The Association between Mental Health and Shift Work: Findings from the Atlantic PATH Study

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Abstract

We evaluated the relationship between mental health and shift work in the Atlantic Partnership for Tomorrow's Health (PATH) cohort study. In a matched study with 12,413 participants, including 4,155 shift workers and 8,258 non-shift workers, we utilized general linear models and logistic regression models to assess the differences in depression, anxiety, and self-rated health. Shift workers reported higher levels of each of the mental health-related domains compared to non-shift workers. There was a significant increased risk of depression (OR=1.13, 95% CI, 1.00-1.27) and poor self-rated health (OR=1.13, 95% CI, 1.14-1.55) among shift workers compared to non-shift workers. Shift workers were more likely to have increased rates of depression and poor self-rated health, as well as depressive and anxiety symptom scores compared to non-shift workers. As a result, shift workers may be at increased risk of comorbidity, poor quality of life, missed work, and early retirement.

Key Words: Shift work, mental health, depression, anxiety, Atlantic PATH

Highlights:

- Shift workers reported higher levels of anxiety, depression and low self-rated health than non-shift workers
- Shift workers were more likely to report major depression and poor self-rated health than non-shift workers
- Female shift workers were more likely to report depressive symptoms and poor self-rated health.

INTRODUCTION

It has become well established that people who engage in shift work will experience sleep disturbances, exposure to light at night, and disruption to circadian rhythms.[1–5] Shift work has been found to influence acute and chronic health outcomes, including cancer, cardiovascular, metabolic, reproductive, gastrointestinal, immunological, and neurological outcome.[2,6,15–18,7–14] This is particularly relevant in the Canadian population where 30% of working age citizens work evening, night and rotating shifts,[3,19] with 13% of Canadians working overnight shifts between 12am-5am.[20]

Mental health is an established indicator of overall health and well-being among the working population.[19] It is also an established predictor of long-term sickness absence and disability leave from work. Poor mental health results in longer periods of missed work than physical illness and injuries,[21–24] and plays a role in early retirement.[14,24–27] In addition to the psychological and social burden at the individual-level, there is an economic burden. Mental health effects are the primary driver in indirect costs related to sick leave and early retirement, including the financial burden on employers and governments. There is also a financial burden for those who reduce their work- and earning-capacity or are unable to continue to participate in the labour market and must retire early.[22,24,28–31]

While there is an increasing understanding about the relationship between shift work and chronic health conditions, less research has focused on the potential association between shift work and mental health. Mental health can be influenced by numerous factors, including psychosocial, biological, demographic, and genetic factors, as well as circadian rhythm.[22] Statistics Canada reports that among adults aged 18-64 who were employed between 2000-2016, there was a 5.4% average annual prevalence of self-reported major depressive episodes and a 4.6% average annual prevalence of self-reported anxiety, with a modest but statistically significant increase of anxiety over time.[31] Common symptoms of depression include depressed mood, loss of interest in activities, change in weight or appearance, sleep disturbances, poor concentration, difficulty making decisions, and decreased energy or fatigue.[32] Furthermore, anxiety disorders impact behaviour, thoughts, emotions, and physical health and may result in long periods of intense feelings of fear or distress.[33]

A recent meta-analysis of observational epidemiological studies conducted by Lee et al. found that night shift work was associated with an overall 40% increased risk of depression, this

positive association remained consistent in subgroup analyses by sex, geographic location, shift duration, and occupation type.[21] Similarly, in the UK longitudinal household study, Weston et al. found a significant association between shift work and depressive symptoms, regardless of occupation, employer, age, or sex.[34]

We have previously examined and established a relationship between shift work and cardiometabolic health.[35] Based on the recent findings that indicate a relationship between shift work and mental health,[34,36] we sought to examine the potential relationship between anxiety, depression and self-rated health among shift workers using data from Atlantic Partnership for Tomorrow's Health (Atlantic PATH). The Atlantic PATH study is part of the Canadian Partnership for Tomorrow's Health (CanPath, formerly the Canadian Partnership for Tomorrow Project), a pan-Canadian longitudinal cohort study examining the role of genetic, environmental, behavioural, and lifestyle factors in the development of cancer and chronic disease.[37,38]

METHODS

Participants in the Atlantic PATH study were aged 35-69 and residents of one of the four Atlantic Canada provinces (Nova Scotia, New Brunswick, Newfoundland and Labrador, and Prince Edward Island). Details on recruitment and data collection have been previously described.[38,39] In brief, all participants provided written consent and completed a set of standardized surveys on sociodemographic characteristics, employment status, work schedule, health, diet, and lifestyle factors.

Assessment of Work Schedule

Consistent with our previously published work on this population,[35] we selected participants in the age range of 35-65 in order to represent the working age population within the cohort. In total, 20,584 participants had paid jobs and work schedules that fit the criteria and were selected for inclusion in this study, including 4,155 shift workers and 16,429 non-shift workers out of a possible 27,679 working age participants. We conducted a 1:2 match according to participants' age (±2 years), sex and education as well known confounders of job status and in order to reduce bias.[40] The final sample consisted of 12,413 participants, including 4,155 shift workers and 8,258 non-shift workers.[i] Thus, shift workers represent approximately 13% of the total number of participants in the Atlantic PATH cohort.

[i] The majority of participants were matched 1:2. However, 52 shift workers were matched with a single non-shift worker as it was not possible to find a second matched participant.

Participants' work schedules were assessed based on their responses to the surveys and specifically, questions about the work schedule in their current job. Participants were categorized as non-shift workers if they reported working a regular day-time schedule, and as shift workers if they reported working an irregular schedule, including split day shift, evening shift, night shift, rotating shift, or other schedules. We further grouped shift workers as: 1) day-time shift workers for those who reported an irregular day-time work schedule; 2) evening/occasional night shift workers (including split shift); and 3) regular night shift workers.[35]

Assessment of sociodemographic and behavioural factors

Ethnicity was categorized as white and non-white in order to account for a lack of ethnic diversity in the cohort, which is reflective of the larger Atlantic Canadian population.[38] Marital status was grouped as married or living together, and single, divorced, separated, or widowed. For smoking, participants were grouped as non-smokers, former smokers, and current smokers. For alcohol consumption, participants were classified as abstainer, occasional drinker (> 0 to $\leq$ 2–3 times/month), regular drinker (≥ 1 to $\leq$ 2–3 times/week), and habitual drinker ($\geq$ 4–5 times/week). Participants reported sleep duration in hours per day.

Assessment of mental health variables

We used the nine-item Patient Health Questionnaire (PHQ-9) to calculate a depression severity score.[41] It is based on the Primary Care Evaluation of Mental Disorders (PRIME-MD) diagnostic instrument. The PHQ-9 is a self-reported depression module that utilizes nine DSM-IV (*Diagnostic and Statistic Manual of Mental Disorders*, 4th ed.) criteria scored either zero ("not at all"), one ("several days"), two ("more than half the days"), or three ("nearly every day").[41–43] In evaluating the validity of the PHQ-9, it was determined that 93% of patients with no depressive disorder had a PHQ-9 score of less than 10, while 88% of patients with major depression had scores of $\geq$10.[41]

Participants were asked to complete the PHQ-9 based on their experiences in the two weeks prior to completing the survey. Based on participants' responses, a total score ranging from 0 (minimum) to 27 (maximum) was assigned to each individual. Major depression was defined as a PHQ-9 score $\geq$ 10 and/or current use of antidepressants based on self-report of medication use.[39]

We also used the seven-item Generalized Anxiety Disorder (GAD-7) scale, which is based on the Primary Care Evaluation of Mental Disorders (PRIME-MD) diagnostic instrument. The GAD-7 is a self-reported anxiety module that utilizes seven criteria scored either zero ("not at all"), one ("several days"), two ("more than half the days"), or three ("nearly every day"). The GAD-7 has a sensitivity of 89% and a specificity of 82% for generalized anxiety disorder.[44–47]

Participants were asked to complete the GAD-7 based on their experiences in the two weeks prior to completing the survey. Based on participants' responses, a total score ranging from 0 (minimum) to 21 (maximum) was assigned to each individual. Major anxiety was defined as a GAD-7 score ≥ 10. [47]

Self-rated health is a commonly collected and utilized variable by Statistics Canada[48] and across cohort studies to measure general health, including one's overall physical and mental health.[49–52] Similar to other studies on self-rated health, participants were asked to rate their general health as excellent, very good, good, fair, or poor.[49,53–56] Those who reported fair or poor overall health were classified as having a poor self-rated health status.[57]

Statistical Analyses

We performed the statistical analysis using the maximum non-missing values available in the matched study sample. Differences in study participant characteristics between shift workers and non-shift workers were tested with the *student-t* test for continuous variables and the *chi-square* test for categorical variables (Table 1). We utilized multiple logistic regression models to compute odds ratios (OR) and 95% confidence intervals (CI) for binary categorical variables, including major depression, major anxiety, and poor self-rated health (Table 2 and Table 4). In the multivariable regression analysis, we adjusted for sociodemographic and behavioural factors (province, ethnicity, marital status, sleep duration, smoking status, and alcohol consumption). We also employed general linear regression models to evaluate the differences in depression and anxiety symptom scores between shift workers and non-shift workers, and between categories of shift workers (Table 3 and Table 5). Statistical significance was defined as $P < 0.05$. All P values were two-sided. Data management and analyses were performed with SAS statistical package version 9.4 (SAS Institute, Cary, North Carolina).

Table 1. Characteristics of study participants

Characteristics	n=8253	Non-shift worker		n=4155	Shift worker		p-value[d]
Sex, female, n (%)	8253	5556	(67.3)	4155	2780	(66.9)	0.6433
Age, year, mean (SD)		50.4	(8.0)		50.4	(8.0)	0.7191
Province, n (%)							<.0001
Nova Scotia		3966	(48.1)		2396	(57.7)	
New Brunswick		2675	(32.4)		1096	(26.4)	
Newfoundland and Labrador		1278	(15.5)		525	(12.6)	
Prince Edward Island		334	(4.0)		138	(3.3)	
Ethnicity, n (%)							0.0602
White		7154	(86.7)		3608	(86.8)	
Non-white		559	(6.8)		312	(7.5)	
DNK/PNA		540	(6.5)		235	(5.7)	
Marital status, n (%)							0.0002
Married or living together		6586	(79.8)		3187	(76.7)	
Single, divorced, or widowed		1642	(19.9)		949	(22.8)	
DNK/PNA		25	(0.3)		19	(0.5)	
Depressive symptom score, mean (SD)	5844	3.1	(3.6)	2801	3.4	(3.8)	0.0003
Major depression[b], yes, n (%)		955	(16.3)		523	(18.7)	0.0071
Anxiety symptom score, mean (SD)	5844	2.2	(3.3)	2801	2.4	(3.4)	0.0169
Anxiety n (%)							0.0185
Mild Anxiety (5≥GAD7≤9), n(%)		747	(12.8)		416	(14.9)	
Major anxiety[c], GAD7>10), n(%)		266	(4.6)		138	(4.9)	
Self-rated health n (%)							<.0001
Poor		37	(0.5)		31	(0.8)	
Fair		413	(5.0)		271	(6.5)	
Good		2478	(30.0)		1393	(33.5)	
Very good		3814	(46.2)		1760	(42.4)	
Excellent		1473	(17.9)		681	(16.4)	
DNK/PNA		38	(0.5)		19	(0.5)	
Sleep duration, hour/day, mean (SD)	8142	7.1	(1.1)	4070	7.1	(1.3)	0.3879
Smoking status, *n* (%)							0.2366
Never		4038	(48.93)		2044	(49.19)	
Former		3226	(39.09)		1568	(37.74)	
Current		930	(11.27)		514	(12.37)	
DNK/PNA		59	(0.71)		29	(0.7)	
Alcohol drinking, n (%)							<.0001

Abstainer	833	(10.1)	515	(12.4)
Occasional drinker	3427	(41.5)	1862	(44.8)
Regular drinker (≥ 1 to ≤ 2–3 times/week)	2772	(33.6)	1159	(27.9)
Habitual drinker (≥ 4–5 times/week)	1182	(14.3)	600	(14.4)
DNK/PNA	39	(0.5)	19	(0.5)

DNK/PNA, do not know or prefer not to answer.

[a] Data are means (standard deviation) and number of participants (percentage). Percentages may not total 100 due to rounding.

[b] PHQ-9 ≥ 10 and/or current use of antidepressants.

[c] GAD-7 ≥ 10

[d] p-value of Chi-squared test for categorical variables or t-test for continuous variables

Table 2. Associations of shiftwork with depression, anxiety, and self-rated health

	Non-shift worker		Shift worker		
	Cases/n	**OR (95% CI)**	**Cases/n**		**OR (95% CI)**
		Overall			
Major depression [a]					
Unadjusted	955/5844	1.0 (Reference)	523/2801	1.18	(1.05, 1.32)
Multivariable adjusted [b]		1.0 (Reference)		1.13	(1.00, 1.27)
Major anxiety [c]					
Unadjusted	266/5844	1.0 (Reference)	138/2801	1.1	(0.88,1.34)
Multivariable adjusted[b]		1.0 (Reference)		1	(0.79,1.23)
Poor self-rated health [d]					
Unadjusted	450/8215	1.0 (Reference)	302/4135	1.36	(1.17,1.58)
Multivariable adjusted [b]		1.0 (Reference)		1.33	(1.14,1.55)
		Male			
Major depression [a]					
Unadjusted	194/1918	1.0 (Reference)	106/984	1.07	(0.84, 1.38)
Multivariable adjusted [b]		1.0 (Reference)		0.97	(0.75, 1.26)
Major anxiety [c]					
Unadjusted	73/1918	1.0 (Reference)	47/984	1.27	(0.87, 1.84)
Multivariable adjusted[b]		1.0 (Reference)		1.1	(0.74, 1.62)
Poor self-rated health [d]					
Unadjusted	178/2684	1.0 (Reference)	97/1367	1.08	(0.83, 1.40)
Multivariable adjusted [b]		1.0 (Reference)		0.99	(0.76, 1.30)
		Female			
Major depression [a]					
Unadjusted	761/3926	1.0 (Reference)	417/1817	1.24	(1.08, 1.42)
Multivariable adjusted [b]		1.0 (Reference)		1.21	(1.06, 1.39)
Major anxiety [c]					
Unadjusted	193/3926	1.0 (Reference)	91/1817	1.02	(0.79, 1.32)
Multivariable adjusted[b]		1.0 (Reference)		0.95	(0.73, 1.25)

Poor self-rated health [d]						
Unadjusted	272/5531	1.0 (Reference)		205/2769	1.55	(1.28, 1.86)
Multivariable adjusted [b]		1.0 (Reference)			1.56	(1.29, 1.90)

OR = odds ratios; CI = confidence intervals.
[a] PHQ-9 ≥ 10 and/or current use of antidepressants.
[b] Adjusted for province, ethnicity, marital status, sleep duration, smoking status, and alcohol drinking.
[c] GAD-7 ≥ 10.
[d] Self-rated health in 'Poor' or 'Fair'

Table 3. Differences in depression and anxiety symptom scores between matched non-shift workers and shift workers

	Non-shift worker			Shift worker			
	n	**Mean (95% CI)**		**n**	**Mean (95% CI)**		***P* value**
							Overall
			Overall				
Depressive symptom score							
Unadjusted	5844	3.1	(3.0, 3.2)	2801	3.4	(3.2, 3.5)	<0.001
Multivariable adjusted[a]	5844	3.6	(3.0, 4.2)	2801	3.9	(3.1, 4.4)	0.0086
Anxiety symptom score							
Unadjusted	5844	2.2	(2.1,2.3)	2801	2.4	(2.3,2.5)	0.0159
Multivariable adjusted[a]	5844	3	(2.4,3.6)	2801	3.1	(2.5,3.7)	0.1014
			Male				
Depressive symptom score							
Unadjusted	1918	2.6	(2.4, 2.7)	984	2.9	(2.6, 3.1)	0.025
Multivariable adjusted[a]	1918	4.2	(2.8, 5.6)	984	4.4	(3.0, 5.7)	0.208
Anxiety symptom score							
Unadjusted	1918	1.9	(1.8, 2.1)	984	2.2	(2.0, 2.4)	0.083
Multivariable adjusted[a]	1918	3.8	(2.5, 5.1)	984	4	(2.6, 5.3)	0.233
			Female				
Depressive symptom score							
Unadjusted	3926	3.3	(3.2, 3.4)	1817	3.7	(3.5, 3.8)	0.001
Multivariable adjusted[a]	3926	3.4	(2.6, 4.1)	1817	3.7	(2.9, 4.4)	0.007
Anxiety symptom score							
Unadjusted	3926	2.4	(2.3, 2.5)	1817	2.6	(2.4, 2.7)	0.057
Multivariable adjusted[a]	3926	2.7	(2.0, 3.4)	1817	2.9	(2.2, 3.6)	0.148

Data are means (95% confidence intervals).
[a] Adjusted for province, ethnicity, and marital status, sleep duration, smoking status and alcohol consumption.

Table 4. Associations of different shift work schedules with depression, anxiety, and self-rated health

	Non-shift worker		Day-time shift worker		Non-shift worker		Evening or occasional night shift worker		Non-shift worker		Regular night shift worker	
	Cases/n	OR (95% CI)	Cases/n	OR (95% CI)	Cases/n	OR (95% CI)	Cases/n	OR (95% CI)	Cases/n	OR (95% CI)	Cases/n	OR (95% CI)
Major depression [b]												
Unadjusted	523/3359	1.0 (Reference)	290/1679	1.13 (0.97, 1.32)	84/457	1.0 (Reference)	46/206	1.28 (0.85, 1.91)	348/2028	1.0 (Reference)	187/916	1.24 (1.02, 1.51)
Multivariable adjusted [a]		1.0 (Reference)		1.11 (0.94, 1.31)		1.0 (Reference)		1.04 (0.68, 1.61)		1.0 (Reference)		1.14 (0.93, 1.40)
Major anxiety [c]												
Unadjusted	143/3359	1.0 (Reference)	73/1679	1.02 (0.77,1.36)	21/457	1.0 (Reference)	13/206	1.40 (0.69,2.85)	102/2028	1.0 (Reference)	52/916	1.14 (0.81,1.60)
Multivariable adjusted [a]		1.0 (Reference)		0.98 (0.73,1.33)		1.0 (Reference)		0.97 (0.45,2.12)		1.0 (Reference)		0.95 (0.66,1.37)
Poor self-rated health [d]												
Unadjusted	233/4717	1.0 (Reference)	171/2374	1.49 (1.22,1.83)	38/635	1.0 (Reference)	34/320	1.87 (1.15,3.03)	179/2863	1.0 (Reference)	97/1442	1.08 (0.84,1.40)
Multivariable adjusted [a]		1.0 (Reference)		1.60 (1.29,2.00)		1.0 (Reference)		1.56 (0.94,2.59)		1.0 (Reference)		0.96 (0.74,1.26)

OR = odds ratios; CI = confidence intervals.

[a] Adjusted for province, ethnicity, marital status, sleep duration, smoking status, and alcohol drinking.

[b] PHQ-9 ≥ 10 and/or current use of antidepressants.

cGAD-7 ≥ 10.

[d] Self-rated health in 'Poor' or 'Fair'

Table 5. Differences in depression and anxiety symptom scores between matched non-shift workers and shift workers according to different work schedules

	Non-shift worker		Day-time shift worker			Non-shift worker		Evening or occasional night shift worker			Non-shift worker		Regular night shift worker		
	Mean (95% CI) n=3,359		Mean (95% CI) n=1,679		*P* value	Mean (95% CI) n=457		Mean (95% CI) n=206		*P* value	Mean (95% CI) n=2,028		Mean (95% CI) n=916		*P* value
Depressive symptom score															
Unadjusted	2.9	(2.8,3.0)	3.3	(3.1,3.4)	<0.001	3.1	(2.8,3.5)	3.9	(3.3,4.4)	0.02	3.3	(3.2,3.5)	3.5	(3.2,3.7)	0.463
Multivariable adjusted[a]	3.2	(2.4,4.1)	3.6	(2.7,4.4)	0.0006	5	(2.3,7.6)	5.3	(2.6,8.0)	0.2585	3.8	(2.7,5.0)	3.7	(2.6,4.9)	0.6264
Anxiety symptom score															
Unadjusted	2.1	(2.0,2.2)	2.4	(2.2,2.5)	0.019	2.4	(2.0,2.7)	2.6	(2.1,3.1)	0.4025	2.4	(2.2,2.5)	2.5	(2.3,2.7)	0.4045
Multivariable adjusted[a]	2.3	(1.5,3.1)	2.5	(1.7,3.3)	0.0419	3.7	(1.1,6.2)	3.6	(1.1,6.2)	0.8674	4	(2.9,5.0)	3.9	(2.9,5.0)	0.9218

Data are means (95% confidence intervals).

[a] Adjusted for province, ethnicity, marital status, sleep duration, smoking status, and alcohol drinking.

RESULTS

Shift Workers vs. Non-Shift Workers

The characteristics of Atlantic PATH study participants have been previously published.[35] Consistent with the over-representation of females in the larger Atlantic PATH cohort (69.7% females and 30.3% males), females in this study represented 67.2% of the sample. Most shift workers resided in Nova Scotia (57.7%), with 26.4% from New Brunswick, 12.6% from Newfoundland and Labrador, and 3.3% from Prince Edward Island (Table 1, Supplementary Table 1).

Both shift workers and non-shift workers reported the same amount of sleep (7.1 hours/day). Shift workers were more likely to be a current smoker than non-shift workers (12.4% and 11.3%, respectively). Overall, shift and non-shift workers had similar rates of habitual alcohol consumption (14.4% and 14.3%, respectively at ≥4-5/week). Non-shift workers were more likely to regularly consume alcohol ≥1 to ≤2-3 /week than shift-workers (33.6% and 27.9%, respectively), and were less likely to abstain from alcohol compared to shift workers (10.1% and 12.4%, respectively).

Shift workers reported higher levels of each of the mental health domains compared to non-shift workers. Major depression was reported among 18.7% of shift workers and 16.3% of non-shift workers. Shift workers were more likely to report both mild and major anxiety (14.9% and 4.9%) than non-shift workers (12.8% and 4.6%). Shift workers also consistently reported lower self-rated health scores, with 7.3% reporting poor self-rated health compared to 5.5% of non-shift workers (Table 1).

Shift workers were 13% more likely to report major depression (OR=1.13, 95% CI, 1.00-1.27). Although not significant in male shift workers, female shift workers were 21% more likely to report major depression (OR=1.21, 95% CI, 1.06-1.39) (Table 2). The mean depressive symptom score was found to be significantly higher in shift workers (3.9, 95% CI, 3.1-4.4) than in non-shift workers (3.6, 95% CI, 3.0-4.2) with p-value of 0.0086. This difference was true for female but not male workers (Table 3).

Shift workers were 33% more likely to report poor self-rated health (OR=1.33, 95% CI, 1.14-1.55) (Table 2). Although not significant in male shift workers, female shift workers were 56% more likely to report poor self-rated health (OR=1.56, 95% CI, 1.29-1.90) (Table 2).

Categories of shift workers vs non-shift workers

Day-time shift workers were 60% (OR=1.6, 95% CI, 1.29-2.00) more likely to report poor self-rated health (Table 4). The mean anxiety symptom score was significantly higher in day-time shift workers (2.5, 95% CI, 1.7-3.3) compared to non-shift workers (2.3, 95% CI, 1.5-3.1) (Table 5). Major anxiety was not found to be significant among day-time shift workers (OR=0.98, 95% CI, 0.73-1.33) (Table 4). The mean depressive symptom score was found to be significantly higher in day-time shift workers (3.6, 95% CI, 2.7-4.4) than in the matched non-shift workers (3.2, 95% CI, 2.4-4.1) with p-value of 0.001 (Table 5). However, major depression was not found to be significant in day-time shift workers (OR=1.11, 95% CI, 0.94-1.31) (Table 4).

DISCUSSION

Many studies on shift workers have focused predominantly on specific occupational groups.[21,58–62] However, population-based studies of the broader workforce are also necessary in order to produce findings that may be generalizable to the larger population. There is a growing body of literature on the association of shift work and cardiometabolic health, and cardiovascular disease, obesity and diabetes in particular, including our shift work population and the UK Biobank cohort.[5,35] While not all research conducted to date has found an association between shift work and mental health,[63,64] our findings are consistent with those that find shift work to be associated with multiple chronic health conditions, including adverse mental health outcomes.[5,21,58,59,61,65–70]

Our findings that shift workers in Atlantic Canada experienced higher rates of depression, anxiety and poor self-rated health than non-shift workers are consistent with recently published results from Europe. In the UK Biobank population, Wyse et al. found that shift work was associated with multiple indicators of poor health, including depression, mood instability, reduced job satisfaction, high neuroticism scores, and feeling tired, depressed and lacking enthusiasm.[5] Increased depressive symptoms were also found in the UK Household Longitudinal Study[34] and the Maastricht cohort study in the Netherlands.[22] In contrast to the studies analyzed by Lee et al. in a meta-analysis of depression and shift work, we did not find an association between night shift work and either depression or anxiety in comparison to non-shift work.[21] However, these studies were, with one exception, smaller than the present study and dichotomized shift work. Furthermore, only one study used the PHQ-9 to assess depression.[36] In this latter study, shift work was defined as not having a regular daytime schedule, rather they

included all shift work groups and did not distinguish between night and daytime shift work, which may explain the difference between this study and ours.

Shift work schedules, as well as psychosocial stressors, job demands, and work environment can all contribute to depression and anxiety symptoms among workers.[71] A worker's mental health status can have a significant impact on health-related quality of life,[24,72] as well as an increased likelihood of comorbidity.[23] Workers may experience numerous difficulties in the workplace itself as a result of the symptoms they experience, fear of disclosure, stigma, and misunderstanding about the nature of mental health issues within the workplace.[23,71,73]

Mental health also has both direct and indirect costs to the healthcare system and reduced productivity, sick leave, and early retirement.[23,24,71] Wedegaertner et al. identify workers as a population who are at high risk for missing work and retiring early due to anxiety and depression and as a group for the development of targeted interventions.[23] The inclusion of shift work in analyses would allow for further specialized efforts to provide mental health supports for employees.

The majority of studies on temporal work patterns focus on male workers, or do not separate men and women.[34] This study adds to the evidence demonstrating the importance of analyzing data on both male and female participants. The mean depression score was significantly higher for female participants, and female participants were also more likely to experience major depression. This is consistent with findings from studies of predominantly female nurses who experienced a higher prevalence of depressive symptoms compared to non-shift workers.[36,59] It is also consistent with findings from the population-based UK Household Longitudinal Study, where females working ≥55 hours/week experienced more depressive symptoms, but was not found among males with similar work hours.[34] In contrast, the Maastricht cohort study found depressive symptoms were more significant in male employees than females.[22]

Evidence of a causal relationship between shift work and mental health is not yet well established due to the cross-sectional nature of many studies. However, our cross-sectional analysis confirmed a significant association and future longitudinal cohort studies such as Atlantic PATH, a regional component of a national study, and the UK Biobank will allow for the continuation of this work by following participants' work and mental health over time, as well as

their cardiometabolic health and overall risk of comorbidity. Our future work will also allow for the inclusion of types of occupation.

One of the primary strengths of this study is that it draws participants from the general working population, compared to studies that are single-sex or occupation-specific. It also benefits from a large sample size from across four Atlantic Canadian provinces. We acknowledge potential limitations, including differences in the definition of shift work across studies,[21,36] which may limit the generalizability of the findings. While we utilized the maximum non-missing values available in the matched study sample, we acknowledge the loss of data. Future research may include applying multiple imputation to address missing data in related analyses. In this study, we did not include other self-reported health conditions, such as cardiovascular disease, diabetes, obesity, or cancer but this may also be considered in future research. Other potential limitations include the volunteer nature of participation in the study (i.e., self-selection bias), and the reliance on self-reported data. However, with a matched study design, we minimized the bias that was possibly introduced by the volunteer participants.

CONCLUSIONS

This study finds that shift workers in the general working population are more likely to experience higher rates of anxiety, depression and low self-rated health than non-shift workers. It contributes to the emerging evidence that mental health should be considered as a standalone health condition, as well as a comorbidity in the population conducting shift work. Future research, particularly as part of longitudinal cohort studies, should consider how to reduce the detrimental health outcomes associated with shift work. The health impacts associated with shift work, including depression and anxiety, should be considered by public health practitioners, policy makers and employers to address the role of work patterns in health inequities.

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Supplementary Table 1. Characteristics of study participants stratified by sex

Characteristics	Non-shift worker			Shift worker			p-value[d]
Male n=4072							
Age, year, mean (SD)	2697	51	(8.1)	1375	51	(8.0)	0.5245
Province, n (%)							<.0001
Nova Scotia		1315	(48.8)		769	(55.9)	
New Brunswick		865	(32.1)		356	(25.9)	
Newfoundland and Labrador		415	(15.4)		210	(15.3)	
Prince Edward Island		102	(3.8)		40	(2.9)	
Ethnicity, n (%)							0.2281
White		2390	(88.6)		1202	(87.4)	
Non-white		157	(5.8)		99	(7.2)	
DNK/PNA		150	(5.6)		74	(5.4)	
Marital status, n (%)							0.0977
Married or living together		2342	(86.8)		1160	(84.4)	
Single, divorced, or widowed		349	(12.9)		211	(15.3)	
DNK/PNA		6	(0.2)		4	(0.3)	
Depressive symptom score, mean (SD)	1918	3.6	(3.4)	984	2.9	(3.5)	0.0270
Major depression[b], yes, n (%)		194	(10.1)		106	(10.8)	0.5817
Anxiety symptom score, mean (SD)	1918	1.9	(3.2)	984	2.2	(3.3)	0.0866
Anxiety n (%)							0.3669
Mild Anxiety (5≥GAD7≤9), n(%)		216	(11.3)		118	(12)	
Major anxiety[c], GAD7>10), n(%)		73	(3.8)		47	(4.8)	
Self-rated health n (%)							0.4632
Poor		16	(0.6)		11	(0.8)	
Fair		162	(6)		86	(6.3)	
Good		894	(33.1)		492	(35.8)	
Very good		1171	(43.4)		574	(41.7)	
Excellent		441	(16.4)		204	(14.8)	
DNK/PNA		13	(0.5)		8	(0.6)	
Sleep duration, hour/day, mean (SD)	2667	7.1	(1.1)	1348	7.0	(1.1)	0.3533
Smoking status, *n* (%)							0.6654
Never		1295	(48)		652	(47.4)	
Former		1076	(39.9)		538	(39.1)	
Current		313	(11.6)		178	(12.9)	
DNK/PNA		13	(0.5)		7	(0.5)	
Alcohol drinking, n (%)							<.0001
Abstainer		286	(10.6)		180	(13.1)	
Occasional drinker		783	(29)		471	(34.3)	
Regular drinker (≥ 1 to ≤ 2–3 times/week)		1057	(39.2)		451	(32.8)	

Habitual drinker (≥ 4–5 times/week)		555	(20.6)		268	(19.5)	
DNK/PNA		16	(0.6)		5	(0.4)	
	Female n=8336						
Age, year, mean (SD)	5556	50.2	(8.0)	2780	50.2	(8.0)	0.9745
Province, n (%)							<.0001
Nova Scotia		2651	(47.7)		1627	(58.5)	
New Brunswick		1810	(32.6)		740	(26.6)	
Newfoundland and Labrador		863	(15.5)		315	(11.3)	
Prince Edward Island		232	(4.2)		98	(3.5)	
Ethnicity, n (%)							0.0897
White		4764	(85.7)		2406	(86.5)	
Non-white		402	(7.2)		213	(7.7)	
DNK/PNA		390	(7)		161	(5.8)	
Marital status, n (%)							
Married or living together		4244	(76.4)		2027	(72.9)	
Single, divorced, or widowed		1293	(23.3)		738	(26.5)	
DNK/PNA		19	(0.3)		15	(0.5)	
Depressive symptom score, mean (SD)	3926	3.3	(3.7)	1817	3.7	(4.0)	0.0019
Major depression[b], yes, n (%)		761	(19.4)		417	(22.9)	0.0019
Anxiety symptom score, mean (SD)	3926	2.4	(3.4)	1817	2.6	(3.5)	0.0598
Anxiety n (%)							0.0143
Mild Anxiety (5≥GAD7≤9), n(%)		531	(13.5)		298	(16.4)	
Major anxiety[c], GAD7>10), n(%)		193	(4.9)		91	(5)	
Self-rated health n (%)							<.0001
Poor		21	(0.4)		20	(0.7)	
Fair		251	(4.5)		185	(6.7)	
Good		1584	(28.5)		901	(32.4)	
Very good		2643	(47.6)		1186	(42.7)	
Excellent		1032	(18.6)		477	(17.2)	
DNK/PNA		25	(0.4)		11	(0.4)	0.1078
Sleep duration, hour/day, mean (SD)	8142	7.1	(1.1)	4070	7.2	(1.3)	
Smoking status, *n* (%)							0.3777
Never		2743	(49.4)		1392	(50.1)	
Former		2150	(38.7)		1030	(37.1)	
Current		617	(11.1)		336	(12.1)	
DNK/PNA		46	(0.8)		22	(0.8)	
Alcohol drinking, n (%)							<.0001
Abstainer		547	(9.8)		335	(12.1)	
Occasional drinker		2644	(47.6)		1391	(50)	
Regular drinker (≥ 1 to ≤ 2–3 times/week)		1715	(30.9)		708	(25.5)	

Habitual drinker (≥ 4–5 times/week)	627	(11.3)	332	(11.9)
DNK/PNA	23	(0.4)	14	(0.5)

DNK/PNA, do not know or prefer not to answer.
[a] Data are means (standard deviation) and number of participants (percentage). Percentages may not total 100 due to rounding.
[b] PHQ-9 ≥ 10 and/or current use of antidepressants.
[c] GAD-7 ≥ 10
[d] p-value of Chi-squared test for categorical variables or t-test for continuous variables

Author's Contributions

Study conception and design: ES, YC, ZY, AA, TD
Acquisition, analysis, and interpretation of data: YC, ZY, ES AA, TD
Drafting of manuscript: ES, YC
Critical revision of the manuscript: ES, ZY, AA, TD, YC, VD, CF, SG, MK

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Data Access

Data and biosamples from Atlantic PATH are available to researchers through a data access process. Additional information can be obtained by contacting info@atlanticpath.ca.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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