1 (13)	134.4
Breast cancer	17 (25)	7.6	14 (21)	23.5	14 (21)	405.8	13 (19)	135.0
Ovarian cancer	8 (36)	3.4	7 (32)	9.4	7 (32)	159.5	7 (32)	334.0

Table 16. Relative rate (RR) for lung cancer, for butadiene (BD) ppm-years, styrene (STY) ppm-years, dimethyldithiocarbamate (DMDTC) mg-years/cm and BD ppm-years >100, adjusted for age, years since hire, and other agent(s) in the models

		Model number and agent(s) in model*						
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
		BD only	STY only	DMDTC only	BD+DMDTC	STY+DMDTC	BD ppm-years >100	BD ppm-years >100+DMDTC
LC†/PY*		RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
BD ppm-years								
0	61/126,200	1.0			1.0			
>0-<1.9	11/10,993	2.8 (1.5 – 5.3)			2.8 (1.4 – 5.5)			
1.9 – <12.8	10/12,282	1.9 (1.0 – 3.7)			1.8 (0.9 – 3.7)			
12.8 – <56.3	11/8,884	2.3 (1.2 – 4.4)			2.2 (1.1 – 4.5)			
56.3+	11/8,919	2.1 (1.1 – 3.9)			2.1 (0.9 – 4.9)			
STY ppm-years								
0	60/118,785		1.0			1.0		
0 – <0.8	11/17,046		1.7 (0.9 – 3.2)			1.6 (0.8 – 3.1)		
0.8 – <6.0	11/15,420		1.5 (0.8 – 2.8)			1.4 (0.7 – 2.7)		
6.0 – <21.6	11/7,321		2.9 (1.5 – 5.4)			2.7 (1.4 – 5.5)		
21.6+	11/8,705		2.0 (1.0 – 3.8)			2.0 (0.8 – 4.8)		
DMDTC mg-years/cm								
0	87/148,875			1.0	1.0	1.0		1.0
0 – <8.9	4/6,961			1.9 (0.7 – 5.2)	1.0 (0.3 – 2.9)	1.4 (0.5 – 4.0)		0.9 (0.3 – 2.6)
8.9 – <71.7	5/5,533			2.0 (0.8 – 4.9)	1.2 (0.4 – 3.1)	1.2 (0.5 – 3.2)		1.1 (0.4 – 3.1)
71.7 – <673.6	4/3,700			1.9 (0.7 – 5.2)	1.1 (0.3 – 3.4)	1.0 (0.4 – 3.2)		1.1 (0.4 – 3.6)
673.6+	4/2,208			1.6 (0.6 – 4.4)	0.9 (0.3 – 3.4)	0.9 (0.3 – 3.3)		1.0 (0.3 – 3.9)
BD ppm-years >100								
0	67/133,927						1.0	1.0
>0-<1.4	9/8,416						3.1 (1.5 – 6.1)	3.2 (1.5 – 6.9)
1.4 – <10.8	9/9,664						1.9 (1.0 – 3.8)	1.9 (0.9 – 4.0)
10.8 – <40.1	9/6,636						2.4 (1.2 – 4.8)	2.3 (1.1 – 4.9)
40.1+	10/8,634						1.8 (0.9 – 3.6)	1.8 (0.7 – 4.5)

*The model for each column included indicator variables for categories of age, years since hire, and the agent(s) specified in the column heading.

†LC, number of lung cancers; PY, person-years.

Table 17. Relative rate (RR) for lung cancer, for total number of high-butadiene (BD) intensity tasks, total number of high-styrene (STY) intensity tasks, and dimethyldithiocarbamate (DMDTC) mg-years/cm, adjusted for age, years since hire, and other agent(s) in the models

LC†/PY*	Model number and agent(s) in model*				
	Model 1 BD only RR (95% CI)	Model 2 STY only RR (95% CI)	Model 3 DMDTC only RR (95% CI)	Model 4 BD+DMDTC RR (95% CI)	Model 5 STY+DMDTC RR (95% CI)
High-BD intensity tasks					
0	67/133,771	1.0		1.0	
>0 – <70.6	9/10,638	2.4 (1.2 – 4.9)		2.4 (1.1 – 5.2)	
70.6 – <387.2	10/10,609	2.0 (1.1 – 4.0)		2.0 (1.0 – 4.2)	
387.2 – <1,052.4	9/5,270	2.5 (1.3 – 5.1)		2.6 (1.2 – 5.7)	
1052.4+	9/6,989	1.9 (0.9 – 3.8)		1.9 (0.9 – 4.3)	
High-STY intensity tasks					
0	71/136,895	1.0			1.0
>0 – <127.1	8/12,027	1.8 (0.9 – 3.9)			1.6 (0.7 – 3.8)
127.1 – <897.4	8/7,936	1.5 (0.7 – 3.1)			1.4 (0.6 – 3.1)
897.4 – <3,505.0	8/5,066	2.4 (1.2 – 5.0)			2.3 (1.0 – 5.0)
3,505.0+	9/5,353	2.1 (1.1 – 4.2)			2.0 (0.9 – 4.4)
DMDTC mg-years/cm					
0	87/148,875		1.0	1.0	1.0
0 – <8.9	4/6,961		1.9 (0.7 – 5.2)	1.0 (0.3 – 3.1)	1.4 (0.4 – 4.4)
8.9 – <71.7	5/5,533		2.0 (0.8 – 4.9)	1.0 (0.4 – 2.8)	1.2 (0.5 – 3.4)
71.7 – <673.6	4/3,700		1.9 (0.7 – 5.2)	1.1 (0.4 – 3.2)	1.1 (0.4 – 3.6)
673.6+	4/2,208		1.6 (0.6 – 4.4)	0.8 (0.3 – 2.5)	1.1 (0.3 – 3.2)

*The model for each column included indicator variables for categories of age, years since hire, and the agent(s) specified in the column heading.

†LC, number of lung cancers; PY, person-years.

Table 18. Relative rate (RR) for breast cancer, for butadiene (BD) ppm-years and styrene (STY) ppm-years, adjusted for age, and years since hire

	BC [†] /PY*	Model 1 BD only RR (95% CI)	Model 2 STY only RR (95% CI)
BD ppm-years			
0	50/126,200	1.0	
>0 – <3.8	4/15,055	0.8 (0.3 – 2.3)	
3.8 – <19.9	4/11,371	0.9 (0.3 – 2.5)	
19.9 – <322.8	5/12,110	1.0 (0.4 – 2.6)	
322.8+	4/2,541	2.6 (0.9 – 7.3)	
STY ppm-years			
0	50/118,785		1.0
>0 – <1.3	4/21,099		0.5 (0.2 – 1.5)
1.3 – <5.5	4/10,891		0.9 (0.3 – 2.5)
5.5 – <86.4	5/13,726		0.8 (0.3 – 2.1)
86.4+	4/2,777		2.3 (0.8 – 6.4)

*The model for each column included indicator variables for categories of age, years since hire, and the agent(s) specified in the column heading.

[†]BC, number of breast cancers; PY, person-years.

APPENDICES

Appendix A. Work area/job title group codes

100	ADMINISTRATION GENERAL
109	ADMINISTRATION LABOR
110	ADMINISTRATION MULTIPLE AREAS
200	SERVICE GENERAL
209	SERVICE LABOR
210	SAFETY SBR/ SP/ LATEX FIREMAN INSPECTOR
211	SAFETY SBR/ SP/ LATEX GUARD MARSHALL ENG
212	SAFETY SBR/SP/LATEX
219	SAFETY LABOR
300	WAREHOUSE DISTRIBUTION
309	WAREHOUSE DISTRIBUTION LABOR
400	ENGINEERING SBR/SP/LATEX
410	DESIGN ENGINEERING GENERAL
420	PROCESS ENGINEERING SBR
430	PROCESS CONTROL SBR
500	MAINTENANCE UNSPEC/SHOP NO EXPOSURE
501	MAINTENANCE UNSPEC/SHOP MIN. EXPOSURE
502	MAINTENANCE UNSPEC/SHOP OPERATIVE UNSPEC
503	MAINTENANCE UNSPEC/SHOP PL/PA/CA/EL/IN/ST
504	MAINTENANCE UNSPEC/SHOP/ IR/SH/WE
505	MAINTENANCE UNSPEC/SHP
509	MAINTENANCE UNSPEC/SHOP LABOR
510	MAINTENANCE FILED NO EXPOSURE
511	MAINTENANCE FIELD MIN. EXPOSURE
512	MAINTENANCE FILED IN/MET/EL/MI
513	MAINTENANCE FIELD PF/OI/ME/BO/BL
514	MAINTENANCE FIELD DRIVER/MISC/UNSPEC
519	MAINTENANCE FIELD LABOR
520	MAINTENANCE BUTADIENE NO EXPOSURE
521	MAINTENANCE BUTADIENE MIN EXPOSURE
522	MAINTENANCE BUTADIENE IN/MET/EL/MI
523	MAINTENANCE BUTADIENE PF/OI/ME/BO/MA
524	MAINTENANCE BUTADIENE OPERATIVE UNSPEC
529	MAINTENANCE BUTADIENE LABOR
530	MAINTENANCE REACTOR NO EXPOSURE
531	MAINTENANCE REACTOR MIN EXPOSURE
532	MAINTENANCE REACTOR IN/MET/EL/MI
533	MAINTENANCE REACTOR PF/OI/MEBO/MA
539	MAINTENANCE REACTOR LABOR
540	MAINTENANCE RECOVERY NO EXPOSURE
541	MAINTENANCE RECOVERY MIN EXPOSURE
542	MAINTENANCE RECOVERY IN/MET/EL/MI

Appendix A. Work area/job title group codes

543 MAINTENANCE RECOVERY PF/OI/ME/BO/MA
549 MAINTENACE RECOVERY LABOR

550 MAINTENANCE FINISHING NO EXPOSURE
551 MAINTENANCE FINISHING MIN EXPOSURE
552 MAINTENANCE FINISHING IN/MET/EL/MI
553 MAINTENANCE FINISHING PF/OI/ME/BO/MA
559 MAINTENANCE FINISHING LABOR

560 MAINTENANCE PILOT PLANT NO EXPOSURE
561 MAINTENANCE PILOT PLANT MIN EXPOSURE
562 MAINTENANCE PILOT PLANT IN/MET/EL/MI
563 MAINTENANCE PILOT PLANT PF/OI/ME/BO/MA
569 MAINTENANCE PILOT PLANT LABOR

570 B & Y OPERATOR
571 B & Y/LABOR UNSPEC FORMAN/SUPER
578 B & Y JANITOR/YARDMAN
579 B & Y/LABOR UNSPEC LABORER

580 MAINTENANCE UTILITES NO EXPOSURE
581 MAINTENANCE UTILITES MIN EXPOSURE
582 MAINTENANCE UTILITES OPERATIVE
589 MAINTENANCE UTILITES LABOR

583 MAINTENANCE LATEX NO EXPOSURE
584 MAINTENANCE LATEX MIN EXPOSURE
585 MAINTENANCE LATEX OPERATIVE
586 MAINTENANCE LATEX LABOR

600 UTILITES OPERATIVE UNSPEC/MISC
609 UTILITIES LABOR
610 UTILITIES MIN EXPOSURE
620 UTILITIES POWERHOUSE
630 UTILITIES PUMP HOUSE
640 UTILITIES REFRIGERATION

700 BUTADIENE PRODUCTION OPERATIVE UNSPEC
701 BUTADIENE PRODUCTION MIN EXPOSURE
702 BUTADIENE PRODUCTION TANK FARM
703 BUTADIENE PRODUCTIONDEHYDRO
704 BUTADIENE PRODUCTIONEXTRACTION
707 BUTADIENE REGRIGERATION COMPRESSION
709 BUTADIENE PRODUCTION LABOR

705 POLYETHYLENE NO/MIN EXPOSURE
706 POLYETHYLENE OPERATIVE

800 PRODUCTON SBR NO EXPOSURE
801 PRODUCTON SBR MIN EXPOSURE
802 PRODUCTON SBR OPERATIVE UNSPEC
803 PRODUCTON SBR PRODUCTION CONTROL
809 PRODUCTON SBR LABOR

Appendix A. Work area/job title group codes

810	POLYMERIZATION SBR NO EXPOSURE
811	POLYMERIZATION SBR MIN EXPSOURE
812	POLYMERIZATION SBR OPERATIVE UNSPEC
813	POLYMERIZATION SBR TANK FARM
814	POLYMERIZATION SBR PIGMENT PREP
815	POLYMERIZATION SBR REACTOR
816	POLYMERIZATION SBR REACTOR RECOVERY
817	POLYMERIZATION SBR RECOVERY
819	POLYMERIZATION SBR LABOR
820	COAGULATION SBR
829	CARBON BLACK UNLOADER
830	FINISHING SBR NO EXPOSURE
831	FINISHING SBR MIN EXPOSURE
832	FINISHING SBR OPERATIVE UNSPEC
833	FINISHING SBR FILTER
834	FINISHING SBR DRYER
835	FINISHING SBR BALDER
839	FINISHING SBR LABOR
840	AO PLANT NO EXPOSURE
841	AO PLANT MIN EXPOSURE
842	AO PLANT OPERATOR
850	LATEX PLANT NO EXPOSURE
851	LATEX PLANT MIN EXPOSURE
852	LATEX PLANT OPERATOR
859	LATEX PALNT LABOR
860	PRODUCTION LP NO EXPOSURE
861	PRODUCTION LP MIN EXPOSURE
862	PRODUCTION LP OPERATIVE
865	PRODUCTION SP NO EXPOSURE
866	PRODUCTION SP MIN EXPOSURE
867	PRODUCTION SP OPERATIVE
870	POLYMERIZATION SP NO EXPOSURE
871	POLYMERIZATION SP MIN EXPOSURE
872	POLYMERIZATION SP OPERATIVE UNSPEC
873	POLYMERIZATION SP SOLV CHARGE/PUR/REC
874	COAGULATION SP DESOLV/DEWAT/CRUMB
875	COAGULATION SP EXP/CONVEY/PANEL BRD
879	POLYMERIZATION SP LABOR
880	FINISHING SP NO EXPOSURE
881	FINISHING SP MIN EXPOSURE
882	FINISHING SP OPERATIVE UNSPEC
883	FINISHING SP PACK/BAL/RECL
889	FINISHING SP LABOR

Appendix A. Work area/job title group codes

890	PRODUCTION SBR/SP NO EXPOSURE
891	PRODUCTION SBR/SP MIN EXPOSURE
892	PRODUCTION SBR/SP OPER FINISHING
893	PRODUCTION SBR/SP OPER PACK/BAL
894	PRODUCTION SBR/SP OPERATIVE UNSPEC
899	PRODUCTION SBR/SP LABOR FINISHING
900	TECHNICAL TECHNICIAN
901	TECHNICAL CHEMIST
902	TECHNICAL NO EXPOSURE
909	TECHNICAL LABOR
910	RUBBER CONTROL TECHNICIAN
911	RUBBER CONTROL CHEMIST
912	RUBBER CONTROL NO EXPOSURE
913	RUBBER CONTROL SAMPLER
914	RUBBER CONTROL SOLIDS TESTER
915	RUBBER CONTROL PHYSICAL TESTER
919	RUBBER CONTROL LABOR
920	BD CONTROL TECHNICIAN
921	BD CONTROL CHEMIST
922	BD CONTROL NO EXPOSURE
929	BD CONTROL LABOR
930	APPLICATIONS RESEARCH TECHNICIAN
931	APPLICATIONS RESEARCH CHEMIST
932	APPLICATIONS RESEARCH NO EXPOSURE
939	APPLICATIONS RESEARCH LABOR
940	RESEARCH TECHNICIAN
941	RESEARCH CHEMIST
942	RESEARCH NO EXPOSURE
949	RESEARCH LABOR
950	PILOT PLANT TECHNICIAN
951	PILOT PLANT CHEMIST
952	PILOT PLANT NO EXPOSURE
959	PILOT PLANT LABOR
960	LIQ POLY LAB TECHNICIAN
961	LIQ POLY LAB CHEMIST
962	LIQ POLY LAB NO EXPOSURE
970	POLYETHYLEN LAB TECHNICIAN
971	POLYETHYLEN LAB CHEMIST
972	POLYETHYLEN LAB NO EXPOSURE
979	POLYETHYLEN LAB LABOR
980	SBR PROCESS CONT TECHNICIAN
981	SBR PROCESS CONT CHEMIST
982	SBR PROCESS CONT COORD/FOREM/SUPER

ADDITIONAL GROUPS FOR POLYSAR

301	WAREHOUSE BUTYL
302	WAREHOUSE PS GENL
303	WAREHOUSE LABOR BUTYL
304	WAREHOUSE LABOR PS GEN401 ENGINEERING BD
402	ENGINEERING STYRENE
403	ENGINEERING PETROCHEMICALS
404	ENGINEERING UTILITIES / BUTYL/ABS/FP
405	ENGINEERING FIELD UNSPEC
406	ENGINEERING MISC/UNSPEC
421	PROCESS ENGINEERING ABS
422	PROCESS ENGINEERING BD
423	PROCESS ENGINEERING BUTYL/FP
424	PROCESS ENGINEERING PETROCHEMICALS
425	PROCESS ENGINEERING LATEX
426	PROCESS ENGINEERING STEREO
427	PROCESS ENGINEERING STYRENE
428	PROCESS ENGINEERING UTILITIES
429	PROCESS ENGINEERING GEN/UNSPEC
431	PROCESS CONTROL BD
432	PROCESS CONTROL BUTYL/FEED PREP
433	PROCESS CONTROL ABS
434	PROCESS CONTROL PETROCHEMICALS
435	PROCESS CONTROL STEREO
436	PROCESS CONTROL STYRENE
437	PROCESS CONTROL UTILITIES
438	PROCESS CONTROL GEN/UNSPEC
440	ABS MAINTENANCE NO/MIN EXP
441	ABS MAINTENANCE OPERATIVE
310	ABS TECHNICAL TECHNICIAN
311	ABS TECHNICAL NO EXP/CHEM
710	ABS PRODUCTION NO EXP
711	ABS PRODUCTION MIN EXP
712	ABS PRODUCTION OPERATIVE
719	ABS PRODUCTION LABORER
450	BUTYL MAINTENANCE NO/MIN EXP
451	BUTYL MAINTENANCE OPERATIVE
459	BUTYL MAINTENANCE LABORER
320	BUTYL TECHNICAL TECHNICIAN
321	BUTYL TECHNICAL NO/MIN EXP
720	BUTYL PRODUCTION NO/MIN EXP
721	BUTYL PRODUCTION OPERATIVE

Appendix A. Work area/job title group codes

729 BUTYL PRODUCTION LABORER

460 PETROCHEM MAINTENANCE NO EXP
461 PETROCHEM MAINTENANCE MIN EXP
462 PETROCHEM MAINTENANCE OPERATIVE
469 PETROCHEM MAINTENANCE LABORER
730 PETROCHEM PRODUCTION NO EXP
731 PETROCHEM PRODUCTION MIN EXP
732 PETROCHEM PRODUCTION OPERATIVE
739 PETROCHEM PRODUCTION LABORER

470 FP OTHER NO/MIN EXP
471 FP OTHER OPERATIVE
479 FP OTHER LABORER

740 FP OTHER PRODUCTION NO/MIN EXP
741 FP OTHER PRODUCTION OPERATIVE
749 FP OTHER PRODUCTION LABORER

472 FP LER MAINTENANCE OPERATIVE

750 FP LER PRODUCTION NO/MIN EXP
751 FP LER PRODUCTION OPERATIVE
759 FP LER PRODUCTION LABORER

473 FP K1 MAINTENANCE OPERATIVE

760 FP K1 PRODUCTION NO EXP
761 FP K1 PRODUCTION MIN EXP
762 FP K1 PRODUCTION OPERATIVE
769 FP K1 PRODUCTION LABORER

480 STEREO MAINTENANCE NO EXP
481 STEREO MAINTENANCE MIN EXP
482 STEREO MAINTENANCE OPERATIVE
489 STEREO MAINTENANCE LABORER

330 STEREO TECHNICAL TECHNICIAN
331 STEREO TECHNICAL MIN EXP/CHEM
332 STEREO TECHNICAL NO EXP/SUPERV

770 STEREO PRODUCTION NO EXP
771 STEREO PRODUCTION MIN EXP
772 STEREO PRODUCTION OPERATIVE
773 STEREO REFRIG/COMP OPERATIVE

490 STYRENE MAINTENANCE MIN EXP
791 STYRENE MAINTENANCE OPERATIVE
499 STYRENE MAINTENANCE LABORER

340 STYRENE TECHNICAL TECHNICIAN
341 STYRENE TECHNICAL MIN EXP/CHEM
342 STYRENE TECHNICAL NO EXP/SUPERV

Appendix A. Work area/job title group codes

780	STYRENE PRODUCTION NO EXP
781	STYRENE PRODUCTION MIN EXP
782	STYRENE PRODUCTION TANK FARM
783	STYRENE PRODUCTION ETHYLBENZENE
784	STYRENE PRODUCTION CRACKING
785	STYRENE PRODUCTION FINISHING
786	STYRENE PRODUCTION MISC/UNSPEC
789	STYRNE PRODUCTION LABORER
590	PS GENL/RUBBER UNSPEC MAINTENANCE NO EXP
591	PS GENL/RUBBER UNSPEC MAINTENANCE MIN EXP SHOP/BG/CS/US
592	PS GENL/RUBBER UNSPEC MAINTENANCE MIN EXP FIELD
593	PS GENL/RUBBER UNSPEC MAINTENANCE EQUIP/VEH OP/ GAR ME
594	PS GENL/RUBBER UNSPEC MAINTENANCE CONST/BG/RG/SF/PA/CA/MA/IN
595	PS GENL/RUBBER UNSPEC MAINTENANCE METAL/MA/WE/MI
596	PS GENL/RUBBER UNSPEC MAINTENANCE PF/ME/BK/BS/OI
597	PS GENL/RUBBER UNSPEC MAINTENANCE EL/IN
598	PS GENL/RUBBER UNSPEC MAINTENANCE OPER MISC/UNSPEC
599	PS GENL/RUBBER UNSPEC MAINTENANCE LABORER NON EXPOSED
350	PS GENL/RUBBER UNSPEC TECHNICAL TECHNICIAN
351	PS GENL/RUBBER UNSPEC TECHNICAL CHEM
352	PS GENL/RUBBER UNSPEC TECHNICAL NO EXP/SUPERV
353	PS GENL/RUBBER UNSPEC TECHNICAL SAMPLER
354	PS GENL/RUBBER UNSPEC TECHNICAL FIELD/MOONEY
355	PS GENL/RUBBER UNSPEC TECHNICAL NON EXPOSED
359	PS GENL/RUBBER UNSPEC TECHNICAL LABOR
399	PS GENL/RUBBER EXP MAINTENACE LABORER
790	PS GENL/RUBBER UNSPEC PRODUCTION NO EXP
791	PS GENL/RUBBER UNSPEC PRODUCTION MIN EXP
792	PS GENL/RUBBER UNSPEC PRODUCTION OPER FINISHING
793	PS GENL/RUBBER UNSPEC PRODUCTION OPER OTHER/UNSPEC
794	PS GENL/RUBBER UNSPEC SAFETY OPER
799	PS GENL/RUBBER UNSPEC PRODUCTION
605	COPYMER EFFLUENT OPERATIVE
641	POLYSAR REFRIGERATION/COMPRESSION UNSPECIFIED
650	LABORATORY EMULSION POLYMERS R&D TECHNICIAN
651	LABORATORY EMULSION POLYMERS R&D MIN EXP/CHEMIST
652	LABORATORY EMULSION POLYMERS R&D SUPERVISOR
659	LABORATORY EMULSION POLYMERS R&D LABOR
660	LABORATORY POLY BD, EPDM, SOLUTIONS N.S. TECHINICIAN
661	LABORATORY POLY BD, EPDM, SOLUTIONS N.S. MIN EXP/CHEMIST
662	LABORATORY POLY BD, EPDM, SOLUTIONS N.S.SUPERVISOR
669	LABORATORY POLY BD, EPDM, SOLUTIONS N.S. LABOR

Appendix A. Work area/job title group codes

670	LABORATORY BOTTLE POLYMERIZATION/BATCH REACTORS TECHNICIAN
671	LABORATORY BOTTLE POLYMERIZATION/BATCH REACTORS MIN EXP/CHEM
672	LABORATORY BOTTLE POLYMERIZATION/BATCH REACTORS SUPERVISOR
679	LABORATORY BOTTLE POLYMERIZATION/BATCH REACTORS LABOR
680	LABORATORY HYDROCARBON R&D TECHNICIAN
681	LABORATORY HYDROCARBON R&D MIN EXP/CHEMIST
682	LABORATORY HYDROCARBON R&D SUPERVISOR
689	LABORATORY HYDROCARBON R&D LABOR
690	LABORATORY LOW EXPOSURE POLYMER R&D TECHNICIAN
691	LABORATORY LOW EXPOSURE POLYMER R&D MIN EXP /CHEMIST
692	LABORATORY LOW EXPOSURE POLYMER R&D SUPERVISOR
699	LABORATORY LOW EXPOSURE POLYMER R&D LABOR

Appendix B. Work area/job groups for SBR-related operations, administration and residual operations by pay status* and by plants (US / Canada)

Pay status*	Group	Work area/Job titles	Plants		
			US	Canada	
SBR					
H		209	SERVICE LABOR	X	X
	M	300	WAREHOUSE DISTRIBUTION	X	X
H		309	WAREHOUSE DISTRIBUTION LABOR	X	
H		330	STEREO TECHNICAL TECHNICIAN		X
H		489	STEREO MAINTENANCE LABORER		X
H		502	MAINTENANCE UNSPEC/SHOP OPERATIVE UNSPEC		X
H		503	MAINTENANCE UNSPEC/SHOP PL/PA/CA/EL/IN/ST	X	
H		504	MAINTENANCE UNSPEC/SHOP IR/SH/WE	X	
H		505	MAINTENANCE UNSPEC/SHOP MA	X	
H		509	MAINTENANCE UNSPEC/SHOP LABOR	X	
H		512	MAINTENANCE FIELD IN/MET/EL/MI	X	
H		513	MAINTENANCE FIELD PF/OI/ME/BO/MA/BL	X	
H		514	MAINTENANCE FIELD DRIVER/MISC/UNSPEC	X	
H		519	MAINTENANCE FIELD LABOR	X	
H		559	MAINTENANCE FINISHING LABOR	X	
H		578	B & Y JANITOR/YARDMAN	X	
H		579	B & Y/LABOR UNSPEC LABORER	X	X
H		586	MAINTENANCE LATEX LABOR		X
H		589	MAINTENANCE UTILITIES LABOR		X
	M	600	UTILITIES OPERATIVE UNSPEC/MISC	X	X
		609	UTILITIES LABOR	X	X
H		620	UTILITIES POWERHOUSE	X	
H		630	UTILITIES PUMP HOUSE	X	
H		700	BUTADIENE PRODUCTION OPERATIVE UNSPEC	X	X
H		704	BUTADIENE PRODUCTION EXTRACTION		X
H		772	STEREO PRODUCTION OPERATIVE		X
H		802	PRODUCTION SBR OPERATIVE UNSPEC	X	X
H		809	PRODUCTION SBR LABOR	X	
H		814	POLYMERIZATION SBR PIGMENT PREP	X	
H		815	POLYMERIZATION SBR REACTOR	X	
H		817	POLYMERIZATION SBR LABOR	X	
H		820	COAGULATION SBR	X	
H		832	FINISHING SBR OPERATIVE UNSPEC	X	X
H		834	FINISHING SBR DRYER	X	
	M	835	FINISHING SBR BALER	X	
		839	FINISHING SBR LABOR	X	
H		875	COAGULATION SP EXP/CONVEY/PANEL BRD	X	
H		882	FINISHING SP OPERATIVE UNSPEC	X	
H		883	FINISHING SP PACK/BAL/RECL	X	
	M	900	TECHNICAL TECHNICIAN	X	X
H		909	TECHNICAL LABOR	X	
	M	910	RUBBER CONTROL TECHNICIAN	X	
	M	913	RUBBER CONTROL SAMPLER	X	
	M	914	RUBBER CONTROL SOLIDS TESTER	X	
	M	915	RUBBER CONTROL PHYSICAL TESTER	X	
	M	920	BD CONTROL TECHNICIAN	X	X

Appendix B. Work area/job groups for SBR-related operations, administration and residual operations by pay status* and by plants (US / Canada)

Pay status*	Group	Work area/Job titles	Plants	
			US	Canada
M	930	APPLICATIONS RESEARCH TECHNICIAN	X	X
M	940	RESEARCH TECHNICIAN	X	X
H	949	RESEARCH LAOBOR	X	
H	950	PIOLT PLANT TECHNICIAN	X	
H	980	SBR PROCESS CONT TECHNICIAN	X	
RESIDUAL				
M	100	ADMINISTRATION GENERAL	X	X
M	200	SERVICE GENERAL	X	
M	211	SAFETY SBR/ SP/ LATEX GUARD MARSHALL ENG	X	
M	212	SAFETY SBR/SP/LATEX	X	X
S	311	ABS TECHNICAL NO EXP/CHEM		X
S	321	BUTYL TECHNICAL NO/MIN EXP		X
S	331	STEREO TECHNICAL MIN EXP/CHEM		X
S	332	STEREO TECHNICAL NO EXP/SUPERV		X
S	351	PS GENL/RUBBER UNSPEC TECHNICAL CHEM		X
S	352	PS GENL/RUBBER UNSPEC TECHNICAL NO EXP/SUPERV		X
M	400	ENGINEERING SBR/SP/LATEX	X	
S	405	ENGINEERING FIELD UNSPEC		X
S	406	ENGINEERING MISC/UNSPEC		X
S	410	DESIGN ENGINEERING GENERAL	X	X
S	420	PROCESS ENGINEERING SBR	X	
S	423	PROCESS ENGINEERING BUTYL/FP		X
S	424	PROCESS ENGINEERING PETROCHEMICALS		X
S	425	PROCESS ENGINEERING LATEX		X
S	426	PROCESS ENGINEERING STEREO		X
S	429	PROCESS ENGINEERING STYRENE		X
S	430	PROCESS ENGINEERING UTILITIES		X
S	440	PROCESS ENGINEERING GEN/UNSPEC		X
S	450	BUTYL MAINTENANCE NO/MIN EXP		X
	H 451	BUTYL MAINTENANCE OPERATIBE		X
	H 459	BUTYL MAINTENANCE LABORER		X
S	460	PETROCHEM MAINTENANCE NO EXP		X
S	461	PETROCHEM MAINTENANCE MIN EXP		X
	H 462	PETROCHEM MAINTENANCE OPERATIVE		X
	H 469	PETROCHEM MAINTENANCE LABORER		X
S	480	STEREO MAINTENANCE NO EXP		X
M	500	MAINTENANCE UPSPEC/SHOP NO EXPOSURE	X	X
M	580	MAINTENANCE UTILITES NO EXPOSURE		X
S	590	PS GENL/RUBBER UNSPEC MAINTENANCE NO EXP		X
M	591	PS GENL/RUBBER UNSPEC MAINTENANCE MIN EXP SHOP/BG/CS/US		X
S	592	PS GENL/RUBBER UNSPEC MAINTENANCE MIN EXP FIELD		X
	H 593	PS GENL/RUBBER UNSPEC MAINTENANCE EQUIP/VEH OP/ GAR ME		X
	H 594	PS GENL/RUBBER UNSPEC MAINTENANCE		X

Appendix B. Work area/job groups for SBR-related operations, administration and residual operations by pay status* and by plants (US / Canada)

Pay status*	Group	Work area/Job titles	Plants	
			US	Canada
		CONST/BG/RG/SF/PA/CA/MA/IN		
	H	596 PS GENL/RUBBER UNSPEC MAINTENANCE METAL/MA/WE/MI		X
	H	597 PS GENL/RUBBER UNSPEC MAINTENANCE PF/ME/BK/BS/OI		X
	H	598 PS GENL/RUBBER UNSPEC MAINTENANCE EL/IN		X
M		599 PS GENL/RUBBER UNSPEC MAINTENANCE OPER MISC/UNSPEC		X
S		610 UTILITIES MIN EXPOSURE	X	X
S		651 LABORATORY EMULSION POLYMERS R&D MIN EXP/CHEMIST		X
S		652 LABORATORY EMULSION POLYMERS R&D SUPERVISOR		X
S		662 LABORATORY POLY BD, EPDM, SOLUTIONS N.S.SUPERVISOR		X
S		701 BUTADIENE PRODUCTION MIN EXPOSURE	X	X
S		705 POLYETHYLENE NO/MIN EXPOSURE	X	
S		710 ABS PRODUCTION NO EXP		X
S		720 BUTYL PRODUCTION NO/MIN EXP		X
	H	721 BUTYL PRODUCTION OPERATIVE		X
S		730 PETROCHEM PRODUCTION NO EXP		X
	H	732 PETROCHEM PRODUCTION OPERATIVE		X
	H	739 PETROCHEM PRODUCTION LABORER		X
S		770 STEREO PRODUCTION NO EXP		X
S		780 STYRENE PRODUCTION NO EXP		X
	H	786 STYRENE PRODUCTION MISC/UNSPEC		X
S		790 PS GENL/RUBBER UNSPEC PRODUCTION NO EXP		X
S		791 PS GENL/RUBBER UNSPEC PRODUCTION MIN EXP		X
	M	800 PRODUCTON SBR NO EXPOSURE	X	X
S		801 PRODUCTON SBR MIN EXPOSURE	X	X
	M	831 FINISHING SBR MIN EXPOSURE	X	X
S		850 LATEX PLANT NO EXPOSURE		X
S		860 PRODUCTON LP NO EXPOSURE	X	
S		881 FINISHING SP MIN EXPOSURE	X	
	M	901 TECHNICAL CHEMIST	X	
	M	902 TECHNICAL NO EXPOSURE	X	X
S		912 RUBBER CONTROL NO EXPOSURE	X	
S		921 BD CONTROL CHEMIST		X
S		922 BD CONTROL NO EXPOSURE		X
S		932 APPLICATIONS RESEARCH NO EXPOSURE	X	X
S		941 RESEARCH CHEMIST	X	X
	M	942 RESEARCH NO EXPOSURE	X	X
S		951 PILOT PLANT CHEMIST	X	X
	M	952 PILOT PLANT NO EXPOSURE	X	X
S		962 LIQ POLY LAB NO EXPOSURE	X	
S		982 SBR PROCESS CONT COORD/FOREM/SUPER	X	

* S=Never hourly, H=Never salaried, M=Hourly and/or salaried

Appendix C1. Plant 1 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total	Ever hourly
		(PY=5,193)	(PY=1,316)
All causes	Obs/Exp	28/34	8/10
	SMR	82	80
	95% CI	54-118	34-157
All cancer	Obs/Exp	6/10	3/3.0
	SMR	60	100
	95% CI	22-130	21-292
Buccal cavity & pharynx	Obs/Exp	0/0.1	0/0.0
	SMR	0	-
	95% CI	0-3497	-
Esophagus	Obs/Exp	0/0.1	0/0.0
	SMR	0	-
	95% CI	0-4461	-
Stomach	Obs/Exp	0/0.2	0/0.1
	SMR	0	0
	95% CI	0-2049	0-7054
Colorectum	Obs/Exp	1/1.0	0/0.3
	SMR	96	0
	95% CI	2-536	0-1209
Liver	Obs/Exp	0/0.2	0/0.1
	SMR	0	0
	95% CI	0-1734	0-6034
Pancreas	Obs/Exp	0/0.4	0/0.1
	SMR	0	0
	95% CI	0-897	0-2954
Larynx	Obs/Exp	0/0.0	0/0.0
	SMR	-	-
	95% CI	-	-
Lung	Obs/Exp	2/2.6	2/0.8
	SMR	78	251
	95% CI	9-282	30-908
Breast	Obs/Exp	1/1.9	0/0.6
	SMR	53	0
	95% CI	1-295	0-654
Uterus	Obs/Exp	0/0.6	0/0.2
	SMR	0	0
	95% CI	0-584	0-1999

Appendix C1. Plant 1 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=5,193)	Ever hourly (PY=1,316)
Ovary	Obs/Exp	1/0.5	0/0.2
	SMR	185	0
	95% CI	5-1030	0-2454
Bladder	Obs/Exp	0/0.1	0/0.0
	SMR	0	-
	95% CI	0-3661	-
Kidney	Obs/Exp	0/0.2	0/0.1
	SMR	0	0
	95% CI	0-2173	0-7598
Brain	Obs/Exp	0/0.3	0/0.1
	SMR	0	0
	95% CI	0-1438	0-5402
LHC	Obs/Exp	0/0.8	0/0.2
	SMR	0	0
	95% CI	0-462	0-1642
NHL	Obs/Exp	0/0.3	0/0.1
	SMR	0	0
	95% CI	0-1168	0-4365
Hodgkin lymphoma	Obs/Exp	0/0.0	0/0.0
	SMR	-	-
	95% CI	-	-
Leukemia	Obs/Exp	0/0.3	0/0.1
	SMR	0	0
	95% CI	0-1256	0-4393
Multiple myeloma	Obs/Exp	0/0.2	0/0.1
	SMR	0	0
	95% CI	0-2505	0-7906
Other cancer	Obs/Exp	1/1.0	1/0.2
	SMR	100	500
	95% CI	3-557	13-2786
Benign neoplasms	Obs/Exp	0/0.1	0/0.0
	SMR	0	-
	95% CI	0-3560	-
Blood disorders	Obs/Exp	1/0.1	0/0.0
	SMR	756	-
	95% CI	19-4212	-

Appendix C1. Plant 1 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=5,193)	Ever hourly (PY=1,316)
Mental disorders	Obs/Exp	1/0.4	0/0.1
	SMR	285	0
	95% CI	7-1588	0-3626
Allergic, endocrine & metabolic disease	Obs/Exp	1/1.4	0/0.4
	SMR	72	0
	95% CI	2-401	0-843
Nervous system disease	Obs/Exp	2/0.9	0/0.2
	SMR	225	0
	95% CI	27-814	0-1761
Circulatory disease	Obs/Exp	7/14	1/4.0
	SMR	51	25
	95% CI	21-106	1-139
Nonmalignant respiratory disease	Obs/Exp	5/2.8	3/0.8
	SMR	176	369
	95% CI	57-411	76-1077
Digestive disease	Obs/Exp	1/1.3	0/0.4
	SMR	79	0
	95% CI	2-440	0-1007
Genitourinary disease	Obs/Exp	1/0.7	0/0.2
	SMR	142	0
	95% CI	4-790	0-1605
External causes	Obs/Exp	1/1.9	0/0.5
	SMR	53	0
	95% CI	1-292	0-763
Other known	Obs/Exp	1/0.4	0/0.4
	SMR	250	0
	95% CI	6-1393	0-922
Unknown		1	1

Appendix C2. Plant 2 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total	Ever-hourly
		(PY=12,529)	(PY=6,669)
All causes	Obs/Exp	141/152	78/94
	SMR	93	83
	95% CI	78-110	65-103
All cancer	Obs/Exp	39/36	20/21
	SMR	107	96
	95% CI	76-146	59-148
Buccal cavity & pharynx	Obs/Exp	0/0.5	0/0.3
	SMR	0	0
	95% CI	0-821	0-1463
Esophagus	Obs/Exp	1/0.4	0/0.2
	SMR	269	0
	95% CI	7-1496	0-1576
Stomach	Obs/Exp	0/1.1	0/0.7
	SMR	0	0
	95% CI	0-351	0-548
Colorectum	Obs/Exp	4/3.9	2/2.4
	SMR	101	83
	95% CI	28-260	10-300
Liver	Obs/Exp	1/1.0	1/0.6
	SMR	97	168
	95% CI	2-542	4-937
Pancreas	Obs/Exp	2/2.0	1/1.2
	SMR	101	84
	95% CI	12-363	2-467
Larynx	Obs/Exp	0/0.1	0/0.1
	SMR	0	0
	95% CI	0-3146	0-5525
Lung	Obs/Exp	8/7.3	5/3.8
	SMR	110	131
	95% CI	47-216	42-305
Breast	Obs/Exp	11/6.1	4/3.4
	SMR	179	117
	95% CI	89-321	32-301
Uterus	Obs/Exp	1/2.5	1/1.6
	SMR	40	63
	95% CI	1-224	2-351

Appendix C2. Plant 2 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=12,529)	Ever-hourly (PY=6,669)
Ovary	Obs/Exp	2/2.1	1/1.2
	SMR	94	85
	95% CI	11-340	2-476
Bladder	Obs/Exp	2/0.5	2/0.3
	SMR	438	685
	95% CI	53-1581	83-2475
Kidney	Obs/Exp	0/0.6	0/0.4
	SMR	0	0
	95% CI	0-588	0-1054
Brain	Obs/Exp	0/0.8	0/0.4
	SMR	0	0
	95% CI	0-460	0-903
LHC	Obs/Exp	5/3.4	2/1.9
	SMR	148	105
	95% CI	48-346	13-378
NHL	Obs/Exp	2/1.3	1/0.7
	SMR	156	145
	95% CI	19-564	4-808
Hodgkin lymphoma	Obs/Exp	0/0.2	0/0.1
	SMR	0	0
	95% CI	0-2450	0-4489
Leukemia	Obs/Exp	0/1.2	0/0.7
	SMR	0	0
	95% CI	0-302	0-526
Multiple myeloma	Obs/Exp	2/1.0	1/0.6
	SMR	207	158
	95% CI	25-746	4-881
Other cancer	Obs/Exp	2/3.7	1/2.5
	SMR	54	40
	95% CI	7-195	1-223
Benign neoplasms	Obs/Exp	0/0.6	0/0.4
	SMR	0	0
	95% CI	0-657	0-1043
Blood disorders	Obs/Exp	1/0.7	1/0.4
	SMR	151	246
	95% CI	4-840	6-1368

Appendix C2. Plant 2 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=12,529)	Ever-hourly (PY=6,669)
Mental disorders	Obs/Exp	2/1.8	1/1.1
	SMR	111	89
	95% CI	13-400	2-498
Allergic, endocrine & metabolic disease	Obs/Exp	5/6.4	1/4.0
	SMR	78	25
	95% CI	25-182	1-139
Nervous system disease	Obs/Exp	6/7.8	5/5.5
	SMR	77	91
	95% CI	28-167	30-212
Circulatory disease	Obs/Exp	61/65	33/42
	SMR	94	78
	95% CI	72-121	54-109
Nonmalignant respiratory disease	Obs/Exp	12/11	7/6.6
	SMR	106	106
	95% CI	55-185	43-219
Digestive disease	Obs/Exp	4/6.1	2/3.6
	SMR	66	56
	95% CI	18-169	7-200
Genitourinary disease	Obs/Exp	0/3.4	0/2.3
	SMR	0	0
	95% CI	0-109	0-161
External causes	Obs/Exp	6/5.7	4/3.3
	SMR	106	123
	95% CI	39-230	34-315
Other known	Obs/Exp	3/7.5	3/3.8
	SMR	40	79
	95% CI	8-117	16-231
Unknown		2	1

Appendix C3. Plant 3 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=16,595)	Ever-hourly (PY=4,970)
All causes	Obs/Exp	91/122	46/50
	SMR	75	92
	95% CI	60-92	68-123
All cancer	Obs/Exp	36/34	12/12
	SMR	106	99
	95% CI	74-147	51-172
Buccal cavity & pharynx	Obs/Exp	1/0.4	0/0.2
	SMR	230	0
	95% CI	6-1279	0-2288
Esophagus	Obs/Exp	1/0.3	0/0.1
	SMR	293	0
	95% CI	7-1635	0-2663
Stomach	Obs/Exp	1/0.7	1/0.4
	SMR	142	283
	95% CI	4-792	7-1579
Colorectum	Obs/Exp	1/3.3	1/1.3
	SMR	30	77
	95% CI	1-170	2-430
Liver	Obs/Exp	2/0.7	1/0.3
	SMR	273	373
	95% CI	33-987	9-2079
Pancreas	Obs/Exp	0/1.7	0/0.7
	SMR	0	0
	95% CI	0-217	0-568
Larynx	Obs/Exp	0/0.1	0/0.1
	SMR	0	0
	95% CI	0-2970	0-7977
Lung	Obs/Exp	7/7.9	1/2.5
	SMR	89	41
	95% CI	36-182	1-226
Breast	Obs/Exp	7/6.2	2/2.2
	SMR	112	93
	95% CI	45-232	11-336
Uterus	Obs/Exp	1/1.8	1/0.9
	SMR	57	118
	95% CI	1-317	3-659

Appendix C3. Plant 3 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=16,595)	Ever-hourly (PY=4,970)
Ovary	Obs/Exp	3/1.8	0/0.6
	SMR	172	0
	95% CI	35-501	0-632
Bladder	Obs/Exp	1/0.4	0/0.2
	SMR	285	0
	95% CI	7-1589	0-2313
Kidney	Obs/Exp	1/0.7	0/0.2
	SMR	155	0
	95% CI	4-861	0-1738
Brain	Obs/Exp	1/0.8	0/0.2
	SMR	133	0
	95% CI	3-742	0-1647
LHC	Obs/Exp	1/3.0	0/1.1
	SMR	33	0
	95% CI	1-185	0-349
NHL	Obs/Exp	1/1.2	0/0.4
	SMR	82	0
	95% CI	2-459	0-967
Hodgkin lymphoma	Obs/Exp	0/0.2	0/0.1
	SMR	0	0
	95% CI	0-2371	0-6573
Leukemia	Obs/Exp	0/1.1	0/0.4
	SMR	0	0
	95% CI	0-338	0-948
Multiple myeloma	Obs/Exp	0/0.7	0/0.3
	SMR	0	0
	95% CI	0-549	0-1147
Other cancer	Obs/Exp	8/4.2	5/1.0
	SMR	190	500
	95% CI	82-375	162-1167
Benign neoplasms	Obs/Exp	0/0.6	0/0.2
	SMR	0	0
	95% CI	0-672	0-1531
Blood disorders	Obs/Exp	0/0.6	0/0.2
	SMR	0	0
	95% CI	0-619	0-1536

Appendix C3. Plant 3 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=16,595)	Ever-hourly (PY=4,970)
Mental disorders	Obs/Exp	1/1.1	1/0.4
	SMR	92	249
	95% CI	2-514	6-1387
Allergic, endocrine & metabolic disease	Obs/Exp	2/5.8	2/2.6
	SMR	35	78
	95% CI	4-125	10-282
Nervous system disease	Obs/Exp	2/4.9	2/2.7
	SMR	41	75
	95% CI	5-149	9-271
Circulatory disease	Obs/Exp	22/47	13/21
	SMR	47	62
	95% CI	30-72	33-106
Nonmalignant respiratory disease	Obs/Exp	6/8.6	1/3.1
	SMR	70	32
	95% CI	26-151	1-179
Digestive disease	Obs/Exp	4/4.9	3/1.9
	SMR	82	160
	95% CI	23-211	33-467
Genitourinary disease	Obs/Exp	3/3.0	2/1.4
	SMR	101	146
	95% CI	21-294	18-528
External causes	Obs/Exp	8/6.7	7/2.2
	SMR	119	318
	95% CI	52-235	128-656
Other known	Obs/Exp	5/4.8	2/2.3
	SMR	104	87
	95% CI	34-243	11-314
Unknown		2	1

Appendix C4. Plant 4 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total	Ever-hourly
		(PY=31,528)	(PY=11,815)
All causes	Obs/Exp	250/299	125/132
	SMR	84	95
	95% CI	74-95	79-113
All cancer	Obs/Exp	71/79	31/31
	SMR	90	99
	95% CI	70-113	67-141
Buccal cavity & pharynx	Obs/Exp	0/1.0	0/0.4
	SMR	0	0
	95% CI	0-355	0-915
Esophagus	Obs/Exp	1/0.8	0/0.4
	SMR	123	0
	95% CI	3-687	0-1029
Stomach	Obs/Exp	1/1.8	0/1.0
	SMR	56	0
	95% CI	1-309	0-389
Colorectum	Obs/Exp	7/8.1	2/3.4
	SMR	86	58
	95% CI	35-177	7-210
Liver	Obs/Exp	0/1.8	0/0.7
	SMR	0	0
	95% CI	0-209	0-525
Pancreas	Obs/Exp	4/4.3	2/1.8
	SMR	94	113
	95% CI	26-240	14-409
Larynx	Obs/Exp	0/0.3	0/0.1
	SMR	0	0
	95% CI	0-1264	0-3161
Lung	Obs/Exp	23/18	13/6.2
	SMR	127	211
	95% CI	81-191	113-362
Breast	Obs/Exp	7/14	4/5.4
	SMR	50	74
	95% CI	20-104	20-190
Uterus	Obs/Exp	2/4.1	2/2.1
	SMR	49	95
	95% CI	6-176	12-342

Appendix C4. Plant 4 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=31,528)	Ever-hourly (PY=11,815)
Ovary	Obs/Exp	6/4.1	2/1.5
	SMR	148	134
	95% CI	54-322	16-484
Bladder	Obs/Exp	0/0.9	0/0.4
	SMR	0	0
	95% CI	0-402	0-879
Kidney	Obs/Exp	0/1.5	0/0.6
	SMR	0	0
	95% CI	0-244	0-674
Brain	Obs/Exp	1/1.7	0/0.6
	SMR	60	0
	95% CI	2-336	0-647
LHC	Obs/Exp	9/7.2	3/2.8
	SMR	125	109
	95% CI	57-238	23-318
NHL	Obs/Exp	4/2.9	2/1.0
	SMR	140	203
	95% CI	38-358	25-732
Hodgkin lymphoma	Obs/Exp	0/0.4	0/0.1
	SMR	0	0
	95% CI	0-1013	0-2569
Leukemia	Obs/Exp	3/2.6	0/1.0
	SMR	117	0
	95% CI	24-343	0-367
Multiple myeloma	Obs/Exp	2/1.7	1/0.8
	SMR	117	120
	95% CI	14-421	3-669
Other cancer	Obs/Exp	10/9.4	3/3.6
	SMR	106	83
	95% CI	51-196	17-244
Benign neoplasms	Obs/Exp	0/1.4	0/0.6
	SMR	0	0
	95% CI	0-271	0-591
Blood disorders	Obs/Exp	1/1.4	0/0.6
	SMR	70	0
	95% CI	2-391	0-589

Appendix C4. Plant 4 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=31,528)	Ever-hourly (PY=11,815)
Mental disorders	Obs/Exp	0/2.8	0/1.3
	SMR	0	0
	95% CI	0-131	0-291
Allergic, endocrine & metabolic disease	Obs/Exp	8/14	7/7.1
	SMR	56	99
	95% CI	24-109	40-204
Nervous system disease	Obs/Exp	6/12	2/6.5
	SMR	50	31
	95% CI	18-108	4-112
Circulatory disease	Obs/Exp	119/121	62/57
	SMR	98	109
	95% CI	82-118	84-140
Nonmalignant respiratory disease	Obs/Exp	18/21	8/8.4
	SMR	84	96
	95% CI	50-133	41-189
Digestive disease	Obs/Exp	6/12	4/4.8
	SMR	52	83
	95% CI	19-113	23-214
Genitourinary disease	Obs/Exp	5/7.7	3/3.8
	SMR	65	79
	95% CI	21-151	16-230
External causes	Obs/Exp	4/13	3/5.3
	SMR	30	56
	95% CI	8-76	12-164
Other known	Obs/Exp	7/14	2/5.6
	SMR	51	36
	95% CI	21-105	4-129
Unknown		5	3

Appendix C5. Plant 5 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=2,024)	Ever-hourly (PY=299)
All causes	Obs/Exp	6/6.8	0/0.5
	SMR	88	0
	95% CI	32-191	0-677
All cancer	Obs/Exp	3/2.5	0/0.2
	SMR	120	0
	95% CI	25-350	0-1903
Buccal cavity & pharynx	Obs/Exp	0/0.0	0/0.0
	SMR	-	-
	95% CI	-	-
Esophagus	Obs/Exp	0/0.0	0/0.0
	SMR	-	-
	95% CI	-	-
Stomach	Obs/Exp	0/0.1	0/0.0
	SMR	0	-
	95% CI	0-7271	-
Colorectum	Obs/Exp	0/0.2	0/0.0
	SMR	0	-
	95% CI	0-1957	-
Liver	Obs/Exp	0/0.1	0/0.0
	SMR	0	-
	95% CI	0-6111	-
Pancreas	Obs/Exp	0/0.1	0/0.0
	SMR	0	-
	95% CI	0-3834	-
Larynx	Obs/Exp	0/0.0	0/0.0
	SMR	-	-
	95% CI	-	-
Lung	Obs/Exp	0/0.6	0/0.0
	SMR	0	-
	95% CI	0-604	-
Breast	Obs/Exp	1/0.6	0/0.1
	SMR	183	0
	95% CI	5-1021	0-7374
Uterus	Obs/Exp	1/0.1	0/0.0
	SMR	708	-
	95% CI	18-3947	-

Appendix C5. Plant 5 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=2,024)	Ever-hourly (PY=299)
Ovary	Obs/Exp	0/0.2	0/0.0
	SMR	0	-
	95% CI	0-2497	-
Bladder	Obs/Exp	0/0.0	0/0.0
	SMR	-	-
	95% CI	-	-
Kidney	Obs/Exp	0/0.1	0/0.0
	SMR	0	-
	95% CI	0-8141	-
Brain	Obs/Exp	0/0.1	0/0.0
	SMR	0	-
	95% CI	0-4669	-
LHC	Obs/Exp	1/0.2	0/0.0
	SMR	481	-
	95% CI	12-2677	-
NHL	Obs/Exp	0/0.1	0/0.0
	SMR	0	-
	95% CI	0-4482	-
Hodgkin lymphoma	Obs/Exp	0/0.0	0/0.0
	SMR	-	-
	95% CI	-	-
Leukemia	Obs/Exp	1/0.1	0/0.0
	SMR	1280	-
	95% CI	32-7130	-
Multiple myeloma	Obs/Exp	0/0.0	0/0.0
	SMR	-	-
	95% CI	-	-
Other cancer	Obs/Exp	0/0.1	0/0.1
	SMR	0	0
	95% CI	0-3689	0-3689
Benign neoplasms	Obs/Exp	0/0.0	0/0.0
	SMR	-	-
	95% CI	-	-
Blood disorders	Obs/Exp	0/0.0	0/0.0
	SMR	-	-
	95% CI	-	-

Appendix C5. Plant 5 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=2,024)	Ever-hourly (PY=299)
Mental disorders	Obs/Exp	0/0.0	0/0.0
	SMR	-	-
	95% CI	-	-
Allergic, endocrine & metabolic disease	Obs/Exp	0/0.3	0/0.0
	SMR	0	-
	95% CI	0-1075	-
Nervous system disease	Obs/Exp	0/0.1	0/0.0
	SMR	0	-
	95% CI	0-2588	-
Circulatory disease	Obs/Exp	2/1.8	0/0.1
	SMR	111	0
	95% CI	14-402	0-3281
Nonmalignant respiratory disease	Obs/Exp	0/0.5	0/0.0
	SMR	0	-
	95% CI	0-763	-
Digestive disease	Obs/Exp	0/0.3	0/0.0
	SMR	0	-
	95% CI	0-1114	-
Genitourinary disease	Obs/Exp	0/0.1	0/0.0
	SMR	0	-
	95% CI	0-3997	-
External causes	Obs/Exp	1/0.7	0/0.1
	SMR	146	0
	95% CI	4-816	0-3795
Other known	Obs/Exp	0/0.5	0/0.1
	SMR	0	0
	95% CI	0-738	0-3689
Unknown		0/0.0	0

Appendix C6. Plant 6 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=22,575)	Ever-hourly (PY=8,182)
All causes	Obs/Exp	224/236	74/82
	SMR	95	90
	95% CI	83-108	71-113
All cancer	Obs/Exp	71/58	22/19
	SMR	122	116
	95% CI	96-154	73-176
Buccal cavity & pharynx	Obs/Exp	2/0.7	0/0.2
	SMR	274	0
	95% CI	33-991	0-1613
Esophagus	Obs/Exp	0/0.6	0/0.2
	SMR	0	0
	95% CI	0-650	0-1677
Stomach	Obs/Exp	0/1.6	0/0.6
	SMR	0	0
	95% CI	0-237	0-624
Colorectum	Obs/Exp	5/6.2	2/2.1
	SMR	81	94
	95% CI	26-190	11-341
Liver	Obs/Exp	1/1.6	0/0.5
	SMR	62	0
	95% CI	2-343	0-705
Pancreas	Obs/Exp	5/3.1	3/1.0
	SMR	162	287
	95% CI	53-377	59-840
Larynx	Obs/Exp	0/0.2	0/0.1
	SMR	0	0
	95% CI	0-1973	0-5830
Lung	Obs/Exp	21/12	5/3.4
	SMR	179	146
	95% CI	111-273	48-341
Breast	Obs/Exp	17/10	2/3.4
	SMR	168	60
	95% CI	98-268	7-216
Uterus	Obs/Exp	2/3.7	1/1.5
	SMR	54	67
	95% CI	7-193	2-372

Appendix C6. Plant 6 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=22,575)	Ever-hourly (PY=8,182)
Ovary	Obs/Exp	3/3.4	0/1.0
	SMR	88	0
	95% CI	18-258	0-355
Bladder	Obs/Exp	1/0.7	1/0.3
	SMR	144	400
	95% CI	4-802	10-2230
Kidney	Obs/Exp	1/1.0	0/0.3
	SMR	98	0
	95% CI	3-548	0-1154
Brain	Obs/Exp	1/1.4	0/0.4
	SMR	74	0
	95% CI	2-412	0-965
LHC	Obs/Exp	4/5.4	2/1.7
	SMR	74	117
	95% CI	20-189	14-423
NHL	Obs/Exp	2/2.1	1/0.6
	SMR	96	167
	95% CI	12-345	4-933
Hodgkin lymphoma	Obs/Exp	0/0.2	0/0.1
	SMR	0	0
	95% CI	0-1512	0-4873
Leukemia	Obs/Exp	1/2.0	0/0.6
	SMR	51	0
	95% CI	1-283	0-588
Multiple myeloma	Obs/Exp	1/1.4	1/0.5
	SMR	73	186
	95% CI	2-405	5-1036
Other cancer	Obs/Exp	8/6.4	6/2.3
	SMR	125	261
	95% CI	54-246	96-568
Benign neoplasms	Obs/Exp	0/0.9	0/0.3
	SMR	0	0
	95% CI	0-435	0-1190
Blood disorders	Obs/Exp	0/1.1	0/0.4
	SMR	0	0
	95% CI	0-350	0-1005

Appendix C6. Plant 6 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=22,575)	Ever-hourly (PY=8,182)
Mental disorders	Obs/Exp	3/3.0	1/0.9
	SMR	102	115
	95% CI	21-297	3-641
Allergic, endocrine & metabolic disease	Obs/Exp	5/9.9	2/3.7
	SMR	50	55
	95% CI	16-118	7-198
Nervous system disease	Obs/Exp	7/10	2/4.0
	SMR	70	50
	95% CI	28-145	6-180
Circulatory disease	Obs/Exp	86/100	28/36
	SMR	86	78
	95% CI	69-106	52-112
Nonmalignant respiratory disease	Obs/Exp	22/18	6/5.4
	SMR	120	111
	95% CI	75-182	41-241
Digestive disease	Obs/Exp	5/9.6	3/3.2
	SMR	52	94
	95% CI	17-121	19-275
Genitourinary disease	Obs/Exp	3/5.0	3/1.9
	SMR	60	155
	95% CI	12-176	32-453
External causes	Obs/Exp	11/9.7	3/3.6
	SMR	113	85
	95% CI	57-203	17-247
Other known	Obs/Exp	6/11	2/3.6
	SMR	56	56
	95% CI	20-121	7-201
Unknown		5	2

Appendix C7. Plant 7 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=57,363)	Ever-hourly (PY=5,965)
All causes	Obs/Exp	226/257	55/46
	SMR	88	119
	95% CI	77-100	89-154
All cancer	Obs/Exp	83/95	16/15
	SMR	88	108
	95% CI	70-108	62-175
Buccal cavity & pharynx	Obs/Exp	0/1.2	0/0.2
	SMR	0	0
	95% CI	0-321	0-1979
Esophagus	Obs/Exp	0/1.1	0/0.2
	SMR	0	0
	95% CI	0-343	0-1978
Stomach	Obs/Exp	2/2.5	1/0.4
	SMR	79	226
	95% CI	10-285	6-1259
Colorectum	Obs/Exp	7/9.0	1/1.6
	SMR	78	64
	95% CI	31-161	2-358
Liver	Obs/Exp	1/1.8	0/0.3
	SMR	56	0
	95% CI	1-313	0-1205
Pancreas	Obs/Exp	2/4.2	0/0.7
	SMR	48	0
	95% CI	6-172	0-504
Larynx	Obs/Exp	0/0.3	0/0.1
	SMR	0	0
	95% CI	0-1258	0-7928
Lung	Obs/Exp	22/18	5/2.6
	SMR	124	193
	95% CI	78-188	63-449
Breast	Obs/Exp	18/21	4/3.1
	SMR	84	129
	95% CI	50-133	35-330
Uterus	Obs/Exp	1/4.9	0/0.8
	SMR	20	0
	95% CI	1-114	0-474

Appendix C7. Plant 7 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=57,363)	Ever-hourly (PY=5,965)
Ovary	Obs/Exp	1/5.9	0/0.9
	SMR	17	0
	95% CI	0-95	0-409
Bladder	Obs/Exp	1/1.0	1/0.2
	SMR	100	517
	95% CI	3-558	13-2882
Kidney	Obs/Exp	0/1.4	0/0.2
	SMR	0	0
	95% CI	0-264	0-1627
Brain	Obs/Exp	2/2.5	0/0.4
	SMR	79	0
	95% CI	10-286	0-1044
LHC	Obs/Exp	10/8.0	3/1.3
	SMR	124	238
	95% CI	60-229	49-695
NHL	Obs/Exp	2/3.2	1/0.5
	SMR	62	200
	95% CI	8-226	5-1113
Hodgkin lymphoma	Obs/Exp	1/0.0	0/0.0
	SMR	0	-
	95% CI	-.	-
Leukemia	Obs/Exp	5/2.9	2/0.5
	SMR	170	443
	95% CI	55-397	54-1602
Multiple myeloma	Obs/Exp	2/1.5	0/0.3
	SMR	137	0
	95% CI	17-494	0-1454
Other cancer	Obs/Exp	16/12	1/2.0
	SMR	131	50
	95% CI	75-213	1-279
Benign neoplasms	Obs/Exp	1/0.4	0/0.1
	SMR	239	0
	95% CI	6-1334	0-5245
Blood disorders	Obs/Exp	0/0.9	0/0.2
	SMR	0	0
	95% CI	0-400	0-2115

Appendix C7. Plant 7 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=57,363)	Ever-hourly (PY=5,965)
Mental disorders	Obs/Exp	2/4.0	0/0.9
	SMR	50	0
	95% CI	6-179	0-409
Allergic, endocrine & metabolic disease	Obs/Exp	1/8.7	0/1.6
	SMR	11	0
	95% CI	0-64	0-226
Nervous system disease	Obs/Exp	5/7.3	0/1.4
	SMR	68	0
	95% CI	22-160	0-267
Circulatory disease	Obs/Exp	74/83	24/18
	SMR	89	136
	95% CI	70-112	87-202
Nonmalignant respiratory disease	Obs/Exp	21/16	4/3.2
	SMR	133	126
	95% CI	82-203	34-323
Digestive disease	Obs/Exp	11/11	2/1.9
	SMR	102	105
	95% CI	51-182	13-378
Genitourinary disease	Obs/Exp	4/3.8	1/0.7
	SMR	105	135
	95% CI	29-268	3-750
External causes	Obs/Exp	15/16	4/2.1
	SMR	92	188
	95% CI	51-151	51-482
Other known	Obs/Exp	9/11	4/0.9
	SMR	83	444
	95% CI	38-157	121-1138
Unknown		0/0.0	0

Appendix C8. Plant 8 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=34,023)	Ever-hourly (PY=12,091)
All causes	Obs/Exp	232/277	120/123
	SMR	84	98
	95% CI	73-95	81-117
All cancer	Obs/Exp	65/76	35/31
	SMR	85	113
	95% CI	66-108	78-157
Buccal cavity & pharynx	Obs/Exp	2/0.9	0/0.4
	SMR	216	0
	95% CI	26-779	0-933
Esophagus	Obs/Exp	0/0.7	0/0.3
	SMR	0	0
	95% CI	0-553	0-1297
Stomach	Obs/Exp	1/1.8	1/0.8
	SMR	56	127
	95% CI	1-310	3-710
Colorectum	Obs/Exp	3/7.3	1/3.2
	SMR	41	31
	95% CI	9-120	1-174
Liver	Obs/Exp	2/2.1	2/0.9
	SMR	95	229
	95% CI	12-345	28-826
Pancreas	Obs/Exp	1/3.8	0/1.6
	SMR	26	0
	95% CI	1-147	0-227
Larynx	Obs/Exp	0/0.2	0/0.1
	SMR	0	0
	95% CI	0-1510	0-3696
Lung	Obs/Exp	23/17	16/6.6
	SMR	132	243
	95% CI	84-199	139-394
Breast	Obs/Exp	10/14	2/5.5
	SMR	73	37
	95% CI	35-133	4-132
Uterus	Obs/Exp	1/4.3	1/1.8
	SMR	23	55
	95% CI	1-130	1-305

Appendix C8. Plant 8 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=34,023)	Ever-hourly (PY=12,091)
Ovary	Obs/Exp	5/4.6	4/1.9
	SMR	110	216
	95% CI	36-256	59-553
Bladder	Obs/Exp	3/0.8	2/0.4
	SMR	386	564
	95% CI	80-1127	68-2038
Kidney	Obs/Exp	0/1.4	0/0.6
	SMR	0	0
	95% CI	0-270	0-671
Brain	Obs/Exp	1/2.0	1/0.8
	SMR	51	132
	95% CI	1-283	3-735
LHC	Obs/Exp	4/7.1	2/2.9
	SMR	57	68
	95% CI	15-145	8-246
NHL	Obs/Exp	4/2.8	2/1.2
	SMR	141	171
	95% CI	39-362	21-619
Hodgkin lymphoma	Obs/Exp	0/0.3	0/0.1
	SMR	0	0
	95% CI	0-1114	0-2751
Leukemia	Obs/Exp	0/2.5	0/1.1
	SMR	0	0
	95% CI	0-145	0-347
Multiple myeloma	Obs/Exp	0/1.6	0/0.7
	SMR	0	0
	95% CI	0-236	0-543
Other cancer	Obs/Exp	9/8.0	3/3.2
	SMR	113	94
	95% CI	51-214	19-274
Benign neoplasms	Obs/Exp	0/0.9	0/0.4
	SMR	0	0
	95% CI	0-392	0-854
Blood disorders	Obs/Exp	1/1.2	1/0.6
	SMR	81	179
	95% CI	2-448	5-1000
Mental disorders	Obs/Exp	2/3.3	1/1.6

Appendix C8. Plant 8 - observed/expected number of deaths, SMR and 95% CI, for all employees and for every-hourly employees

Cause of death		Total (PY=34,023)	Ever-hourly (PY=12,091)
	SMR	61	61
	95% CI	7-219	2-340
Allergic, endocrine & metabolic disease	Obs/Exp	8/12	3/5.1
	SMR	67	59
	95% CI	29-132	12-174
Nervous system disease	Obs/Exp	8/10	3/4.8
	SMR	79	63
	95% CI	34-156	13-183
Circulatory disease	Obs/Exp	96/108	53/51
	SMR	89	103
	95% CI	72-109	77-135
Nonmalignant respiratory disease	Obs/Exp	18/23	8/10
	SMR	79	79
	95% CI	47-124	34-156
Digestive disease	Obs/Exp	11/12	5/5.1
	SMR	92	97
	95% CI	46-165	32-227
Genitourinary disease	Obs/Exp	8/5.3	4/2.5
	SMR	152	161
	95% CI	66-300	44-413
+			
External causes	Obs/Exp	9/13	4/5.1
	SMR	67	78
	95% CI	31-128	21-200
Other known	Obs/Exp	4/12	2/5.8
	SMR	33	34
	95% CI	9-83	4-125
Unknown		2	1

APPENDIX D

Table D1. Observed/expected number of deaths, SMR and 95% CI by pay status, subjects restricted to employment period ≥ 1 year

Cause of death		Ever-hourly	Never-hourly	Total
		(PY=21,606)	(PY=77,297)	(PY=98,904)
All causes	Obs/Exp	203/223	349/472	552/695
	SMR	91	74	80
	95% CI	79-105	66-82	73-86
All cancer	Obs/Exp	56/58	122/149	178/207
	SMR	97	82	86
	95% CI	74-126	68-98	74-100
Buccal cavity & pharynx	Obs/Exp	0/0.7	3/1.8	3/2.5
	SMR	0	166	118
	95% CI	0-509	34-484	24-346
Esophagus	Obs/Exp	0/0.6	3/1.5	3/2.1
	SMR	0	205	144
	95% CI	0-599	42-600	30-422
Stomach	Obs/Exp	2/1.6	2/3.4	4/5.0
	SMR	128	58	80
	95% CI	15-461	7-211	22-205
Colorectum	Obs/Exp	4/6.1	11/14	15/20
	SMR	65	78	74
	95% CI	18-167	39-139	41-122
Liver	Obs/Exp	3/1.4	1/3.3	4/4.8
	SMR	209	30	84
	95% CI	43-610	1-167	23-214
Pancreas	Obs/Exp	1/3.0	2/7.0	3/10
	SMR	33	29	30
	95% CI	1-185	4-103	6-88
Larynx	Obs/Exp	0/0.2	0/0.5	0/0.7
	SMR	0	0	0
	95% CI	0-1946	0-759	0-546
Lung	Obs/Exp	22/12	31/33	53/44
	SMR	191	95	120
	95% CI	120-289	65-135	90-158
Breast	Obs/Exp	7/11	30/30	37/40
	SMR	66	100	92
	95% CI	27-137	68-143	64-126

Table D1. Observed/expected number of deaths, SMR and 95% CI by pay status, subjects restricted to employment period ≥ 1 year

Cause of death		Ever-hourly	Never-hourly	Total
		(PY=21,606)	(PY=77,297)	(PY=98,904)
Uterus	Obs/Exp	2/3.4	1/7.6	3/11
	SMR	58	13	27
	95% CI	7-211	0-73	6-80
Ovary	Obs/Exp	4/3.2	7/8.8	11/12
	SMR	124	79	91
	95% CI	34-316	32-164	46-163
Bladder	Obs/Exp	2/0.7	1/1.5	3/2.2
	SMR	280	67	136
	95% CI	34-1011	2-372	28-396
Kidney	Obs/Exp	0/1.0	1/2.6	1/3.5
	SMR	0	39	28
	95% CI	0-372	1-218	1-157
Brain	Obs/Exp	1/1.3	2/3.9	3/5.1
	SMR	78	52	59
	95% CI	2-437	6-188	12-171
LHC	Obs/Exp	4/5.2	8/13	12/18
	SMR	77	61	65
	95% CI	21-198	26-120	34-114
NHL	Obs/Exp	3/2.0	4/5.4	7/7.4
	SMR	149	75	95
	95% CI	31-437	20-191	38-196
Hodgkin's disease	Obs/Exp	0/0.2	0/0.4	0/0.6
	SMR	0	0	0
	95% CI	0-1985	0-968	0-651
Leukemia	Obs/Exp	0/1.9	2/4.8	2/6.6
	SMR	0	42	30
	95% CI	0-197	5-152	4-109
Multiple myeloma	Obs/Exp	1/1.3	2/2.6	3/3.9
	SMR	78	78	78
	95% CI	2-432	9-282	16-228
Other cancer	Obs/Exp	4/6.6	19/17	23/26
	SMR	61	111	88
	95% CI	17-155	67-174	56-132
Benign neoplasms	Obs/Exp	0/0.8	0/1.4	0/2.1
	SMR	0	0	0
	95% CI	0-492	0-265	0-172

Table D1. Observed/expected number of deaths, SMR and 95% CI by pay status, subjects restricted to employment period ≥ 1 year

Cause of death		Ever-hourly	Never-hourly	Total
		(PY=21,606)	(PY=77,297)	(PY=98,904)
Blood disorders	Obs/Exp	1/1.0	2/2.0	3/3.0
	SMR	101	101	101
	95% CI	3-564	12-365	21-295
Mental disorders	Obs/Exp	2/3.0	5/5.9	7/8.9
	SMR	67	85	79
	95% CI	8-242	28-199	32-163
Allergic, endocrine & metabolic disease	Obs/Exp	4/9.5	6/19	10/29
	SMR	42	32	35
	95% CI	12-108	12-69	17-65
Nervous system disease	Obs/Exp	5/9.5	12/15	17/25
	SMR	53	80	69
	95% CI	17-123	41-139	40-111
Circulatory disease	Obs/Exp	86/93	120/170	206/263
	SMR	93	71	78
	95% CI	74-114	59-84	68-90
Nonmalignant respiratory disease	Obs/Exp	17/16	34/35	51/51
	SMR	103	97	99
	95% CI	60-165	67-136	74-130
Digestive disease	Obs/Exp	4/8.8	11/20	15/29
	SMR	45	55	52
	95% CI	12-116	28-99	29-86
Genitourinary disease	Obs/Exp	6/4.9	9/8.7	15/14
	SMR	123	104	111
	95% CI	45-268	48-197	62-183
External causes	Obs/Exp	11/9.2	14/26	25/36
	SMR	120	53	70
	95% CI	60-215	29-89	46-104
Other known	Obs/Exp	6/9.3	10/20	16/27
	SMR	65	50	59
	95% CI	24-140	24-92	34-96
Unknown		5	4	9

APPENDIX E

Table E1. Observed/expected number of deaths, SMR and 95% CI, employees in SBR-related production and the finishing subgroup

Cause of death		All production	Finishing
		(PY=8,909)	(PY=8,248)
All causes	Obs/Exp	63/56	57/53
	SMR	113	107
	95% CI	87-145	81-139
All cancer	Obs/Exp	15/16	14/15
	SMR	93	91
	95% CI	52-153	50-152
Buccal cavity & pharynx	Obs/Exp	0/0.2	0/0.2
	SMR	0	0
	95% CI	0-1840	0-1924
Esophagus	Obs/Exp	0/0.2	0/0.1
	SMR	0	0
	95% CI	0-2503	0-2611
Stomach	Obs/Exp	0/0.4	0/0.4
	SMR	0	0
	95% CI	0-1014	0-1068
Colorectum	Obs/Exp	1/1.5	1/1.4
	SMR	67	70
	95% CI	2-373	2-391
Liver	Obs/Exp	0/0.4	0/0.4
	SMR	0	0
	95% CI	0-890	0-931
Pancreas	Obs/Exp	2/0.8	2/0.7
	SMR	264	276
	95% CI	32-955	33-997
Larynx	Obs/Exp	0/0.1	0/0.1
	SMR	0	0
	95% CI	0-6572	0-6841
Lung	Obs/Exp	5/3.7	4/3.5
	SMR	137	114
	95% CI	44-319	31-291
Breast	Obs/Exp	1/3.1	1/3.0
	SMR	32	34
	95% CI	1-178	1-188
Uterus	Obs/Exp	0/1.0	0/0.9
	SMR	0	0
	95% CI	0-379	0-401

Table E1. Observed/expected number of deaths, SMR and 95% CI, employees in SBR-related production and the finishing subgroup

Cause of death		All production	Finishing
		(PY=8,909)	(PY=8,248)
Ovary	Obs/Exp	0/0.9	0/0.9
	SMR	0	0
	95% CI	0-391	0-411
Bladder	Obs/Exp	1/0.2	1/0.1
	SMR	668	695
	95% CI	17-3721	17-3873
Kidney	Obs/Exp	0/0.3	0/0.3
	SMR	0	0
	95% CI	0-1313	0-1377
Brain	Obs/Exp	0/0.4	0/0.4
	SMR	0	0
	95% CI	0-882	0-929
LHC	Obs/Exp	2/1.5	2/1.4
	SMR	138	145
	95% CI	17-500	18-524
NHL	Obs/Exp	2/0.6	2/0.6
	SMR	349	365
	95% CI	42-1261	44-1320
Hodgkin lymphoma	Obs/Exp	0/0.1	0/0.1
	SMR	0	0
	95% CI	0-5283	0-5616
Leukemia	Obs/Exp	0/0.5	0/0.5
	SMR	0	0
	95% CI	0-704	0-740
Multiple myeloma	Obs/Exp	0/0.3	0/0.3
	SMR	0	0
	95% CI	0-1167	0-1219
Other cancer	Obs/Exp	3/1.3	3/1.2
	SMR	231	250
	95% CI	48-674	52-731
Benign neoplasms	Obs/Exp	0/0.2	0/0.2
	SMR	0	0
	95% CI	0-1872	0-1972
Blood disorders	Obs/Exp	0/0.3	0/0.3
	SMR	0	0
	95% CI	0-1363	0-1430

Table E1. Observed/expected number of deaths, SMR and 95% CI, employees in SBR-related production and the finishing subgroup

Cause of death		All production (PY=8,909)	Finishing (PY=8,248)
Mental disorders	Obs/Exp	0/0.6	0/0.6
	SMR	0	0
	95% CI	0-574	0-591
Allergic, endocrine & metabolic disease	Obs/Exp	3/2.4	2/2.3
	SMR	124	86
	95% CI	26-361	10-311
Nervous system disease	Obs/Exp	3/1.9	3/1.8
	SMR	158	166
	95% CI	33-461	34-484
Circulatory disease	Obs/Exp	25/20	22/19
	SMR	124	114
	95% CI	80-183	71-173
Nonmalignant respiratory disease	Obs/Exp	5/4.4	5/4.2
	SMR	114	118
	95% CI	37-266	38-275
Digestive disease	Obs/Exp	4/2.4	4/2.3
	SMR	165	173
	95% CI	45-421	47-442
Genitourinary disease	Obs/Exp	1/1.0	1/1.0
	SMR	97	102
	95% CI	2-543	3-566
External causes	Obs/Exp	6/3.2	5/3.0
	SMR	186	166
	95% CI	68-404	54-387
Other known	Obs/Exp	1/3.6	1/3.3
	SMR	28	30
	95% CI	1-155	1-169
Unknown		0/0.0	0

Table E2. Observed/expected number of deaths, SMR and 95% CI, employees in SBR-related labor, laboratories and other operations

Cause of death		Labor PY=(11,170)	Laboratories PY=(18,148)	Other operations PY=(22,768)
All causes	Obs/Exp	87/122	159/168	94/126
	SMR	72	95	74
	95% CI	57-88	80-110	60-91
All cancer	Obs/Exp	23/27	54/46	39/40
	SMR	87	117	97
	95% CI	55-130	88-153	69-132
Buccal cavity & pharynx	Obs/Exp	0/0.3	0/0.6	1/0.5
	SMR	0	0	207
	95% CI	0-1208	0-625	5-1151
Esophagus	Obs/Exp	0/0.4	0/0.4	1/0.4
	SMR	0	0	272
	95% CI	0-925	0-877	7-1515
Stomach	Obs/Exp	1/1.1	1/1.0	0/0.8
	SMR	93	99	0
	95% CI	2-518	3-549	0-437
Colorectum	Obs/Exp	1/3.0	3/4.5	6/3.6
	SMR	33	66	165
	95% CI	1-184	14-194	61-359
Liver	Obs/Exp	0/0.6	1/1.2	1/0.9
	SMR	0	84	109
	95% CI	0-578	2-468	3-608
Pancreas	Obs/Exp	2/1.5	1/2.4	1/1.8
	SMR	131	42	55
	95% CI	16-475	1-234	1-304
Larynx	Obs/Exp	0/0.1	0/0.2	0/0.1
	SMR	0	0	0
	95% CI	0-3458	0-2353	0-2783
Lung	Obs/Exp	6/4.3	25/11	10/9.3
	SMR	140	235	108
	95% CI	52-305	152-346	52-199
Breast	Obs/Exp	3/4.6	7/8.1	7/8.1
	SMR	65	87	86
	95% CI	13-189	35-179	35-177
Uterus	Obs/Exp	1/2.7	5/2.4	1/2.0
	SMR	37	207	50
	95% CI	1-206	67-483	1-278

Table E2. Observed/expected number of deaths, SMR and 95% CI, employees in SBR-related labor, laboratories and other operations

Cause of death		Labor	Laboratories	Other operations
		PY=(11,170)	PY=(18,148)	PY=(22,768)
Ovary	Obs/Exp	2/1.2	3/2.7	2/2.4
	SMR	167	113	84
	95% CI	20-603	23-331	10-304
Bladder	Obs/Exp	0/0.4	1/0.5	1/0.4
	SMR	0	202	276
	95% CI	0-945	5-1128	7-1536
Kidney	Obs/Exp	0/0.4	0/0.9	0/0.7
	SMR	0	0	0
	95% CI	0-946	0-436	0-516
Brain	Obs/Exp	0/0.4	2/1.1	1/1.1
	SMR	0	181	93
	95% CI	0-968	22-655	2-517
LHC	Obs/Exp	3/2.1	1/4.3	3/3.6
	SMR	142	23	84
	95% CI	29-414	1-131	17-246
NHL	Obs/Exp	2/0.6	0/1.7	1/1.5
	SMR	348	0	69
	95% CI	42-1257	0-212	2-382
Hodgkin lymphoma	Obs/Exp	0/0.1	0/0.2	0/0.1
	SMR	0	0	0
	95% CI	0-4096	0-1847	0-2869
Leukemia	Obs/Exp	0/0.8	0/1.5	1/1.3
	SMR	0	0	78
	95% CI	0-471	0-245	2-432
Multiple myeloma	Obs/Exp	1/0.9	1/1.0	1/0.7
	SMR	109	104	149
	95% CI	3-609	3-581	4-831
Other cancer	Obs/Exp	4/3.9	4/4.7	4/4.3
	SMR	103	85	93
	95% CI	28-263	23-218	25-238
Benign neoplasms	Obs/Exp	0/0.6	0/0.7	0/0.4
	SMR	0	0	0
	95% CI	0-652	0-565	0-915
Blood disorders	Obs/Exp	1/0.6	1/0.8	1/0.6
	SMR	180	128	181
	95% CI	5-1001	3-712	5-1007

Table E2. Observed/expected number of deaths, SMR and 95% CI, employees in SBR-related labor, laboratories and other operations

Cause of death		Labor PY=(11,170)	Laboratories PY=(18,148)	Other operations PY=(22,768)
Mental disorders	Obs/Exp	0/1.0	4/2.0	0/1.5
	SMR	0	199	0
	95% CI	0-363	54-510	0-250
Allergic, endocrine & metabolic disease	Obs/Exp	4/7.4	3/7.3	2/5.4
	SMR	54	41	37
	95% CI	15-138	9-121	5-135
Nervous system disease	Obs/Exp	1/6.8	4/6.4	1/3.9
	SMR	15	63	26
	95% CI	0-82	17-161	1-144
Circulatory disease	Obs/Exp	40/54	58/66	27/44
	SMR	74	88	62
	95% CI	53-101	67-114	41-90
Nonmalignant respiratory disease	Obs/Exp	1/6.0	12/14	8/9.5
	SMR	17	87	84
	95% CI	0-93	45-151	36-165
Digestive disease	Obs/Exp	5/4.2	4/7.1	4/5.4
	SMR	119	57	74
	95% CI	39-277	15-145	20-188
Genitourinary disease	Obs/Exp	7/3.8	1/3.5	1/2.3
	SMR	184	28	43
	95% CI	74-380	1-158	1-239
External causes	Obs/Exp	1/4.9	8/7.4	4/7.7
	SMR	20	108	52
	95% CI	1-113	46-212	14-133
Other known	Obs/Exp	1/5.7	7/6.8	5/5.3
	SMR	18	103	94
	95% CI	0-98	41-212	31-220
Unknown		3	3	2