

Original Article

Health and Work in Women and Men in the Welding and Electrical Trades: How Do They Differ?

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Abstract

Objectives: There is little information on how work tasks, demands, and exposures differ between women and men in nominally the same job. This is critical in setting workplace standards that will protect the health of both men and those women moving into less traditional work roles. Information used in setting standards is currently based almost entirely on male workers. This paper describes differences in work and health, and the relation between them, in women and men who have undergone the same trade training for the welding or electrical trades.

Method: Four cohorts were established. Two were women across Canada in the welding and electrical trades who had been in an apprenticeship since 2005. Cohorts of men in the same trades during the same period were established in the province of Alberta, Canada. Participants completed a baseline questionnaire at recruitment and were followed up every 6 months to collect detailed information on work carried out and on their health and habits. At the end of the study (up to 5 years for women and up to 3 years for men), the cohort members completed a final questionnaire including questions on mental health, harassment, and gender.

Results: The four cohorts comprised 1001 welders (447 female; 554 male) and 885 in the electrical trades (438 female; 447 male). Follow-up information was available for 89%. Women were more likely than men to have had some post-secondary education before starting their trade and were less likely to be living as married or to have a child. More welders smoked, and more men were heavy drinkers. At recruitment, more welders than those in the electrical trades reported rhinitis (sneezing and runny nose), depression, and anxiety. Female welders reported more depression (38%) than male welders (30%), compared to 24% in the electrical trades. At first follow-up, new-onset shoulder pain was more frequent in men and new-onset asthma or wheezing in welders. Within each trade, women reported less variety in tasks. Women welders were less likely to be employed in construction than men, and women were less likely to become industrial electricians. Overall, 54% of women

and 46% of men reported never using respiratory protection when welding. In the end-of-study questionnaires received to date, 49% reported bullying or harassment during the apprenticeship, with higher proportions in welding than electrical trades and in women compared with men. Such harassment was reflected in higher anxiety and depression scores.

Conclusions: This is the first report on these four cohorts and demonstrates the capacity for detailed analysis of the differences in exposure and new-onset occupationally related ill-health. While women and men in the same trades appear to be doing broadly similar work, and to have similar patterns on health at the first follow-up, there are some significant differences in the types of employment and variety of tasks. The very detailed information collected will allow more precise estimates of exposures to be correlated with health outcomes at the end of the follow-up period.

Keywords: cohort studies; electrical trades; gender; occupational health; sex; welding

Introduction

Although the movement of women into non-traditional work is an important feature of the modern workforce, there is little knowledge on whether risks to health from work differ between women and men. Such risks might arise not only as a result of biological differences but also through uncharted differences in job demands and exposures for men and women in nominally the same type of work. A major unanswered question is whether such systematic differences exist and, if they do, how they impact risk of injury or work-related ill-health. This is important in understanding how such differences come about, how we account for this in estimating risk and how we set occupational exposure guidelines that protect everyone and not simply the male workers who provided almost all the health data on which guidelines are based.

There has been thoughtful discussion of the extent to which sex may determine work tasks and exposures even within the same job or trade, and how such differences may arise. This debate was usefully summarized by Quinn (2011) who concluded that the phenomenon of women and men with the same job title experiencing different exposures represents gender bias, and, quoting a study by Messing et al. (1998) that gendered assignment of tasks within a job limits economic opportunities for women. In studying work exposures and their potential effects on health, we have to consider not only that women and men within nominally the same job may be assigned to different tasks, but also that they may encounter different exposures, be less well protected by personal protective equipment and may absorb, metabolize, or excrete toxic substances at different rates. It is of note that there are few studies explicitly addressing these issues: important contributions include those of Messing et al. (1994), Hoofman et al. (2005), and Eng et al. (2011). A systematic review (Campos-Serna et al.

(2013) found 30 articles addressing the relation between working conditions, health, and gender.

Sex differences in exposure have seldom been reported using quantitative exposure assessment. In British Columbia, Canada, Kennedy and Koehoorn (2003) reported that women working as retail clerks and managers within the same organization had significantly greater exposure to airborne dust than men with the same job titles. In Newfoundland, Canada, Howse et al. (2006) showed that female snow crab processors were found in different work areas and had higher exposures to crab allergen (and higher sensitization rates) than male workers.

While many publications in this area use the term 'gender' this frequently refers simply to biological sex (or the sex with which the respondent identifies) and less often addresses the broader concept of gender, identified by the World Health Organization as 'the socially constructed roles, behaviours, activities, and attributes that a given society considers appropriate for men and women'. A number of studies have used such a gender concept to examine work role, health, and attitudes to safe working. Lavalée and Pelletier (1992) studied gender characteristics among women working and training for non-traditional and traditional jobs. Their results showed that women in non-traditional jobs were more likely to have scores on the Bem Sex Role Inventory (BSRI) (Bem, 1974) that categorized them as 'masculine', and women in traditional jobs were more likely to have scores that categorized them as 'feminine'. Nash and Chrisler (2000) compared scores on the BSRI for women in clerical work and those in metalworking or training for jobs in the trades. Women in clerical work had higher 'feminine' scores than those in, or entering, less traditional work. Within traditional jobs, women managers were found by Lipińska-Grobelny and Wasiak (2010) to be more 'masculine' on the BSRI than non-managers.

Emslie et al. found that scores on the BSRI were more strongly related than biological sex to poor mental health, both among bank employees (Emslie et al. 1999a) and university staff (Emslie et al. 1999b). Nielsen et al. (2015) used the BRSI to look at the impact of masculinity on men's health and safety in male-dominated occupations, a theme also considered by a Canadian network of researchers (Stergiou-Kita et al, 2015). Gender, in addition to sex, must then be considered when comparing work roles, tasks and exposures, and their relation to health outcomes.

Concern in Canada about the health and safety of women moving into non-traditional trades provided the impetus for the cohorts on which this report is based. The Committee on Safety in Welding of the Canadian Standards Association (CSA) asked us to investigate whether women (and/or their fetuses) were at risk from exposures in welding. To answer this question, we established a cohort of women welders across Canada, with women in electrical trades (without direct welding fume exposure) as a comparison group. We also established cohorts of men in Alberta, working in the same trades. Such cohorts provide a powerful research platform from which to study the role of sex and gender: if women and men in the same trades, with closely similar skills and training, are found to differ in reported tasks, work demands and exposures, we need to find out why this happens and how it affects their work-related ill-health and injury.

There are occupational health risks associated with the trades chosen for this study. Welders are at risk of respiratory disease, including asthma (Banga et al, 2011) rhinitis (Storaas et al., 2015), perhaps chronic obstructive lung disease (Szram et al, 2013) and pneumonia (Palmer and Cosgrove, 2012). They are exposed to neurotoxic metals (Flynn and Susi, 2009) and skin sensitizers such as chromium (Athavale et al, 2007). Ultraviolet radiation ('arc eye', 'welders' flash') may result in acute inflammation of the cornea. Women welders have been found at increased risk on new-onset affective disorders (Cherry et al., 2012). The musculoskeletal demands of welding result in an increase in shoulder (Herberts et al, 1981) and possibly back pain and grinding tasks in these workers may increase the risk of Raynaud's syndrome (Mirbod et al., 1999). Among those in the electrical trades exposure to electromagnetic fields is a concern, together with increased risk of electric shock and electrical burns (Taylor et al., 2002). The ergonomic risk will depend, in part, on the field of electrical work, with linesmen being at increased risk of shoulder and back pain (Padmanathan et al., 2016). Although exposure to fumes, chemicals, and metals would be lower than in

welders, cable joining by electricians may involve exposure to sensitizers including epoxy resins.

The current study is of conditions that occur during the early working life of those in these trade, rather than resultant long latency disease, but it should be noted that welding fume and ultraviolet exposure in welding have recently been classified as 'carcinogenic to humans' by the International Agency for Research on Cancer (Guha et al, 2017). Ocular melanoma, though rare, is a risk in both electrical workers in transmission installations (Behrens et al., 2010) and in welding (Guha et al., 2017)

This paper focusses on differences between men and women entering the welding and electrical trades, on the proportions reporting potentially work-related disease and on the similarities and differences in the tasks and work practices between the sexes. Although the initial motive for setting up the study was to look at reproductive outcomes, these are not considered here but will be published, together with estimated exposures to particulates, metals and ergonomic demands, once the cohort follow-up is completed in 2018.

Methods

Recruitment

Preparations to set up cohorts of women in the welding and electrical trades began in 2010, following preliminary work to determine whether such a study would be acceptable to women in the trades and to develop a self-report questionnaire that accurately reflected welding tasks (Cherry, 2011). In discussion with Alberta Apprenticeship and Industry Training (AAIT), we defined welding trades as welding, boiler-making, steam fitting, and pipefitting: these and the electrical trades are all compulsory certification (registered) trades in Alberta. The AAIT agreed to send out letters on our behalf from January 2011 to women who had started an apprenticeship in one of these trades in 2005–2012. For apprentices starting in 2013–2014 in Alberta, direct mailing proved possible, following signing of a confidentiality agreement with the AAIT. With these letters, we included an information sheet about the study and a consent sheet which we asked them to sign and send back to the research team, if they were willing to take part in the study. Over the next 2 years, we approached apprenticeship boards (or a parallel body) across Canada and asked them to help us identify women who had started a welding or electrical apprenticeship in their jurisdiction since 2005: every province and territory agreed. The study became known as Women's Health in Apprenticeship Trades—Metalworking and Electrical (WHAT-ME).

The parallel cohort for men in the same trades was set up in 2013 with the first tradesmen recruited in January 2014. This part of the study, which used an identical recruitment procedure but with direct mailing throughout, was restricted to Alberta. To keep the numbers manageable, and similar to those in the WHAT-ME study, we approached a random sample of men to take part in the study and restricted date of apprenticeship start to 2005–2012. The male study is referred to as Workers' Health in Alberta Trades—MEN (WHAT-MEN).

This approach gave us four cohorts of skilled workers: women and men in the welding and electrical trades. For the women, to include the largest possible number of pregnancies conceived while working in their trade, follow-up continued for up to 5 years. For men, where the focus was on new-onset work-related ill-health, follow-up was for 3 years. Questionnaires could be completed in English or French, by telephone or online. No financial incentive to join the study was offered to any of the cohorts.

Data collected

Baseline information was collected as soon as possible after a consent form was received and subsequently at 6-month intervals. The baseline questionnaire collected demographic information, including education and training, a job history, use of tobacco, alcohol and medication, sexual activity and contraception, periods of infertility and, for women, details of all pregnancies and births. The medical history included current health problems, of asthma and wheezing, sneezing, a runny or blocked nose (without a cold), dermatitis, shoulder pain, low back pain, episodes of finger whitening with numbness or tingling, days of sadness or depression or worry and anxiety. The last three of these eight conditions were added only after the start of WHAT-ME and were present at baseline for all the men but not for women recruited before March 2013. We also asked about injuries on the job. At each periodic (6-month) follow-up, the data on current health problems (the eight conditions listed above), injuries at work, and use of alcohol, tobacco, and medication were brought up to date, information was collected on sexual activity and pregnancy, all jobs since the last contact were recorded and detailed trade-specific questionnaires completed about tasks and activities on the last day at work (in the previous 6 months) on which they carried out their trade. These included the main tasks for the day (yes/no to a list of pre-specified tasks), ergonomic demands, the physical environment and, for welders, subroutines for each main type of welding, including types of metal welded, filler rods or wires, type of flux and shielding gas, and

coating with paints or primers. For each welding type reported, the participant also answered detailed questions about ventilation and personal protective equipment. The periodic questionnaire for the electrical trades followed the same design but without the specifics of welding-related task exposures. Questions about the field of electrical work (commercial, industrial or residential) were added after the start of WHAT-ME, and this distinction is not available for the follow-ups completed before May 2013.

When a woman in WHAT-ME became pregnant, additional information on work exposures and on tobacco and alcohol use was collected as early as possible and again mid-pregnancy. On at least one occasion those still working in their trade have been asked to mail in a urine sample for analysis of metal concentrations (Arrandale et al., 2015). Women who were pregnant also gave a further urine sample for analysis of metals as early as possible during the pregnancy. At the end of their time in the study, the participant was asked to complete (online or by mail) a final questionnaire including questions on issues that might have jeopardized retention had they been asked in the periodic follow-up questionnaires. These include ethnicity, sexual orientation, use of street drugs, bullying and harassment (both during the apprenticeship and in their trade since), the 14-item Hospital Anxiety and Depression Scale (HADS) (Bjelland et al, 2002), and the 30-item BSRI (Bem, 1974).

Statistical methods

This paper was descriptive in comparing differences between the four cohorts. The information for the main analyses was taken only from the baseline and first follow-up questionnaire (six or more months after recruitment). Having described the cohorts and compared substance use, baseline prevalence of the eight potentially work-related conditions of interest was examined. Patterns of new-onset ill-health were then considered for those free of the condition at baseline. Differences between types of task between sexes within trade were explored and use of personal protective equipment quantified. Information (still being collected) from the final 'wrap-up' questionnaire was used to compare responses from women and men on experience of bullying and harassment, on gender profiles and on mental health. For these analyses, harassment was considered present if a respondent reported any type (psychological, physical, sexual) of harassment. Total scores were computed on masculinity, femininity, and androgyny scales of the BSRI and anxiety and depression scales from the HADS. Statistical inference on comparisons made was restricted to the likelihood ratio estimate of chi-square

for categorical variables and *t*-tests for continuous ones. The relations of anxiety and depression to trade, harassment, biological sex, and gender scores were examined with multivariable regression. Probability values are shown as calculated except that $P = 0.001$ is used where $P < 0.001$.

Results

Participation

A baseline questionnaire in WHAT-ME was completed by 447 women in welding and 438 in electrical trades. For WHAT-MEN, baselines were present for 554 welders and 447 in the electrical trades. The complete number of eligible women in the welding and electrical trades is unknown, and cannot reliably be estimated from published data. However, estimates for Alberta ([Supplementary Material](#), available at *Annals of Work Exposures and Health* online) suggest a take-up rate of at most of 15% women and 5% of men included on AAIT lists. The rate of a first contact after the baseline was very similar for women (90.2%) and men (88.8%), but in both sexes, welders had a higher failure rate (women 12.3%, men 14.1%) than those in the electrical trades. In those for whom a first contact was achieved, the mean period to the first successful follow-up was similar for the two trades overall (welding 250 days: electrical 254 days) but that for female welders (274 days) notably longer than for male welders (231 days).

Comparison of demographic features at recruitment of the four cohorts

In both trades women were younger than men at the time they were recruited to the cohorts, with women in welding being some 3 years younger than women in the electrical trades ([Table 1](#)). Women in welding started their training more recently than the men, reflecting not only the inclusion of later apprenticeships (to 2014) but also the additional training opportunities in this trade, discussed below: men and women started training at much the same age. Most of the people in the cohorts had completed high school (or, if educated outside North America, had left school at 17 years or later). A higher proportion of women than men, in both trades, attended some full-time post-secondary education before starting their trade training. Fewer women in both trades were living as married and fewer had had (or fathered) a pregnancy. Women welders were less likely than women in the electrical trades to be living as married, perhaps reflecting their younger age. In both trades, more women were current

Table 1. Baseline demographic and training characteristics of four cohorts of women from across Canada and men from Alberta in a welding or electrical apprenticeship since 2005.

	Welding trades				Electrical trades			
	Women N = 447	Men N = 554	Both N = 1001	P	Women N = 438	Men N = 447	Both N = 885	P
Mean age: years (SD)	29.9 (8.6)	35.4 (9.4)	32.9 (9.5)	0.001	32.8 (9.2)	35.3 (9.7)	34.0 (9.5)	0.001
Mean year started apprenticeship (SD)	2008.1 (5.3)	2005.0 (7.7)	2006.4 (6.9)	0.001	2006.5 (6.5)	2006.6 (5.3)	2006.6 (5.9)	0.781
Mean age at start of apprenticeship (SD)	24.5 (7.3)	25.2 (8.0)	24.9 (7.7)	0.155	25.6 (7.3)	26.7 (9.1)	26.2 (8.3)	0.049
Completed high school %	91.3	89.4	90.2	0.312	94.1	94.6	94.4	0.715
Attended post-secondary full time %	49.6	31.4	39.5	0.001	62.3	52.8	57.5	0.004
Living as married %	44.8	59.6	53.0	0.001	52.5	62.0	57.3	0.004
Been Pregnant or Made Woman Pregnant %	42.5	57.9	50.9	0.001	45.9	55.8	50.8	0.003
Current smoker %	29.2	27.1	28.1	0.466	17.6	8.9	13.2	0.001
Current drinker %	67.9	71.8	70.0	0.179	69.9	74.5	72.2	0.124
Heavy drinker (10 ≥ drinks/session) %	23.9	40.1	32.9	0.001	18.3	34.9	26.7	0.001

smokers, noticeably so in the electrical trades where few men reported smoking. Overall, those in the welding trades (28.1%) reported smoking more frequently ($P = 0.001$) than those in the electrical trades (13.2%). The differences with alcohol use were less marked, although men in both trades were somewhat more likely than women to say that they currently drank alcohol at least once a month. Heavy drinking (at least 10 alcoholic drinks in a single session) was, however, more common in men in both trades, with more welders of both sexes reporting such a pattern of heavy drinking (Table 1).

Health complaints at recruitment

When we examined the eight health complaints chosen because of their potential to be work-related by trade and sex (Table 2), we found rather few differences of note. Within welding, the only statistically significant difference between men and women was for depression where 38% of women and 30% of men reported that they had days when they felt 'sad, empty or depressed' most of the time (depression). In the electrical trades, more women than men reported 'sneezing, a runny or blocked nose' (rhinitis). Overall, those in the welding trades were more likely than those in electrical trades to report rhinitis ($P = 0.002$), depression ($P = 0.001$) (in both women and men), and days when they felt 'worried or anxious most of the time' (anxiety) ($P = 0.032$). When the relation to health complaints was compared between sexes regardless of trade, more women than men told us they had 'dermatitis or itchy/inflamed skin' (dermatitis) (men; 15.8%: women; 19.5% $P = 0.036$).

Health complaints at first follow-up

New-onset conditions arising between baseline and first follow-up were then compared, limiting each comparison to those who did not report the problem at baseline. As can be seen in Table 3, within this short follow-up, no important difference in new-onset conditions was seen between sexes within trade. A somewhat higher proportion of women in welding told us about new-onset dermatitis: men in the electrical trades were more likely to report new-onset wheezing (based on a small number of cases). Overall, more welders (6.2%) than those in the electrical trades (2.7%) reported new-onset asthma or wheezing ($P = 0.001$). In both trades, somewhat more men complained of new-onset shoulder pain, and this was an overall difference in reporting between the sexes (men; 11.6%: women; 7.9% $P = 0.019$).

Table 2. Health complaints at baseline by trade and sex.^a

	Welding trades				Electrical trades				P
	Women	Men	Both	P	Women	Men	Both	P	
	%	N	%	N	%	N	%	N	
Asthma or wheezing without a cold	15.5	446	16.6	553	16.1	999	12.1	447	0.094
Sneezing, runny or blocked nose without a cold	36.6	445	38.7	553	37.8	998	27.1	447	0.014
Dermatitis or itchy inflamed skin	19.8	445	15.7	553	17.5	998	15.9	447	0.197
Shoulder pain interfering with activity	20.4	445	18.1	553	19.1	998	15.4	447	0.166
Low back pain interfering with activity	22.7	445	26.4	553	24.7	998	21.3	447	0.057
Episodes of white finger with pain/numbness	25.4	193	22.2	553	23.1	746	20.4	447	0.313
Days sad, empty, depressed	38.3	193	30.2	553	32.3	746	23.5	447	0.410
Days worried/anxious	37.0	192	32.4	553	33.6	745	27.3	447	0.431

^aWomen from across Canada, men from Alberta only, in a welding or electrical trade since 2005.

Table 3. New-onset health complaints between baseline and 6-month follow-up by trade and sex: those with symptom at baseline excluded.^a

	Welding trades						Electrical trades						
	Women		Men		Both		Women		Men		Both		P
	%	N	%	N	%	N	%	N	%	N	%	N	
Asthma or wheezing without a cold	7.6	331	5.0	400	6.2	731	1.5	339	3.8	366	2.7	705	0.049
Sneezing, runny or blocked nose without a cold	20.9	244	22.8	298	22.0	542	17.9	262	22.7	299	20.5	561	0.160
Dermatitis or itchy inflamed skin	14.0	308	9.7	401	11.6	709	7.3	327	11.8	348	9.6	675	0.049
Shoulder pain interfering with activity	8.1	307	12.1	390	10.3	697	7.6	328	11.1	350	9.4	678	0.115
Low back pain interfering with activity	11.2	304	14.7	353	13.1	657	10.8	297	10.2	324	10.5	621	0.811
Episodes of white finger with pain/numbness	13.7	117	12.4	372	12.7	489	11.5	130	10.6	329	10.9	459	0.781
Days sad, empty, depressed	12.5	96	12.0	343	12.1	439	6.3	126	9.5	315	8.6	441	0.270
Days worried/anxious	12.2	98	14.9	328	14.3	426	13.4	119	15.4	305	14.9	424	0.606

^aWomen from across Canada, men from Alberta only, in a welding or electrical trade since 2005.

Work

The type of work within trade can be considered first, for those in the welding trades, by whether the training reported at recruitment was as a welder, boilermaker or as a gas fitter/steamfitter. Most of those qualified as a gas fitter/steamfitter had previously qualified as a welder, but they have been coded here by the more recent trade training. Women in the welding trades were much more likely than men to be qualified simply as a welder. This was the case for 87.7% of the women but only 72.7% of the men. Among the men, 23.6% had gone on to a gas/steam fitting qualification, but only 10.5% of the women had done so. Boilermakers accounted for only 3.6% of men and 1.8% of women in these trades. As the names of electrical trade apprenticeships vary across the country, a similar breakdown by qualification was difficult, but the type of work reported within the electrical trades is considered by sex below.

As can be seen in Table 4, at first follow-up more women than men reported not having worked at all in the previous 6 months, but among those who had worked, women welders were as likely as men to say they had worked in their trade. Those who had worked in their trade in the last 6 months (and had welded or carried out electrical tasks) were given a checklist of tasks specific to their trade and asked to say whether or not they were part of their work on the most recent day in their trade. These tasks are shown in the top half of Tables 5 and 6. In both welding and electrical trades women reported fewer of the tasks than men: welding mean tasks; women 1.69, men 2.04 $P = 0.001$; electrical mean tasks; women = 1.92, men = 2.15 $P = 0.023$. Inspection of the individual tasks for welding (Table 5) suggested that fewer women were employed in construction or repair or in mixed tasks, while in the electrical trades (Table 6) women were much less likely to report that they were involved in the preparation to carry out a task.

In welders, we were also able to look at specific types of welding. A lower proportion of women than men reported that they did MMAW (manual metal arc welding, also known as SMAW, shielded metal arc welding) (Table 5) and, overall, they reported fewer welding processes (women mean processes 1.22, men 1.30 $P = 0.066$). In Table 6, we also compare the type of electrical work reported by men and women. The numbers of women are low as the question was introduced part way through the study, but women are seen to be less likely than men to be working as an industrial electrician.

Finally, in this analysis of tasks and processes, we looked at the reported use of respiratory protective equipment (RPE). For welding, we considered reported

Table 4. Work status by trade and sex at first follow-up, 6 months or more since recruitment questionnaire.

	Welding trades				Electrical trades			
	Women		Men		Women		Men	
	N	%	N	%	N	%	N	%
No follow-up completed	55	12.3	78	14.1	32	7.3	34	7.6
In last 6 months:								
Not worked	56	12.5	29	5.2	53	12.1	30	6.7
Worked but not in trade	34	7.6	49	8.8	41	9.4	19	4.3
In trade, but no trade tasks	47	10.5	47	8.5	13	3.0	17	3.8
In trade with trade tasks but no task details for last day	17	3.8	14	2.5	12	2.7	1	0.2
In trade with trade tasks and trade task details for last day	236	52.8	337	60.8	287	65.5	346	77.4
Unknown work status	2	0.4	0	0	0	0	0	0
Total	447	100.0	554	100.0	438	100.0	447	100.0

Table 5. Tasks and processes in the welding trades by sex for those who had worked in welding since the recruitment questionnaire and given details about their welding tasks on the last day at work before completing the first follow-up questionnaire.

	Women	Men	Both	<i>P</i>
	%	%	%	
Tasks				
Pipe welding	25.2	27.7	26.7	0.508
Fabricator	61.5	68.1	65.4	0.108
Repair	26.1	34.2	30.9	0.037
Construction	14.1	26.4	21.3	0.001
Mixed	18.4	26.4	23.1	0.024
Other	12.3	11.1	11.6	0.653
N	235	335	570	
Processes				
MMAW (Manual Metal Arc Welding)	50.2	66.3	59.6	0.001
SAAW (Semi-Automatic Arc Welding)	53.6	48.1	50.4	0.191
AWTE (Arc Welding with Tungsten Electrode)	11.9	10.7	11.2	0.664
N	235	335	570	

use of RPE 'ever' while carrying out any of the three types of welding process shown in Table 5. Only 54.4% of men and 45.7% of women ($P = 0.042$) reported ever using any form of RPE. Use of RPE was infrequent in the electrical trades for either sex, with only 12.4% of men and 14.4% of women reporting that they ever used it.

At this time, only 162 end-of-study 'wrap up' questionnaires have been completed and entered for analysis, 48 by female welders, 49 by women in the electrical trades, and 65 by men (26 welders and 39 in the electrical

Table 6. Tasks and types of work in the electrical trades by sex for those who had worked in the electrical trades since the recruitment questionnaire and given details about their electrical tasks on the last day at work before completing the first follow-up questionnaire.

	Women	Men	Both	<i>P</i>
	%	%	%	
Tasks				
Preparation	35.2	50.1	43.2	0.001
Shop work	14.5	18.3	16.6	0.207
Preventive maintenance	19.7	22.0	20.9	0.463
Installation/repair	73.8	77.7	75.9	0.254
High voltage	6.6	7.8	7.2	0.536
Cable splicing	23.8	20.0	21.7	0.249
N	290	345	635	
Types of electrical work ^a				
Commercial	41.1	40.1	40.3	0.862
Industrial	46.7	62.6	59.5	0.006
Residential	20.0	13.6	14.8	0.135
N	90	369	459	

^aThis question was included in the follow-up questionnaire in May 2013 and so was not collected at first follow-up for women recruited before December 2012.

trades). A preliminary examination was made of the proportions reporting psychological harassment, physical violence, or sexual harassment during or since they completed their training. This showed higher rates for women than men in both trades and both time periods (training and since) (Table 7). For both men and women, rates were higher in the welding than electrical trades, during apprenticeship and later. Those who reported harassment during training had higher mean anxiety (7.2) and depression (4.2) scores at the end of the study than those not reporting such harassment (anxiety 5.3; depression

2.9) ($P = 0.003$; $P = 0.007$) but scores were not elevated overall for those reporting that they had been harassed in the trade since the end of the apprenticeship.

Initial inspection of the ‘masculinity’, ‘femininity’, and ‘androgyny’ scores derived from the BSRI showed no difference between women and men in these trades on the ‘masculinity’ and ‘femininity’ scales, but men scored higher than women on the androgyny scale. Only 5 of the 30 individual items differentiated the participants by biological sex. Four of these were items considered ‘androgynous’: women rated themselves to be less conventional ($P = 0.001$), less conceited ($P = 0.009$), less secretive ($P = 0.002$), and less tactful (0.049). They also rated themselves as being less willing to take risks ($P = 0.038$), considered by Bem (1974) to be a masculine trait. Male welders had a higher mean masculinity score (5.03) than men in the electrical trades (4.6) ($P = 0.034$), but among women, mean scores for masculinity were much the same in the two trades (welders 4.7; electrical 4.8; $P = 0.536$). In this subgroup of the study population, biological sex was unrelated to anxiety or depression, but a lower level of masculinity was related to a higher depression score. Scores on the androgyny scale were positively associated with both anxiety and depression and, having adjusted for these factors, harassment during training remained associated with higher anxiety and depression scores (Table 8).

Discussion

This report is the first to fully describe the data collected on women and men who have consented to take part in the WHAT-ME and WHAT-MEN studies of men

Table 7. Harassment by trade, sex, and training status (% reporting being harassed on the end-of-study questionnaire).

	Welding trades		Electrical trades	
	%	N	%	N
During training				
Women	72.9	48	55.1	49
Men	42.3	26	15.4	39
Total	62.2	74	37.5	88
P	0.010		0.001	
Since training (work in trade)				
Women	63.2	38	44.4	36
Men	23.8	21	15.2	33
Total	49.2	59	30.4	69
P	0.003		0.007	

and women in the welding and electrical trades. The description gives some idea of the factors that will need to be considered in a definitive analysis of the difference in risk of work-related ill-health between the sexes, in these cohorts where men and women are largely equivalent in initial trade training. The study showed rather few differences between women and men on many of the characteristics that might be expected to relate to ill-health, which will simplify the attribution of outcomes to exposure. Comparison of the work done by women and men did show systematic differences within trade that will be important in examining health outcomes at the end of the follow-up. At this point in the study, when considering only a short follow-up from baseline, there was little new-onset ill-health with only new-onset wheeze in male electrical workers related to sex within trade. The absence of important differences in health complaints is consistent with some, but not all, earlier studies comparing men and women in similar work. Alterman et al. (2008), for example, found few differences between white non-Latino female and male agricultural workers in musculoskeletal respiratory or skin complaints. Emslie et al. (1999a,b) found no difference in physical complaints for women and men either in bank employees or university staff. In contrast, Campos-Serna et al. (2013), in a systematic review that addressed differences in work-related symptoms, concluded that the evidence supported more musculoskeletal and mental health issues in women than men. When complete follow-up data are available, we will be able to reach stronger conclusions on the similarity of health complaints in these four cohorts.

Table 8. Multivariable regressions of sex, gender, trade, and harassment during training with anxiety and depression score on the Hospital Anxiety and Depression (HADS) questionnaire as the dependent variables ($N = 148$).

	Anxiety			Depression		
	B	SE	P	B	SE	P
Sex						
Male	-0.60	0.71	0.399	0.27	0.54	0.621
Gender						
Masculinity	-0.36	0.37	0.340	-0.62	0.28	0.029
Femininity	-0.41	0.35	0.242	-0.19	0.26	0.469
Androgyny	2.70	0.67	0.001	1.47	0.50	0.004
Trade						
Welding	-0.85	0.65	0.193	-0.26	0.49	0.597
Harassed during apprenticeship	1.88	0.70	0.008	1.55	0.53	0.004

Abbreviation: SE = standard error.

Although the four cohorts present a powerful opportunity to examine differences in job demands, exposures, and work-related ill-health, the study does have limitations, not all of which can be overcome by statistical modeling and longer follow-up in future publications. First, we are comparing women in welding and electrical trades across Canada with men in the same trades in Alberta. While the analysis can be stratified to allow for this, this may reduce the power of the comparisons. Secondly, although in the supplementary material (available at *Annals of Work Exposures and Health* online) we have done our best to estimate response rates in Alberta, we do not have any good idea of how many of those we approached (directly or through apprenticeship bodies) received the invitation and, among those that did, how many were still in their trade. We were recruiting people up to 9 years after they started their apprenticeship and many of the addresses listed at apprenticeship enrolment will have been long out of date. A recent [Red Seal \(2014\)](#) report estimated that some 50–60% who start an apprenticeship do not complete, and those who had left the trade before we approached them would be unlikely to respond. In practice, they would have added little to the study if they were no longer in their trade: the aim of the study was to recruit people in the trade and access through apprenticeship records was a means to find such people. The study was not designed as one of apprenticeship *per se*. Tradespeople leaving their trade, perhaps because of ill-health, and those who were geographically mobile will have been under-represented in the population receiving and responding to the invitation to take part. Further, it is fair to assume that the majority of those who received the invitation and did not respond were not interested in taking part. Those who did may have differed in many unquantified ways, perhaps being more interested in their health, more likely to plan a pregnancy or have greater literacy or more compliant natures than those who did not. Importantly, there was no difference in the response rates between trades for either women or men. While many effects of differential recruitment will be minimized by restricting analyses to internal comparisons, there will remain questions about how far results can be generalized to the whole population of tradespeople. Third, although some members of the cohorts were recruited very soon after they started an apprenticeship, few were completely new to the trade at the time of completing the recruitment questionnaire. The baseline data does not represent an unexposed population. Finally, the study was not designed to look at sex and gender differences in work, and much material that might have been of interest (such as family structure, roles played in the home, and home care

availability) have not been collected. We have attempted to address some additional issues through the post-study wrap-up questionnaire, which is addressed only briefly in the final paragraphs of the results section. The analysis presented there, based on a small, early sample of respondents, probably unrepresentative of the overall cohorts, is included to illustrate some of the use that may be made of these data, differentiating biological sex and gender.

Although the aim of this paper was largely to describe the study population and the data available for future analyses, some of the early results presented here warrant further attention. Of note are new-onset asthma or wheeze in welders, their low use of respiratory protection, even lower in female welders, and the high rates of harassment, particularly during apprenticeship in female welders, and its apparently long-term effect on mental health. The study was set up at the request of the Committee on Safety in Welding of the Canadian Standards Association and has elicited great interest in the international welding community: there has been buy-in from every apprenticeship board across Canada. As such, there are immense opportunities for knowledge dissemination and working towards change in practice. Such discussion, already underway, will accelerate with the publication of further definitive results.

Supplementary Data

Supplementary data are available at *Annals of Work Exposures and Health* online.

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Ethics: The research described here was approved by the Health Ethics Review Board of the University of Alberta.

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