The Inclusion of Women in Studies of Occupational Cancer: A Review of the Epidemiologic Literature From 1991–2009

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Introduction *Since the early 1990s, researchers have been concerned with the low rate at which women are included in epidemiologic studies of occupational cancer. A previous evaluation determined that one-third of articles published between 1970 and 1990 included women.*

Methods *To assess whether there has been an improvement in recent years, papers on occupational cancer between 1991 and 2009 were reviewed in fifteen journals.*

Results *The proportion of articles that included men remained stable around 90%, while the proportion of articles that included women increased substantially, from 39% in 1991–1995 to 62% in 2006–2009. Articles that assessed risk among men only or men and women presented a higher number of risk estimates and were more likely to evaluate dose-response relationships than studies including women.*

Conclusions *Despite advances in the inclusion of women in studies of occupational cancer, disparities remain in the number of studies of occupational cancer and depth of analysis in studies that included women.* Am. J. Ind. Med. 58:276–281, 2015.

KEY WORDS: workplace; occupations; neoplasms; women's health

INTRODUCTION

Since the early 1990 s, researchers have been concerned with the low rate at which women are included in epidemiologic studies of occupational cancer [Zahm et al., 1994; Blair et al., 1999; Gunnarsdottir et al., 1999; Niedhammer et al., 2000; Zahm and Blair, 2003]. The lack of data on women is of concern for a number of reasons: the increased number of women in the workforce, which has increased in the United States in 1972 to 58% in 2012 United States Department of Labor, 2014 the higher proportion of women holding jobs with potentially hazardous exposures, the reliance on data to determine risk of occupational cancer risk that predominantly comes from white men in previous decades [Pottern et al., 1994; Zahm and Fraumeni, 1995; Blair et al., 1999; Niedhammer et al., 2000; Zahm and Blair, 2003; Friesen et al., 2013].

Studies that evaluate the risk of cancer related to an occupation, industry, or workplace exposure among men are often ineffective in determining the risk to women for several reasons. First, and most obviously, studies of occupational cancer in men cannot evaluate female gynecologic cancers [Blair et al., 1999]. Second, studies of occupational cancer in men are unable to account for sex (i.e., biological) and gender (i.e., contextual) differences in exposure patterns and susceptibility including factors related to their physical environments, absorption rate, and the amount of exposure that reaches the target site [Blair et al., 1999; Arbuckle, 2006;

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Friesen et al., 2012]. Third, studies of occupational cancer among men cannot account for differences in job tasks between men and women, which can occur even when job titles are the same [Kennedy and Koehoorn, 2003; Locke et al., 2014]

Studies of occupational cancer that specifically evaluate risk for women are clearly warranted [Zahm and Fraumeni, 1995; Kennedy and Koehoorn, 2003; Kogevinas and Zahm, 2003; Messing et al., 2003; Zahm and Blair, 2003; Messing and Mergler, 2006]. In some cases, methodological adjustments need to be made, such as: increasing the sample sizes due to the generally smaller numbers of exposed women, utilizing gender-specific exposure assessment techniques, and considering sex- and gender-specific confounders related to reproductive and lifestyle factors [Blair et al., 1999; Kennedy and Koehoorn, 2003; Arbuckle, 2006].

In 1994, Zahm and colleagues published a review that quantified the inclusion of women and minorities in epidemiologic studies of occupational cancer [Zahm et al., 1994]. Their review of eight journals from 1971–1990 found that 35% of articles included analyses examining white women and 10% of studies included analyses examining non-white women. Similarly, in 2000, Niedhammer and colleagues reviewed articles published in 1997 in six journals and found that 31% of articles that assessed occupational health broadly included men and women and 7% included women *only* [Niedhammer et al., 2000]. In the same decade, several international conferences and dedicated journal issues highlighted methodological barriers and promoted the inclusion of women in epidemiologic studies of occupational cancer [Pottern et al., 1994; Gunnarsdottir et al., 1999; Kogevinas and Zahm 2003].

This review was undertaken to determine whether the proportion of articles assessing cancer risk among women associated with an occupation, industry, or workplace exposure have increased since Zahm and colleagues' review was completed in 1990, and to characterize studies that include women in terms of the number of risk estimates presented (i.e., the number of odds ratios or other measures), the presence of dose-response analyses, and the types of cancers and occupations analyzed. The eight journals assessed by Zahm and colleagues were reviewed from 1991–2009, along with an additional seven journals that frequently publish epidemiological articles on occupational cancer.

MATERIALS AND METHODS

Journals

All issues and supplements were reviewed in the following fifteen journals from 1991–2009: American Journal of Epidemiology; American Journal of Industrial Medicine; Annals of Epidemiology; Annals of Occupational Hygiene; Archives of Environmental Health; British Journal of Industrial Medicine/Occupational and Environmental Medicine; Cancer Causes and Control; Environmental Health Perspectives; Epidemiology; International Journal of Environmental and Occupational Health; International Journal of Epidemiology; Journal of Occupational and Environmental Hygiene; Journal of Occupational Medicine; Journal of the National Cancer Institute; Scandinavian Journal of Work, Environment and Health. Although information from each journal was abstracted by a single reviewer, standardized training was provided for each reviewer and periodic checks were completed to ensure that information was being obtained in a standardized manner.

Inclusion Criteria

Articles were included in the review if they reported original risk estimates (e.g., odds ratios) for an association between a cancer and an occupation, industry, or a workplace exposure. Systematic reviews, meta-analyses, and exposure assessment studies were excluded. Articles were also excluded if it was not possible to determine the gender composition of the study population.

Gender

An article was classified as including men, women or both based on the presence of risk estimates reported for those groups in the paper. Articles that excluded a gender group following the presentation of descriptive statistics were not considered to include that group. Counts were produced separately for articles that included:

(1) Any men (i.e., men only or men and women)
(2) Men *only*
(3) Any women (i.e., women only or women and men)
(4) Women *only*
(5) Both men and women

These five gender categories were included to allow for comparisons of counts of articles where men or women were the sole focus of the paper (i.e., the study was specifically designed to evaluate risk among either men or women) and articles where men and women are included but are not necessarily the sole focus of the paper (i.e., gender was not explicitly part of the inclusion or exclusion criteria). Due to this categorization method, there is some overlap: the "any men" category includes all studies in the "men *only*" category plus the studies that include both "men and women." Similarly, the "any women" category includes all

studies in the "women *only*" category plus the studies that include both "men and women."

Occupations and Cancers

Cancers were categorized according to the International Classification of Disease (ICD-9). Occupations were classified according to the 2010 Standard Occupational Classification [United States Bureau of Labor Statistics, 2010].

Risk Estimates and Dose-Response Analyses

The number of risk estimates and the presence of dose-response analyses were determined for each article to serve as proxies for the depth of analyses performed. It was assumed that a greater number of risk estimates or the presence of dose-response, as opposed to simple binary, analyses signified greater depth.

Analyses

Data were entered into a Microsoft Access database and analyzed using SAS 9.2 [SAS Institute Inc., 2011].

RESULTS

In total, 1,457 articles assessing cancer risk in relation to an occupation, industry, or workplace exposure were published in 15 journals from 1991–2009. Two articles were removed from further consideration because the gender composition of the study sample could not be determined, leaving 1,455 articles for analysis. The greatest numbers of articles were published between 1991–1995 and 1996–2000 there was a decline in the number of articles published in the two subsequent time periods (Table I). Across the entire study period, 91% of articles assessed the risk of occupational cancer among men and 50% among women. Considering all 1,455 papers, 41% assessed risk among both men and women, 50% among men *only*, and 9% among women *only*.

Over time, the proportion of articles that assessed the risk of occupational cancer among men remained stable, while the proportion of articles that assessed cancer risk among men *only* declined in each time period from 61% in 1991–1995 to 38% in 2006–2009 (Fig. 1). The proportion of articles that assessed the risk of occupational cancer among women increased substantially, from 39% in 1991–1995 to 62% in 2006–2009. The proportion of articles that assessed cancer risk among women *only* was unstable over the time periods, likely because of the small number of publications. The proportion of articles that assessed cancer risk for both men and women increased from 31% in 1991–1995 to 50% in 2006–2009.

TABLE I. Characteristics of Articles Assessing the Relationship Between an Occupational Factor and Cancer

Publication period	Number of articles	Percent
1991–1995	439	30.2
1996–2000	439	30.2
2001–2005	382	26.3
2006–2009*	195	13.4
Total	1455	100.0
Gender inclusion	**Number of articles**	**Percent**
Any men	1322	90.9
Women *only*	133	9.1
Any women	726	49.9
Men *only*	729	50.1
Men and women	593	40.8

*This group includes 4 years; all other groups contain 5 years.

Risk Estimates and Dose-Response Analyses

Articles that assessed the risk of occupational cancer among both men and women reported a higher number of risk estimates (mean = 117.0) than articles that assessed cancer risk among men *only* (mean = 96.2). Articles on women *only* had the lowest number of risk estimates reported (mean = 79.6). The proportion of articles that assessed dose-response relationships also differed: the proportion of articles that assessed the risk of occupational cancer among both men and women (43.6%) and men *only* (41.9%) were similar, and lower for women *only* (34.6%). These results suggest that studies including men and women and men *only* present more detailed analyses than studies of women *only*.

Cancers

Disparities in the inclusion of women in studies of occupational cancer are present in non-sex-specific cancers. In studies of respiratory cancers, which affect both men and women, men were included 95.2% of the time and women were included 43.2% of the time (Table II). Similarly, men were included in 94.1% of studies of digestive cancers, whereas women were included in only 49.4%. There were similar disparities for other cancers, except for breast.

Occupations

Occupations evaluated by gender composition of the study were similar. The most common occupations evaluated in articles assessing both men and women were production; construction and extraction; transportation and material moving; farming, fishing, and forestry; and office and

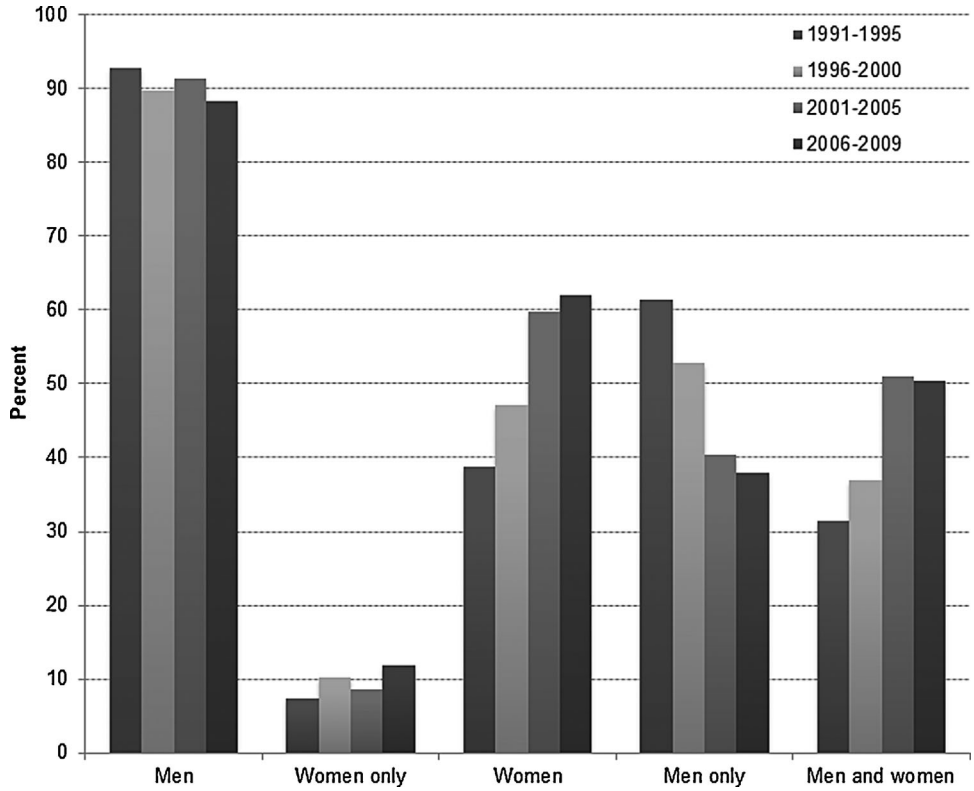

FIGURE 1. Articles assessing the relationship between an occupational factor and cancer, by publication period and gender inclusion.

TABLE II. Percent of Articles Assessing the Relationship Between and Occupational Factor and Cancer by Cancer Type

	All	Any men		Women *only*		Any women		Men *only*		Men and women	
Cancer type	**N**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Oral cavity and pharynx	433	415	95.8	18	4.2	226	52.2	207	47.8	208	48.0
Digestive system	767	722	94.1	45	5.9	379	49.4	388	50.6	334	43.5
Respiratory system	935	890	95.2	44	4.7	404	43.2	529	56.6	360	38.5
Bones and joints	173	170	98.3	3	1.7	96	55.5	77	44.5	93	53.8
Skin excluding basal and squamous cell	424	401	94.6	23	5.4	227	53.5	197	46.5	204	48.1
Breast	328	238	72.6	90	27.4	284	86.6	44	13.4	194	59.1
Female genital system	205	–	–	45	22.0	205	100.0	–	–	158	77.1
Male genital system	556	556	100.0	–	–	–	–	301	54.1	255	45.9
Urinary	625	592	94.7	33	5.3	322	51.5	303	48.5	289	46.2
Eye and orbit	71	68	95.8	3	4.2	45	63.4	26	36.6	42	59.2
Brain and other nervous system	514	487	94.7	27	5.3	280	54.5	234	45.5	253	49.2
Endocrine system	185	174	94.1	11	5.9	120	64.9	65	35.1	109	58.9
Lymphoma	630	598	94.9	32	5.1	321	51.0	309	49.0	290	46.0
Myeloma	366	345	94.3	21	5.7	204	55.7	162	44.3	183	50.0
Leukemia	642	611	95.2	31	4.8	344	53.6	298	46.4	313	48.8
Mesothelioma	88	87	98.9	1	1.1	40	45.5	48	54.5	39	44.3
Kaposi sarcoma	6	6	100.0	0	0.0	3	50.0	3	50.0	3	50.0

administrative. The most common occupations evaluated in articles assessing cancer risk among men were production; construction and extraction; transportation and material moving; farming, fishing, and forestry; and installation, maintenance and repair. The most common occupations evaluated in articles that included women were production; construction and extraction; farming, fishing, and forestry; transportation and material moving; and office and administrative.

Several types of occupations were more likely to include men than women (Table III). The largest disparities were in areas such as construction and extraction; installation, maintenance, and repair; production; transportation and material moving; and military specific occupations. However, some occupations were more likely to include women, such as community and social services; legal; healthcare practitioners; and healthcare support workers.

DISCUSSION

From 1991–2009, there was a substantial increase in the number of epidemiological articles that assessed the risk of cancer related to an occupation, industry or workplace exposure among women. Although the articles that examined risk among women *only* remained around 10% of the total through the entire period, the proportion of studies that included any women rose from 39% to 62%. Because of methodological differences including the lack of distinction between racial or ethnic groups in this review and the additional journals reviewed, these results are not directly comparable to those reported by Zahm and colleagues in 1994. But, these results do suggest inclusion of women in studies of occupational cancer showed an increase of 30–40% from the 1970 s through the early 1990 s [Zahm et al., 1994].

The reason for the increase in articles including women is not well understood. However, there were several conferences and dedicated journal issues published during this time period that may have contributed [Gunnarsdottir et al., 1999; Kogevinas and Zahm, 2003; Pottern et al., 1994]. In addition, during the same time period, organizations such as the National Institutes of Health were making an effort to ensure women were not excluded from epidemiologic studies without a good scientific reason. It should be noted that the total number of studies of occupational cancer did not

TABLE III. Percent of Articles Assessing the Relationship Between an Occupational Factor and Cancer by Standard Occupational Classification (SOC) Category

	All	Any men		Women *only*		Any women		Men *only*		Men and women	
Standard occupational classification (SOC number)	**N**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Management (11)	151	125	82.8	26	17.2	102	67.5	49	32.5	76	50.3
Business and financial (13)	63	46	73.0	17	27.0	44	69.8	19	30.2	27	42.9
Computer and mathematical (15)	40	28	70.0	12	30.0	30	75.0	10	25.0	18	45.0
Architecture and engineering (17)	125	113	90.4	12	9.6	71	56.8	54	43.2	59	47.2
Life, physical and social science (19)	116	98	84.5	18	15.5	83	71.6	33	28.4	65	56.0
Community and social services (21)	61	41	67.2	20	32.8	46	75.4	15	24.6	26	42.6
Legal (23)	31	21	67.7	10	32.3	23	74.2	8	25.8	13	41.9
Education, training and library (25)	122	91	74.6	31	25.4	92	75.4	30	24.6	61	50.0
Arts, design, entertainment, sports and media (27)	92	70	76.1	22	23.9	64	69.6	28	30.4	42	45.7
Healthcare practitioners and technical (29)	135	89	65.9	46	34.1	106	78.5	29	21.5	60	44.4
Healthcare support (31)	58	38	65.5	20	34.5	50	86.2	8	13.8	30	51.7
Protective service (33)	105	96	91.4	9	8.6	52	49.5	53	50.5	43	41.0
Food preparation and serving (35)	121	94	77.7	27	22.3	84	69.4	37	30.6	57	47.1
Building and grounds cleaning and maintenance (37)	138	116	84.1	22	15.9	91	65.9	47	34.1	69	50.0
Personal care and service (39)	112	87	77.7	25	22.3	82	73.2	30	26.8	57	50.9
Sales and related (41)	151	124	82.1	27	17.9	107	70.9	44	29.1	80	53.0
Office and administrative (43)	193	153	79.3	40	20.7	135	69.9	58	30.1	95	49.2
Farming, fishing and forestry (45)	246	215	87.4	31	12.6	155	63.0	91	37.0	124	50.4
Construction and extraction (47)	370	348	94.1	22	5.9	154	41.6	216	58.4	132	35.7
Installation, maintenance and repair (49)	217	196	90.3	21	9.7	116	53.5	101	46.5	95	43.8
Production (51)	660	599	90.8	61	9.2	331	50.2	329	49.8	270	40.9
Transportation and material moving (53)	286	259	90.6	27	9.4	152	53.1	134	46.9	125	43.7
Military specific (55)	59	55	93.2	4	6.8	24	40.7	35	59.3	20	33.9

increase in the same time period, [Raj et al., 2014] and, therefore, cannot account for the increase in the number of articles including women.

A limitation of this review is the sole inclusion of English language journals. It is unknown whether the gender balance over time would be different for non-English language articles.

The cancers most commonly assessed in the articles included in this review correspond with those frequently associated with occupational factors. Articles including men evaluated most major cancer sites. Among women, except for breast cancer, specific sites were included in only about 50 to 60 percent of the papers. The percentages of the papers including the various cancer sites in papers focusing on men or women only were considerably smaller than papers than included both genders. Lymphoma was among the top five in articles including men, men *only* or men and women, and leukemia was among the top five in articles including men, women or men and women. In articles that examined a single gender, sex-specific cancers were among the most commonly assessed.

Despite increases in the proportion of articles reporting on the risk of occupational cancer among women, it appears that disparities remain in terms of the depth of analysis. Articles reporting on women *only* had fewer risk estimates than articles reporting on men and women, or men *only*, and were less likely to report on dose-response relationships. This could be because of smaller numbers of women in the study, but may also indicate that including sufficient numbers of women for analysis was not a high priority in the study design. As discussed above methodological adjustments may need to be made when studying women, such as: increasing the sample sizes due to lower exposure rates, utilizing gender-specific exposure assessment techniques, and considering sex- and gender-specific confounders [Blair et al., 1999; Kennedy and Koehoorn, 2003; Arbuckle, 2006].

This analysis suggests there have been considerable improvements in the inclusion of women in articles assessing occupational cancer over the past two decades. This could be due to the increased workforce participation of women in some industries of interest, an increase in studies specifically aimed at women or women's cancers, along with an awareness of the need for such information on women to make sound societal decisions. Despite gains, attention needs to be paid to ensure that analyses on women are at the same level of depth as those for men.

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