

# **The associations between shift work exposure and frailty among middle-aged and older adults at three years of follow-up**

**Results from  
the Canadian Longitudinal Study on Aging**

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# The Association Between Shift Work Exposure and Frailty Among Middle-Aged and Older Adults

## Results From the Canadian Longitudinal Study on Aging

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**Objective:** To investigate the association between shift work exposure and frailty. **Methods:** Longitudinal secondary data analyses were performed using Canadian Longitudinal Study on Aging. Individuals aged 45 to 85 years were included at baseline (N = 47,740). Primary shift work (SW) variables were derived at baseline: ever exposed to SW, SW exposure in longest job, and SW exposure in current job. Multinomial regression models were constructed to evaluate the association between SW and frailty at 3 years of follow-up. **Results:** Participants ever exposed to SW were associated with frailty compared with those who worked only daytime. Particularly, females worked in rotating shifts in their longest jobs were more likely to be classified as frail compared with those who worked only daytime. **Conclusions:** This study suggests that SW may play a role in development of frailty and this warrants further investigation.

**Keywords:** aging, CLSA, frailty, shift work, occupational health, night shift work, rotating shift work

Frailty is a concept that is frequently used to describe elderly people who are more susceptible to morbidity and mortality and is gaining importance as a healthcare priority in countries with aging populations.<sup>1</sup> Closely linked to advanced age and disease-related processes, frailty is defined as a “*medical syndrome with multiple causes and contributors that is characterized by diminished strength, endurance, and reduced physiologic function that increases an individual’s vulnerability for developing increased dependency and/or death.*”<sup>2,3</sup> It allows researchers to quantitatively summarize individual vulnerability, which cannot be inferred from chronological age alone. Those who are frail are at increased risk of premature mortality, institutionalization, and worsening disability.<sup>3</sup> While frailty naturally occurs with age, previous literature have consistently shown that women are more likely to be frail than men of the same age<sup>4–8</sup> and is significantly related to lifestyle choices like physical activity,

### CME Learning Objectives

After completing this enduring educational activity, the learner will be better able to:

- Investigate and outline the association between shift work exposure and frailty
- Assess the role of gender in the relationship between shift work exposure and proportion of frailty at three years of follow-up, among middle-aged and older age groups, utilizing Canadian Longitudinal Study on Aging
- Analyze the association between shift work exposure and proportion of frailty at three years of follow-up, among middle-aged and older adults, utilizing Canadian Longitudinal Study on Aging

healthy diet,<sup>1,9</sup> and sociodemographic factors such as poverty, educational level, marital status,<sup>9–12</sup> and participation in social organizations.<sup>13,14</sup>

Shift work (SW), which involves any work outside the regular daytime hours,<sup>15–17</sup> may significantly contribute to the development of frailty. A complete range of SW includes the following: (1) evening shift, (2) night shift, (3) rotating shift (day to evening and/or night), and (4) other less specified shifts including on-call or casual shift (no prearranged schedule) and irregular shifts.<sup>16,18–21</sup> In recent years, SW has risen globally. A significant proportion of Canadian employees (28%) work outside the regular daytime hours.<sup>16,17</sup> Despite being a social and economic need, SW has a negative impact on the well-being of work force. Growing evidence suggest that a wide range of negative

# 46 news stories, Reddit stories

## The Association Between Shift Work Exposure and Frailty Among Middle-Aged and Older Adults

Overview of attention for article published in Journal of Occupational & Environmental Medicine, October 2023



### ? About this Attention Score

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Rheumatology Advisor

### Shift Work Linked to Later Frailty

Rheumatology Advisor, 07 Apr 2023

HealthDay News — Shift work may play a role in developing later frailty, according to a study published online March 10 in the...



### Shift Work Tied to Later Frailty - News Azi

News Azi, 04 Apr 2023

Lori Solomon MONDAY, April 3, 2023 (HealthDay News) — Shift work may play a role in developing later frailty, according to a...

# Shift work

- A globalized 24-hour society - never shuts down
- Continuous services- security, emergency, production and supply



## What is shift work (SW)?

*“Any work outside the regular daytime hours(9am-5pm)”<sup>1</sup>*

A full spectrum of SW comprises:<sup>2</sup>

- Regular evening SW
  - after 3 p.m., ending before midnight
- Regular night SW
  - after 11 p.m., ending before 11 a.m.
- Rotating SW
  - day to evening and/or night
- On-call or casual shift (no pre-arranged schedule)
- Irregular shifts

# Prevalence of Shift work<sup>1,3</sup>

- One in every fourth Canadian is working in shifts other than regular daytime hours
- Two-third of protective service workers (police-officers, firefighters, and security guards)
- 45% of health workers,
- 40% of sales and service workers, and
- 42% of primary industry workers (i.e. farm workers, miners, forestry workers, etc.)

# Shift work and short term effects

- Sleep disorders<sup>6</sup>
- Accidents and work injuries <sup>7</sup>
- Mood disorders<sup>8</sup>

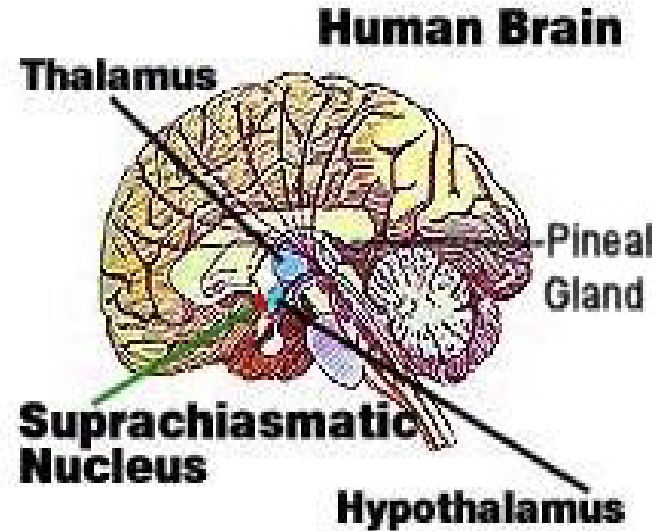
# Possible long term health effects related to shift work

- Physical health
  - CVD<sup>9</sup>
  - Diabetes<sup>10</sup>
  - Peptic ulcers<sup>11</sup>
  - Cancers<sup>12</sup>
- Social health issues<sup>1</sup>
- Mental health
  - Depression<sup>13</sup>
  - Mood disorders<sup>8</sup>



# How does the body work-The circadian timing system (CTS)<sup>4</sup>

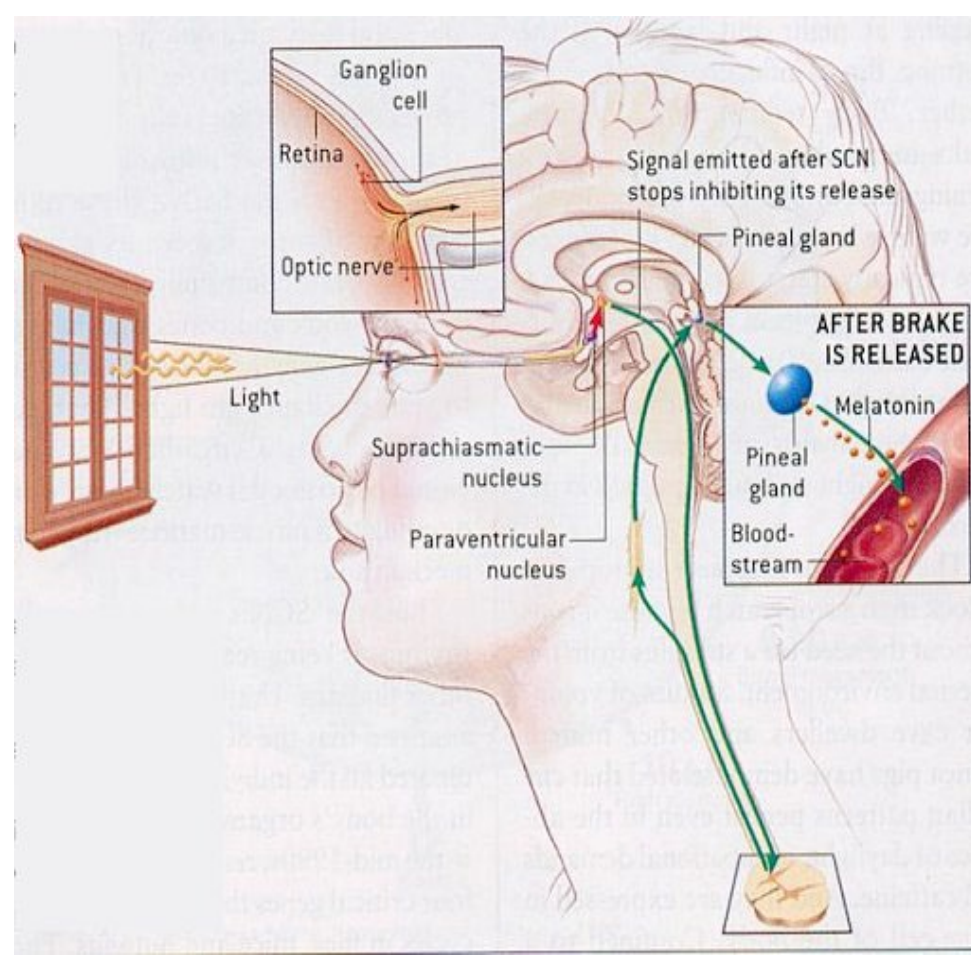
- Internal biological clock is located in the supra-chiasmatic nuclei in hypothalamus
- Internal and external factors synchronize us to a 24 hour day
- Any interference in regular circadian rhythm could result in disturbed metabolic, hormonal and inflammatory responses



**The human internal clock is the suprachiasmatic nuclei, located on each side of the hypothalamus.**

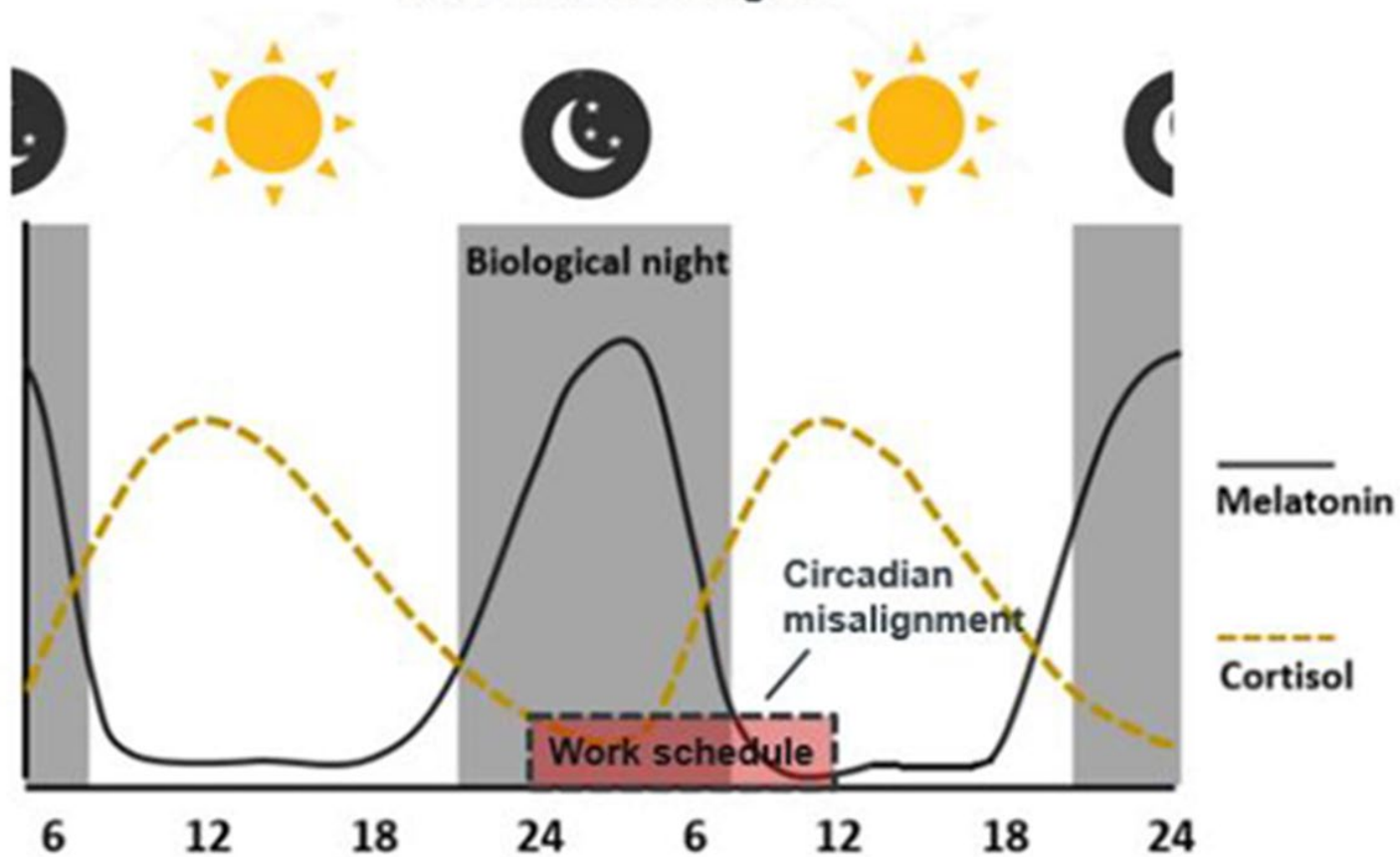
# Light/Dark Cycle

- Exposure to light at night can reduce circulating melatonin levels<sup>5</sup>
- If the light is bright, the levels can be completely suppressed
- Negative effects on health



# Circadian rhythms of melatonin and cortisol

## Circadian misaligned



# Behavioral factors

- Eating at irregular timings
- Low physical activity
- Higher incidence of smoking
- Higher intake of alcohol

Multiple pathways potentially explaining the link between shift work and adverse health outcomes

Rajaratnam SMW, Howard ME, Grunstein RR. Sleep loss and circadian disruption in shift work: Health burden and management. *Med J Aust.* 2013;199(8):S11-S15. doi:10.5694/mja13.10561



# International Commission on Occupational Health

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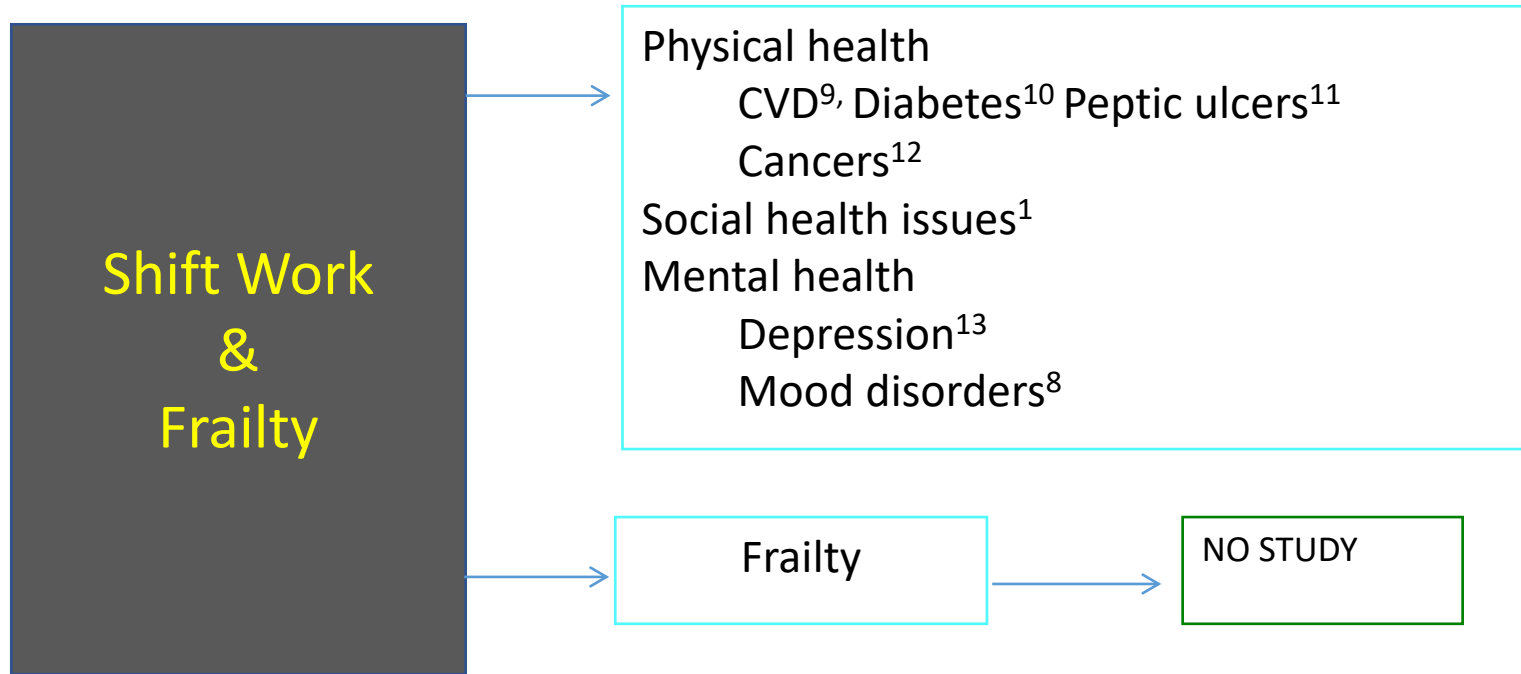
*Founded in 1906 as Permanent Commission*



A consensus statement-2019 stated; <sup>20</sup>

- Strong evidence linking shift work to CVD, gastrointestinal and metabolic disorders (type 2 diabetes; metabolic syndrome)
- Less consistent evidence linking shift work to mental health problems and reproduction-related problems

# Literature review SW and Frailty



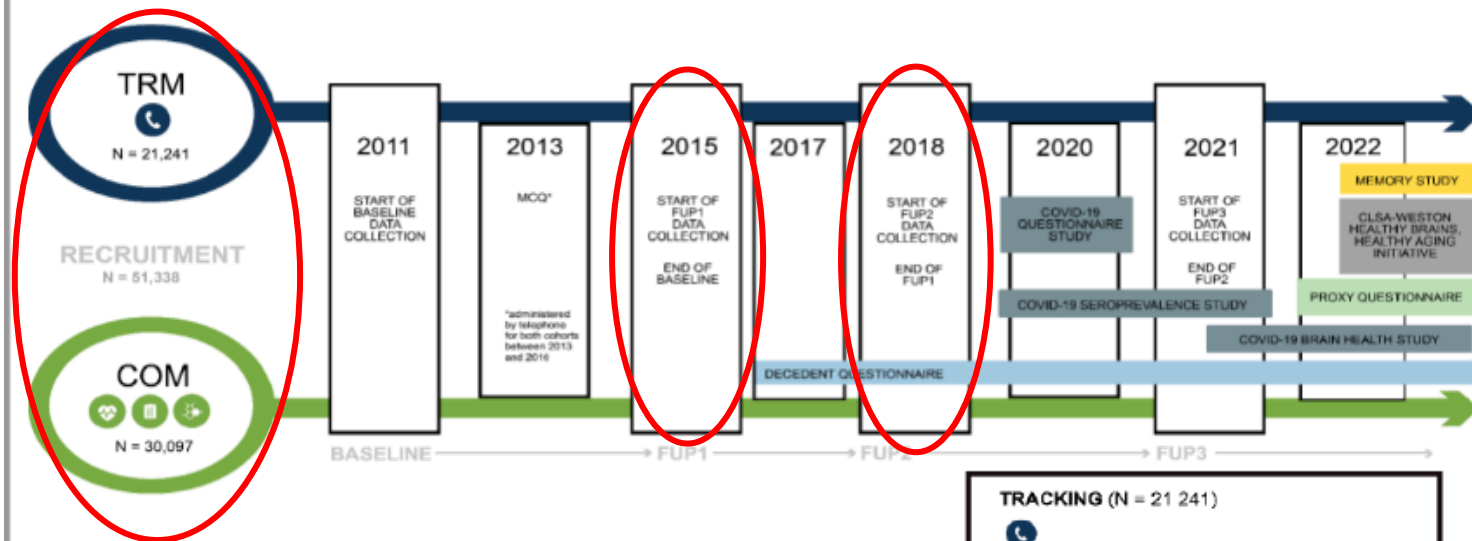
# Study objective

To investigate the associations between shift work exposure (SW) and Frailty among middle aged and older adults

# Methodology



# CLSA Data Collection



TRM - Tracking Cohort  
 COM - Comprehensive Cohort  
 MCQ - Maintaining Contact Questionnaire  
 FUP1 - Follow-Up 1  
 FUP2 - Follow-Up 2  
 FUP3 - Follow-Up 3

**TRACKING (N = 21 241)**

— Refers to data collected from the Tracking cohort via Computer Assisted Telephone Interviews (CATI)

**COMPREHENSIVE (N = 30 097)**

— Refers to data collected from the Comprehensive cohort via in-home interviews and assessments completed at CLSA Data Collection Sites (DCS)

# CLSA inclusion criteria

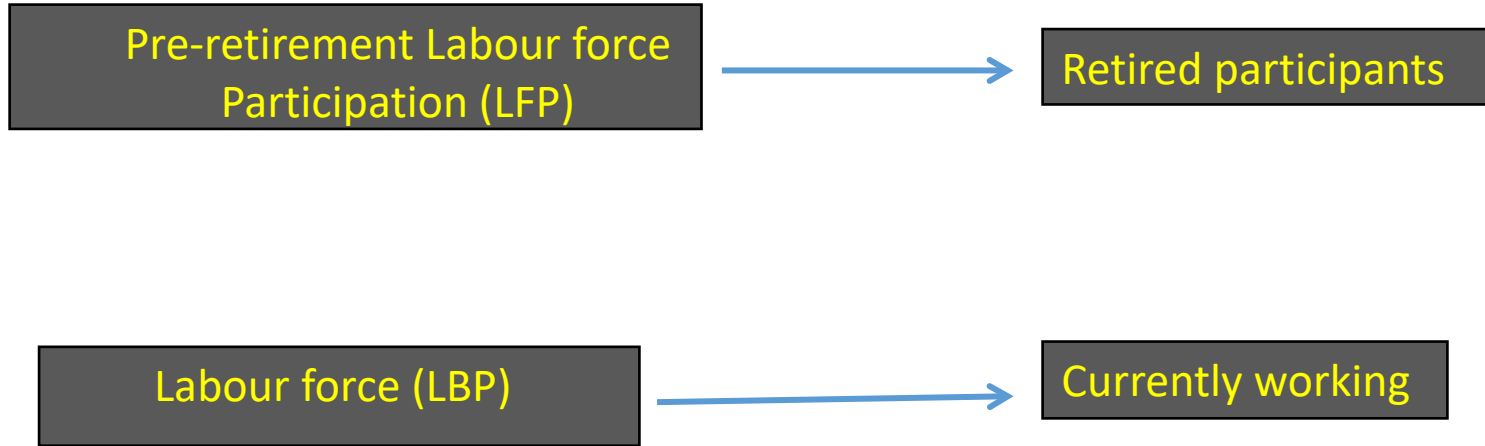
- Community dwelling
- Cognitively healthy, and
- Able to speak and understand English or French

# CLSA exclusion criteria

- Being a resident of a federal First Nations reserve or other First Nations settlements in the provinces
- Being a full-time member of the Canadian Armed Forces; and
- Not a permanent resident or Canadian citizen, and
- Individuals living in long-term care institutions (i.e., those providing 24-hour nursing care)

# Primary Exposure Shift Work (SW)

- CLSA Labour Force modules



# Three primary SW exposures

SW variables	Categories
1. Ever exposed to SW	Day time work (No) Reference group Exposed to any SW (Yes)
2. SW exposure in current job	Day time work(unexposed) Reference group Night SW Rotating SW
3. SW exposure in longest job	Day time work(unexposed) Reference group Night SW Rotating SW

# Frailty

*“Medical syndrome with multiple causes and contributors that is characterized by diminished strength, endurance, and reduced physiologic function that increases an individual’s vulnerability for developing increased dependency and/or death”*

Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. Lancet. 2013;381(9868):752-762. doi:10.1016/S0140-6736(12)62167-9

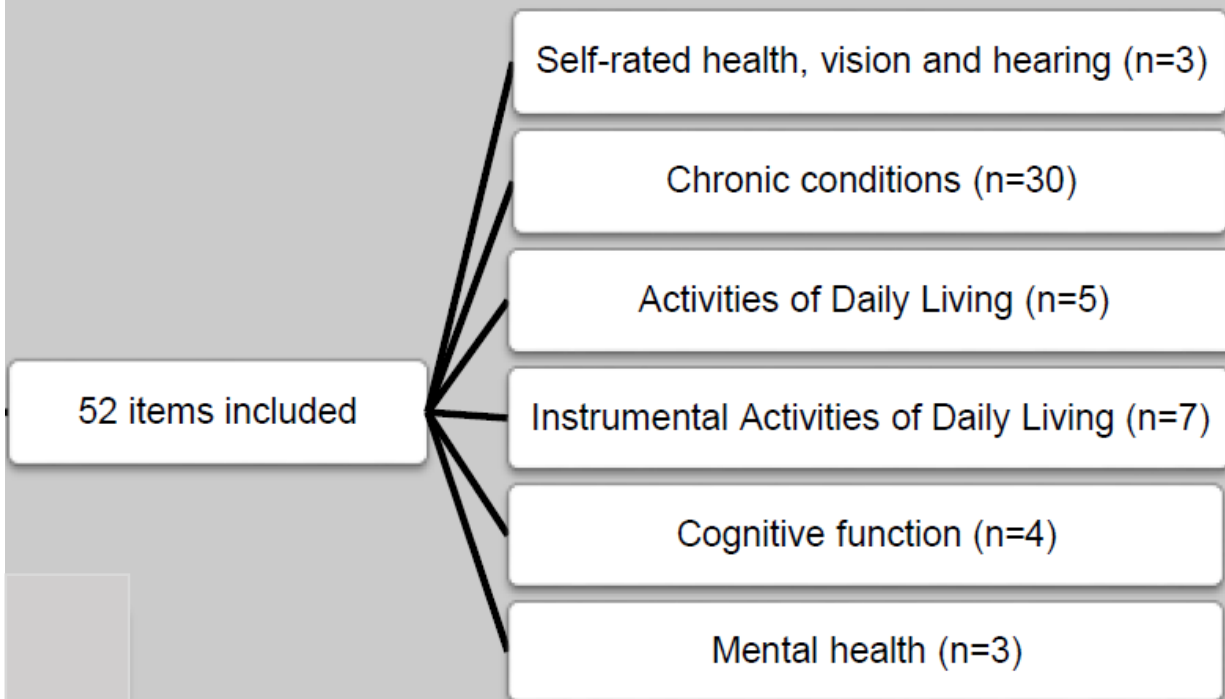
Fried LP, Tangen CM, Walston J, et al. Frailty in Older Adults: Evidence for a Phenotype. Journals Gerontol Ser A Biol Sci Med Sci. 2001;56(3):M146-M157. doi:10.1093/gerona/56.3.m146

# Frailty assessment

- Frailty index (FI)
  - Based on standard procedures (Accumulation of Deficits Model)
  - Recently applied by Pérez-Zepeda et al to create population-based normative frailty values for Canada utilizing CLSA data base

# Pooled data set

(Tracking+Comprehensive cohorts)





# Frailty assessment

- Total of 52 variables
- Transformed into a 0 (no deficit) to 1 (deficit) scale
- Interval or ordinal variables with more than two responses were coded as a fraction of the complete deficit

# Frailty assessment

To calculate each participant's FI score, we summed the deficits and divided that count by the total number of deficits measured, using the formula

$$FI = \frac{\textit{Number of deficits present on a determined individual}}{\textit{Number of deficits measured for that individual}}$$

# Classification of Frailty

- Continuous FI scores into the following categories
  - Robust/non frail ( $FI \leq 0.10$ )
  - Mild frail ( $FI > 0.10$  to  $FI < 0.20$ ) and
  - Frail ( $FI \geq 0.20$ )

# Example

	Number of deficits present	Total number of deficits considered	Frailty Index (FI)	Frailty category
1	15	52	$15/52=0.29$	Frail
2	7	52	$7/52=0.13$	Mild frail
3	4	52	$4/52=0.07$	Robust/non-frail

Robust/non frail ( $FI \leq 0.10$ )

Mild frail ( $FI > 0.10$  to  $FI < 0.20$ ) and

Frail ( $FI \geq 0.20$ )

# Study variables

## Independent variable

3 primary SW exposures

## Dependent variable

*Accumulation of Deficits Model*

*52 variables utilized*

*Frailty Index (FI)*

$$FI = \frac{\text{Number of deficits present on a determined individual}}{\text{Number of deficits measured for that individual}}$$

3 Categories

Robust/non frail (FI  $\leq$  0.10)

Mild frail (FI  $>$  0.10 to FI  $<$  0.20) and

Frail (FI  $\geq$  0.20)

## Covariates

### ➤ Socio-demographic & life style factors

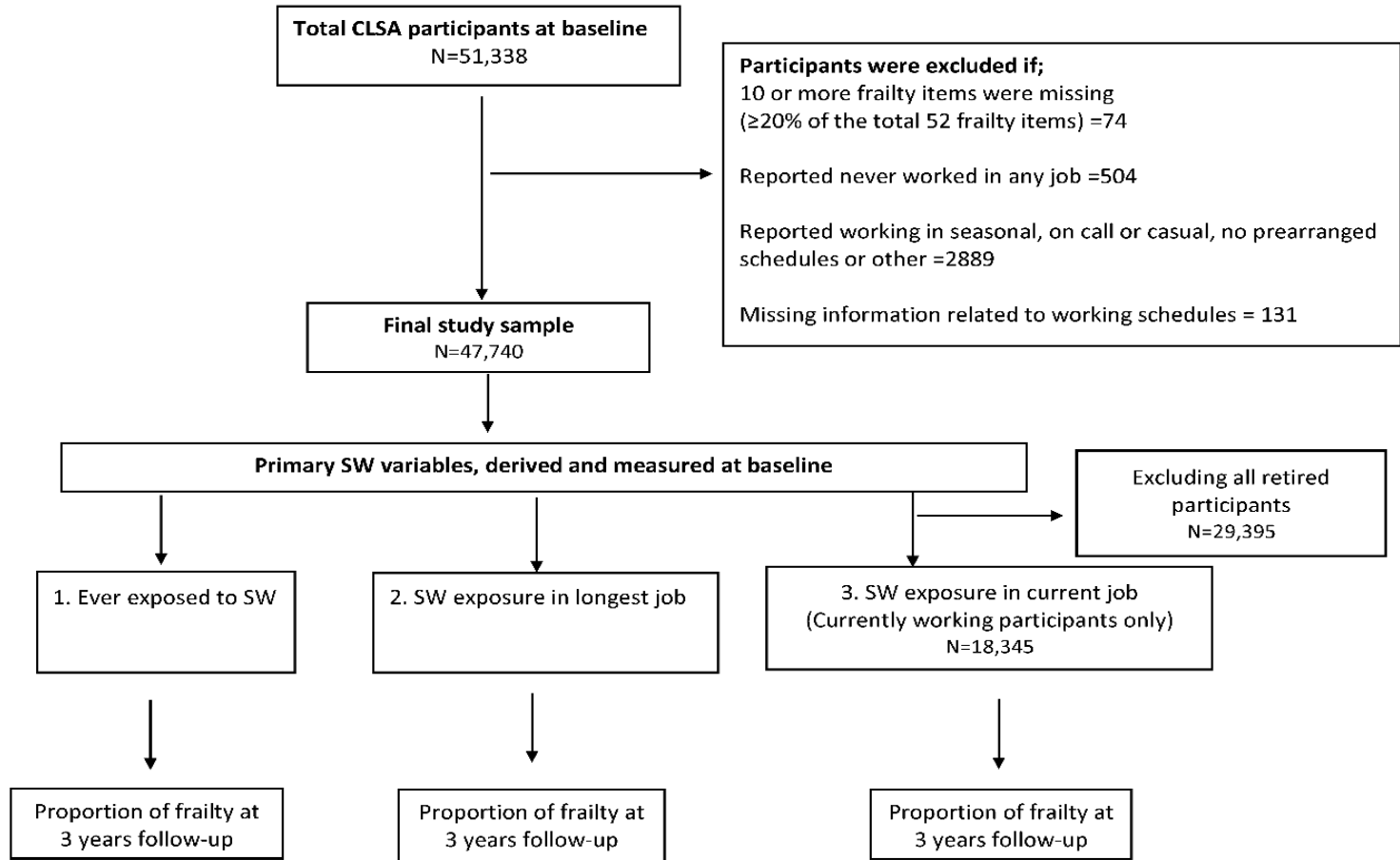
Sex, age, ethnicity, marital status, education, household income; and major lifestyle factors such as smoking, alcohol intake, retirement status and baseline frailty

### ➤ Health related factors

BMI

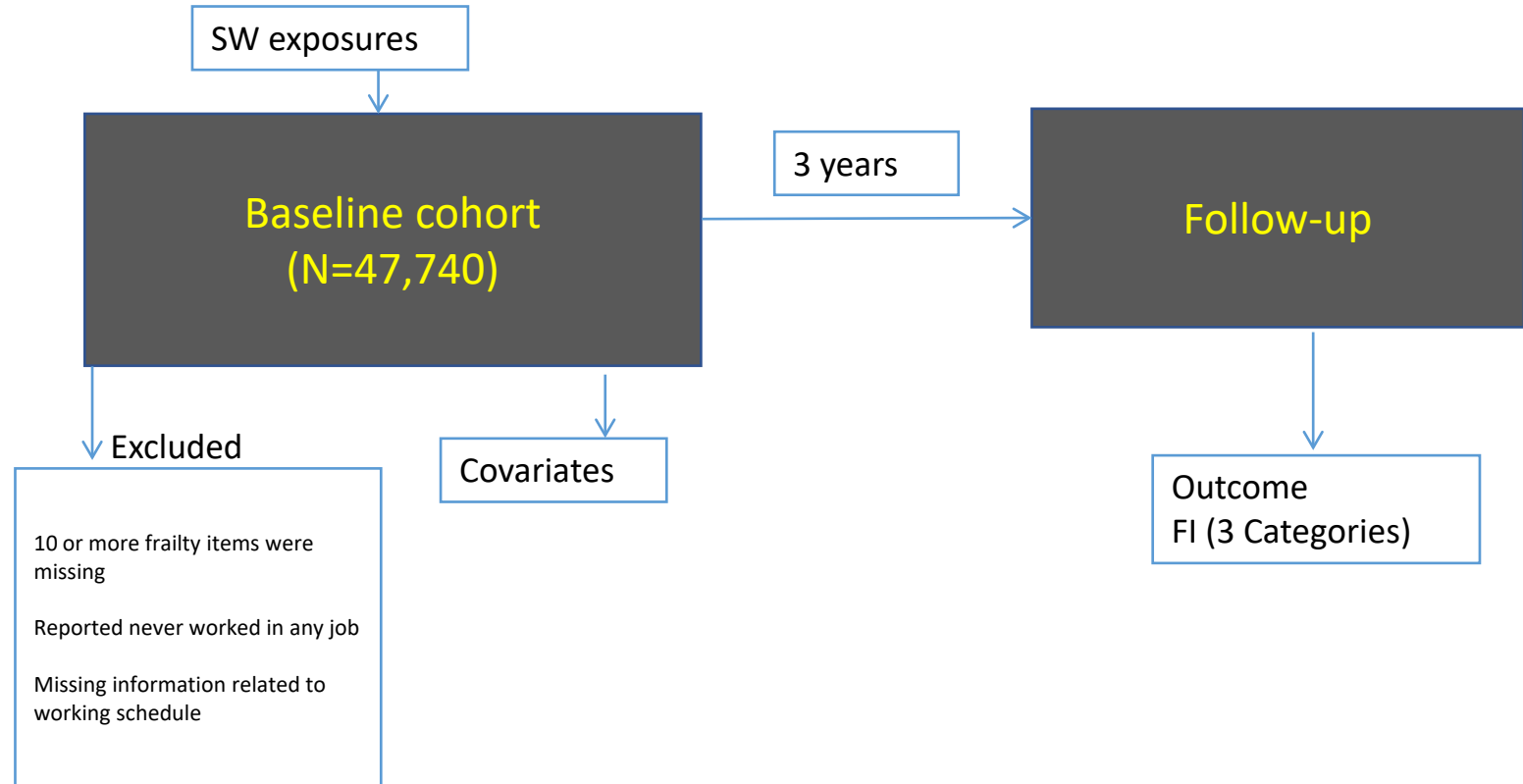
### ➤ Reproductive factors

Parity (number of pregnancies), history of hormone therapy, use of oral contraceptives, menopause classification

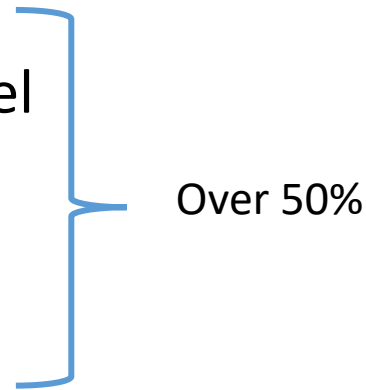


# Methodology

## Data source and study population



# Study sample characteristics



- Mean age at baseline → 59.7 years (SD 10.15)
  - Women → 51.4%
  - White → 95%
  
  - Reported to be living with partners
  - Having education of high school to some college level
  - Former smokers
  - Drinking at least weekly and
  - Had household income 50,000 CAD and above
- 
- Over 50%



# Study sample characteristics

- Ever exposed to SW → 21.1%
- Currently working population
  - 3.7% night SW
  - 11.6% rotating SW
- Longest job
  - 3.8% night SW
  - 15.6% rotating SW

# Analysis

- Multinomial regression models stratified on sex
  - Three separate models were generated for three primary SW exposures
- Odds ratios (ORs) and 95% Confidence Interval (CIs)
- ORs greater than 1            increase risk of frailty
- ORs less than 1            decrease risk of frailty

# Overall, at three years of follow-up

- 66.8% non frail/robust
- 26% as mild frail
- 7.2% as frail

**Table 5: Adjusted multinomial regression longitudinal models, odds ratios (ORs) and 95% Confidence Intervals(CI) for proportion of frailty at 3 years follow-up**

Primary SW exposures	Adjusted multinomial regression at 3 years follow-up			
	Male		Female	
	Mild frail OR <sup>a,b</sup> (95% CI)	Frail OR <sup>a,b</sup> (95% CI)	Mild frail OR <sup>a,c</sup> (95% CI)	Frail OR <sup>a,c</sup> (95% CI)
<b>Model 1</b>				
<b>Ever exposed to SW</b>				
Never exposed to SW (Daytime work only)	1.00	1.00	1.00	1.00
Ever exposed to SW	1.05 (0.91-1.21)	1.30 (1.01-1.68)*	1.16 (1.01-1.34)*	1.41 (1.09-1.83)*
<b>Model 2</b>				
<b>SW exposure in longest job</b>				
Not exposed to SW (Daytime work only)	1.00	1.00	1.00	1.00
Night SW	1.31 (0.93-1.86)	1.68 (0.95-2.97)	1.04 (0.77-1.40)	1.50 (0.92-2.45)
Rotating SW	1.02 (0.88-1.18)	1.29 (0.98-1.72)	1.28 (1.09-1.51)*	1.55 (1.17-2.07)*
<b>Model 3</b>				
<b>SW exposure in current job<sup>d</sup></b>				
Not exposed to SW (Daytime work only)	1.00	1.00	1.00	1.00
Night SW	1.33 (0.78-2.30)	1.08 (0.28-4.20)	1.14 (0.70-1.86)	1.49 (0.56-4.03)
Rotating SW	1.08 (0.82-1.43)	1.21 (0.62-2.62)	1.07 (0.82-1.40)	1.76 (0.87-3.61)

<sup>a</sup> The adjusted ORs and 95% CI were calculated using survey analytical weights.

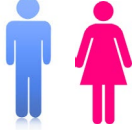

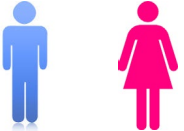
<sup>b</sup> Models are adjusted for age, ethnicity, marital status, income, education, retirement status, baseline frailty, smoking, alcohol, BMI categories

<sup>c</sup> Models are adjusted for age, ethnicity, marital status, income, education, retirement status, baseline frailty, smoking, alcohol, BMI categories, contraceptive use, parity, HRT, menopause classification

<sup>d</sup> For current job, only those participants were included who reported currently working (not retired) at baseline (N=18,345)

\*P value <0.05

# Summarizing main findings

- Ever exposed SW  → increase risk of frailty at 3 years of follow-up
- Rotating SW in longest job  → increase risk of frailty at 3 years of follow-up
- Current job  → No significant associations

# Patho-physiological basis of our findings

Impaired body levels of cortisol<sup>25</sup>

Increase pro- and anti-inflammatory proteins<sup>24</sup>

Plasma tumor necrosis factor-alpha (TNF- $\alpha$ )

Interleukin 10 (IL-10)

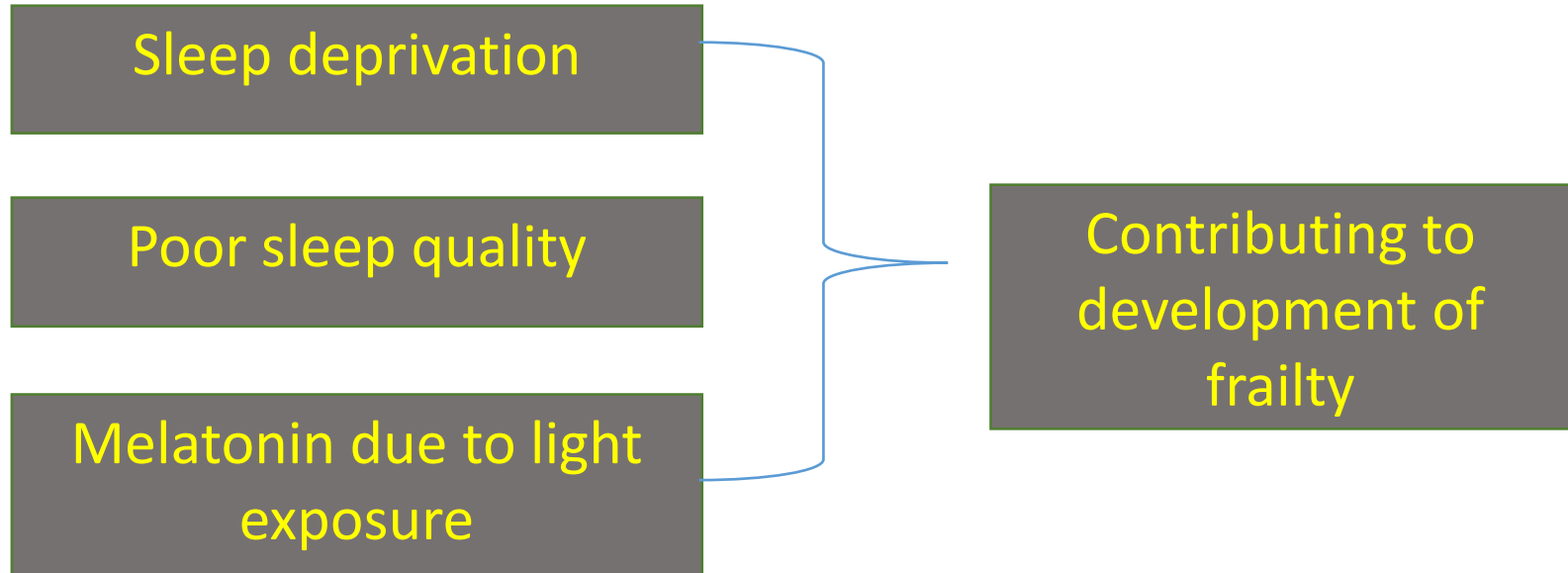
C-reactive protein (CRP)



Contribute to ongoing disease processes

Preliminary markers for occurrence of frailty

# Patho-physiological basis of our findings<sup>27,28</sup>



# Limitations

Unable to capture some SW related information,

- the type and direction of rotating shifts,
  - number of consecutive night shifts worked, and
  - the number of days off between shifts
- 
- Unable to capture the exact timing of occurrence of the exposure
  - Evening and night SW were pooled together
  - Generalizability of our findings (ethnicity 95% white)



# Strengths

- To our knowledge, it is the first study to investigate the associations between SW exposure and frailty
- Utilized large Canadian population based longitudinal data CLSA
- Current and retired Labour force data
- Both work schedules (night and rotating)
- Diverse group of Canadian workers
- CLSA questionnaire utilized standard measuring tools, compatible with other international surveys

# Significance and conclusion

- Considering gender when addressing frailty and targeting interventions in old age
- Modifiable factors of frailty like SW exposure among working populations is of clinical relevance, will assist in extending healthy active life expectancy
- Designing SW schedules that are less disruptive to the circadian rhythms

# Implications and future directions

- Education, counseling and health promotion
- Health surveillance and work-fitness evaluation
- Organization of shift scheduling
- Shift work regulations
- More research is needed with detailed information
  - Related to SW scheduling
  - Workplace and personal factors
  - Including extended follow-up periods

# Acknowledgements

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  - Hala Tamim
- Committee members
  - Michael Rotondi
  - Heather Edgell
- Co-author Chris Verschoor
- CLSA team for providing data base and all required support

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Thank you

Questions?