Associations between Shift Work and Empty Calorie Food/Beverage Consumption

BY

TING-TI LIN
B.S., National Defense Medical Center, 2007
M.S., National Taiwan University, 2012

THESIS

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Defense Committee:

Shannon N. Zenk, Chair and Advisor
Chang Park
Mary C. Kapella
Pamela Martyn-Nemeth
Lisa Tussing-Humphreys, College of Medicine
Kathleen M. Rospenda, Psychiatric Institute

This dissertation is dedicated to my family for their encouragement and support.

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SUMMARY

Unhealthy eating behaviors may be a pathway by which shift work increases risk of chronic diseases. Yet, most research has focused on the role of shift work in between-person differences in unhealthy eating behaviors. Recent studies have shown that variations in daily or momentary experiences for a person are related to that person's variations in eating behaviors. Therefore, the purpose of this dissertation was to examine the role of shift work in within-person fluctuations in eating behaviors, and specifically empty calorie food/beverage consumption. In studying these associations, I considered the complexity of shift work: shift timing, shift intensity, and shift speed. In addition, I tested whether these associations differed depending on daily sleep quality and duration.

I employed a 14-day intensive longitudinal study design with ecological momentary assessment. A convenience sample of 80 registered nurses working in Taiwanese hospitals was recruited. Participants' empty calorie food/beverage consumption was assessed with a 21-item food checklist. A registry-based work schedule was used to derive measures of shift work. Daily sleep quality and duration was assessed by the Core Consensus Sleep Diary and Actigraph GT3X, respectively. Multi-level mixed-effects regression models were used to test the hypotheses.

I found that working on night shifts versus day shifts was associated with greater intake of empty calorie foods and beverages. Greater night shift intensity was associated with the increased likelihood of sweetened beverage intake. Associations between the likelihood of sweetened beverage intake and shift timing or work shift intensity were stronger among participants assigned higher levels of shift speed. Daily poor sleep quality exacerbated positive associations between the likelihood of fried food/fast food intake and shift timing or shift speed.

SUMMARY (continued)

Shift work is unavoidable in certain types of industries (e.g., healthcare). Strategies to reduce unhealthy eating behaviors on night shifts and to improve sleep quality will be beneficial to shift workers’ eating behaviors and ultimately health.

1. INTRODUCTION

1.1 Background

To provide around-the-clock services, several industries (e.g., healthcare) employ shift work to extend their operational hours to “24/7”: 24 hours per day and 7 days per week (Tucker & Folkard, 2012). In general, shift work refers to work that requires workers to be on duty between 6:00 pm to 6:00 am (McMenamin, 2007). According to the 2015 National Health Interview Survey (NHIS) in the United States (U.S.) and the 2015 European Working Conditions Survey, shift workers accounted for approximately 20-25% of the workforce (Eurofound, 2015; National Center for Health Statistics, 2015).

Prior research has suggested that shift work is associated with increased likelihood of occupational stress (Buja et al., 2013; Coffey, Skipper, & Jung, 1988; Harada et al., 2005; Lin et al., 2015), fatigue (Dall'Ora, Ball, Recio-Saucedo, & Griffiths, 2016; Han, Trinkoff, & Geiger-Brown, 2014), occupational injuries (e.g., sprain/strain injury, car accidents) (Stimpfel, Brewer, & Kovner, 2015; Trinkoff, Le, Geiger-Brown, & Lipscomb, 2007), and poor work performance (Chang et al., 2011; Niu et al., 2013). Furthermore, a large body of literature has revealed that shift work is related to increased risk of chronic illnesses such as obesity (Peplonska, Bukowska, & Sobala, 2015; Sun et al., 2018; Zhao, Bogossian, & Turner, 2012), metabolic syndrome (Bedrosian, Fonken, & Nelson, 2016; Karlsson, Knutsson, & Lindahl, 2001; Korsiak, Tranmer, Day, & Aronson, 2018; Li, Sato, & Yamaguchi, 2011; Pietroiusti et al., 2010; Wang et al., 2014), cardiovascular disease (Manohar, Thongprayoon, Cheungpasitporn, Mao, & Herrmann, 2017; Vetter et al., 2016), and type 2 diabetes (Hansen, Stayner, Hansen, & Andersen, 2016; Pan, Schernhammer, Sun, & Hu, 2011).

Considerable research has been directed at identifying the mechanisms by which shift work increases chronic disease risk. One possible pathway is an imbalanced endocrine system. Exposure to artificial light at night and changed sleep-wake cycle may disrupt shift workers' circadian rhythm (i.e., a biological clock with a 24-hour cycle) (Bedrosian et al., 2016; Boivin & Boudreau, 2014; Czeisler et al., 1999), which affects balance of the endocrine system (e.g., the secretion of melatonin) and the autonomic nerve system, thus increasing risk of chronic diseases (Bedrosian et al., 2016; Korkmaz, Topal, Tan, & Reiter, 2009). Unhealthy eating behaviors may be another pathway by which shift work increases risk of chronic diseases (Bonham, Bonnell, & Huggins, 2016; Chang et al., 2017; Chang & Liao, 2015; McCarthy et al., 2006; O'Connor et al., 2015; Papier et al., 2017). A large body of evidence has suggested that shift work is associated with between-person differences in emotional eating behaviors (Almajwal, 2016; Wong, Wong, Wong, & Lee, 2010), defined as eating in response to emotional events (van Strien, Frijters, Bergers, & Defares, 1986), and increased empty calorie food/beverage consumption (Bonnell et al., 2017; de Assis, Kupek, Nahas, & Bellisle, 2003; Heath, Coates, Sargent, & Dorrian, 2016; Mashhadi, Saadat, Afsharmanesh, & Shirali, 2016; Tada et al., 2014; Tsai et al., 2014; Yoshizaki et al., 2018), defined as foods and beverages high in solid fats or added sugars and low in nutrients such as sugar-sweetened beverages or desserts (Guenther et al., 2013; Nicklas & O'Neil, 2015).

Recent studies have shown that people's empty calorie food/beverage consumption can vary day-to-day or moment-to-moment based on their exposures in the environment in real time (e.g., stress, shift work), suggesting that empty calorie food/beverage consumption may not only vary between persons but also within person (Elliston, Ferguson, Schuz, & Schuz, 2017;

Newman, O'Connor, & Conner, 2007; Niu et al., 2017; O'Connor, Conner, Jones, McMillan, & Ferguson, 2009; O'Connor, Jones, Conner, McMillan, & Ferguson, 2008; Richard, Meule, Reichenberger, & Blechert, 2017; Tremaine et al., 2013; Zenk et al., 2014). However, most of the literature has investigated the contribution of shift work to between-person variations in empty calorie food/beverage consumption. The contribution to within-person variations remains largely unexplored.

The concept of shift work is complex, and it contains several domains such as shift timing (i.e., day, evening, night, rotating shifts), shift intensity (e.g., number of consecutive work shifts), shift speed (e.g., number of days between two different shifts), shift regularity (e.g., changing shift timing periodically or irregularly), or direction of shift rotation (forward: day to evening to night shifts, or backward: night to evening to day shifts) (International Agency for Research on Cancer, 2007; Stevens et al., 2011). However, the majority of studies investigating associations between shift work and empty calorie food/beverage consumption has focused on the impacts of shift timing (e.g., differences in empty calorie food/beverage consumption between rotating shift workers and day workers or between night shift workers and day workers) (Mashhadi et al., 2016; Tada et al., 2014; Waterhouse, Buckley, Edwards, & Reilly, 2003; Yoshizaki et al., 2016; Yoshizaki et al., 2018). Evidence on other domains of shift work remains limited.

In addition, the conditions under which shift work increases empty calorie food/beverage consumption have not been adequately addressed in the literature. Several studies have revealed positive associations between both poor sleep quality (Ferranti et al., 2016; Heath, Dorrian, & Coates, 2019; Katagiri et al., 2014) and short sleep duration (i.e., less than seven hours per day) with empty calorie food/beverage consumption (Broussard et al., 2016; Dashti, Scheer, Jacques, Lamon-Fava, & Ordovas, 2015; Garaulet, Ordovas, & Madrid, 2010; Heath et al., 2012; Imaki, Hatanaka, Ogawa, Yoshida, & Tanada, 2002; Kant & Graubard, 2014; Martinez et al., 2017; McNeil et al., 2016; Nedeltcheva et al., 2009; Westerlund, Ray, & Roos, 2009). Poor sleep quality (Blumfield, Bei, Zimberg, & Cain, 2018) and short sleep duration (Smith, Ludy, & Tucker, 2016; Tasali, Chapotot, Wroblewski, & Schoeller, 2014) are associated with increased desire for empty calorie foods/beverages. Recent studies suggested that shift workers' sleep quality and sleep duration might vary day-to-day depending on their shift timing that day (i.e., day, evening, night). On days before working on evening shifts, sleep quality was better (Tremaine et al., 2013) and sleep duration was longer (Niu et al., 2017). Shift work and poor sleep quality may independently contribute to people's dietary intake (Heath et al., 2019). Therefore, it is possible that, on days with poor sleep quality or short sleep duration, associations between shift work and workers' empty calorie consumption will be exacerbated. However, the majority of the aforementioned studies has examined shift work and sleep problems in relation to empty calorie food/beverage consumption separately. To my knowledge, no study has examined whether these within-person associations are moderated by daily sleep quality or duration.

1.2 Purpose

Therefore, there are two purposes of this dissertation. The first purpose is to examine within-person associations between shift work and empty calorie food/beverage consumption, considering the complexity of shift work. The second purpose is to examine whether within-person associations between shift work and empty calorie food/beverage consumption are moderated by daily sleep behaviors (i.e., sleep quality, sleep duration).

1.3 Method

I employed a 14-day intensive longitudinal study design (Bolger & Laurenceau, 2013) with ecological momentary assessment (EMA). Irregular shift work patterns (i.e., a monthly work schedule includes day, evening, and night shifts, with no certain pattern for changes in shift timing) (Shiao & Hu, 2015) and empty calorie food/beverage consumption (Tsai et al., 2014) are common among registered nurses working in hospitals in Taiwan. Therefore, the target population was hospital nurses working on rotating shifts in Taiwan.

In terms of the measurement tools, I used registry-based work schedules to derive measures of three domains of shift work: timing, intensity, and speed. Over a two-week period, participants were prompted to complete surveys on a smartphone four times daily. Their empty calorie food/beverage consumption was assessed at each prompt with a 21-item food checklist created based on the top sources of empty calorie foods and beverages reported in the 2003-2006 National Health and Nutrition Examination Survey (NHANES) (Huth, Fulgoni, Keast, Park, & Auestad, 2013) and the 1993-1996 and 2005-2008 Nutrition and Health Survey in Taiwan (NAHSIT) (Wu, Pan, Yeh, & Chang, 2011). Sleep quality and duration were assessed with the Core Consensus Sleep Diary and Actigraph GT3X accelerometer, respectively.

Multi-level mixed-effects regression models were employed for data analysis. The within-person component captured how day-to-day changes in shift work for a person related to momentary variations in empty calorie food/beverage consumption, accounting for that person’s usual conditions of shift work across time. The moderating effects of sleep quality and duration were tested using multiplicative interactions between each aforementioned measure of shift work and sleep. Significant interactions suggested that within-person associations between shift work and empty calorie consumption differed depending on daily sleep quality or duration.

1.4 Overview of the Chapters

This dissertation is comprised of three chapters. This chapter (i.e., Chapter 1) serves as an introduction to the area of interest, research purpose and method. Chapter 2 addresses the first specific purpose: to examine within-person associations between shift work and empty calorie food/beverage consumption, considering the complexity of shift work. Chapter 3 addresses the second specific purpose: to examine whether sleep quality and duration moderate within-person associations between shift work and empty calorie food/beverage consumption.

1.5 Implications

There are several important implications of this dissertation. First, by employing an intensive longitudinal study design with ecological momentary method, the short-term within-person effects of shift work on shift worker's empty calorie food/beverage consumption can be determined. Second, by considering the complexity of shift work, it may help to identify the most hazardous shift patterns for rotating shift workers' empty calorie food/beverage consumption. Building upon this, recommendations can be provided to policy makers for future strategies in improving shift workers' eating behaviors. Additionally, by understanding the potential moderating effects of sleep, it helps to design interventions that may attenuate the adverse effects of shift work on shift workers' empty calorie food/beverage consumption.

References

Almajwal, A. M. (2016). Stress, shift duty, and eating behavior among nurses in Central Saudi Arabia. *Saudi Medical Journal, 37*(2), 191-198. doi:10.15537/smj.2016.2.13060

Bedrosian, T. A., Fonken, L. K., & Nelson, R. J. (2016). Endocrine Effects of Circadian Disruption. *Annual Review of Physiology, 78*, 109-131. doi:10.1146/annurev-physiol-021115-105102

Blumfield, M. L., Bei, B., Zimberg, I. Z., & Cain, S. W. (2018). Dietary disinhibition mediates the relationship between poor sleep quality and body weight. *Appetite, 120*, 602-608. doi:10.1016/j.appet.2017.10.022

Boivin, D. B., & Boudreau, P. (2014). Impacts of shift work on sleep and circadian rhythms. *Pathologie Biologie, 62*(5), 292-301. doi:10.1016/j.patbio.2014.08.001

Bolger, N., & Laurenceau, J. P. (2013). *Intensive longitudinal methods : an introduction to diary and experience sampling research*. New York, NY: Guilford Press.

Bonham, M. P., Bonnell, E. K., & Huggins, C. E. (2016). Energy intake of shift workers compared to fixed day workers: A systematic review and meta-analysis. *Chronobiology International, 33*(8), 1086-1100. doi:10.1080/07420528.2016.1192188

Bonnell, E. K., Huggins, C. E., Huggins, C. T., McCaffrey, T. A., Palermo, C., & Bonham, M. P. (2017). Influences on Dietary Choices during Day versus Night Shift in Shift Workers: A Mixed Methods Study. *Nutrients, 9*(3). doi:10.3390/nu9030193

Broussard, J. L., Kilkus, J. M., Delebecque, F., Abraham, V., Day, A., Whitmore, H. R., & Tasali, E. (2016). Elevated ghrelin predicts food intake during experimental sleep restriction. *Obesity (Silver Spring), 24*(1), 132-138. doi:10.1002/oby.21321

Buja, A., Zampieron, A., Mastrangelo, G., Petean, M., Vinelli, A., Cerne, D., & Baldo, V. (2013). Strain and health implications of nurses' shift work. *International Journal of Occupational Medicine and Environmental Health, 26*(4), 511-521. doi:10.2478/s13382-013-0122-2

Chang, H. C., Yang, H. C., Chang, H. Y., Yeh, C. J., Chen, H. H., Huang, K. C., & Pan, W. H. (2017). Morbid obesity in Taiwan: Prevalence, trends, associated social demographics, and lifestyle factors. *PloS One, 12*(2), e0169577. doi:10.1371/journal.pone.0169577

Chang, S. J., & Liao, W. C. (2015). Prevalence of and risk factors associated with metabolic syndrome among nurses. *Taiwan Journal of Public Health, 34*(3), 268-283. doi:10.6288/TJPH201534104003

Chang, Y. S., Wu, Y. H., Hsu, C. Y., Tang, S. H., Yang, L. L., & Su, S. F. (2011). Impairment of perceptual and motor abilities at the end of a night shift is greater in nurses working fast rotating shifts. *Sleep Medicine, 12*(9), 866-869. doi:10.1016/j.sleep.2011.03.018

Coffey, L. C., Skipper, J. K., & Jung, F. D. (1988). Nurses and shift work: Effects on job performance and job-related stress. *Journal of Advanced Nursing, 13*(2), 245-254. doi:10.1111/j.1365-2648.1988.tb01414.x

Czeisler, C. A., Duffy, J. F., Shanahan, T. L., Brown, E. N., Mitchell, J. F., Rimmer, D. W., . . . Kronauer, R. E. (1999). Stability, precision, and near-24-hour period of the human circadian pacemaker. *Science, 284*(5423), 2177-2181. doi:10.1126/science.284.5423.2177

Dall'Ora, C., Ball, J., Recio-Saucedo, A., & Griffiths, P. (2016). Characteristics of shift work and their impact on employee performance and wellbeing: A literature review. *International Journal of Nursing Studies, 57*, 12-27. doi:10.1016/j.ijnurstu.2016.01.007

Dashti, H. S., Scheer, F. A., Jacques, P. F., Lamon-Fava, S., & Ordovas, J. M. (2015). Short sleep duration and dietary intake: epidemiologic evidence, mechanisms, and health implications. *Advances in Nutrition, 6*(6), 648-659. doi:10.3945/an.115.008623

de Assis, M. A., Kupek, E., Nahas, M. V., & Bellisle, F. (2003). Food intake and circadian rhythms in shift workers with a high workload. *Appetite, 40*(2), 175-183. doi:10.1016/S0195-6663(02)00133-2

Elliston, K. G., Ferguson, S. G., Schuz, N., & Schuz, B. (2017). Situational cues and momentary food environment predict everyday eating behavior in adults with overweight and obesity. *Health Psychology, 36*(4), 337-345. doi:10.1037/hea0000439

Eurofound. (2015). *European Working Conditions Survey, Working Time.* Retrieved from https://www.eurofound.europa.eu/data/european-working-conditions-survey?locale=EN&dataSource=EWCS2016&media=png&width=740&question=y15_Q88&plot=euBars&countryGroup=linear&subset=agecat_3&subsetValue=All

Ferranti, R., Marventano, S., Castellano, S., Giogianni, G., Nolfo, F., Rametta, S., . . . Mistretta, A. (2016). Sleep quality and duration is related with diet and obesity in young adolescent living in Sicily, Southern Italy. *Sleep Science, 9*(2), 117-122. doi:10.1016/j.slsci.2016.04.003

Garaulet, M., Ordovas, J. M., & Madrid, J. A. (2010). The chronobiology, etiology and pathophysiology of obesity. *International Journal of Obesity (2005), 34*(12), 1667-1683. doi:10.1038/ijo.2010.118

Guenther, P. M., Casavale, K. O., Reedy, J., Kirkpatrick, S. I., Hiza, H. A., Kuczynski, K. J., . . . Krebs-Smith, S. M. (2013). Update of the Healthy Eating Index: HEI-2010. *Journal of the Academy of Nutrition and Dietetics, 113*(4), 569-580. doi:10.1016/j.jand.2012.12.016

Han, K., Trinkoff, A. M., & Geiger-Brown, J. (2014). Factors associated with work-related fatigue and recovery in hospital nurses working 12-hour shifts. *Workplace Health & Safety, 62*(10), 409-414. doi:10.3928/21650799-20140826-01

Hansen, A. B., Stayner, L., Hansen, J., & Andersen, Z. J. (2016). Night shift work and incidence of diabetes in the Danish Nurse Cohort. *Occupational and Environmental Medicine, 73*(4), 262-268. doi:10.1136/oemed-2015-103342

Harada, H., Suwazono, Y., Sakata, K., Okubo, Y., Oishi, M., Uetani, M., . . . Nogawa, K. (2005). Three-shift system increases job-related stress in Japanese workers. *Journal of Occupational Health 47*(5), 397-404. doi:10.1539/joh.47.397

Heath, G., Coates, A., Sargent, C., & Dorrian, J. (2016). Sleep Duration and Chronic Fatigue Are Differently Associated with the Dietary Profile of Shift Workers. *Nutrients, 8*(12), 771. doi:10.3390/nu8120771

Heath, G., Dorrian, J., & Coates, A. (2019). Associations between shift type, sleep, mood, and diet in a group of shift working nurses. *Scandinavian Journal of Work, Environment and Health*. doi:10.5271/sjweh.3803

Heath, G., Roach, G. D., Dorrian, J., Ferguson, S. A., Darwent, D., & Sargent, C. (2012). The effect of sleep restriction on snacking behaviour during a week of simulated shiftwork. *Accident Analysis and Prevention, 45 Suppl*, 62-67. doi:10.1016/j.aap.2011.09.028

Huth, P. J., Fulgoni, V. L., Keast, D. R., Park, K., & Auestad, N. (2013). Major food sources of calories, added sugars, and saturated fat and their contribution to essential nutrient intakes in the U.S. diet: Data from the National Health and Nutrition Examination Survey (2003-2006). *Nutrition Journal, 12*, 116. doi:10.1186/1475-2891-12-116

Imaki, M., Hatanaka, Y., Ogawa, Y., Yoshida, Y., & Tanada, S. (2002). An epidemiological study on relationship between the hours of sleep and life style factors in Japanese factory workers. *Journal of Physiological Anthropology and Applied Human Science, 21*(2), 115-120. doi:10.2114/jpa.21.115

International Agency for Research on Cancer. (2007). *Shiftwork.* Retrieved from http://monographs.iarc.fr/ENG/Monographs/vol98/mono98-8.pdf

Kant, A. K., & Graubard, B. I. (2014). Association of self-reported sleep duration with eating behaviors of American adults: NHANES 2005-2010. *American Journal of Clinical Nutrition, 100*(3), 938-947. doi:10.3945/ajcn.114.085191

Karlsson, B., Knutsson, A., & Lindahl, B. (2001). Is there an association between shift work and having a metabolic syndrome? Results from a population based study of 27,485 people. *Occupational and Environmental Medicine, 58*(11), 747-752. doi:10.1136/oem.58.11.747

Katagiri, R., Asakura, K., Kobayashi, S., Suga, H., Sasaki, S., & Diets, T. G. S. W. (2014). Low Intake of Vegetables, High Intake of Confectionary, and Unhealthy Eating Habits are Associated with Poor Sleep Quality among Middle-aged Female Japanese Workers. *Journal of Occupational Health, 56*(5), 359-368. doi:10.1539/joh.14-0051-OA

Korkmaz, A., Topal, T., Tan, D. X., & Reiter, R. J. (2009). Role of melatonin in metabolic regulation. *Reviews in Endocrine & Metabolic Disorders, 10*(4), 261-270. doi:10.1007/s11154-009-9117-5

Korsiak, J., Tranmer, J., Day, A., & Aronson, K. J. (2018). Sleep duration as a mediator between an alternating day and night shift work schedule and metabolic syndrome among female hospital employees. *Occupational and Environmental Medicine, 75*(2), 132-138. doi:10.1136/oemed-2017-104371

Li, Y., Sato, Y., & Yamaguchi, N. (2011). Shift work and the risk of metabolic syndrome: A nested case-control study. *International Journal of Occupational and Environmental Health, 17*(2), 154-160. doi:10.1179/107735211799030960

Lin, P. C., Chen, C. H., Pan, S. M., Chen, Y. M., Pan, C. H., Hung, H. C., & Wu, M. T. (2015). The association between rotating shift work and increased occupational stress in nurses. *Journal of Occupational Health, 57*(4), 307-315. doi:10.1539/joh.13-0284-OA

Manohar, S., Thongprayoon, C., Cheungpasitporn, W., Mao, M. A., & Herrmann, S. M. (2017). Associations of rotational shift work and night shift status with hypertension: A systematic review and meta-analysis. *Journal of Hypertension, 35*(10), 1929-1937. doi:10.1097/HJH.0000000000001442

Martinez, S. M., Tschann, J. M., Butte, N. F., Gregorich, S. E., Penilla, C., Flores, E., . . . Deardorff, J. (2017). Short Sleep Duration Is Associated With Eating More Carbohydrates and Less Dietary Fat in Mexican American Children. *Sleep, 40*(2). doi:10.1093/sleep/zsw057

Mashhadi, N. S., Saadat, S., Afsharmanesh, M. R., & Shirali, S. (2016). Study of association between beverage consumption pattern and lipid profile in shift workers. *Diabetes & Metabolic Syndrome, 10*(4), 227-229. doi:10.1016/j.dsx.2016.06.011

McCarthy, S. N., Robson, P. J., Livingstone, M. B., Kiely, M., Flynn, A., Cran, G. W., & Gibney, M. J. (2006). Associations between daily food intake and excess adiposity in Irish adults: Towards the development of food-based dietary guidelines for reducing the prevalence of overweight and obesity. *International Journal of Obesity (2005), 30*(6), 993-1002. doi:10.1038/sj.ijo.0803235

McMenamin, T. M. (2007). *A time to work: Recent trends in shift work and flexible schedules*. Retrieved from https://www.bls.gov/opub/mlr/2007/12/art1full.pdf.

McNeil, J., Doucet, E., Brunet, J. F., Hintze, L. J., Chaumont, I., Langlois, E., . . . Forest, G. (2016). The effects of sleep restriction and altered sleep timing on energy intake and energy expenditure. *Physiology and Behavior, 164*(Pt A), 157-163. doi:10.1016/j.physbeh.2016.05.051

National Center for Health Statistics. (2015). National Health Interview Survey (NHIS), 2015 Data Release. Retrieved from http://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_ Documentation/NHIS/2015/samadult_freq.pdf

Nedeltcheva, A. V., Kilkus, J. M., Imperial, J., Kasza, K., Schoeller, D. A., & Penev, P. D. (2009). Sleep curtailment is accompanied by increased intake of calories from snacks. *American Journal of Clinical Nutrition, 89*(1), 126-133. doi:10.3945/ajcn.2008.26574

Newman, E., O'Connor, D. B., & Conner, M. (2007). Daily hassles and eating behaviour: The role of cortisol reactivity status. *Psychoneuroendocrinology, 32*(2), 125-132. doi:10.1016/j.psyneuen.2006.11.006

Nicklas, T. A., & O'Neil, C. E. (2015). Development of the SoFAS (solid fats and added sugars) concept: The 2010 Dietary Guidelines for Americans. *Advances in Nutrition, 6*(3), 368S-375S. doi:10.3945/an.114.007021

Niu, S. F., Chu, H., Chen, C. H., Chung, M. H., Chang, Y. S., Liao, Y. M., & Chou, K. R. (2013). A comparison of the effects of fixed- and rotating-shift schedules on nursing staff attention levels: A randomized trial. *Biological Research for Nursing, 15*(4), 443-450. doi:10.1177/1099800412445907

Niu, S. F., Miao, N. F., Liao, Y. M., Chi, M. J., Chung, M. H., & Chou, K. R. (2017). Sleep Quality Associated With Different Work Schedules: A Longitudinal Study of Nursing Staff. *Biological Research for Nursing, 19*(4), 375-381. doi:10.1177/1099800417695483

O'Connor, D. B., Conner, M., Jones, F., McMillan, B., & Ferguson, E. (2009). Exploring the benefits of conscientiousness: An investigation of the role of daily stressors and health behaviors. *Annals of Behavioral Medicine, 37*(2), 184-196. doi:10.1007/s12160-009-9087-6

O'Connor, D. B., Jones, F., Conner, M., McMillan, B., & Ferguson, E. (2008). Effects of daily hassles and eating style on eating behavior. *Health Psychology, 27*(1S), S20-31. doi:10.1037/0278-6133.27.1.S20

O'Connor, L., Imamura, F., Lentjes, M. A., Khaw, K. T., Wareham, N. J., & Forouhi, N. G. (2015). Prospective associations and population impact of sweet beverage intake and type 2 diabetes, and effects of substitutions with alternative beverages. *Diabetologia, 58*(7), 1474-1483. doi:10.1007/s00125-015-3572-1

Pan, A., Schernhammer, E. S., Sun, Q., & Hu, F. B. (2011). Rotating night shift work and risk of type 2 diabetes: Two prospective cohort studies in women. *PLoS Medicine, 8*(12), e1001141. doi:10.1371/journal.pmed.1001141

Papier, K., D'Este, C., Bain, C., Banwell, C., Seubsman, S., Sleigh, A., & Jordan, S. (2017). Consumption of sugar-sweetened beverages and type 2 diabetes incidence in Thai adults: Results from an 8-year prospective study. *Nutrition & Diabetes, 7*(6), e283. doi:10.1038/nutd.2017.27

Peplonska, B., Bukowska, A., & Sobala, W. (2015). Association of Rotating Night Shift Work with BMI and Abdominal Obesity among Nurses and Midwives. *PloS One, 10*(7), e0133761. doi:10.1371/journal.pone.0133761

Pietroiusti, A., Neri, A., Somma, G., Coppeta, L., Iavicoli, I., Bergamaschi, A., & Magrini, A. (2010). Incidence of metabolic syndrome among night-shift healthcare workers. *Occupational and Environmental Medicine, 67*(1), 54-57. doi:10.1136/oem.2009.046797

Richard, A., Meule, A., Reichenberger, J., & Blechert, J. (2017). Food cravings in everyday life: An EMA study on snack-related thoughts, cravings, and consumption. *Appetite, 113*, 215-223. doi:10.1016/j.appet.2017.02.037

Shiao, S. C., & Hu, P. Y. (2015). *Mental Health Investigation and Prevention Strategies in Nurses*. New Taipei City: Institute of Labor, Occupational Safety And Health, Ministry of Labor. Retrieved from https://labor-elearning.mol.gov.tw/co_report_detail.php?rid=842.

Smith, S. L., Ludy, M. J., & Tucker, R. M. (2016). Changes in taste preference and steps taken after sleep curtailment. *Physiology and Behavior, 163*, 228-233. doi:10.1016/j.physbeh.2016.05.002

Stevens, R. G., Hansen, J., Costa, G., Haus, E., Kauppinen, T., Aronson, K. J., . . . Straif, K. (2011). Considerations of circadian impact for defining 'shift work' in cancer studies: IARC Working Group Report. *Occupational and Environmental Medicine, 68*(2), 154-162. doi:10.1136/oem.2009.053512

Stimpfel, A. W., Brewer, C. S., & Kovner, C. T. (2015). Scheduling and shift work characteristics associated with risk for occupational injury in newly licensed registered nurses: An observational study. *International Journal of Nursing Studies, 52*(11), 1686-1693. doi:10.1016/j.ijnurstu.2015.06.011

Sun, M., Feng, W., Wang, F., Li, P., Li, Z., Li, M., . . . Tse, L. A. (2018). Meta-analysis on shift work and risks of specific obesity types. *Obesity Reviews, 19*(1), 28-40. doi:10.1111/obr.12621

Tada, Y., Kawano, Y., Maeda, I., Yoshizaki, T., Sunami, A., Yokoyama, Y., . . . Togo, F. (2014). Association of body mass index with lifestyle and rotating shift work in Japanese female nurses. *Obesity (Silver Spring), 22*(12), 2489-2493. doi:10.1002/oby.20908

Tasali, E., Chapotot, F., Wroblewski, K., & Schoeller, D. (2014). The effects of extended bedtimes on sleep duration and food desire in overweight young adults: A home-based intervention. *Appetite, 80*, 220-224. doi:10.1016/j.appet.2014.05.021

Tremaine, R., Dorrian, J., Paterson, J., Neall, A., Piggott, E., Grech, C., & Pincombe, J. (2013). Actigraph estimates of the sleep of Australian midwives: The impact of shift work. *Biological Research for Nursing, 15*(2), 191-199. doi:10.1177/1099800411422249

Trinkoff, A. M., Le, R., Geiger-Brown, J., & Lipscomb, J. (2007). Work schedule, needle use, and needlestick injuries among registered nurses. *Infection Control and Hospital Epidemiology, 28*(2), 156-164. doi:10.1086/510785

Tsai, S. M., Wong, R. H., Hwang, S. L., Yang, H. C., Lin, Y. C., & Liao, W. C. (2014). A study relating shift work to the parameters of metabolic syndrome among nurses in a medical center. *Taiwan Journal of Public Health, 33*(2), 119-130. doi:10.6288/TJPH201433102110

Tucker, P., & Folkard, S. (2012). *Working time, health, and safety: A research synthesis paper.* Retrieved from http://www.ilo.org/travail/whatwedo/publications/WCMS_181673/lang--en/index.htm

van Strien, T., Frijters, J. E. R., Bergers, G. P. A., & Defares, P. B. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for Assessment of Restrained, Emotional, and External Eating Behavior. *International lournal of Eating Disorders, 5*(2), 295-315. doi:10.1002/1098-108X(198602)5:23.0.CO;2-T

Vetter, C., Devore, E. E., Wegrzyn, L. R., Massa, J., Speizer, F. E., Kawachi, I., . . . Schernhammer, E. S. (2016). Association Between Rotating Night Shift Work and Risk of Coronary Heart Disease Among Women. *JAMA, 315*(16), 1726-1734. doi:10.1001/jama.2016.4454

Wang, F., Zhang, L., Zhang, Y., Zhang, B., He, Y., Xie, S., . . . Tse, L. A. (2014). Meta-analysis on night shift work and risk of metabolic syndrome. *Obesity Reviews, 15*(9), 709-720. doi:10.1111/obr.12194

Waterhouse, J., Buckley, P., Edwards, B., & Reilly, T. (2003). Measurement of, and some reasons for, differences in eating habits between night and day workers. *Chronobiology International, 20*(6), 1075-1092. doi:10.1081/CBI-120025536

Westerlund, L., Ray, C., & Roos, E. (2009). Associations between sleeping habits and food consumption patterns among 10-11-year-old children in Finland. *British Journal of Nutrition, 102*(10), 1531-1537. doi:10.1017/S0007114509990730

Wong, H., Wong, M. C., Wong, S. Y., & Lee, A. (2010). The association between shift duty and abnormal eating behavior among nurses working in a major hospital: A cross-sectional study. *International Journal of Nursing Studies, 47*(8), 1021-1027. doi:10.1016/j.ijnurstu.2010.01.001

Wu, S. J., Pan, W. H., Yeh, N. H., & Chang, H. Y. (2011). Trends in nutrient and dietary intake among adults and the elderly: From NAHSIT 1993-1996 to 2005-2008. *Asia Pacific Journal of Clinical Nutrition, 20*(2), 251-265. doi:10.6133/apjcn.2011.20.2.15

Yoshizaki, T., Kawano, Y., Noguchi, O., Onishi, J., Teramoto, R., Sunami, A., . . . Togo, F. (2016). Association of eating behaviours with diurnal preference and rotating shift work in Japanese female nurses: A cross-sectional study. *BMJ Open, 6*(11), e011987. doi:10.1136/bmjopen-2016-011987

Yoshizaki, T., Komatsu, T., Tada, Y., Hida, A., Kawano, Y., & Togo, F. (2018). Association of habitual dietary intake with morningness-eveningness and rotating shift work in Japanese female nurses. *Chronobiology International, 35*(3), 392-404. doi:10.1080/07420528.2017.1410169

Zenk, S. N., Horoi, I., McDonald, A., Corte, C., Riley, B., & Odoms-Young, A. M. (2014). Ecological momentary assessment of environmental and personal factors and snack food intake in African American women. *Appetite, 83*, 333-341. doi:10.1016/j.appet.2014.09.008

Zhao, I., Bogossian, F., & Turner, C. (2012). Does maintaining or changing shift types affect BMI? A longitudinal study. *Journal of Occupational and Environmental Medicine, 54*(5), 525-531. doi:10.1097/JOM.0b013e31824e1073

2. ASSOCIATIONS BETWEEN SHIFT WORK AND EMPTY CALORIE FOOD/BEVERAGE CONSUMPTION

2.1 Background

2.1.1 Shift Work and Chronic Disease Risk

Shift workers account for one-fifth of working populations (Harrington, 2001; McMenamin, 2007). Referring to work that requires workers to be on duty outside the regular working hours (i.e., 6:00 a.m. to 6:00 pm) (McMenamin, 2007), shift work may adversely affect health by disrupting a person's circadian rhythm, or biological clock with an approximate 24-hour cycle that regulates the secretion of hormones and modulates human behaviors (Bedrosian, Fonken, & Nelson, 2016; Boivin & Boudreau, 2014; Czeisler et al., 1999). Specifically, it is thought that exposure to artificial light at night and a changed sleep-wake cycle may disrupt shift workers' circadian rhythm (Bedrosian et al., 2016). This may influence the secretion of melatonin, desynchronize appetite hormones (e.g., leptin, ghrelin), and imbalance the autonomic nervous system; thus, increasing chronic disease risk (Bedrosian et al., 2016; Korkmaz, Topal, Tan, & Reiter, 2009). Previous studies have found significant associations between shift work and chronic diseases such as obesity (Peplonska, Bukowska, & Sobala, 2015; Sun et al., 2018; Zhao, Bogossian, & Turner, 2012), metabolic syndrome (Bedrosian et al., 2016; Karlsson, Knutsson, & Lindahl, 2001; Li, Sato, & Yamaguchi, 2011; Pietroiusti et al., 2010; Wang et al., 2014), cardiovascular disease (Manohar, Thongprayoon, Cheungpasitporn, Mao, & Herrmann, 2017; Vetter et al., 2016), and type 2 diabetes (Hansen, Stayner, Hansen, & Andersen, 2016; Pan, Schernhammer, Sun, & Hu, 2011).

2.1.2 Eating Behaviors and Chronic Disease Risk

Eating behaviors are a key risk factor for the aforementioned chronic diseases (Chang & Liao, 2015; Chang, Liao, & Wang, 2017; O'Connor et al., 2015; Papier et al., 2017; Schwingshackl, Bogensberger, & Hoffmann, 2018; Schwingshackl & Hoffmann, 2015). Two systematic and meta-analysis reviews of cohort studies documented that better diet quality, defined as adherence to daily recommendation of food and nutrient intake, was significantly associated with reduced incidence of chronic illnesses (e.g., cardiovascular diseases, diabetes) (Schwingshackl et al., 2018; Schwingshackl & Hoffmann, 2015). On the other hand, research suggests that empty calorie food/beverage consumption contributes to the increased likelihood of the aforementioned chronic diseases (Chang et al., 2017; Chang & Liao, 2015; McCarthy et al., 2006; O'Connor et al., 2015; Papier et al., 2017). Empty calories refer to calories from solid fats or added sugars (e.g., sugar-sweetened beverages, desserts, and fried food), which have limited nutrients (Guenther et al., 2013; Nicklas & O'Neil, 2015). Top sources of solid fats and added sugars in the United States (U.S.) are sugar-sweetened beverages (e.g., soft drinks, soda, fruit drinks/-ades), candy, sugars, sugary foods, cakes, cookies, quick breads, pastries, pies, and milk desserts (Huth, Fulgoni, Keast, Park, & Auestad, 2013). Relatedly, the common food/beverage sources that provide “low nutrient density” in Taiwan are pastries/cookies (i.e., pastries, cookies, jelly, and puddings) and simple sugar (i.e., candy/chocolate, sweetened shaved ice desserts, sugary drink, and sugar-added processed juice) (Wu, Pan, Yeh, & Chang, 2011).

2.1.3 Daily Variation in Empty Calorie Food/Beverage Consumption

Prior research has shown that people’s eating behaviors, including empty calorie food/beverage or “snack food” consumption, vary day-to-day. For example, Flueckiger and colleagues (2017) conducted two intensive longitudinal studies (N = 292 in study 1 and N = 304 in study 2) to examine university students' variations in daily health behaviors. They found only 38-41% of the variation in snacking behaviors was between-person; the rest reflected within-person daily variation (Flueckiger, Lieb, Meyer, Witthauer, & Mata, 2017). People's experiences and exposures each day may contribute to these within-person daily differences (Dunton & Atienza, 2009; Elliston, Ferguson, Schuz, & Schuz, 2017; Newman, O'Connor, & Conner, 2007; O'Connor, Conner, Jones, McMillan, & Ferguson, 2009; O'Connor, Jones, Conner, McMillan, & Ferguson, 2008; Richard, Meule, Reichenberger, & Blechert, 2017; Zenk et al., 2014). For instance, studies have found exposures in the food environment (e.g., proximity to food outlets that predominately carry snack foods such as pastries and cakes) are associated with increased in-the-moment snack food intake (Elliston et al., 2017; Zenk et al., 2014). Additionally, people's experiences and exposures on a given day may influence their behaviors on the subsequent day (Cain, Filtness, Phillips, & Anderson, 2015; Zenk et al., 2014). For instance, an experimental study with a counter-balanced design (i.e., control and a simulated night shift) among 16 adults (8 women) found that participants consumed more high-fat foods on the following morning after being exposed to a simulated night shift (Cain et al., 2015). Thus, examination of contributors to within-person daily differences in consumption of empty calorie foods/beverages may provide new insights in developing personal strategies to improve people's empty calorie food/beverage consumption.

2.1.4 Shift Work, Abnormal Eating Behaviors and Empty Calorie Food/Beverage Consumption

Shift work may negatively influence eating behaviors (Nicholls, Perry, Duffield, Gallagher, & Pierce, 2017; Power, Kiezebrink, Allan, & Campbell, 2017). Some studies have shown that working on rotating shifts (i.e., changing shift timing within day, evening, and night shifts periodically) is associated with irregular meal timing and frequency (Han, Choi-Kwon, & Kim, 2016; Lowden, Moreno, Holmback, Lennernas, & Tucker, 2010; Nahm, Warren, Zhu, An, & Brown, 2012; Nea, Kearney, Livingstone, Pourshahidi, & Corish, 2015; Strzemecka, Bojar, Strzemecka, & Owoc, 2014; Yoshizaki et al., 2016). Some studies reported that people working four or more night shifts per month were more likely to engage in abnormal eating style such as emotional eating (Almajwal, 2016; Wong, Wong, Wong, & Lee, 2010), defined as eating in reaction to emotional events (van Strien, Frijters, Bergers, & Defares, 1986). Emotional eating behaviors are generally associated with greater energy-dense snack consumption (e.g., chocolate, cakes, biscuits, or pastries), particularly among women (Camilleri et al., 2014). This indicates that shift work may increase workers' emotional eating behaviors and consequently their consumption of energy-dense snacks.

A systematic and meta-analysis review suggested that food choice (i.e., what types of foods consumed) might be more important than energy intake (i.e., total daily calorie consumption) in shift workers' increased risk of chronic diseases (Bonham, Bonnell, & Huggins, 2016). Several studies reported positive associations between shift work and empty calorie food/beverage consumption. In animal studies, simulated shift work has been linked to changed diet preference (McDonald et al., 2013). Rats exposed to chronic photoperiod shifts (i.e., a changing light-dark schedule that has been employed to disrupt rats' circadian rhythm) (Craig & McDonald, 2008; Deibel, Hong, Himmler, & McDonald, 2014; McDonald et al., 2013) switched their diet preferences from complex to simple carbohydrates (McDonald et al., 2013). In human epidemiological studies, working on night shifts was associated with more energy-dense diets (Bonnell et al., 2017; Cain et al., 2015; Centofanti et al., 2018; Heath, Coates, Sargent, & Dorrian, 2016) and increased snack food intake (Waterhouse, Buckley, Edwards, & Reilly, 2003) compared to working on regular day shifts (i.e., only working during regular daytime hours). Relative to working on regular day shifts, working on non-day shifts (i.e., evening or night shifts) was related to higher intake of sweetened foods (de Assis, Kupek, Nahas, & Bellisle, 2003; Yoshizaki et al., 2018) and sweetened beverages (Mashhadi, Saadat, Afsharmanesh, & Shirali, 2016; Tada et al., 2014; Yoshizaki et al., 2018).

Regarding differences in people's food or beverage consumption between working days and off-duty days, findings remain inconsistent (An, 2016; Haines, Hama, Guilkey, & Popkin, 2003; Lennernas, Hambraeus, & Akerstedt, 1995; Orfanos et al., 2007; Waterhouse et al., 2003; Yang, Black, Barr, & Vatanparast, 2014). Lennernas et al. (1995) noted that workers' dietary intake from sucrose and saturated fat was lower on off-duty days than that on working days. Other studies found, on off-duty days, eating behaviors were less healthy and more empty calorie foods/beverages were consumed (An, 2016; Haines et al., 2003; Orfanos et al., 2007; Power et al., 2017; Yang et al., 2014). Waterhouse et al. (2003) reported that workers' decisions on food selection mainly depended on their appetites on off-duty days; while on working days, time availability accounted more. This suggests that workers' food/beverage consumption may vary between working and off-duty days.

2.1.5 Gaps in the Literature

Although prior studies have suggested shift work is associated with greater empty calorie food/beverage consumption, there are still gaps in the literature that hinder people's understanding of this association. The following sections will examine these gaps.

2.1.5.1 Broad Assessment of Shift Work

First, the assessment of shift work in previous studies that focused on empty calorie food/beverage consumption has been relatively broad and inconsistent (Nea et al., 2015). For instance, some studies compared empty calorie food/beverage consumption between regular night shift and regular day shift workers (Mashhadi et al., 2016; Waterhouse et al., 2003), whereas other studies only compared shift workers (i.e., having any non-daytime work) (Tada et al., 2014) or rotating shift workers (Roskoden et al., 2017; Yoshizaki et al., 2016; Yoshizaki et al., 2018) to regular day shift workers. Additionally, some studies compared food consumption between regular day, evening, and night shift workers (de Assis et al., 2003).

A report from the International Agency for Research on Cancer (IARC) working group recommended that research on shift work and health should consider the complexity of shift work (e.g., shift timing, shift intensity, shift speed, regularity of shift) (Stevens et al., 2011). Shift work can be classified according to shift timing as evening shifts, night shifts, rotating shifts (Hall, Franche, & Koehoorn, 2018; McMenamin, 2007; Smith, Folkard, Tucker, & Macdonald, 1998), split shifts (i.e., working in two distinct periods per day) (McMenamin, 2007; Smith et al., 1998), and employer-arranged irregular schedules (i.e., no certain rules for changes in shift timing) (McMenamin, 2007). Taking the length of shift cycle into account, shift intensity is mainly assessed with the number of consecutive working days. Relatedly, more than four consecutive night shifts are considered as a high intensity of night shifts (Harma et al., 2015). The definition of shift speed (i.e., how often the shift timing changes, e.g., from day to evening shifts) is inconsistent in prior literature. According to IARC (2007) rotating shifts can be roughly classified as fast (i.e., changing shift timing every 1- 3 days), intermediate (i.e., changing shift timing every 7 days), or slow (i.e., changing shift timing every 10 days or less frequently). Considering both shift timing and speed within a 2-week period, shift schedules can be categorized as regular day, regular evening, regular night, slow frequency rotating (i.e., up to 1-shift change), medium frequency rotating (i.e., 2-3 shift changes, e.g., a shift timing pattern of day, evening, day would be counted as two shift changes), or rapid frequency rotating shifts (i.e., 4 or more shift changes) (Hall et al., 2018).

A cross-sectional study of 11,450 Canadian registered nurses demonstrated that employing a high-precision assessment of shift work (i.e., considering both shift timing and speed) might obtain better estimations of relationships between shift work and adverse health outcomes compared to moderate-precision (i.e., considering shift timing only) or low-precision assessments of shift work (i.e., regular day shifts versus non-daytime shifts) (Hall et al., 2018). Results from this study showed that the likelihood of depression was 0.99 for rotating shift workers compared to regular day shift workers. However, when examining shift work patterns in greater detail, the likelihoods of depression for rapid frequency, medium frequency, and slow frequency rotating shift workers were 1.51, 1.00, and 0.79, respectively, compared to regular day workers. This demonstrates that considering the complexity of shift work is critical to understanding the impact of shift work on health.

In sum, due to the heterogeneity of the assessment of shift work, there is still insufficient evidence on associations between shift work and empty calorie food/beverage consumption. Further, to date, no studies that have examined associations between shift work and empty calorie food/beverage consumption have taken into account the complexity of shift work.

2.1.5.2 Between-person Effects of Shift Work

The second gap in the literature is that prior research has focused on the role of shift work in between-person differences in empty calorie food/beverage consumption (Mashhadi et al., 2016; Tada et al., 2014; Tsai et al., 2014; Yoshizaki et al., 2018). An individual's decisions about empty calorie food/beverage consumption (e.g., what to eat) can change daily or momentarily based on their exposures that day (Dunton & Atienza, 2009; Elliston et al., 2017; Newman et al., 2007; O'Connor et al., 2009; O'Connor et al., 2008; Richard et al., 2017; Zenk et al., 2014), or the previous day (Cain et al., 2015; Zenk et al., 2014). This indicates it is possible that a person's empty calorie food/beverage consumption differs depending on their shift work that day or the previous day. Yet, no study has examined how changes in shift work relate to within-person fluctuations in empty calorie food/beverage consumption.

2.1.6 Study Purpose and Hypotheses

Building on this prior research and addressing these gaps in the literature, the purpose of this study was to examine contributions of shift work to within-person variations in empty calorie food/beverage consumption using an intensive longitudinal study design (Bolger & Laurenceau, 2013) with ecological momentary assessment (EMA). Four hypotheses on within-person associations were tested: (H1a) On days when working evening or night shifts, empty calorie food/beverage consumption will be higher compared to days when working day shifts. (H1b) Empty calorie food/beverage consumption will significantly differ on off-duty days compared to day shifts; (H2) On days when working evening or night shifts, empty calorie food/beverage consumption will be higher on the subsequent day compared to days when working day shifts; (H3a) Work shift intensity will be positively associated with increased consumption of empty calorie foods/beverages. (H3b) A high level of night shift intensity will be associated with increased consumption of empty calorie foods/beverages; and (H4) A higher level of shift speed (i.e., slow versus medium/rapid shift speed) will exacerbate the positive associations between empty calorie food/beverage consumption and shift timing (see H1) or shift intensity (see H3).

2.2 Methods

2.2.1 Sample

Irregular shift work patterns (e.g., varying number of consecutive night shifts) are common for nurses working in hospitals in Taiwan (Shiao & Hu, 2015). Research has also shown that the consumption of empty calorie foods/beverages is prevalent among Taiwanese registered nurses working in the hospital (63.6-79.2%) (Chang & Liao, 2015; Tsai et al., 2014). To this end, for this study, a convenience sample of registered nurses working in the Taiwan accredited hospitals (Ministry of Health and Welfare, 2017) was recruited using electronic flyers shared on social media platforms (e.g., Facebook).

Inclusion criteria were as follows: (1) Taiwanese registered nurse working full-time (i.e., 40 hours per week), (2) aged 20-65 years old, (3) working on rotating shifts (i.e., a monthly work schedule including at least two shift timings such as day and evening shifts) in the hospital for at least six months and in the next 30 days, and (4) no intention to leave the nursing profession in the next month. Exclusion criteria were: (1) having no smartphone or having a smartphone without access to Internet services, (2) unwilling or unable to provide registry-based work schedule, (3) working in an administrative position such as Dean, Associate Dean, Director of Nursing Supervisor, or Head Nurse, and (4) pregnant.

The within-person effects of shift work on empty calorie food/beverage consumption were the main interest in this study. Therefore, I used the Gpower program with the option of within-between associations to estimate the targeted sample size. The settings for sample size calculation included: (1) power level (β) at 0.80, (2) significance level (α) at 0.05 (two-tailed), (3) three groups (i.e., day-, evening-, and night-shift), (4) a small effect size of 0.13 (Cohen, 1988), and (5) 14 for the number of repeated measures. Given the limited evidence of within-person variations in momentary (within-daily) empty calorie food/beverage consumption by shift timing, the estimated total sample size of 63 persons was based on the day-level findings in the literature (de Assis et al., 2003; Flueckiger et al., 2017).

Eighty registered nurses working in hospitals in Taiwan were recruited between October 2018 and January 2019. One participant dropped out of the study before the first EMA survey was sent, resulting in a sample size of 79 persons (person level), 971 person-days (day level), and 2,491 observations from EMA surveys (moment level). The EMA survey response rate, defined as a percentage of initiated EMA surveys out of the total possible EMA surveys over the two weeks, was 56.3%. Because the main interest was within-person associations between shift work and empty calorie food/beverage consumption, I excluded participants with an EMA response rate of less than 10% (i.e., less than six completed EMA surveys) or with less than 10% of possible valid EMA survey days, defined as completing less than two daily EMA surveys. As a result, the analytic sample comprised 77 participants. Only EMA surveys with complete data in outcome variables (i.e., empty calorie food/beverage consumption) and covariates (e.g., emotions) were included in the analysis. The detailed information related to data exclusion is displayed in Appendix A (see Figure A-1).

2.2.2 Study Design and Procedure

This is an intensive 14-day longitudinal study (Bolger & Laurenceau, 2013) using EMA with three phases: baseline visit, consecutive 14-day EMA data collection period, and post visit (approximately two weeks after the baseline survey). After a participant agreed to participate in the study, an in-person meeting for the baseline survey was scheduled.

During the baseline survey visit, I (1) explained the purpose of the study and the study protocol, (2) obtained written informed consent, (3) administered a baseline questionnaire covering the following topics: demographics, body mass index (BMI), eating style, chronotype, occupational history, and work characteristics, (4) provided instructions for EMA surveys, and (5) collected the self-printed published work schedule during the past 30 days and the prospective work schedule for the next 30 days.

During the 14-day EMA data collection period, empty calorie food/beverage intake, work schedule, and potential confounders (e.g., emotions) were collected using the EMA surveys. Participants were signaled to complete the EMA survey using a provided survey link by either text message or e-mail four times per day at random during the following time blocks: 3:00-9:00 a.m., 9:00 a.m.-3:00 p.m., 3:00-9:00 p.m., and 9:00 p.m.-3:00 a.m. On average, each EMA survey took approximately 3-5 minutes. Based on a participant's anticipated shift schedule and wake-sleep pattern, these four time blocks were adjusted as required (i.e., participants only received signals during their waking time). Most survey signals were sent by a text message, with a text reminder every 15 minutes if there was no response from the participant. The survey was available for an hour after the initial text message was sent. If the participant did not complete the survey within an hour, the survey was closed and recorded as missing. Due to an unforeseen technical problem in which the messaging system had regular maintenance downtime each day from 1:00 to 4:00 p.m. local time, a secondary system was employed. Specifically, if the sampled EMA time was during this 3-hour window, an email survey signal was sent using this secondary system. For participants who had not responded to the survey for more than two days, I contacted them in case there were technical issues.

During the post visit, I administered a post survey related to changes in shift schedules over the prior two weeks, and provided an incentive for their participation, up to approximately USD 30 in cash. Participants received USD 3 for completing the baseline survey, USD 10 for completing any EMA survey, USD 2 for completing the post survey, and a bonus of USD 10 for completing 80% of the EMA surveys. If they completed 100% of the EMA surveys, the bonus was USD 15. This study was approved by the Institutional Review Boards (IRB) at the University of Illinois at Chicago and National Taiwan University Hospital.

2.2.3 Measures

2.2.3.1 Shift Work

Three domains of shift work were assessed: shift timing, shift intensity, and shift speed. These were obtained through the published work schedules (i.e., a printed work schedule that recorded participants' actual shift schedule) that were collected during the baseline visit. Shift timing was a day-level measure and was assessed based on the time when a participant started their work shift (i.e., day, evening, night, and off-duty) (Hall et al., 2018; McMenamin, 2007; Smith et al., 1998), documented on the published work schedule. However, the definitions of days working on night shifts were inconsistent in different hospitals. To be consistent, I operationally defined night shifts as days with working hours covering midnight through 8:00 a.m.

Shift intensity was assessed with two day-level measures: the number of consecutive work shifts and the number of consecutive night shifts (Harma et al., 2015), based on the published work schedule. The number of consecutive work shifts is referred to "work shift intensity" and was measured daily by retrospectively counting the total number of consecutive work shifts (including all day, evening, night shifts) over the two weeks. For example, if a participant had been working for six work shifts and did not have any off-duty day during this period, then work shift intensity that day was recorded as six. Any off-duty day stopped the accumulation of work shift intensity and was considered as a day with a work shift intensity of "0". Work shift intensity was treated as a continuous variable in the analysis.

The number of consecutive night shifts is referred to as "night shift intensity". The measurement was similar to work shift intensity except I retrospectively counted the total number of consecutive night shifts over the two weeks. Approximately 80% of person-day observations had no consecutive night shift and less than 3% of person-day observations had four or more consecutive night shifts. Therefore, night shift intensity was dichotomized as <=2 and > 2 consecutive night shifts based on a prior study (Harma et al., 2018). In that study, there were significant within-person associations between working for more than two consecutive night shifts and fatigue during work and off-duty days. Therfore, days with more than two consecutive night shifts were considered days with a high level of night shift intensity.

Shift speed was a person-level measure and was assessed based on the published work schedule by evaluating how many changes in shift timing a participant had within a month period. Since there was no consistency in the categorization of shift speed in the literature, and the majority of participants worked on rotating shifts with irregular patterns, I categorized participants' shift speed based on Hall et al.'s (2018) (a national survey among Canadian nurses) schema (i.e., one change: from days to evenings, two changes: from days to evenings, then from evenings to nights, or from evenings to days): slow (i.e., up to 1 change in shift timing in the past two weeks prior to the first EMA survey), medium (i.e., 2-3 changes in shift timing in the past two weeks prior to the first EMA survey), and rapid (i.e., four or more changes in shift timing in the past two weeks prior to the first EMA survey). Due to low prevalence rates of rapid shift speed (approximately 8%), I combined the medium and rapid shift speed categories together in the analysis.

2.2.3.2 Empty Calorie Food/Beverage Consumption

Consumption of empty calorie foods/beverages was assessed four times per day with a 21-item checklist based on the following question: "*Since the last signal, have you consumed or used any of the following items? (Please check all that apply).*" The 21-item food checklist was created based on the top sources of empty calorie foods/beverages reported in the 2003-2006 National Health and Nutrition Examination Survey (NHANES) (Huth et al., 2013), the 1993-1996 Nutrition and Health Survey in Taiwan (NAHSIT), and the 2005-2008 NAHSIT (Wu et al., 2011). Items in the food checklist were as follows: *"fried food/fast food (e.g. fries, fried chicken),* *candy, chocolate, cookies, brownies, doughnuts, cakes, pastries, pies, jelly, puddings, sweetened shaved ice desserts or ice cream, popcorn, salty snacks (e.g., chips), carbonated beverages (e.g., soda, Coke), sugar-added processed juice, lactic acid drinks (e.g., Bifido, Yakult), sports drinks (e.g., Supau, Pocari), instant powered drinks (e.g., Nestea, Matcha), chocolate beverages (e.g., Milo, Ovaltine), and tea (e.g., green tea, black tea, oolong tea, milk tea).*" If a participant indicated tea consumption, they were further asked if they added any of the following items: *"self-added sugar or honey, added toppings (e.g., tapioca, mixed jelly, herbal jelly, pudding), pre-sweetened tea, or other*".

Based on the food/beverage items listed in the food frequency questionnaire employed in the NAHSIT (Lo et al., 2017), the aforementioned 21 food/beverage items were grouped into the following four food categories: fried food/fast food, sweetened snacks (i.e., candy, chocolate, cookies, brownies, doughnuts, cakes, pastries, pies, jelly, puddings, sweetened shaved ice desserts or ice cream, popcorn), salty snacks, and sugar-sweetened beverages (i.e., carbonated beverages, sugar-added processed juice, lactic acid drinks, sports drinks, instant powered drinks, chocolate beverages, and tea with added-sugar and/or toppings). Each food category was analyzed as a separate outcome variable. Because of the right skewed distributions of empty calorie food/beverage consumption, I dichotomized these variables as none and at least one. Because salty snack consumption was reported in less than 5% of the surveys, sweetened snack and salty snack consumption were combined as sweet or salty snack food consumption in the analysis. In addition, I also examined the overall empty calorie food/beverage consumption, calculated by summing the total count of reported food/beverage items on the list within an EMA survey.

2.2.3.3 Covariates

2.2.3.3.1 Time-varying Covariates

The time-varying covariates in this study included emotions, experienced stress, daily working hours, number of completed EMA surveys per day (ranging from one to four), and the sequence of EMA survey day (i.e., the 1st, the 2nd, …, or the 14th day).

Emotions were assessed four times per day using the 10-item International Positive and Negative Affect Schedule Short Form (I-PANAS-SF) (Thompson, 2007) and four items from the affect subscale of the University of Wales Institute of Science and Technology (UWIST) mood scale (Johnston et al., 2016; Matthews, Jones, & Chamberlain, 1990). The I-PANAS-SF, which is a short version of the 20-item Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988), has demonstrated good validity (Thompson, 2007) and reliability in prior studies (Karim, Weisz, & Rehman, 2011; Merz et al., 2013; Thompson, 2007; Yoo, Burrola, & Steger, 2010). Among the Taiwanese population, the 20-item PANAS also showed good validity and reliability (Teng & Chang, 2006). The PANAS has been used in prior EMA studies (Berg et al., 2015; Lavender et al., 2013; Steptoe, Gibson, Hamer, & Wardle, 2007; Zenk et al., 2014). In response to the question, *"How have you been feeling since the last time you completed a survey?",* items from the I-PANAS-SF (Thompson, 2007) were assessed on a 5-point Likert scale (i.e., never, seldom, sometimes, often, always), while items on the UWIST (Johnston et al., 2016; Matthews et al., 1990) were assessed on a 4-point Likert scale (i.e., definitely not, slightly not, slightly, definitely). Measures of positive emotions and negative emotions were constructed by summing scores of the seven positive affect items (ranging from 7 to 33) and of the seven negative affect items (ranging from 7 to 33), respectively.

Experienced stress was assessed with a single item in the tense arousal UWIST subscale: "*stressed*" (Johnston et al., 2016; Matthews et al., 1990). As described above, this item was assessed on a 4-point Likert scale from definitely not (1) to definitely (4).

Daily working hours were assessed based on the record in the published work schedule. An off-duty day was defined as zero working hours that day.

2.2.3.3.2 Time-invariant Covariates

Assessed as part of the baseline survey, time-invariant covariates (i.e., person-level measures) included the following demographics: age (in years), gender, educational attainment (i.e., high school, associate degree or diploma, bachelor's degree, master/doctoral degree), marital status (i.e., single, cohabitant, married, separated, divorced, widowed), family responsibility (i.e., being as a main caregiver for kids or disabled persons in their family), and per capita household income. Because less than 5% of participants had a master/doctoral degree, educational attainment was dichotomized as "associate degree or below" and "bachelor's degree or above". Less than 4% of participants had a marital status other than single or married (i.e., cohabitant: 2.6%, divorced: 1.3%); therefore, marital status was dichotomized as "a status other than married" and married. Per capita household income was grouped based on the criteria announced by the Department of Social Assistance and Social Work, Ministry of Health and Welfare (2019). Per capita household income less than USD 4,955, USD 4,955 to 7,433, and more than 7,433 were considered as low, middle, above middle income, respectively.

Eating style was considered a potential confounder in this study given its significant associations with shift work (Almajwal, 2016; Wong et al., 2010) and sweetened food consumption (Camilleri et al., 2014) in prior work. Eating style was assessed using the Chinese version of Dutch Eating Behavioral Questionnaire (C-DEBQ) (Wang, Ha, Zauszniewski, & Ross, 2018), which was based on the Dutch Eating Behavioral Questionnaire (DEBQ) (van Strien et al., 1986). Three subscales with a total of 33 items were included in the DEBQ: (1) emotional eating, defined as eating in reaction to emotional events (e.g., being irritated) (13 items), (2) external eating, defined as eating in react to food cues even not being hungry (e.g., appearances) (10 items), and (3) restrained eating, defined as restricting food consumption in order to lose or control weight (e.g., eating less than usual when gaining weight) (10 items). Each item was ranked on a 5-point Likert scale (1=never, 5=very often). The scores of each subscale were calculated by averaging the respective total scores. Higher scores indicated higher frequency on the corresponding subscale (van Strien et al., 1986). The DEBQ had been employed in previous studies with good validity and reliability (Almajwal, 2016; Wang et al., 2018; Wardle, Steptoe, Oliver, & Lipsey, 2000; Wong et al., 2010). In this study, this scale had high internal consistency reliability (Cronbach's α: 0.92 for emotional eating, 0.92 for external eating, and 0.88 for restrained eating).

Chronotype indicates how a person synchronizes their circadian rhythm with the light-dark cycle by adjusting their sleep time (e.g., lark or owl) (Roenneberg, 2012; Roenneberg, Daan, & Merrow, 2003; Roenneberg, Hut, Daan, & Merrow, 2010). Recent studies suggested that a person's chronotype was correlated with shift work and eating behaviors (Yoshizaki et al., 2016; Yoshizaki et al., 2018); therefore, chronotype was considered another confounder in this study. Chronotype was assessed using the Chinese version of Munich ChronoType Questionnaire for shift workers ($\text{MCTQ}^{\text{shift}}$) (Cheng & Hang, 2018), which was developed by Juda and colleagues

(2013) based on the original MCTQ (Roenneberg, Wirz-Justice, & Merrow, 2003). According to Juda et al. (2013), the mid-sleep time (i.e., the time that a person has slept for half of the sleep duration after sleep onset) on off-duty days after evening shifts ($\mathrm{MSF}^{\mathrm{E}}$) better predicted shift workers' chronotype relative to that after the day shifts or night shifts. Therefore, a participant's chronotype was measured based on that person's $\mathrm{MSF}^{\mathrm{E}}$, which was derived from the following five items: time to bed, time preparing to sleep, time needed for falling asleep, wake up time, and alarm use to wake up. Given that participants might sleep longer on off-duty days in order to balance the disrupted sleep-wake cycle from the previous shift cycle, the $\mathrm{MSF}^{\mathrm{E}}$ should be adjusted. The detailed steps and algorithms for $\mathrm{MSF}^{\mathrm{E}}$ and corrected $\mathrm{MSF}^{\mathrm{E}}$ ($\mathrm{MSF}^{\mathrm{E}}_{\mathrm{SC}}$) can be found in Juda et al.'s (2013) article. The Chinese-version of $\mathrm{MCTQ}^{\mathrm{shift}}$ revealed good predictive validity among Taiwanese registered nurses working on irregular rotating shifts (Cheng & Hang, 2018). Based on Juda et al.'s (2013) definition, $\mathrm{MSF}^{\mathrm{E}}_{\mathrm{SC}}$ earlier than 4:00 a.m., between 4:00 a.m. and 4:59 a.m., and 5:00 a.m. or later were considered as early, intermediate, and late chronotype, respectively.

Other person-level covariates included body mass index (BMI) derived from self-reported height (cm) and weight (kg), health conditions (e.g., medical history), smoking and tobacco use (yes/no), occupational history such as year(s) of working as a registered nurse and history of rotating shift work (in years), and work unit (e.g., surgical, medical ward, or intensive care unit). Participants' health conditions were assessed by asking whether they had been diagnosed or told by a doctor of the following diseases: diabetes (type 1 or type 2) or high blood sugar, heart disease (e.g., coronary artery disease, angina, congestive heart failure), hypertension, stroke, high cholesterol/hyperlipidemia, thyroid problems (e.g., hyperthyroidism, hypothyroidism), kidney diseases (e.g., chronic renal failure), cancer or a malignant tumor (excluding minor skin cancer), digestive problems (such as ulcer, colitis, or gallbladder disease), mental illnesses (e.g., depression, anxiety), and sleep problems (e.g., insomnia). Any of the aforementioned conditions was considered “1= having at least one chronic condition.”

2.2.4 Analysis

2.2.4.1 Descriptive Statistics

STATA 15 (Statacorp, College Station, TX, USA) was employed for data analysis. The analytic methods included descriptive statistics and inferential statistics. Descriptive statistics were employed to describe participants’ characteristics (e.g., demographics), daily shift work, momentary empty calorie food/beverage intake (i.e., fried food/fast food, sweet or salty snacks, sweetened beverages, and overall empty calorie food/beverage intake), and other time-varying covariates (e.g., emotions). In addition, momentary empty calorie food/beverage intake was presented by shift timing (i.e., day, evening, night, and off-duty).

2.2.4.2 Inferential Statistics

Multilevel mixed-effects logistic regression models were employed to test associations between shift work and three categories of empty calorie food/beverage consumption: fried food/fast food, sweet or salty snacks, and sweetened beverages. Because the distribution of overall empty calorie food/beverage consumption was right-skewed, and its variance (i.e., 2.1) was almost two times higher than its mean (i.e., 1.1), multilevel mixed-effects negative binomial regression models were used for this outcome variable in analysis.

Mixed-effects regression models are comprised of two components: within-person effects and between-person effects (Hedeker & Gibbons, 2006; Neuhaus & Kalbfleisch, 1998).

In this study, given a sample size of 77, I mainly focused on the within-person effects that captured how changes in a time-varying independent variable in a person (i.e., the deviance of person i at time t from the mean level/proportion of person i across time) contributed to that person's variations in a dependent variable, accounting for that person's mean level/proportion of that variable across time (Hedeker, Mermelstein, & Demirtas, 2008; Neuhaus & Kalbfleisch, 1998; Zenk et al., 2014).

Due to the small sample size at the person level (n=77), I employed backward selection methods to select the most parsimonious model for analysis. First, I included all of the time-varying and time-invariant covariates in the same model for each outcome variable. Second, covariates with insignificant p value (i.e., p>0.05) were dropped from the model one at a time. Third, based on results of the likelihood ratio test (LRT), I identified significant covariates for each outcome variable. Fourth, all models were adjusted for the same set of time-invariant and time-varying covariates. If a covariate was significantly associated with any outcome variable, that covariate was retained in the final models for all outcomes. As a result of this process, the identified moment-level covariates were emotions and experienced stress, the day-level covariates were the number of complete EMA surveys and the sequence of EMA survey days. The identified person-level covariates were age, BMI, educational attainment, family responsibility, and health conditions.

A common analytic approach for the four hypotheses was followed. First bivariate regression analyses were employed to estimate crude associations between shift work and empty calorie food/beverage consumption. Then multivariate regression analyses including the identified covariates were employed to examine the adjusted association between an independent variable and a dependent variable.

2.2.4.2.1 Hypothesis 1

To test H1a (on days when working evening or night shifts, empty calorie food/beverage consumption will be higher compared to days when working day shifts) and H1b (empty calorie food/beverage consumption will significantly differ on off-duty days compared to day shifts), I regressed empty calorie food/beverage consumption on same-day shift timing (i.e., predictor) and the identified time-varying and time-invariant covariates.

2.2.4.2.2 Hypothesis 2

To test H2 (on days when working evening or night shifts, empty calorie food/beverage consumption will be higher on the subsequent day compared to days when working day shifts), I regressed empty calorie food/beverage consumption on prior-day shift timing, controlling for covariates first. In the final models, same-day shift timing was also included. Namely, I regressed empty calorie food/beverage consumption on prior-day shift timing, same-day shift timing and the identified covariates.

2.2.4.2.3 Hypothesis 3

For H3a (work shift intensity will be positively associated with increased consumption of empty calorie foods/beverages), the main predictor was changed to the work shift intensity. I regressed each outcome on work shift intensity and the identified covariates first. In the respective final models, I also included same-day shift timing in the analysis.

For H3b (a high level of night shift intensity will be associated with increased consumption of empty calorie foods/beverages), the analytical strategy was the same as for

H3b except the main predictor was switched to night shift intensity. To prevent collinearity, work shift intensity and night shift intensity were analyzed in separate models.

2.2.4.2.4 Hypothesis 4

To test H4 (a higher level of shift speed will exacerbate the positive associations between empty calorie food/beverage consumption and shift timing or shift intensity), I added cross-level multiplicative interaction terms between shift speed (i.e., slow, medium/rapid) and each within- and between-person shift timing (e.g., medium/rapid frequency* evening shift$_{\text{within}}$, medium/rapid frequency* evening shift$_{\text{between}}$) and each within- and between-person shift intensity variable (e. g., medium/rapid frequency* work shift intensity$_{\text{within}}$, medium/rapid frequency* night shift intensity$_{\text{between}}$) into the respective final models for H1 (test for shift timing) and H3 (test for shift intensity). If a cross-level interaction term was significant, the predicted values of the dependent variable were calculated based on the estimated coefficients from the regression model and were graphed in order to depict the nature of the relationships.

2.2.4.3 Sensitivity Analysis

Our primary strategy involved matching intake in a 24-hour calendar day to shift timing that same calendar day. This approach can capture the intake prior to the start of a shift, particularly on evening shifts. However, it is possible that shift work affects subsequent intake only. As a result, for working days, I tested the sensitivity of results by matching the start of a 24-hour consumption window to the start of a shift. For off-duty days, to avoid an overlap in the 24-hour consumption window, I only included those days that had at least 48 hours separating the start of two shifts. Thus, after limiting to those observations that met these criteria, 2,031 momentary observations were included in the sensitivity analysis.

2.3 Findings

2.3.1 Descriptive Statistics

After excluding observations with incomplete data, a total of 2,444 EMA surveys nested within 961 person-day observations and 77 participants were included. The average number of EMA surveys per person-day was 2.5 (SD=1.0). Sample characteristics are presented in Table 1-1. The mean age of participants was 27.9 years (SD=4.5). Most were female (94.8%), unmarried (88.3%), and had a bachelor’s degree or above (84.4%). On average, BMI was 23.1 (SD= 5.0) kg/m^2. About one in four (23.4%) of participants had at least one chronic health condition. The average years of rotating shift work was 5.4 years (SD=4.2). The majority of participants were slow shift speed workers (58.4%) (see Table 1-1).

Out of the 961 person-day observations, participants worked day shifts 23.8%, evening shifts 22.0%, night shifts 22.3%, and were off-duty for 32.0% of the data collection period. With regards to shift intensity, on average, participants worked 1.7 (SD= 1.6, ranging from 0 to 8) consecutive work shifts and 0.5 (SD= 1.0, ranging from 0 to 5) consecutive night shifts. Only 7.5% of the person-days were high for night shift intensity. The average hours per working day was 8.2 hours (SD= 0.4).

Descriptive statistics for each empty calorie food/beverage intake outcome measure is presented in Table 1-2. Participants reported consuming fried food or fast food at 16.1% of the signals, sweet or salty snacks at 32.2% of signals, and sweetened beverages at 34.8%. Overall, participants reported an average of 1.1 (SD=1.5, ranging from 0 to 20) empty calorie food/beverage items at each EMA signal.

2.3.2 Inferential Statistics

2.3.2.1 Hypothesis 1

Table 1-3 shows associations between shift timing and same-day empty calorie food/beverage consumption. In the crude models, working evening shifts was associated with a 40% increase in the likelihood of sweet or salty snack intake, compared to working day shifts (OR=1.40, 95% CI [1.04, 1.89]). Working night shifts was associated with a 69% increase in the likelihood of fried food/fast food intake, compared to working day shifts (OR=1.69, 95% CI [1.14, 2.52]). On off-duty days, the likelihoods of reporting consumption of all three categories of empty foods/beverages (i.e., fried food/fast food, sweet or salty snacks, sweetened beverages) were higher compared to days when working day shifts. Participants reported consuming 0.27 more empty calorie foods/beverages at a signal on off-duty days compared to days when they worked day shifts (b=0.27, 95% CI [0.12, 0.41]).

After adjusting for covariates, accounting for a person's usual conditions of shift timing, working night shifts was associated with a 73% increase in the likelihood of fried food/fast food consumption (OR=1.73, 95% CI [1.16, 2.59]) and a 46% increase in the likelihood of sweetened beverage consumption (OR=1.46, 95% CI [1.10, 2.10]). The overall reported empty calorie food/beverage items were 0.17 more (b=0.17, 95% CI [0.00, 0.33]) at a signal when working night shifts as relative to days when they worked day shifts. On off-duty days, the likelihoods of all three categories of empty calorie food/beverage consumption were increased, compared to working day shifts. The overall reported empty calorie food/beverage items at a signal on off-duty days were 0.32 more than that of days working day shifts (b= 0.32, 95% CI [0.18, 0.46]).

2.3.2.2 Hypothesis 2

Table 1-4 shows associations between shift timing and subsequent-day empty calorie food/beverage consumption. In the crude and adjusted models, shift timing was neither significantly associated with the likelihood of reporting empty calorie food/beverage consumption nor the overall consumption counts of empty calorie foods/beverages on the subsequent day.

2.3.2.3 Hypothesis 3

Table 1-5 shows associations of empty calorie food/beverage consumption with both work shift intensity and night shift intensity. Work shift intensity is in the upper panel; night shift intensity is in the lower panel. In the crude models, the number of consecutive work shifts was not associated with the likelihood of any of the particular types of empty calorie food/beverage consumption. However, work shift intensity was negatively associated with the overall empty calorie food/beverage items reported at a signal (b= -0.03, 95% CI [-0.07, 0.00]). Adjusting for covariates (Model 1), greater work shift intensity was associated with a lower likelihood of sweet and salty snack consumption (OR= 0.92, 95% CI [0.87, 0.99]). Additionally, after adjusting for covariates, the magnitude of the association between work shift intensity and the overall count of empty calorie foods/beverage items strengthened (b= -0.05, 95% CI [-0.08, -0.01]) slightly. However, none of the associations between work shift intensity and empty calorie food/beverage consumption were statistically significant after controlling for same-day shift timing and the identified covariates (Model 2).

As shown in the lower panel in Table 1-5, a high level of night shift intensity was not associated with any of the four measures of empty calorie food/beverage consumption in the crude models. Adjusting for covariates (Model 3), a high level of night shift intensity was associated with a 62% increase in the likelihood of fried food/fast food consumption compared to days without a high level of night shift intensity (OR= 1.62, 95% CI [1.03, 2.55]). However, the association between night shift intensity and fried food/fast food consumption was attenuated after controlling for same-day shift timing and covariates (Model 4). High night shift intensity was associated with a 64% increase in the likelihood of reporting sweetened beverage intake (OR= 1.64, 95% CI [1.01, 2.68]), controlling for both same-day shift timing and covariates.

2.3.2.4 Hypothesis 4

Hypothesis 4 is concerned with whether shift speed moderates positive associations between both shift timing and shift intensity with empty calorie food/beverage intake. Table 1-6 shows associations of empty calorie food/beverage consumption with shift timing, shift speed, and their interactions. In the crude models, there is one significant interaction for sweetened beverage intake between shift speed and working evening shifts (OR= 2.54, 95% CI [1.30, 5.08]). After adjusting for covariates, this significant interaction remained. Among participants assigned either a medium or rapid shift speed schedule, on days working evening shifts versus day shifts, the likelihood of sweetened beverage intake was increased (OR=2.91, 95% CI [1.44, 5.91]). In contrast, among participants assigned a slow shift speed schedule, there were no significant differences in the likelihood of sweetened beverage consumption between days working on evening shifts and days working on day shifts (OR=0.84, 95% CI [0.55, 1.30]). The predicted probability of sweetened beverage consumption by the combination of shift timing and shift speed is displayed in Figure 1-1. Providing some support for H4, participants assigned a shift schedule with either medium or rapid shift speed were more likely to consume sweetened beverages when working evening shifts compared to when working day shifts. However, among slow shift speed workers, the direction of that association was the opposite.

Table 1-7 shows associations of empty calorie food/beverage consumption with work shift intensity, shift speed, and their interactions. In the crude models, work shift intensity was associated with the increased likelihood of sweetened beverage intake among participants assigned a shift schedule with either medium or rapid shift speed (OR= 1.19, 95% CI [1.03, 1.36]). Among participants assigned either a medium or rapid shift speed schedule, greater work shift intensity (i.e., each additional consecutive work shift) was associated with 0.07 more reported empty calorie food/beverage items (95% CI [0.01, 0.14]).

Adjusting for covariates (Model 1), interactions between shift speed and work shift intensity remained significant for the likelihood of sweetened beverage intake (OR= 1.23, 95% CI [1.06, 1.42]) and the overall count of empty calorie food/beverage items reported (b= 0.08, 95% CI [0.02, 0.15]). After controlling for same-day shift timing and covariates (Model 2), the association between work shift intensity and the likelihood of sweetened beverage intake was still moderated by shift speed. Among medium/rapid shift speed workers, accounting for their usual levels of work shift intensity, working an extra work shift was associated with a 17% increase in the likelihood of sweetened beverage consumption (OR= 1.17, 95% CI [1.01, 1.35]). However, among slow shift speed workers, there was no association between work shift intensity and sweetened beverage consumption. The association between work shift intensity and overall empty calorie food/beverage consumption was attenuated, adjusting for same-day shift timing and covariates. The predicted probability of sweetened beverage intake by different levels of shift speed and work shift intensity is displayed in Figure 1-2. Consistent with H4, participants assigned a shift schedule with either medium or rapid shift speed had a higher likelihood of sweetened beverage consumption when they had greater work shift intensity. However, for those assigned a shift schedule with slow shift speed, the direction of the association was the opposite.

Table 1-8 shows associations of empty calorie food/beverage consumption with night shift intensity, shift speed, and their interactions. As shown in Table 1-8, associations between night shift intensity and empty calorie food/beverage consumption did not vary by shift speed.

2.3.3 Sensitivity Analysis

For H1, results in the sensitivity analysis were consistent with those presented in Table 2-4. In terms of H2, results of the analysis were similar to what was shown in Table 2-5 except the effects of off-duty days on the likelihood of sweetened beverage consumption, and on overall empty calorie food/beverage intake were significant in the sensitivity analysis (see Supplemental Table 1-1). For H4, results of interactions between shift timing and shift speed were consistent with the results presented in Table 1-6 (see Supplemental Table 1-2).

2.4 Discussion

This is the first study to examine dynamic within-person associations between shift work and workers' empty calorie food/beverage consumption. In addition, this study considers the complexity of shift work to better understand the multiple mechanisms by which shift work may influence empty calorie food/beverage intake. In summary, findings suggested that, working night shifts versus day shifts was associated with a higher likelihood of reporting intake of fried food/fast food; sweetened beverages and more empty calorie food/beverage items. On off-duty days, the likelihood of several types of empty calorie food/beverage intake and the overall count of empty calorie food/beverage items reported were higher relative to days working day shifts. Greater night shift intensity increased the likelihood of sweetened beverage consumption. Shift speed moderated associations between the likelihood of sweetened beverage consumption and same-day shift timing or work shift intensity. No associations were found between empty calorie food/beverage consumption and prior-day shift timing or work shift intensity.

2.4.1 Hypothesis 1: Non-day shifts would be positively associated with increased empty calorie food/beverage consumption compared to day shifts

Providing little support in multivariable models for H1, I did not find significant differences in participants' empty calorie food/beverage consumption on days when working evening shifts compared to day shifts. Whereas, consistent with Cain et al.'s (2015) and Bonnell et al.'s (2017) findings, results suggested that on days when working night shifts, the likelihood of fried food/fast food consumption and overall reported count of empty calorie foods/beverages were higher than on days working day shifts.

There are multiple possible explanations for the findings that working at night is associated with increased empty calorie food/beverage consumption. First, working at night is often contrary to a person's biological clock, which may result in increased risk of circadian disruption (Bedrosian et al., 2016) and further contribute to imbalanced secretion of appetite-hormones, such as decreased leptin (James, Honn, Gaddameedhi, & Van Dongen, 2017; McHill et al., 2014; Scheer, Hilton, Mantzoros, & Shea, 2009), or increased ghrelin (James et al., 2017;

Schiavo-Cardozo, Lima, Pareja, & Geloneze, 2013). Decreased leptin and increased ghrelin have been linked to increased appetite and food consumption (James et al., 2017; Nakazato et al., 2001). Thus, changed levels of appetite hormones ascribing to circadian disruption on days working night shifts may explain my findings.

Second, the food environment (e.g., food availability) has been linked to a person's snack food consumption (Elliston et al., 2017; Zenk et al., 2014). Bonnell et al. (2017) reported that rotating shift workers consumed a greater proportion of discretionary snack foods on night shifts compared to days working day shifts. When further examining workers' decisions on food choices, accesibility of food was one of the major themes of increased discretionary snack foods consumption.

Third, it has been documented that night shift workers may consume unhealthy foods (e.g., sweetened snacks) to stay awake during their night shifts (Persson & Martensson, 2006; Tepas & Tepas, 1990). A qualitative study of 12 registered nurses observed that some nurses would consume high sugar foods and sweetened beverages to prevent or to cope with their fatigue (Gifkins, Johnston, & Loudoun, 2018). From this perspective, the increased sweetened beverage consumption on night shifts may be ascribed to shift workers' coping behaviors for fatigue from night shift work.

Additionally, previous studies suggested that time availability either for food preparation (Bonnell et al., 2017) or for food consumption (Persson & Martensson, 2006; Waterhouse et al., 2003) could be one of the dominant influences on workers' food choices. Workers tended to purchase and consume something that was easy and quick to prepare (Bonnell et al., 2017). Therefore, it is also possible that increased consumption of empty calorie foods/beverages on night shifts may be related to decreased time availability for food preparation or consumption on night shifts compared to days working day shifts.

In terms of off-duty days, results demonstrated that participants' empty calorie food/beverage consumption was significantly higher on off-duty days compared to working on day shifts. Several studies have suggested that people tend to eat out and consume more empty calorie foods/beverages on weekends relative to weekdays (An, 2016; Haines et al., 2003; Orfanos et al., 2007; Yang et al., 2014). A qualitative study of shift working nurses found that most nurses considered holidays a distraction from work, which might increase their disinhibited eating behaviors (i.e., uncontrolled food consumption). Nurses also reported an increased desire to socialize with others (e.g., friends, family) and to "savor" their off-duty days (Power et al., 2017). Therefore, the observed increased empty calorie food/beverage consumption on off-duty days versus day shifts may be attributed to social influences.

2.4.2 Hypothesis 2: Compared to day shifts, non-day shifts would be associated with increased subsequent-day empty calorie food/beverage consumption

Providing no support for H2, when considering the effects of shift timing on subsequent-day empty calorie food/beverage consumption, I found no associations. To my knowledge, no study has investigated the dynamic effects of shift timing on shift workers' empty calorie food/beverage consumption. Shift work may disrupt workers' circadian alignment (Bedrosian et al., 2016), which may further imbalance the appetite hormones (e.g., ghrelin). Previous studies suggested increased pre-prandial levels of ghrelin were associated with greater appetite or food consumption during that meal (Attele, Shi, & Yuan, 2002; Klok, Jakobsdottir, & Drent, 2007; Pico, Oliver, Sanchez, & Palou, 2003). These findings are consistent with the possibility that the effect of appetite hormones on food intake is transient instead of long-term.

2.4.3 Hypothesis 3: Greater shift intensity would be associated with increased empty calorie food/beverage consumption

There were no significant associations between work shift intensity and empty calorie food/beverage consumption after accounting for same-day shift timing. However, providing some support for H3, in contrast, a high level of night shift intensity was positively associated with the increased likelihood of sweetened beverage consumption. This is the first study to examine whether the effect of shift work on empty calorie food/beverage consumption could be cumulative. Providing a unique contribution to the literature, results suggested that shift timing may be the more important factor to consider in empty calorie food/beverage consumption than work shift intensity, and the effect of night shift work can be cumulative.

A population-based longitudinal study revealed that a higher level of night shift intensity (i.e., >2 consecutive night shifts) was positively associated with increased levels of fatigue during work and off-duty days (Harma et al., 2018). Fatigue due to shift work might hinder shift workers' healthy eating behaviors (Griffiths et al., 2014; Power et al., 2017). The possible explanation for the increased likelihood of sweetened beverage consumption on days with high night shift intensity in this study might be attributed to increased and accumulated fatigue from night shift work.

2.4.4 Hypothesis 4: Higher levels of shift speed would exacerbate positive associations between empty calorie food/beverage consumption and shift timing or shift intensity

Providing some support for H4, the likelihood of sweetened beverage consumption on evening shifts was increased compared to working day shifts, particularly among participants assigned a work schedule with either medium or rapid shift speed. Previous studies suggested rotating shift workers may need to adapt to different working conditions (e.g., different groups of colleagues, different patients, different schedules) often, which may result in greater work-related stress (Coffey, Skipper, & Jung, 1988; Dall'Ora, Ball, Recio-Saucedo, & Griffiths, 2016) and further increase shift workers' likelihood of sweetened beverage intake (Power et al., 2017; Wardle et al., 2000). Future studies examining whether work-related stress mediates associations between shift work and workers' empty calorie food/beverage consumption may help to understand the possible mechansims.

Findings suggested that among participants assigned a higher level of shift speed, there was a dose-response association between work shift intensity and the likelihood of sweetened beverage consumption. Previous studies showed that fewer off-duty days per month might contribute to increased burnout among shift workers (Dall'Ora et al., 2016; Wisetborisut, Angkurawaranon, Jiraporncharoen, Uaphanthasath, & Wiwatanadate, 2014). Given aforementioned positive associations between fatigue and increased sweetened beverage intake (Griffiths et al., 2014; Power et al., 2017), greater work shift intensity may contribute to increased levels of fatigue and further increase the likelihood of sweetened beverage consumption.

With regard to night shift intensity, associations between night shift intensity and empty calorie food/beverage consumption were not moderated by the levels of shift speed. It is noteworthy that less than 8% of person-days were recorded as high night shift intensity. The low variability of this variable may result in the null findings for this hypothesis testing.

2.4.5 Strengths and Limitations

2.4.5.1 Strengths

This study has several strengths. First, this is the first study to examine within-person associations between shift work and empty calorie food/beverage intake considering the complexity of shift work. This provided a more comprehensive view for understanding how daily shift work influences shift workers' empty calorie food/beverage intake. Second, the prospective intensive longitudinal design using EMA methodology helped to assess participants' empty calorie food/beverage consumption in real-time, which reduced the chance of recall bias and increased ecological validity. Momentary assessments also allowed testing of short-term effects of shift work. For instance, whether shift timing influenced same-day behavior or subsequent-day behavior could be examined. In addition, records from published work schedules were employed to assess participants' exposure to shift work, which reduced participants' recall bias of work schedules.

2.4.5.2 Limitations

This study's limitations should also be considered. First, the findings of this study may not be generalizable to all rotating shift workers due to the use of a convenience sample, which is a non-probability sampling method. Participants in this study were relatively young. The healthy work effect (i.e., workers who cannot adjust to shift work may choose not to work on rotating shifts) (McMichael, 1976; Shah, 2009) might also introduce selection bias and affect the generalizability of the findings.

Second, a food checklist was employed to assess participants' empty calorie food/beverage consumption instead of using 24-hour dietary recalls or food records, which might introduce measurement error because some of the participants' empty calorie food/beverage consumption might not be captured. In addition, to reduce participants' burdens, the portion size of each food/beverage item was not included in the EMA survey, which may also contribute to misleading findings. For instance, people may report the same number of empty calorie food/beverage items; however, the portion size or number of servings they consumed may differ.

Third, to representatively capture each participant's shift work pattern, each participant was requested to respond to the EMA survey for 14 days, which may increase their burdens and result in overall low response rates (Spook, Paulussen, Kok, & Van Empelen, 2013). The EMA survey response rate was 56.3%, which is lower than preferred (Stone & Shiffman, 2002) and might hinder the validity of study findings, especially when those observations were missing not randomly. Previous EMA studies among working populations suggested that work demands might reduce compliance in EMA studies (McIntyre et al., 2016; Rutledge et al., 2009). In this study, completed EMA surveys from participants were relatively evenly distributed across different shift timings (day: 229, evening: 211, night: 214, off-duty: 307), which may reduce concerns that responses were mainly collected during certain types of shift timings. By asking participants' empty calorie food/beverage consumption since the last time they completed an EMA survey, it may also help to capture participants' intake if they had missed any EMA surveys.

Additionally, there is no consistency in the categorization of shift speed in the literature. In this study, shift speed was categorized based on the number of changes in shift timing within a two-week period, which may also lose information or produce misleading findings. For instance, two participants may both have four changes in shift timing. One participant may have regular changes in shift timing; the other may have to change shift timings irregularly (i.e., no change within one week but four changes during the other week); however, these two participants were categorized in the same group, which may introduce misclassification bias and misleading results. Finally, the multiple hypotheses testing in this study may also increase the chance of type one error.

2.4.6 Implications for Policy and Practice

This study suggested that working on night shifts was associated with increased likelihood of consumption of several types of empty calorie foods/beverages. Night shift work is unavoidable for certain industries that provide around-the-clock services (e.g., healthcare). Thus, interventions that help to prevent unhealthy eating on night shifts may be beneficial for rotating shift workers' health.

To improve workers' health behaviors, multi-level interventions (e.g., organizational, individual) are recommended (Levy et al., 2018; Risica et al., 2018; Ward et al., 2018). First, at the organizational level, the food environment (e.g., availability) has been noted as one of the main reasons for unhealthy food consumption (Elliston et al., 2017; French et al., 2010; Zenk et al., 2014). Since most food outlets that offer healthier foods at the workplace are closed at night, creating an environment where workers have greater access to nutrient-dense foods (i.e., salad, fruit, non-fat milk) (French et al., 2010; Lowden et al., 2010) and less access to unhealthy foods or beverages (Lowden et al., 2010) may help to decrease shift workers' empty calorie food/beverage consumption on days working night shifts.

In addition, increased incentives for healthy food consumption (French et al., 2010; Lowe et al., 2010) such as lowering the prices of healthy foods in the convenience stores or providing discounts for the purchase of healthy foods in the stores at the workplace may also help to motivate workers' healthy eating behaviors while working.

Previous studies suggested that unhealthy food consumption (i.e., discretionary snacks, sweetened beverages) may be a coping strategy for fatigue on night shifts (Gifkins et al., 2018; Heath et al., 2016; Persson & Martensson, 2006; Tepas & Tepas, 1990). Thus, reducing fatigue from shift work may be beneficial for shift workers' healthy eating behaviors. At the organizational level, providing workers a proper break during night shifts, adequate staffing, and workload balance are recommended for the management of fatigue (Caldwell, Caldwell, Thompson, & Lieberman, 2019).

At the individual level, educational programs that help people develop better coping mechanisms for fatigue (e.g., regular exercise) (Richter, Acker, Adam, & Niklewski, 2016) may help to reduce shift workers' fatigue. In addition, shift workers tend to consume caffeine (e.g., cola, coffee, tea) to promote alertness on night shifts (Buchvold, Pallesen, Oyane, & Bjorvatn, 2015; Caldwell et al., 2019; Shy, Portelli, & Nelson, 2011). Therefore, replacing the source of caffeine intake (e.g., from cola to non-sweetened tea or coffee) may reduce the possibility of sweetened beverage consumption on night shifts.

The combination of increased numbers of consecutive work shifts and being assigned a higher level of shift speed schedule (i.e., at least two shift changes within two weeks) increased participants’ likelihood of sweetened beverage consumption. This indicates the importance of stability of shift timing. Several guidelines have been proposed to reduce the adverse health effects of rotating shift work, such as avoiding a shift schedule that includes both day and night shifts in the same month, minimizing consecutive night shifts, and giving 24 hours of off-duty time after a night shift (Miller, 2008; Smith & Eastman, 2012). Adding to the previous guidelines, avoiding shift schedules with more than one shift change within a 2-week period and minimizing the number of consecutive work shifts may also help to reduce the adverse effects of rotating shift work and improve shift workers’ unhealthy eating behaviors.

2.4.7 Implications for Future Research

There are several implications for future study. First, since convenience sampling was used in this study, employing probability sampling methods in future studies will increase the generalizability of the study findings. Second, I only employed a food checklist to assess empty calorie food/beverage consumption. To combine other dietary assessments such as 24-hour dietary recalls may help to reduce the bias from measurement error and allow capturing more information regarding nutrient intake and overall diet quality.

Third, the definition of shift speed is inconsistent in the literature (i.e., number of changes in shift timing within a 2-week period, or number of working days between two different shift timings) (Hall et al, 2018; IARC, 2007; Postnova et al., 2014). In this study, the cut-off points of different types of shift speed were mainly based on Hall et al.’s (2018) schema; future studies with larger sample sizes may compare the results between different definitions of shift speed to help identify the most appropriate definitions of shift speed when investigating its health effects.

Finally, there are only a few EMA studies of working populations, particularly shift workers, in the literature. Future studies investigating the feasibility and acceptability of an EMA study among shift workers may contribute to the application of EMA study among this populaiton. In addition, it is possible that workers are not able to respond to an EMA survey due to high work demand (McIntyre et al., 2016; Rutledge et al., 2009). Workers often eat when they have time during work. Incorporating event-based EMA surveys during working hours and signal-based EMA surveys during non-working hours or off-duty days may help to better capture shift workers' food intakes and prevent missing surveys during working hours.

2.5 Conclusion

This study considered the complexity of shift work. Findings in this study revealed that shift work might influence same-day empty calorie food/beverage consumption. The effects of night shifts on empty calorie food/beverage intake could be cumulative. In addition, how a shift worker's work shift schedule is assigned (e.g., the number of consecutive work shifts and its interaction with shift speed) might also contribute to empty calorie food/beverage consumption. Shift work is unavoidable for certain types of industries (e.g., healthcare, protective services). Thus, it would be beneficial to shift workers' eating behaviors and overall health if the identified hazardous work shift schedule (e.g., high levels of night shift intensity, the combination of greater work shift intensity and medium or rapid shift speed) assignment can be avoided for rotating shift workers.

References

Almajwal, A. M. (2016). Stress, shift duty, and eating behavior among nurses in Central Saudi Arabia. *Saudi Medical Journal, 37*(2), 191-198. doi:10.15537/smj.2016.2.13060

An, R. (2016). Weekend-weekday differences in diet among U.S. adults, 2003–2012. *Annals of Epidemiology, 26*(1), 57-65. doi:https://doi.org/10.1016/j.annepidem.2015.10.010

Attele, A. S., Shi, Z. Q., & Yuan, C. S. (2002). Leptin, gut, and food intake. *Biochemical Pharmacology, 63*(9), 1579-1583. doi:10.1016/S0006-2952(02)00883-3

Bedrosian, T. A., Fonken, L. K., & Nelson, R. J. (2016). Endocrine Effects of Circadian Disruption. *Annual Review of Physiology, 78*, 109-131. doi:10.1146/annurev-physiol-021115-105102

Berg, K. C., Crosby, R. D., Cao, L., Crow, S. J., Engel, S. G., Wonderlich, S. A., & Peterson, C. B. (2015). Negative affect prior to and following overeating-only, loss of control eating-only, and binge eating episodes in obese adults. *International Journal of Eating Disorders, 48*(6), 641-653. doi:10.1002/eat.22401

Boivin, D. B., & Boudreau, P. (2014). Impacts of shift work on sleep and circadian rhythms. *Pathologie Biologie, 62*(5), 292-301. doi:10.1016/j.patbio.2014.08.001

Bolger, N., & Laurenceau, J. P. (2013). *Intensive longitudinal methods: An introduction to diary and experience sampling research*. New York, NY: Guilford Press.

Bonham, M. P., Bonnell, E. K., & Huggins, C. E. (2016). Energy intake of shift workers compared to fixed day workers: A systematic review and meta-analysis. *Chronobiology International, 33*(8), 1086-1100. doi:10.1080/07420528.2016.1192188

Bonnell, E. K., Huggins, C. E., Huggins, C. T., McCaffrey, T. A., Palermo, C., & Bonham, M. P. (2017). Influences on Dietary Choices during Day versus Night Shift in Shift Workers: A Mixed Methods Study. *Nutrients, 9*(3). doi:10.3390/nu9030193

Buchvold, H. V., Pallesen, S., Oyane, N. M., & Bjorvatn, B. (2015). Associations between night work and BMI, alcohol, smoking, caffeine and exercise--a cross-sectional study. *BMC Public Health, 15*, 1112. doi:10.1186/s12889-015-2470-2

Cain, S. W., Filtness, A. J., Phillips, C. L., & Anderson, C. (2015). Enhanced preference for high-fat foods following a simulated night shift. *Scandinavian Journal of Work, Environment and Health, 41*(3), 288-293. doi:10.5271/sjweh.3486

Caldwell, J. A., Caldwell, J. L., Thompson, L. A., & Lieberman, H. R. (2019). Fatigue and its management in the workplace. *Neuroscience and Biobehavioral Reviews, 96*, 272-289. doi:10.1016/j.neubiorev.2018.10.024

Camilleri, G. M., Mejean, C., Kesse-Guyot, E., Andreeva, V. A., Bellisle, F., Hercberg, S., & Peneau, S. (2014). The associations between emotional eating and consumption of energy-dense snack foods are modified by sex and depressive symptomatology. *Journal of Nutrition, 144*(8), 1264-1273. doi:10.3945/jn.114.193177

Centofanti, S., Banks, S., Colella, A., Dingle, C., Devine, L., Galindo, H., . . . Dorrian, J. (2018). Coping with shift work-related circadian disruption: A mixed-methods case study on napping and caffeine use in Australian nurses and midwives. *Chronobiology International, 35*(6), 853-864. doi:10.1080/07420528.2018.1466798

Chang, H. C., Yang, H. C., Chang, H. Y., Yeh, C. J., Chen, H. H., Huang, K. C., & Pan, W. H. (2017). Morbid obesity in Taiwan: Prevalence, trends, associated social demographics, and lifestyle factors. *PloS One, 12*(2), e0169577. doi:10.1371/journal.pone.0169577

Chang, S. J., & Liao, W. C. (2015). Prevalence of and risk factors associated with metabolic syndrome among nurses. *Taiwan Journal of Public Health, 34*(3), 268-283. doi:10.6288/TJPH201534104003

Chang, S. J., Liao, W. C., & Wang, W. S. (2017). The Prevalence of Dyslipidemia in Nursing Personnel and Related Risk Factors. *The Changhua Journal of Medicine, 15*(2), 75-83. doi:10.6501/CJM.1502.003

Cheng, W. J., & Hang, L. W. (2018). Late chronotype and high social jetlag are associated with burnout in evening-shift workers: Assessment using the Chinese-version MCTQ^{shift}. *Chronobiology International*, *35*(7), 910-919. doi:10.1080/07420528.2018.1439500

Coffey, L. C., Skipper, J. K., & Jung, F. D. (1988). Nurses and shift work: Effects on job performance and job-related stress. *Journal of Advanced Nursing, 13*(2), 245-254. doi:10.1111/j.1365-2648.1988.tb01414.x

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, N. J.: L. Erlbaum Associates.

Craig, L. A., & McDonald, R. J. (2008). Chronic disruption of circadian rhythms impairs hippocampal memory in the rat. *Brain Research Bulletin, 76*(1-2), 141-151. doi:10.1016/j.brainresbull.2008.02.013

Czeisler, C. A., Duffy, J. F., Shanahan, T. L., Brown, E. N., Mitchell, J. F., Rimmer, D. W., . . . Kronauer, R. E. (1999). Stability, precision, and near-24-hour period of the human circadian pacemaker. *Science, 284*(5423), 2177-2181. doi:10.1126/science.284.5423.2177

Dall'Ora, C., Ball, J., Recio-Saucedo, A., & Griffiths, P. (2016). Characteristics of shift work and their impact on employee performance and wellbeing: A literature review. *International Journal of Nursing Studies, 57*, 12-27. doi:10.1016/j.ijnurstu.2016.01.007

de Assis, M. A., Kupek, E., Nahas, M. V., & Bellisle, F. (2003). Food intake and circadian rhythms in shift workers with a high workload. *Appetite, 40*(2), 175-183. doi:10.1016/S0195-6663(02)00133-2

Deibel, S. H., Hong, N. S., Himmler, S. M., & McDonald, R. J. (2014). The effects of chronic photoperiod shifting on the physiology of female Long-Evans rats. *Brain Research Bulletin, 103*, 72-81. doi:10.1016/j.brainresbull.2014.03.001

Department of Social Assistance and Social Work, Ministry of Health and Welfare. (2019). *2019 Criteria for assistance in low and middle-to-low income household*. Retrieved from https://dep.mohw.gov.tw/DOSAASW/cp-566-45261-103.html

Dunton, G. F., & Atienza, A. A. (2009). The need for time-intensive information in healthful eating and physical activity research: A timely topic. *Journal of the American Dietetic Association, 109*(1), 30-35. doi:10.1016/j.jada.2008.10.019

Elliston, K. G., Ferguson, S. G., Schuz, N., & Schuz, B. (2017). Situational cues and momentary food environment predict everyday eating behavior in adults with overweight and obesity. *Health Psychology, 36*(4), 337-345. doi:10.1037/hea0000439

Flueckiger, L., Lieb, R., Meyer, A. H., Witthauer, C., & Mata, J. (2017). Day-to-day variations in health behaviors and daily functioning: Two intensive longitudinal studies. *Journal of Behavioral Medicine, 40*(2), 307-319. doi:10.1007/s10865-016-9787-x

French, S. A., Harnack, L. J., Hannan, P. J., Mitchell, N. R., Gerlach, A. F., & Toomey, T. L. (2010). Worksite environment intervention to prevent obesity among metropolitan transit workers. *Preventive Medicine, 50*(4), 180-185. doi:10.1016/j.ypmed.2010.01.002

Gifkins, J., Johnston, A., & Loudoun, R. (2018). The impact of shift work on eating patterns and self-care strategies utilised by experienced and inexperienced nurses. *Chronobiology International, 35*(6), 811-820. doi:10.1080/07420528.2018.1466790

Griffiths, P., Dall'Ora, C., Simon, M., Ball, J., Lindqvist, R., Rafferty, A. M., . . . Consortium, R. C. (2014). Nurses' shift length and overtime working in 12 European countries: The association with perceived quality of care and patient safety. *Medical Care, 52*(11), 975-981. doi:10.1097/MLR.0000000000000233

Guenther, P. M., Casavale, K. O., Reedy, J., Kirkpatrick, S. I., Hiza, H. A., Kuczynski, K. J., . . . Krebs-Smith, S. M. (2013). Update of the Healthy Eating Index: HEI-2010. *Journal of the Academy of Nutrition and Dietetics, 113*(4), 569-580. doi:10.1016/j.jand.2012.12.016

Haines, P. S., Hama, M. Y., Guilkey, D. K., & Popkin, B. M. (2003). Weekend eating in the United States is linked with greater energy, fat, and alcohol intake. *Obesity Research, 11*(8), 945-949. doi:10.1038/oby.2003.130

Hall, A. L., Franche, R. L., & Koehoorn, M. (2018). Examining exposure assessment in shift work research: A study on depression among nurses. *Annals of Work Exposures and Health, 62*(2), 182-194. doi:10.1093/annweh/wxx103

Han, K., Choi-Kwon, S., & Kim, K. S. (2016). Poor dietary behaviors among hospital nurses in Seoul, South Korea. *Applied Nursing Research, 30*, 38-44. doi:10.1016/j.apnr.2015.10.009

Hansen, A. B., Stayner, L., Hansen, J., & Andersen, Z. J. (2016). Night shift work and incidence of diabetes in the Danish Nurse Cohort. *Occupational and Environmental Medicine, 73*(4), 262-268. doi:10.1136/oemed-2015-103342

Harma, M., Karhula, K., Ropponen, A., Puttonen, S., Koskinen, A., Ojajarvi, A., . . . Kivimaki, M. (2018). Association of changes in work shifts and shift intensity with change in fatigue and disturbed sleep: A within-subject study. *Scandinavian Journal of Work, Environment and Health*, *44*(4), 394-402 doi:10.5271/sjweh.3730

Harma, M., Ropponen, A., Hakola, T., Koskinen, A., Vanttola, P., Puttonen, S., . . . Kivimaki, M. (2015). Developing register-based measures for assessment of working time patterns for epidemiologic studies. *Scandinavian Journal of Work, Environment and Health, 41*(3), 268-279. doi:10.5271/sjweh.3492

Harrington, J. M. (2001). Health effects of shift work and extended hours of work. *Occupational and Environmental Medicine, 58*(1), 68-72. doi:http://dx.doi.org/10.1136/oem.58.1.68

Heath, G., Coates, A., Sargent, C., & Dorrian, J. (2016). Sleep duration and chronic fatigue are differently associated with the dietary profile of shift workers. *Nutrients, 8*(12), 771. doi:10.3390/nu8120771

Hedeker, D., Mermelstein, R. J., & Demirtas, H. (2008). An application of a mixed-effects location scale model for analysis of Ecological Momentary Assessment (EMA) data. *Biometrics, 64*(2), 627-634. doi:10.1111/j.1541-0420.2007.00924.x

Hedeker, D. R., & Gibbons, R. D. (2006). *Longitudinal data analysis*. Hoboken, N.J.: Wiley-Interscience.

Huth, P. J., Fulgoni, V. L., Keast, D. R., Park, K., & Auestad, N. (2013). Major food sources of calories, added sugars, and saturated fat and their contribution to essential nutrient intakes in the U.S. diet: Data from the National Health and Nutrition Examination Survey (2003-2006). *Nutrition Journal, 12*, 116. doi:10.1186/1475-2891-12-116

International Agency for Research on Cancer. (2007). *Shiftwork*. Retrieved from http://monographs.iarc.fr/ENG/Monographs/vol98/mono98-8.pdf

James, S. M., Honn, K. A., Gaddameedhi, S., & Van Dongen, H. P. A. (2017). Shift work: Disrupted circadian rhythms and sleep-implications for health and well-being. *Current Sleep Medicine Reports, 3*(2), 104-112. doi:10.1007/s40675-017-0071-6

Johnston, D., Bell, C., Jones, M., Farquharson, B., Allan, J., Schofield, P., . . . Johnston, M. (2016). Stressors, appraisal of stressors, experienced stress and cardiac response: A real-time, real-life investigation of work stress in nurses. *Annals of Behavioral Medicine, 50*(2), 187-197. doi:10.1007/s12160-015-9746-8

Juda, M., Vetter, C., & Roenneberg, T. (2013). The Munich ChronoType Questionnaire for Shift-Workers (MCTQ^{Shift}). *Journal of Biological Rhythms, 28*(2), 130-140. doi:10.1177/0748730412475041

Karim, J., Weisz, R., & Rehman, S. U. (2011). International positive and negative affect schedule short-form (I-PANAS-SF): Testing for factorial invariance across cultures. *Procedia - Social and Behavioral Sciences, 15*, 2016-2022. doi:10.1016/j.sbspro.2011.04.046

Karlsson, B., Knutsson, A., & Lindahl, B. (2001). Is there an association between shift work and having a metabolic syndrome? Results from a population based study of 27,485 people. *Occupational and Environmental Medicine, 58*(11), 747-752. doi:10.1136/oem.58.11.747

Klok, M. D., Jakobsdottir, S., & Drent, M. L. (2007). The role of leptin and ghrelin in the regulation of food intake and body weight in humans: A review. *Obesity Reviews, 8*(1), 21-34. doi:10.1111/j.1467-789X.2006.00270.x

Korkmaz, A., Topal, T., Tan, D. X., & Reiter, R. J. (2009). Role of melatonin in metabolic regulation. *Reviews in Endocrine & Metabolic Disorders, 10*(4), 261-270. doi:10.1007/s11154-009-9117-5

Lavender, J. M., De Young, K. P., Anestis, M. D., Wonderlich, S. A., Crosby, R. D., Engel, S. G., . . . Le Grange, D. (2013). Associations between retrospective versus ecological momentary assessment measures of emotion and eating disorder symptoms in anorexia nervosa. *Journal of Psychiatric Research, 47*(10), 1514-1520. doi:10.1016/j.jpsychires.2013.06.021

Lennernas, M., Hambraeus, L., & Akerstedt, T. (1995). Shift related dietary intake in day and shift workers. *Appetite, 25*(3), 253-265. doi:10.1006/appe.1995.0060

Levy, D. E., Gelsomin, E. D., Rimm, E. B., Pachucki, M., Sanford, J., Anderson, E., . . . Thorndike, A. N. (2018). Design of ChooseWell 365: Randomized controlled trial of an automated, personalized worksite intervention to promote healthy food choices and prevent weight gain. *Contemporary Clinical Trials, 75*, 78-86. doi:10.1016/j.cct.2018.11.004

Li, Y., Sato, Y., & Yamaguchi, N. (2011). Shift work and the risk of metabolic syndrome: A nested case-control study. *International Journal of Occupational and Environmental Health, 17*(2), 154-160. doi:10.1179/107735211799030960

Lo, Y. L., Hsieh, Y. T., Hsu, L. L., Chuang, S. Y., Chang, H. Y., Hsu, C. C., . . . Pan, W. H. (2017). Dietary pattern associated with frailty: Results from Nutrition and Health Survey in Taiwan. *Journal of the American Geriatrics Society, 65*(9), 2009-2015. doi:10.1111/jgs.14972

Lowden, A., Moreno, C., Holmback, U., Lennernas, M., & Tucker, P. (2010). Eating and shift work - effects on habits, metabolism and performance. *Scandinavian Journal of Work, Environment and Health, 36*(2), 150-162. doi:10.2307/40967841

Lowe, M. R., Tappe, K. A., Butryn, M. L., Annunziato, R. A., Coletta, M. C., Ochner, C. N., & Rolls, B. J. (2010). An intervention study targeting energy and nutrient intake in worksite cafeterias. *Eating Behaviors, 11*(3), 144-151. doi:10.1016/j.eatbeh.2010.01.002

Manohar, S., Thongprayoon, C., Cheungpasitporn, W., Mao, M. A., & Herrmann, S. M. (2017). Associations of rotational shift work and night shift status with hypertension: A systematic review and meta-analysis. *Journal of Hypertension, 35*(10), 1929-1937. doi:10.1097/HJH.0000000000001442

Mashhadi, N. S., Saadat, S., Afsharmanesh, M. R., & Shirali, S. (2016). Study of association between beverage consumption pattern and lipid profile in shift workers. *Diabetes & Metabolic Syndrome, 10*(4), 227-229. doi:10.1016/j.dsx.2016.06.011

Matthews, G., Jones, D. M., & Chamberlain, A. G. (1990). Refining the measurement of mood: The UWIST Mood Adjective Checklist. *The British journal of psychology, 81*(1), 17-42. doi:10.1111/j.2044-8295.1990.tb02343.x

McCarthy, S. N., Robson, P. J., Livingstone, M. B., Kiely, M., Flynn, A., Cran, G. W., & Gibney, M. J. (2006). Associations between daily food intake and excess adiposity in Irish adults:

towards the development of food-based dietary guidelines for reducing the prevalence of overweight and obesity. *International Journal of Obesity (2005), 30*(6), 993-1002. doi:10.1038/sj.ijo.0803235

McDonald, R. J., Zelinski, E. L., Keeley, R. J., Sutherland, D., Fehr, L., & Hong, N. S. (2013). Multiple effects of circadian dysfunction induced by photoperiod shifts: Alterations in context memory and food metabolism in the same subjects. *Physiology and Behavior, 118*, 14-24. doi:10.1016/j.physbeh.2013.04.010

McHill, A. W., Melanson, E. L., Higgins, J., Connick, E., Moehlman, T. M., Stothard, E. R., & Wright, K. P., Jr. (2014). Impact of circadian misalignment on energy metabolism during simulated nightshift work. *Proceedings of the National Academy of Sciences of the United States of America, 111*(48), 17302-17307. doi:10.1073/pnas.1412021111

McIntyre, T. M., McIntyre, S. E., Barr, C. D., Woodward, P. S., Francis, D. J., Durand, A. C., . . . Kamarck, T. W. (2016). Longitudinal study of the feasibility of using ecological momentary assessment to study teacher stress: Objective and self-reported measures. *Journal of Occupational Health Psychology, 21*(4), 403-414. doi:10.1037/a0039966

McMenamin, T. M. (2007). *A time to work: Recent trends in shift work and flexible schedules*. Retrieved from https://www.bls.gov/opub/mlr/2007/12/art1full.pdf.

McMichael, A. J. (1976). Standardized mortality ratios and the "healthy worker effect": Scratching beneath the surface. *Journal of Occupational Medicine, 18*(3), 165-168. doi:10.1097/00043764-197603000-00009

Merz, E. L., Malcarne, V. L., Roesch, S. C., Ko, C. M., Emerson, M., Roma, V. G., & Sadler, G. R. (2013). Psychometric properties of Positive and Negative Affect Schedule (PANAS) original and short forms in an African American community sample. *Journal of Affective Disorders, 151*(3), 942-949. doi:10.1016/j.jad.2013.08.011

Miller, J. C. (2008). Fundamentals of shiftwork scheduling. *Ergonomics in Design, 16*(3), 13-17. doi:10.1518/106480408X333109

Ministry of Health and Welfare. (2017). *List of accredited hospitals 2013-2016.* Retrieved from https://www.mohw.gov.tw/dl-23917-a2e699bc-f0bd-4d32-adff- 6cde28f57e1a.html

Nahm, E. S., Warren, J., Zhu, S., An, M., & Brown, J. (2012). Nurses' self-care behaviors related to weight and stress. *Nursing Outlook, 60*(5), e23-31. doi:10.1016/j.outlook.2012.04.005

Nakazato, M., Murakami, N., Date, Y., Kojima, M., Matsuo, H., Kangawa, K., & Matsukura, S. (2001). A role for ghrelin in the central regulation of feeding. *Nature, 409*(6817), 194-198. doi:10.1038/35051587

Nea, F. M., Kearney, J., Livingstone, M. B., Pourshahidi, L. K., & Corish, C. A. (2015). Dietary and lifestyle habits and the associated health risks in shift workers. *Nutrition Research Reviews, 28*(2), 143-166. doi:10.1017/S095442241500013X

Neuhaus, J. M., & Kalbfleisch, J. D. (1998). Between- and within-cluster covariate effects in the analysis of clustered data. *Biometrics, 54*(2), 638-645. doi:10.2307/3109770

Newman, E., O'Connor, D. B., & Conner, M. (2007). Daily hassles and eating behaviour: The role of cortisol reactivity status. *Psychoneuroendocrinology, 32*(2), 125-132. doi:10.1016/j.psyneuen.2006.11.006

Nicholls, R., Perry, L., Duffield, C., Gallagher, R., & Pierce, H. (2017). Barriers and facilitators to healthy eating for nurses in the workplace: An integrative review. *Journal of Advanced Nursing, 73*(5), 1051-1065. doi:10.1111/jan.13185

Nicklas, T. A., & O'Neil, C. E. (2015). Development of the SoFAS (solid fats and added sugars) concept: The 2010 Dietary Guidelines for Americans. *Advances in Nutrition, 6*(3), 368S-375S. doi:10.3945/an.114.007021

O'Connor, D. B., Conner, M., Jones, F., McMillan, B., & Ferguson, E. (2009). Exploring the benefits of conscientiousness: An investigation of the role of daily stressors and health behaviors. *Annals of Behavioral Medicine, 37*(2), 184-196. doi:10.1007/s12160-009-9087-6

O'Connor, D. B., Jones, F., Conner, M., McMillan, B., & Ferguson, E. (2008). Effects of daily hassles and eating style on eating behavior. *Health Psychology, 27*(1S), S20-31. doi:10.1037/0278-6133.27.1.S20

O'Connor, L., Imamura, F., Lentjes, M. A., Khaw, K. T., Wareham, N. J., & Forouhi, N. G. (2015). Prospective associations and population impact of sweet beverage intake and type 2 diabetes, and effects of substitutions with alternative beverages. *Diabetologia, 58*(7), 1474-1483. doi:10.1007/s00125-015-3572-1

Orfanos, P., Naska, A., Trichopoulos, D., Slimani, N., Ferrari, P., van Bakel, M., . . . Trichopoulou, A. (2007). Eating out of home and its correlates in 10 European countries. The European Prospective Investigation into Cancer and Nutrition (EPIC) study. *Public Health Nutrition, 10*(12), 1515-1525. doi:10.1017/S1368980007000171

Pan, A., Schernhammer, E. S., Sun, Q., & Hu, F. B. (2011). Rotating night shift work and risk of type 2 diabetes: Two prospective cohort studies in women. *PLoS Medicine, 8*(12), e1001141. doi:10.1371/journal.pmed.1001141

Papier, K., D'Este, C., Bain, C., Banwell, C., Seubsman, S., Sleigh, A., & Jordan, S. (2017). Consumption of sugar-sweetened beverages and type 2 diabetes incidence in Thai adults: Results from an 8-year prospective study. *Nutrition & Diabetes, 7*(6), e283. doi:10.1038/nutd.2017.27

Peplonska, B., Bukowska, A., & Sobala, W. (2015). Association of rotating night shift work with BMI and abdominal obesity among nurses and midwives. *PloS One, 10*(7), e0133761. doi:10.1371/journal.pone.0133761

Persson, M., & Martensson, J. (2006). Situations influencing habits in diet and exercise among nurses working night shift. *Journal of Nursing Management, 14*(5), 414-423. doi:10.1111/j.1365-2934.2006.00601.x

Pico, C., Oliver, P., Sanchez, J., & Palou, A. (2003). Gastric leptin: A putative role in the short-term regulation of food intake. *British Journal of Nutrition, 90*(4), 735-741. doi:10.1079/BJN2003945

Pietroiusti, A., Neri, A., Somma, G., Coppeta, L., Iavicoli, I., Bergamaschi, A., & Magrini, A. (2010). Incidence of metabolic syndrome among night-shift healthcare workers. *Occupational and Environmental Medicine, 67*(1), 54-57. doi:10.1136/oem.2009.046797

Postnova, S., Postnov, D. D., Seneviratne, M., & Robinson, P. A. (2014). Effects of rotation interval on sleepiness and circadian dynamics on forward rotating 3-shift systems. *Journal of Biological Rhythms, 29*(1), 60-70. doi:10.1177/0748730413516837

Power, B. T., Kiezebrink, K., Allan, J. L., & Campbell, M. K. (2017). Understanding perceived determinants of nurses' eating and physical activity behaviour: A theory-informed qualitative interview study. *BMC Obesity, 4*, 18. doi:10.1186/s40608-017-0154-4

Richard, A., Meule, A., Reichenberger, J., & Blechert, J. (2017). Food cravings in everyday life: An EMA study on snack-related thoughts, cravings, and consumption. *Appetite, 113*, 215-223. doi:10.1016/j.appet.2017.02.037

Richter, K., Acker, J., Adam, S., & Niklewski, G. (2016). Prevention of fatigue and insomnia in shift workers-a review of non-pharmacological measures. *EPMA Journal, 7*, 16. doi:10.1186/s13167-016-0064-4

Risica, P. M., Gorham, G., Dionne, L., Nardi, W., Ng, D., Middler, R., . . . Gans, K. M. (2018). A multi-level intervention in worksites to increase fruit and vegetable access and intake: Rationale, design and methods of the 'Good to Go' cluster randomized trial. *Contemporary Clinical Trials, 65*, 87-98. doi:10.1016/j.cct.2017.12.002

Roenneberg, T. (2012). What is chronotype? *Sleep and Biological Rhythms, 10*(2), 75-76. doi:10.1111/j.1479-8425.2012.00541.x

Roenneberg, T., Daan, S., & Merrow, M. (2003). The art of entrainment. *Journal of Biological Rhythms, 18*(3), 183-194. doi:10.1177/0748730403018003001

Roenneberg, T., Hut, R., Daan, S., & Merrow, M. (2010). Entrainment concepts revisited. *Journal of Biological Rhythms, 25*(5), 329-339. doi:10.1177/0748730410379082

Roenneberg, T., Wirz-Justice, A., & Merrow, M. (2003). Life between clocks: Daily temporal patterns of human chronotypes. *Journal of Biological Rhythms, 18*(1), 80-90. doi:10.1177/0748730402239679

Roskoden, F. C., Kruger, J., Vogt, L. J., Gartner, S., Hannich, H. J., Steveling, A., . . . Aghdassi, A. A. (2017). Physical activity, energy expenditure, nutritional habits, quality of sleep and stress levels in shift-working health care personnel. *PloS One, 12*(1), e0169983. doi:10.1371/journal.pone.0169983

Rutledge, T., Stucky, E., Dollarhide, A., Shively, M., Jain, S., Wolfson, T., . . . Dresselhaus, T. (2009). A real-time assessment of work stress in physicians and nurses. *Health Psychology, 28*(2), 194-200. doi:10.1037/a0013145

Scheer, F. A., Hilton, M. F., Mantzoros, C. S., & Shea, S. A. (2009). Adverse metabolic and cardiovascular consequences of circadian misalignment. *Proceedings of the National Academy of Sciences of the United States of America, 106*(11), 4453-4458. doi:10.1073/pnas.0808180106

Schiavo-Cardozo, D., Lima, M. M., Pareja, J. C., & Geloneze, B. (2013). Appetite-regulating hormones from the upper gut: Disrupted control of xenin and ghrelin in night workers. *Clinical Endocrinology, 79*(6), 807-811. doi:10.1111/cen.12114

Schwingshackl, L., Bogensberger, B., & Hoffmann, G. (2018). Diet quality as assessed by the Healthy Eating Index, Alternate Healthy Eating Index, Dietary Approaches to Stop Hypertension score, and health outcomes: An updated systematic review and meta-analysis of cohort studies. *Journal of the Academy of Nutrition and Dietetics, 118*(1), 74-100 e111. doi:10.1016/j.jand.2017.08.024

Schwingshackl, L., & Hoffmann, G. (2015). Diet quality as assessed by the Healthy Eating Index, the Alternate Healthy Eating Index, the Dietary Approaches to Stop Hypertension score, and health outcomes: A systematic review and meta-analysis of cohort studies. *Journal of the Academy of Nutrition and Dietetics, 115*(5), 780-800 e785. doi:10.1016/j.jand.2014.12.009

Shah, D. (2009). Healthy worker effect phenomenon. *Indian Journal of Occupational and Environmental Medicine, 13*(2), 77-79. doi:10.4103/0019-5278.55123

Shiao, S. C., & Hu, P. Y. (2015). *Mental health investigation and prevention strategies in nurses*. New Taipei City: Institute of Labor, Occupational Safety And Health, Ministry of Labor. Retrieved from https://labor-elearning.mol.gov.tw/co_report_detail.php?rid=842.

Shy, B. D., Portelli, I., & Nelson, L. S. (2011). Emergency medicine residents' use of psychostimulants and sedatives to aid in shift work. *American Journal of Emergency Medicine, 29*(9), 1034-1036 e1031. doi:10.1016/j.ajem.2010.06.004

Smith, L., Folkard, S., Tucker, P., & Macdonald, I. (1998). Work shift duration: A review comparing eight hour and 12 hour shift systems. *Occupational and Environmental Medicine, 55*(4), 217-229. doi:10.1136/oem.55.4.217

Smith, M. R., & Eastman, C. I. (2012). Shift work: Health, performance and safety problems, traditional countermeasures, and innovative management strategies to reduce circadian misalignment. *Nature and Science of Sleep, 4*, 111-132. doi:10.2147/NSS.S10372

Spook, J. E., Paulussen, T., Kok, G., & Van Empelen, P. (2013). Monitoring dietary intake and physical activity electronically: Feasibility, usability, and ecological validity of a mobile-based Ecological Momentary Assessment tool. *Journal of Medical Internet Research, 15*(9), e214. doi:10.2196/jmir.2617

Steptoe, A., Gibson, E. L., Hamer, M., & Wardle, J. (2007). Neuroendocrine and cardiovascular correlates of positive affect measured by ecological momentary assessment and by questionnaire. *Psychoneuroendocrinology, 32*(1), 56-64. doi:10.1016/j.psyneuen.2006.10.001

Stevens, R. G., Hansen, J., Costa, G., Haus, E., Kauppinen, T., Aronson, K. J., . . . Straif, K. (2011). Considerations of circadian impact for defining 'shift work' in cancer studies: IARC Working Group Report. *Occupational and Environmental Medicine, 68*(2), 154-162. doi:10.1136/oem.2009.053512

Stone, A. A., & Shiffman, S. (2002). Capturing momentary, self-report data: A proposal for reporting guidelines. *Annals of Behavioral Medicine, 24*(3), 236-243. doi:10.1207/S15324796ABM2403_09

Strzemecka, J., Bojar, I., Strzemecka, E., & Owoc, A. (2014). Dietary habits among persons hired on shift work. *Annals of Agricultural and Environmental Medicine, 21*(1), 128-131.

Sun, M., Feng, W., Wang, F., Li, P., Li, Z., Li, M., . . . Tse, L. A. (2018). Meta-analysis on shift work and risks of specific obesity types. *Obesity Reviews, 19*(1), 28-40. doi:10.1111/obr.12621

Tada, Y., Kawano, Y., Maeda, I., Yoshizaki, T., Sunami, A., Yokoyama, Y., . . . Togo, F. (2014). Association of body mass index with lifestyle and rotating shift work in Japanese female nurses. *Obesity (Silver Spring), 22*(12), 2489-2493. doi:10.1002/oby.20908

Teng, M.-H., & Chang, S.-H. (2006). A hierarchical model for the comorbidity of GAD and depressive disorder. *Chinese Journal of Psychology, 48*(2), 203-218. doi:10.6129/CJP.2006.4802.06

Tepas, D. I., & Tepas, D. I. (1990). Do eating and drinking habits interact with work schedule variables? *Work and Stress, 4*(3), 203-211. doi:10.1080/02678379008256983

Thompson, E. R. (2007). Development and Validation of an Internationally Reliable Short-Form of the Positive and Negative Affect Schedule (PANAS). *Journal of Cross-Cultural Psychology, 38*(2), 227-242. doi:10.1177/0022022106297301

Tsai, S. M., Wong, R. H., Hwang, S. L., Yang, H. C., Lin, Y. C., & Liao, W. C. (2014). A study relating shift work to the parameters of metabolic syndrome among nurses in a medical center. *Taiwan Journal of Public Health, 33*(2), 119-130. doi:10.6288/TJPH201433102110

van Strien, T., Frijters, J. E. R., Bergers, G. P. A., & Defares, P. B. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behavior. *International lournal of Eating Disorders, 5*(2), 295-315. doi:10.1002/1098-108X(198602)5:23.0.CO;2-T

Vetter, C., Devore, E. E., Wegrzyn, L. R., Massa, J., Speizer, F. E., Kawachi, I., . . . Schernhammer, E. S. (2016). Association between rotating night shift work and risk of coronary heart disease among women. *JAMA, 315*(16), 1726-1734. doi:10.1001/jama.2016.4454

Wang, F., Zhang, L., Zhang, Y., Zhang, B., He, Y., Xie, S., . . . Tse, L. A. (2014). Meta-analysis on night shift work and risk of metabolic syndrome. *Obesity Reviews, 15*(9), 709-720. doi:10.1111/obr.12194

Wang, Y. F., Ha, S., Zauszniewski, J. A., & Ross, R. (2018). Psychometric properties of the Chinese version of the Dutch Eating Behavior Questionnaire in a sample of Taiwanese parents. *Obesity Research & Clinical Practice, 12*(1), 129-132. doi:10.1016/j.orcp.2017.11.005

Ward, D. S., Vaughn, A. E., Hales, D., Viera, A. J., Gizlice, Z., Bateman, L. A., . . . Linnan, L. A. (2018). Workplace health and safety intervention for child care staff: Rationale, design, and baseline results from the CARE cluster randomized control trial. *Contemporary Clinical Trials, 68*, 116-126. doi:10.1016/j.cct.2018.02.018

Wardle, J., Steptoe, A., Oliver, G., & Lipsey, Z. (2000). Stress, dietary restraint and food intake. *Journal of Psychosomatic Research, 48*(2), 195-202. doi:10.1016/S0022-3999(00)00076-3

Waterhouse, J., Buckley, P., Edwards, B., & Reilly, T. (2003). Measurement of, and some reasons for, differences in eating habits between night and day workers. *Chronobiology International, 20*(6), 1075-1092. doi:10.1081/CBI-120025536

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*(6), 1063-1070. doi:10.1037/0022-3514.54.6.1063

Wisetborisut, A., Angkurawaranon, C., Jiraporncharoen, W., Uaphanthasath, R., & Wiwatanadate, P. (2014). Shift work and burnout among health care workers. *Occupational Medicine (Oxford, England), 64*(4), 279-286. doi:10.1093/occmed/kqu009

Wong, H., Wong, M. C., Wong, S. Y., & Lee, A. (2010). The association between shift duty and abnormal eating behavior among nurses working in a major hospital: A cross-sectional study. *International Journal of Nursing Studies, 47*(8), 1021-1027. doi:10.1016/j.ijnurstu.2010.01.001

Wu, S. J., Pan, W. H., Yeh, N. H., & Chang, H. Y. (2011). Trends in nutrient and dietary intake among adults and the elderly: From NAHSIT 1993-1996 to 2005-2008. *Asia Pacific Journal of Clinical Nutrition, 20*(2), 251-265. doi:10.6133/apjcn.2011.20.2.15

Yang, P. H., Black, J. L., Barr, S. I., & Vatanparast, H. (2014). Examining differences in nutrient intake and dietary quality on weekdays versus weekend days in Canada. *Applied Physiology, Nutrition, and Metabolism, 39*(12), 1413-1417. doi:10.1139/apnm-2014-0110

Yoo, H. C., Burrola, K. S., & Steger, M. F. (2010). A preliminary report on a new measure: Internalization of the Model Minority Myth Measure (IM-4) and its psychological correlates among Asian American college students. *Journal of Counseling Psychology, 57*(1), 114-127. doi:10.1037/a0017871

Yoshizaki, T., Kawano, Y., Noguchi, O., Onishi, J., Teramoto, R., Sunami, A., . . . Togo, F. (2016). Association of eating behaviours with diurnal preference and rotating shift work in Japanese female nurses: A cross-sectional study. *BMJ Open, 6*(11), e011987. doi:10.1136/bmjopen-2016-011987

Yoshizaki, T., Komatsu, T., Tada, Y., Hida, A., Kawano, Y., & Togo, F. (2018). Association of habitual dietary intake with morningness-eveningness and rotating shift work in Japanese female nurses. *Chronobiology International, 35*(3), 392-404. doi:10.1080/07420528.2017.1410169

Zenk, S. N., Horoi, I., McDonald, A., Corte, C., Riley, B., & Odoms-Young, A. M. (2014). Ecological momentary assessment of environmental and personal factors and snack food intake in African American women. *Appetite, 83*, 333-341. doi:10.1016/j.appet.2014.09.008

Zhao, I., Bogossian, F., & Turner, C. (2012). Does maintaining or changing shift types affect BMI? A longitudinal study. *Journal of Occupational and Environmental Medicine, 54*(5), 525-531. doi:10.1097/JOM.0b013e31824e1073

Table 1-1. Participants' characteristics (N=77)

Variables	Mean (SD)	Range	n (%)
Personal level			
Demographic data			
Age (in years)	27.9 (4.5)	22.5-41.9	
Female			73 (94.8)
Marital status			
Married			9 (11.7)
Educational attainment			
Bachelor's degree or above			65 (84.4)
Family responsibility			
Taking care of kids/disabled people			12 (15.6)
Per capita household income[1] (n=75)			
Low income (<USD 4,955)			23 (29.9)
Middle income (USD 4,955-7,433)			17 (22.1)
Above middle income (>USD 7,433)			35 (45.5)
Other person level measures			
Body mass index (BMI)	23.1 (5.0)	17.2-39.1	
Having at least one chronic condition[2]			18 (23.4)
Eating style (DEBQ)			
Emotional	2.4 (0.7)	1.0-3.8	
Restrained	3.2 (0.5)	1.1-4.3	
External	2.7 (0.7)	2.0-4.4	
Chronotype ($\text{MCTQ}^{\text{shift}}$) ($\text{MSF}^{E}/\text{MSF}^{E}_{SC}$)[3] (n=53)			
Early			11 (14.3)
Intermediate			6 (7.8)
Late			36 (46.8)
Current smoker			2 (2.6)
Occupational history			
Years of working as an RN (in years)	5.7 (4.2)	0.5-20	
History of rotating shift work (in years)	5.4 (4.2)	0.5-20	
Work characteristics			
Working units			
Intensive care units			40 (52.0)
Shift speed[4]			
Slow			45 (58.4)
Medium or rapid			32 (41.6)
Moment level covariates (n_m= 2,444)			
Emotions			
Positive affect	18.9 (6.2)	7-33	
Negative affect	11.2 (4.5)	7-32	
Experienced stress			827 (37.9)

N: number of participants, n_m: number of momentary observations, SD: standard deviation, DEBQ: Dutch eating behavior questionnaire, MCTQ: Munich Chronotype Questionnaire, MSF^E: mid-sleep time on free days after evening shifts, $\mathrm{MSF}_{\mathrm{SC}}^{\mathrm{E}}$: corrected mid-sleep time on free days after evening shifts, RN: registered nurse.

[1] Two participants refused to report their annual household income. Per capita income was grouped based on the announcement from the Department of Social Assistance and Social Work, Ministry of Health and Welfare (2019).

[2] Chronic conditions included diabetes (type 1 or type 2) or high blood sugar, heart diseases (e.g., coronary artery disease, angina, congestive heart failure), hypertension, stroke, high cholesterol/hyperlipidemia, thyroid problems (e.g., hyperthyroidism, hypothyroidism), kidney diseases (e.g., chronic renal failure), cancer or a malignant tumor (excluding minor skin cancer), digestive problems (such as ulcer, colitis, or gallbladder disease), mental illnesses (e.g., depression, anxiety), and sleep problems (e.g., insomnia).

[3] Chronotype was assessed with the Chinese version of Munich Chronotype Questionnaire ($MCTQ^{shift}$) (Cheng & Hang, 2018). One participant refused to respond to this measure and 23 participants used alarms even they were on off-duty days; thus, only 53 participants' chronotype could be categorized.

[4] Shift speed is categorized based on the number of changes in shift timing. Slow, medium, and rapid shift speed was operationalized as up to 1 change, 2-3 changes, and 4 or more changes in shift timing in the past two weeks prior to the first EMA survey, respectively (Hall et al., 2018).

Table 1-2. Empty Calorie Food/Beverage Consumption by Shift Timing at the Momentary Level (N= 77 n_m= 2,444)[1]

	Overall	Shift Timing			
		Day	Evening	Night	Off
	n= 2444	n= 584	n= 494	n= 528	n = 838
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Empty calorie food/beverage consumption (Any versus none)					
Fried food or fast food	394 (16.1)	67 (11.5)	82 (16.6)	95 (18.0)	150 (17.9)
Sweet or salty snacks	788 (32.2)	149 (25.5)	159 (32.2)	194 (36.7)	286 (34.1)
Sweetened beverages	850 (34.8)	187 (32.0)	163 (33.0)	182 (34.5)	318 (38.0)
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Overall empty calorie food/beverage consumption (count)	1.1 (1.5)	0.9 (1.3)	1.0 (1.2)	1.2 (1.2)	1.3 (1.8)

N: number of participants, n_m: number of momentary observations, SD: standard deviation.

[1] 77 participants completed 2,444 EMA surveys during the 14-day data collection period. Out of 2,444 observations, 584, 494, 528, and 838 observations were reported on days when working on day shifts, evening shifts, night shifts, and off-duty days, respectively.

Table 1-3. Associations between Shift Timing and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N=77, n_m= 2,444)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Crude models								
Shift timing[1]								
Day (reference)								
Evening	1.35	(0.92, 1.99)	1.40	(1.04, 1.89)*	1.23	(0.88, 1.72)	0.12	(-0.04, 0.29)
Night	1.69	(1.14, 2.52)*	1.31	(0.97, 1.78)	1.34	(0.94, 1.90)	0.16	(0.00, 0.33)
Off	1.60	(1.14, 2.25)**	1.39	(1.07, 1.80)*	1.49	(1.11, 2.00)*	0.27	(0.12, 0.41)***
Adjusted models[2]								
Shift timing								
Day (reference)								
Evening	1.30	(0.89, 1.91)	1.30	(0.96, 1.76)	1.11	(0.78, 1.58)	0.05	(-0.11, 0.22)
Night	1.73	(1.16, 2.59)**	1.33	(0.98, 1.81)	1.46	(1.01, 2.10)*	0.17	(0.00, 0.33)*
Off	1.67	(1.18, 2.36)**	1.51	(1.15, 1.98)**	1.90	(1.39, 2.60)***	0.32	(0.18, 0.46)***

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

[1] Only within-person effects were presented in the table. The within-person effect captured how changes in shift timing given a person contributed to that person's variations in same-day empty calorie food/beverage consumption.

[2] The time-varying covariates (i.e., emotions, experienced stress, the number of complete EMA surveys per day, the sequence of the EMA survey days) and time-invariant covariates (i.e., age, BMI, educational attainment, family responsibility, health conditions) were controlled in the respective models.

$^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

Table 1-4. Associations between Shift Timing and Subsequent-Day Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N=77, n_m= 2,444)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Crude models								
Shift timing on the previous day [1]								
Day (reference)								
Evening	1.16	(0.80, 1.67)	1.13	(0.84, 1.52)	0.90	(0.65, 1.26)	-0.04	(-0.20, 0.12)
Night	1.03	(0.70, 1.53)	1.31	(0.97, 1.77)	1.07	(0.76, 1.52)	0.01	(-0.15, 0.18)
Off	1.04	(0.75, 1.46)	1.03	(0.79, 1.34)	0.93	(0.69, 1.24)	-0.07	(-0.21, 0.07)
Adjusted models								
Model 1[2]								
Shift timing on the previous day								
Day (reference)								
Evening	1.16	(0.80, 1.68)	1.11	(0.82, 1.50)	0.91	(0.64, 1.28)	-0.04	(-0.20, 0.12)
Night	1.05	(0.71, 1.56)	1.31	(0.96, 1.77)	1.10	(0.76, 1.58)	0.02	(-0.15, 0.18)
Off	1.05	(0.75, 1.47)	1.03	(0.79, 1.34)	0.93	(0.68, 1.26)	-0.06	(-0.21, 0.08)
Model 2[3]								
Shift timing on the previous day								
Day (reference)								
Evening	0.97	(0.64, 1.48)	0.93	(0.66, 1.31)	0.72	(0.49, 1.07)	-0.15	(-0.33, 0.03)
Night	0.78	(0.49, 1.21)	1.21	(0.85, 1.71)	0.92	(0.61, 1.38)	-0.07	(-0.25, 0.12)
Off	0.89	(0.62, 1.27)	0.96	(0.73, 1.28)	0.83	(0.60, 1.14)	-0.12	(-0.27, 0.04)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

[1] Only within-person effects were presented in the table. The within-person effect examined whether changes in shift timing given a person contributed to that person's variations in subsequent-day empty calorie food/beverage consumption.

[2] The identified time-varying (i.e., emotions, experienced stress, the number of complete EMA surveys per day, the sequence of the EMA survey days) and time-invariant covariates (i.e., age, BMI, educational attainment, family responsibility, health conditions) were controlled in the respective models.

[3] In addition to the variables controlled in the Model 1, same-day shift timing was controlled in the respective final models.

$^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

Table 1-5. Associations between Shift Intensity and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N=77, n_m= 2,444)

	Fried food/fast food		**Sweet or salty snacks**		**Sweetened beverages**		**Overall consumption**	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Crude models								
Work shift intensity^1	0.94	(0.87, 1.02)	0.94	(0.88, 1.00)	0.99	(0.92, 1.06)	-0.03	(-0.07, 0.00)*
Adjusted models								
<u>Model 1^2</u>								
Work shift intensity	0.94	(0.87, 1.02)	0.92	(0.87, 0.99)*	0.96	(0.89, 1.03)	-0.05	(-0.08, -0.01)**
<u>Model 2^3</u>								
Work shift intensity	0.97	(0.89, 1.06)	0.94	(0.87, 1.01)	1.04	(0.96, 1.13)	-0.01	(-0.05, 0.03)
Crude models								
Night shift intensity^4								
Low (reference)								
High	1.56	(1.00, 2.44)	0.99	(0.69, 1.42)	1.47	(0.97, 2.22)	0.10	(-0.10, 0.29)
Adjusted models								
<u>Model 3^2</u>								
Night shift intensity								
Low (reference)								
High	1.62	(1.03, 2.55)*	1.02	(0.71, 1.47)	1.50	(0.97, 2.31)	0.11	(-0.09, 0.30)
<u>Model 4^5</u>								
Night shift intensity								
Low (reference)								
High	1.50	(0.90, 2.48)	1.00	(0.67, 1.51)	1.64	(1.01, 2.68)*	0.15	(-0.07, 0.37)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

[1] Only within-person effects were presented in the table. The within-person effect examined how one consecutive work shift increased related to that person's variations in empty calorie food/beverage consumption.

[2] The identified time-varying (i.e., emotions, experienced stress, the number of complete EMA surveys per day, the sequence of the EMA survey days) and time-invariant covariates (i.e., age, BMI, educational attainment, family responsibility, health conditions) were controlled in the respective models.

[3] Besides variables adjusted in Model 1, same-day shift timing was controlled in the respective models.

[4] The within-person effects examined how changes in levels of night shift intensity for a given person contributed to that person's changes in empty calorie food/beverage consumption.

[5] In addition to variables controlled in Model 3, respective models also adjusted for same-day shift timing.

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 1-6. Associations between Shift Timing, Shift Speed and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N= 77, n_m = 2,444)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Crude models[1]								
Shift timing								
Day (reference)								
Evening	1.32	(0.81, 2.17)	1.42	(0.97, 2.09)	0.84	(0.55, 1.30)	0.05	(-0.16, 0.27)
Night	1.57	(0.90, 2.75)	1.11	(0.72, 1.73)	1.33	(0.80, 2.21)	0.12	(-0.12, 0.37)
Off	1.81	(1.16, 2.83)**	1.29	(0.91, 1.84)	1.24	(0.83, 1.85)	0.27	(0.08, 0.46)**
Shift speed[2]								
S (reference)								
M/R	0.16	(0.04, 0.60)**	0.91	(0.18, 4.74)	0.45	(0.04, 4.78)	-0.26	(-1.05, 0.57)
Shift speed*shift timing[3]								
M/R*Evening	1.04	(0.47, 2.28)	0.93	(0.50, 1.72)	2.54	(1.30, 5.08)**	0.18	(-0.16, 0.52)
M/R*Night	1.14	(0.51, 2.53)	1.35	(0.73, 2.49)	1.08	(0.54, 2.17)	0.08	(-0.25, 0.42)
M/R*Off	0.73	(0.37, 1.46)	1.15	(0.68, 1.94)	1.53	(0.85, 2.74)	-0.01	(-0.30, 0.28)
Adjusted models[4]								
Shift timing								
Day (reference)								
Evening	1.27	(0.78, 2.08)	1.29	(0.87, 1.91)	0.73	(0.46, 1.14)	-0.03	(-0.24, 0.19)
Night	1.67	(0.95, 2.94)	1.15	(0.74, 1.80)	1.50	(0.88, 2.53)	0.15	(-0.09, 0.39)
Off	1.91	(1.21, 3.00)**	1.42	(0.98, 2.04)	1.61	(1.06, 2.46)*	0.35	(0.16, 0.54)***
Shift speed								
S (reference)								
M/R	0.21	(0.06, 0.76)*	0.99	(0.19, 4.99)	0.78	(0.08, 7.49)	-0.06	(-0.80, 0.68)
Shift speed*shift timing								
M/R*Evening	1.05	(0.48, 2.31)	1.00	(0.53, 1.86)	2.91	(1.44, 5.91)**	0.20	(-0.13, 0.53)
M/R*Night	1.06	(0.47, 2.36)	1.30	(0.70, 2.41)	1.02	(0.50, 2.11)	0.05	(-0.28, 0.38)

M/R*Off	0.71	(0.36, 1.41)	1.12	(0.66, 1.90)	1.47	(0.81, 2.70)	-0.04	(-0.32, 0.24)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions, S: slow shift speed, M/R: medium or rapid shift speed.

[1] The between-person effects of shift timing and the between-person multiplicative interactions between shift timing and shift speed were controlled in the respective models and were not shown in the table.

[2] Shift speed was a person-level variable. The between-person effects estimated whether differences in shift speed between persons were associated with their differences in empty calorie food/beverage consumption (Hedeker et al., 2008; Neuhaus & Kalbfleisch, 1998; Zenk et al., 2014).

[3] The multiplicative interactions between shift timing and shift speed were cross-level. These interactions tested if associations between empty calorie food/beverage consumption and shift timing were moderated by shift speed.

[4] The identified time-varying (i.e., emotions, experienced stress, the number of complete EMA surveys per day, the sequence of the EMA survey days) and time-invariant covariates (i.e., age, BMI, educational attainment, family responsibility, health conditions) were controlled in the respective models.

$^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

Table 1-7. Associations between Work Shift Intensity, Shift Speed and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N= 77, n_m= 2,444)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Crude models[1]								
Work shift intensity	0.89	(0.80, 1.00)*	0.93	(0.85, 1.01)	0.91	(0.82, 1.00)	-0.07	(-0.12, -0.02)**
Shift speed								
S (reference)								
M/R	1.44	(0.55, 3.78)	0.49	(0.15, 1.63)	0.66	(0.13, 3.46)	-0.27	(-0.87, 0.33)
Shift speed*work shift intensity[2]								
M/R*work shift intensity	1.12	(0.96, 1.31)	1.03	(0.91, 1.16)	1.19	(1.03, 1.36)*	0.07	(0.01, 0.14)*
Adjusted models								
Model 1[3]								
Work shift intensity	0.89	(0.79, 0.99)*	0.91	(0.83, 0.99)*	0.88	(0.77, 0.96)**	-0.09	(-0.14, -0.04)***
Shift speed								
S (reference)								
M/R	1.58	(0.64, 3.88)	0.45	(0.15, 1.34)	0.80	(0.17, 3.79)	-0.19	(-0.72, 0.35)
Shift speed* work shift intensity								
M/R*work shift intensity	1.14	(0.97, 1.33)	1.04	(0.92, 1.18)	1.23	(1.06, 1.42)**	0.08	(0.02, 0.15)*
Model 2[4]								
Work shift intensity	0.92	(0.81, 1.04)	0.93	(0.84, 1.03)	0.95	(0.85, 1.07)	-0.04	(-0.10, 0.01)
Shift speed								
S (reference)								
M/R	2.07	(0.87, 4.96)	0.47	(0.15, 1.42)	1.02	(0.21, 4.99)	0.01	(-0.50, 0.53)
Shift speed* work shift intensity								
M/R*work shift intensity	1.11	(0.95, 1.30)	1.03	(0.90, 1.17)	1.17	(1.01, 1.35)*	0.06	(-0.01, 0.13)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions, S: slow shift speed, M/R: medium or rapid shift speed.

[1] The between-person effects of work shift intensity and the between-person multiplicative interaction terms between work shift intensity and shift speed were controlled in the respective models.

[2] The multiplicative interactions between work shift intensity and shift speed were cross-level. These interactions tested if associations between empty calorie food/beverage consumption and work shift intensity were moderated by shift speed.

[3] The identified time-varying (i.e., emotions, experienced stress, the number of complete EMA surveys per day, the sequence of the EMA survey days) and time-invariant covariates (i.e., age, BMI, educational attainment, family responsibility, health conditions) were controlled in the respective models.

[4] Besides covariates adjusted in the Model 1, same-day shift timing was adjusted in the respective models.

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 1-8. Associations between Night Shift Intensity, Shift Speed and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N= 77, n_m= 2,444)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Crude models[1]								
Night shift intensity								
Low (reference)								
High	1.20	(0.64, 2.25)	1.05	(0.64, 1.73)	1.41	(0.79, 2.54)	0.09	(-0.18, 0.37)
Shift speed								
S (reference)								
M/R	0.80	(0.55, 1.17)	0.74	(0.48, 1.17)	0.75	(0.40, 1.39)	-0.17	(-0.39, 0.06)
Shift speed*night shift intensity[2]								
M/R*high	1.74	(0.71, 4.26)	0.88	(0.43, 1.82)	1.08	(0.47, 2.45)	0.01	(-0.39, 0.40)
Adjusted models								
Model 1[3]								
Night shift intensity								
Low (reference)								
High	1.24	(0.66, 2.34)	1.05	(0.64, 1.74)	1.06	(0.90, 1.26)	0.08	(-0.19, 0.36)
Shift speed								
S (reference)								
M/R	0.85	(0.59, 1.22)	0.79	(0.52, 1.21)	1.42	(0.77, 2.62)	-0.09	(-0.30, 0.12)
Shift speed* night shift intensity								
M/R*high	1.76	(0.72, 4.33)	0.93	(0.45, 1.93)	0.85	(0.46, 1.54)	0.05	(-0.34, 0.44)
Model 2[4]								
Night shift intensity								
Low (reference)								
High	1.16	(0.59, 2.28)	1.06	(0.62, 1.81)	1.60	(0.83, 3.07)	0.14	(-0.15, 0.43)
Shift speed								
S (reference)								

M/R	0.88	(0.62, 1.26)	0.76	(0.49, 1.18)	0.91	(0.50, 1.68)	-0.09	(-0.30, 0.11)
Shift speed*night shift intensity								
M/R*high	1.71	(0.70, 4.18)	0.90	(0.43, 1.86)	1.05	(0.45, 2.49)	0.02	(-0.36, 0.41)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions, S: slow shift speed, M/R: medium or rapid shift speed.

[1] Respective models adjusted for the between-person effects of night shift intensity and the between-person multiplicative interactions between night shift intensity and shift speed.

[2] The multiplicative interactions between night shift intensity and shift speed were cross-level. These interactions tested if associations between empty calorie food/beverage consumption and night shift intensity were moderated by shift speed.

[3] The identified time-varying (i.e., emotions, experienced stress, the number of complete EMA surveys per day, the sequence of the EMA survey days) and time-invariant covariates (i.e., age, BMI, educational attainment, family responsibility, health conditions) were controlled in the respective models.

[4] Besides covariates controlled in the Model 1, respective models adjusted for same-day shift timing.

*p< 0.05, **p< 0.01, ***p< 0.001

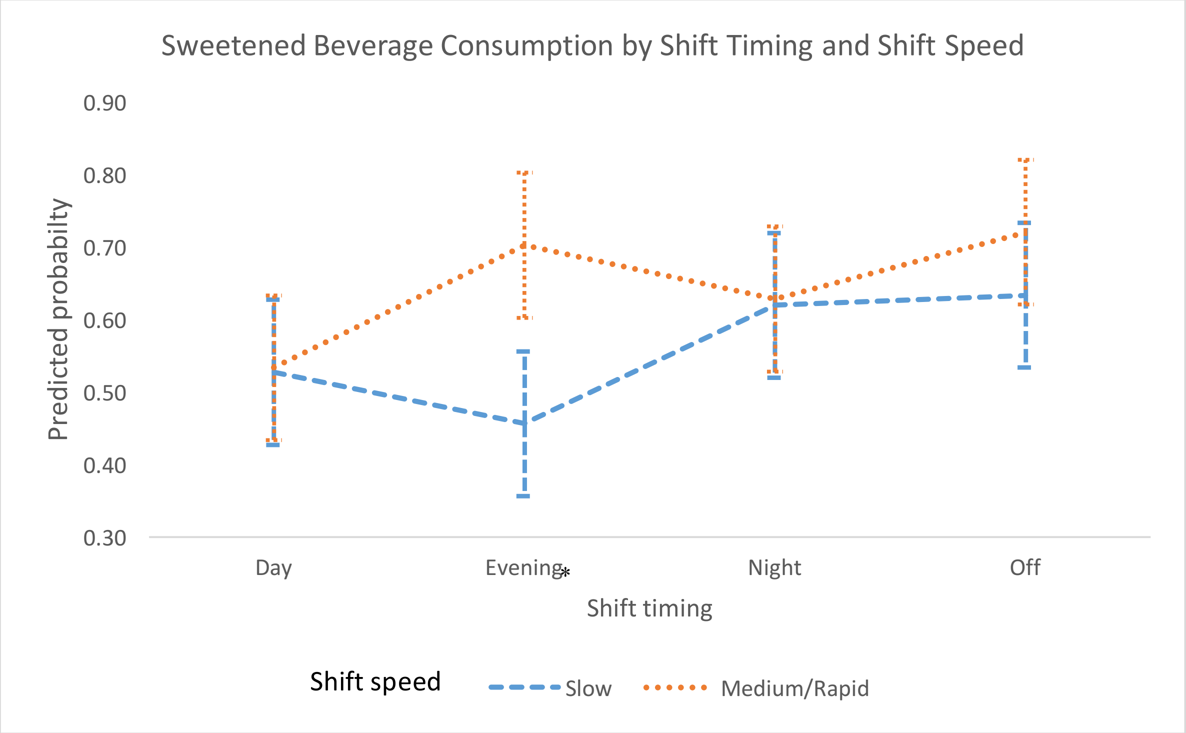


Figure 1-1. Predicted probability of sweetened beverage consumption by within-person shift timing and shift speed. Error bars represented standard errors. (*p<0.05)

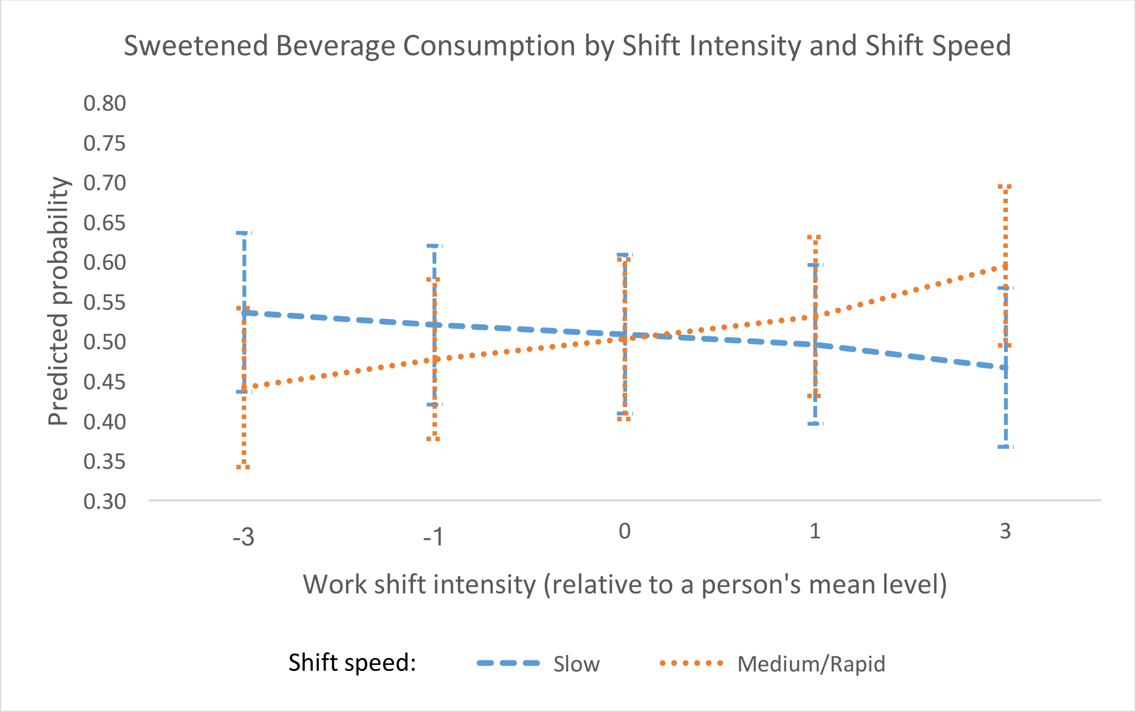


Figure 1-2. Predicted probability of sweetened beverage consumption by within-person work shift intensity and shift speed. Error bars represented standard errors. The numbers on the x axis referred to changes in the number of consecutive work shifts deviance from their usual levels of work shift intensity over the two weeks. “0” referred to no differences from their usual levels. “1” referred to adding an extra work shift to their usual levels. “-1” referred to reducing one work shift from their usual levels.

3. DO ASSOCIATIONS BETWEEN SHIFT WORK AND EMPTY CALORIE FOOD/BEVERAGE CONSUMPTION DEPEND ON SLEEP?

3.1 Background

3.1.1 Shift Work and Chronic Disease

An estimated 20-25% of the working population engage in shift work, that is, they work outside the regular daytime hours of 6:00 a.m. to 6:00 p.m., Monday through Friday (McMenamin, 2007; National Center for Health Statistics, 2015). Shift work may force workers to synchronize their lifestyles with their work schedules (e.g., change sleep times, meal times) which may disrupt their circadian rhythm (i.e., a biological clock with a 24-hour cycle) (Bedrosian, Fonken, & Nelson, 2016; Korkmaz, Topal, Tan, & Reiter, 2009; Wehrens et al., 2017). A large body of evidence has revealed that circadian disruption may increase risk of chronic diseases by disturbing sympathovagal and hormonal balance (e.g., melatonin, leptin, ghrelin) (Bedrosian et al., 2016; Gautron & Elmquist, 2011; James, Honn, Gaddameedhi, & Van Dongen, 2017; Korkmaz et al., 2009; Nakazato et al., 2001), impairing glucose metabolism (i.e., changing glucose tolerance), increasing inflammatory responses, or inducing sleep deficiency (Bedrosian et al., 2016; James et al., 2017). Considerable research has found associations between shift work and increased risk of obesity (Peplonska, Bukowska, & Sobala, 2015; Sun et al., 2018; Zhao, Bogossian, & Turner, 2012), metabolic syndrome (Bedrosian et al., 2016; Karlsson, Knutsson, & Lindahl, 2001; Li, Sato, & Yamaguchi, 2011; Pietroiusti et al., 2010; Wang et al., 2014), type 2 diabetes (Hansen, Stayner, Hansen, & Andersen, 2016; Pan, Schernhammer, Sun, & Hu, 2011), and cardiovascular diseases (Manohar, Thongprayoon, Cheungpasitporn, Mao, & Herrmann, 2017; Vetter et al., 2016). The mechanisms linking shift work and incidence of chronic diseases, however, are still under investigation.

3.1.2 Empty Calorie Food/Beverage Consumption and Chronic Disease

Several prospective cohort studies have suggested that empty calorie food/beverage intake (i.e., calories from solid fats or added sugars, for instance, calories from sugar-sweetened beverages or desserts) (Guenther et al., 2013; Nicklas & O'Neil, 2015) is associated with increased risk of chronic diseases (e.g., obesity, type 2 diabetes) (McCarthy et al., 2006; O'Connor et al., 2015; Papier et al., 2017). In the United States (U.S.), the top sources of sugar-sweetened beverages are soft drinks, soda, and fruit drinks/-ades. The top sources of sugar-sweetened desserts are candy, sugary foods (e.g., chocolate), cakes, cookies, quick breads, pastries, pies, and milk desserts (Huth, Eliades, Handwork, Englehart, & Messenger, 2013). Similarly, in Taiwan, the common sources of low-nutrient-density food or beverages are: sugar-sweetened beverages (i.e., sugary drinks, and sugar-added processed juices) and sugar-sweetened desserts (i.e., pastries, cookies, jelly, puddings, candy, chocolate, sweetened shaved ice desserts) (Wu, Pan, Yeh, & Chang, 2011).

3.1.3 Shift Work and Empty Calorie Food/Beverage Consumption

Shift work is one of the contributors to higher empty calorie food/beverage consumption (Bonnell et al., 2017; Cain, Filtness, Phillips, & Anderson, 2015; de Assis, Kupek, Nahas, & Bellisle, 2003; Heath, Coates, Sargent, & Dorrian, 2016; Mashhadi, Saadat, Afsharmanesh, & Shirali, 2016; Tada et al., 2014; Tsai et al., 2014; Yoshizaki et al., 2018). Previous studies suggested that shift work might influence the secretion of appetite hormones such as suppression of leptin (i.e., a satiety hormone) (James et al., 2017; McHill et al., 2014;

Scheer, Hilton, Mantzoros, & Shea, 2009), increased ghrelin (i.e., a hunger hormone) (James et al., 2017; Schiavo-Cardozo, Lima, Pareja, & Geloneze, 2013) and lowered xenin (i.e., an anorexigenic hormone) (Schiavo-Cardozo et al., 2013).

The effects of appetite hormones (e.g., leptin, ghrelin) on regulation of food intake (e.g., appetite, meal size, number of servings) could be short-term. Previous studies suggested that increased ghrelin was related to increased appetite and could initiate a person's food consumption even without time- or food-related cues (Attele, Shi, & Yuan, 2002; Klok, Jakobsdottir, & Drent, 2007; Pico, Oliver, Sanchez, & Palou, 2003). Building upon this, a participant's empty calorie food/beverage consumption can vary day-to-day or in-the-moment across the day depending on their daily exposures to shift work. In addition, a person's experiences one day may also influence their behaviors on the following day (Cain et al., 2015; Zenk et al., 2014). For instance, Cain et al. (2015) noted that participants who were exposed to a simulated night shift consumed more high-fat foods the following morning.

A randomized case-crossover study (i.e., four consecutive nights of 8.5 hours in bed and four consecutive nights of 4.5 hours in bed) of 19 healthy men found that increased ghrelin during the evening was positively associated with increased daily calorie consumption from sweetened foods, particularly on days with sleep restriction (Broussard et al., 2016). This suggested that dysynchronized appetite hormones may contribute to shift workers' increased likelihood of empty calorie food/beverage consumption, and short sleep duration may influence these associations.

3.1.4 Sleep Quality, Sleep Duration and Empty Calorie Food/Beverage Consumption

Sleep quality and duration may play a role in empty calorie food/beverage consumption. Some cross-sectional studies found that people with poor sleep quality were more likely to consume empty calorie foods/beverages (Ferranti et al., 2016; Katagiri et al., 2014). Another cross-sectional study of 602 adults showed that poor sleep quality was positively associated with hunger level and disinhibited eating behaviors (i.e., overeating in response to the presence of palatable foods or emotional stress) (Blumfield, Bei, Zimberg, & Cain, 2018).

In addition to sleep quality, a large body of literature has suggested that there are positive within- and between-person associations between short sleep duration (i.e., less than seven hours per day) and empty calorie food/beverage consumption (Dashti, Scheer, Jacques, Lamon-Fava, & Ordovas, 2015; Garaulet, Ordovas, & Madrid, 2010; Heath et al., 2012; Imaki, Hatanaka, Ogawa, Yoshida, & Tanada, 2002; Kant & Graubard, 2014; Martinez et al., 2017; McNeil et al., 2016; Nedeltcheva et al., 2009; Westerlund, Ray, & Roos, 2009). With regard to within-person associations, an experimental study of 24 healthy males suggested that severe sleep restriction (i.e., four hours of sleep) was associated with an increased likelihood of empty calorie food/beverage consumption compared to moderate sleep restriction (i.e., six hours of sleep) (Heath et al., 2012). Another randomized case-crossover study of 16 healthy males revealed that total sleep deprivation (i.e., no sleep in the previous day) contributed to increased plasma ghrelin, appetite, and preferences for larger portions of snacks (Hogenkamp et al., 2013). Broussard et al. (2016) found that increased ghrelin during the evening was associated with increased calorie intake from sweetened foods, particularly on days with sleep restriction. Smith, Ludy, and Tucker (2016) found that food preference was not significantly different between habitual long-sleepers and short-sleepers. However, habitual long-sleepers' desire for sweetened foods were higher after encountering short sleep duration. In summary, research suggests an individual's empty calorie food/beverage intake on a day may differ depending on their sleep quality and duration.

3.1.5 Shift Work, Sleep Quality and Sleep Duration

Prior research suggested that people who do shift work tend to have poor sleep quality (Lin et al., 2012; Ma et al., 2018; Monk et al., 2013; Waage et al., 2014) and shorter sleep duration (Akerstedt, Nordin, Alfredsson, Westerholm, & Kecklund, 2010; Boivin, Boudreau, James, & Kin, 2012; Centers for Disease Control and Prevention, 2012; Ko, 2013; Ohayon, Smolensky, & Roth, 2010). A cross-sectional study of 769 rotating shift workers revealed that working more than 15 night shifts in the past two months was associated with poor sleep quality (Lin et al., 2012). A report from the 2010 National Health Interview Survey (NHIS) showed that short sleep duration was more prevalent among regular night workers (i.e., only working on night shifts) (44.0%) compared to regular day workers (28.8%) (Centers for Disease Control and Prevention, 2012). A population-based cross-sectional survey among Taiwanese employees (n=16,440) suggested that regular night shift work was associated with short sleep duration (Cheng & Cheng, 2017).

Additionally, recent studies have revealed that shift workers' sleep quality and sleep duration may vary according to their shift timing (i.e., day, evening, night). A 28-day prospective study of 17 Australian midwives showed that participants had better sleep quality on days before evening shifts relative to days before day, night shifts or off-duty. Sleep quality was better on days before off-duty days compared to day shifts (Tremaine et al., 2013). Another 12-day prospective study of 30 regular day shift and 32 rotating shift nurses suggested that rotating shift workers had longer daily total sleep time (TST) on evening shifts than regular day shift workers did. In addition, rotating shift workers' daily TST on evening shifts was significantly longer compared to days that they worked on day or night shifts (Niu et al., 2017). This suggests that shift workers' daily sleep quality and sleep duration differs when they work on different shift timings.

3.1.6 Gaps in the Literature

Based on the evidence reviewed above, shift work may be associated with within- and between-person variations in empty calorie food/beverage consumption (Bonnell et al., 2017; Cain et al., 2015; de Assis et al., 2003; Heath et al., 2016; Mashhadi et al., 2016; Tada et al., 2014; Yoshizaki et al., 2018). However, how shift work contributes to within- and between-person variations in workers' empty calorie food/beverage consumption remains unclear.

A large body of literature has suggested that poor sleep quality (Ferranti et al., 2016; Huth et al., 2013) and short sleep duration (Broussard et al., 2016; Heath et al., 2012; Hogenkamp et al., 2013; McNeil et al., 2016; McNeil et al., 2017; Nedeltcheva et al., 2009; Smith et al., 2016; Westerlund et al., 2009) are significantly associated with increased empty calorie food/beverage consumption. In addition, recent evidence has indicated that changes in shift workers' daily sleep quality and sleep duration differ day-to-day depending on their same-day shift timing (Niu et al., 2017; Tremaine et al., 2013). A recent study revealed that poor sleep quality and shift work were each independently associated with dietary intake (Heath, Dorrian, & Coates, 2019). Therefore, it is possible that on days with poor sleep quality or short sleep duration, the adverse effects of shift work on empty calorie food/beverage consumption are worse. However, to my knowledge, no study has examined whether the effect of shift work on consumption differs by sleep quality or sleep duration.

Recent literature has suggested that the complexity of shift work (e.g., shift timing, shift intensity, shift speed) should be considered when investigating the adverse effects of shift work on health (Hall, Franche, & Koehoorn, 2018; Harma et al., 2015; Stevens et al., 2011). Referred to as shift timing or when a worker starts their work shifts, shift work can be classified as day shifts, evening shifts, night shifts, and rotating shifts (Hall et al., 2018; McMenamin, 2007; Smith, Folkard, Tucker, & Macdonald, 1998). Another domain of shift work is shift intensity, or the total number of consecutive work shifts (Harma et al., 2015). Shift work also varies in terms of shift speed, or how often a shift worker has to change their shift timing, such as changing from day to evening shifts. Shift speed can be further grouped into rapid (i.e., having 4 or more changes in shift timing over 2 weeks), medium (i.e., having 2 to 3 changes in shift timing over 2 weeks), and slow (i.e., having up to 1 change in shift timing over 2 weeks) (Hall et al., 2018). However, of studies investigating associations between shift work and empty calorie food/beverage consumption or relationships between shift work and sleep patterns, most only considered the impact of shift timing. Investigations into the effects of shift intensity or shift speed and to what extent sleep quality or sleep duration moderates effects on empty calorie food/beverage consumption remain limited.

3.1.7 Study Purpose and Hypotheses

To address these gaps, the purpose of this study was to examine if daily sleep quality or sleep duration moderated within-person associations between shift work and empty calorie food/beverage intake. I tested four hypotheses (H). (H1) On days with poor sleep quality or short sleep duration, working evening or night shifts versus day shifts will have a stronger association with increased empty calorie food/beverage consumption. (H2) On days with poor sleep quality or short sleep duration, working evening or night shifts versus day shifts on the previous day will be associated with higher empty calorie food/beverage consumption. (H3a) On days with poor sleep quality or short sleep duration, work shift intensity will be positively associated with increased empty calorie food/beverage consumption. (H3b) On days with poor sleep quality or short sleep duration, night shift intensity will be positively associated with increased empty calorie food/beverage consumption. (H4) On days with poor sleep quality or short sleep duration, medium or rapid shift speed workers versus slow shift speed workers will have higher empty calorie food/beverage consumption.

3.2 Methods

3.2.1 Sample

A nation-wide survey among Taiwanese registered nurses revealed that approximately two thirds (67.9%) had less than 7-hour of sleep duration in the past year, of whom more than half complained that both their life and work had been influenced by short sleep duration. In addition, irregular shift work patterns (e.g., varying number of consecutive work shifts, or night shifts within a month) (Shiao & Hu, 2015) and empty calorie food/beverage consumption (Chang & Liao, 2015; Tsai et al., 2014) are common among this population. Therefore, I recruited registered nurses who worked rotating shifts in Taiwan accredited hospitals (Ministry of Health and Welfare, 2017) by sharing the recruitment flyers on social media platforms (e.g., Facebook).

The inclusion criteria were: (1) Taiwanese registered nurses working full-time (i.e., 40-hours per week), (2) aged 20-65 years old (i.e., adult working population), (3) working on rotating shifts, defined as a monthly work schedule including at least two shift timings such as day and evening shifts, in the hospital for at least six months and in the coming 30 days, and (4) no intention to leave the nursing profession in the next 30 days. The exclusion criteria were: (1) not having smartphones or having smartphones without access to Internet services, (2) unwilling or unable to provide registry-based work schedules, (3) working in an administrative position such as Dean, Associate Dean, Director of Nursing Supervisor, and Head Nurse, and (4) pregnant.

To examine the within-person associations between shift work and empty calorie food/beverage intake, the Gpower program with the option of within-between associations was used to calculate the target sample size. The settings for power calculation were as follows: (1) the power level (β) at 0.8 with significant level (α) at 0.05 (two-tailed); (2) the number of groups at three (i.e., day, evening, night shifts); (3) the number of repeated measures at 14. No prior studies have examined momentary empty calorie food/beverage intake on different shift timings; therefore, the day-level associations in the literature (de Assis et al., 2003; Flueckiger, Lieb, Meyer, Witthauer, & Mata, 2017) were used to estimate the effect size. Based on the aforementioned settings and the estimated small effect size of 0.13 (Cohen, 1988), the target sample size was 63.

Between October 2018 and January 2019, I recruited 80 registered nurses, of whom one participant dropped out of this study before the first EMA signal was prompted, resulting in 79 participants responding to 2,491 EMA surveys on 971 person-days. The EMA survey response rate was 56.3%, which was calculated by dividing the total number of initiated surveys (i.e., 2,491) by the total number of prompted EMA surveys over the two weeks (i.e., 4,424=79 participants*14 days*4 prompts per day) and multiplying this quotient with 100. My main interest was within-person associations between shift work and empty calorie food/beverage consumption; therefore, participants who only responded to EMA surveys on one day or completed less than 10% of total EMA surveys (i.e., less than six surveys over the two weeks) were excluded from the analysis (n=2). One participant had invalid Actigraph data (i.e., no data was collected during study period), which was used to measure sleep. Therefore, an analytical sample of 76 was used in this study. Only observations with complete data in all outcome variables, the measures of shift work, and covariates were included in the analysis. The process of data exclusion is displayed in Appendix A (see Figure A-2).

3.2.2 Study Design and Data Collection

An intensive longitudinal study design (Bolger & Laurenceau, 2013) using ecological momentary assessment (EMA) was employed for this study. The study had three phases: baseline visit, 14-day EMA data collection period, and post visit.

First, an in-person meeting for the baseline survey was scheduled after a participant agreed to participate this study. During the baseline visit, I explained the study and obtained written informed consent; administered a baseline survey that included information on demographics, body mass index (BMI), eating style, smoking and tobacco use, chronotype, occupational history, and work characteristics; provided instructions for the EMA surveys and Actigraph; and collected their self-printed published work schedule during the past 30 days and the published prospective work schedule for the next 30 days.

During the EMA data collection period, I used EMA surveys to assess participants' same-day work schedule, empty calorie food/beverage intake, self-reported sleep quality, emotions, and experienced stress. Participants were prompted four times per day randomly during the following time blocks: 3:00-9:00 a.m., 9:00 a.m.-3:00 p.m., 3:00-9:00 p.m., and 9:00 p.m.-3:00 a.m. According to a participant's shift schedule and sleep-wake time, these four time blocks were adjusted if necessary. For each prompt, a participant received a text message or an e-mail that included the survey link for the EMA survey. Each EMA survey was valid for an hour. During this period, a 15-minute reminder (i.e., a text) was set up until a participant completed the survey. If there was no response from the participant within this given hour, this survey was considered missing. In addition, participants' daily sleep duration was objectively assessed by an accelerometer (i.e., Actigraph GT3X).

During the post visit, I retrieved the accelerometer; administered a post survey to primarily assess whether a participant's work shift schedule changed during the EMA data collection period; and provided incentives for their participation. The incentive was up to USD 30 in cash: USD 3 for the baseline survey, USD 10 for the EMA surveys, USD 2 for the post survey, and a bonus of USD 10 for completing 80% of the EMA survey. If the EMA surveys were 100% completed, an extra payment of USD 5 was given.

Most of the EMA surveys were sent via text messages through a primary platform. Due to an unforeseen technical issue in which that platform often had downtime for maintenance lasting for approximately three hours, a second platform was used. Specifically, if the sampled EMA survey time was between 1:00 p.m. and 4:00 p.m. local time, the EMA survey link was distributed via e-mail by this secondary platform. To avoid missing surveys ascribing to the inconsistent systems for data collection, I also sent an extra reminder via text messages to notify participants. The Institutional Review Boards (IRB) at the University of Illinois at Chicago and at the National Taiwan University Hospital approved this study.

3.2.3 Measures

3.2.3.1 Shift Work

Shift work was assessed objectively by a record that documented participants' actual shift schedule (i.e., the published work schedule collected during the baseline visit). There were two day-level measures (i.e., shift timing and shift intensity) and one person-level measure (i.e., shift speed).

Shift timing (a day-level measure) was assessed according to the records of shift start time in the provided work schedule. There were four types of shift timing: day, evening, night, and off-duty (i.e., no work on that day) (Hall et al., 2018; McMenamin, 2007; Smith et al., 1998). Given inconsistent definitions of night shifts in different hospitals, I defined night shifts as days with working hours covering 12:00 a.m. through 8:00 a.m.

Shift intensity (a day-level measure) was assessed based on the published work schedule by retrospectively counting the total number of consecutive work shifts (i.e., work shift intensity) and the total number of consecutive night shifts (i.e., night shift intensity) (Harma et al., 2015) over the two weeks. For instance, if a person had been working for three consecutive work shifts, the work shift intensity that day was recorded as three. On off-duty days, work shift intensity was recorded as zero. This variable was treated as a continuous variable in the analysis.

The same approach was employed for the measurement of night shift intensity except I retrospectively counted the total number of consecutive night shifts over the two weeks. Most person-days (77.7%) were recorded as “zero” night shift intensity. A Prior study revealed that more than two consecutive night shifts was related to shift workers’ fatigue (Harma et al., 2018). As a result, the measure of night shift intensity was dichotomized as <=2 and >2. More than two consecutive night shifts in a row was considered “high” night shift intensity.

Shift speed (a person-level measure) was assessed by counting the number of changes in shift timing (e.g., two changes: switching from day shifts to evening shifts, and then switching from evening shifts to day shifts) in the two weeks prior to the first EMA survey according to the record in the published work schedule. There were three levels of shift speed: slow (i.e., having up to 1 change), medium (i.e., having 2-3 changes), and rapid (i.e., having 4 or more changes) (Hall et al., 2018). Only six participants (7.9%) were assigned a rapid shift speed schedule. Thus, I combined participants assigned either a medium or rapid shift speed schedule as one group in the analysis.

3.2.3.2 Empty Calorie Food/Beverage Consumption

Empty calorie food/beverage consumption was assessed four times per day with a 21-item food checklist created based on the top sources of empty calorie foods/beverages reported in the 2003-2006 National Health and Nutrition Examination Survey (NHANES) (Huth et al., 2013) and the food sources that provided low nutrient density in the 1993-1996 and 2005-2008 Nutrition and Healthy Survey in Taiwan (NAHSIT) (Wu et al., 2011). A participant was asked to check, since the last prompt, if they had consumed any of the following foods and beverages: *“fried food/fast food (e.g. fries, fried chicken), candy, chocolate, cookies, brownies,* *doughnuts, cakes, pastries, pies, jelly, puddings, sweetened shaved ice desserts, popcorn, salty snacks (e.g., chips), carbonated beverages (e.g., soda, Coke), sugar-added processed juice, lactic acid drinks (e.g., Bifido, Yakult), sports drinks (e.g., Supau, Pocari), instant powered drinks (e.g., Nestea, Matcha), chocolate beverages (e.g., Milo, Ovaltine), and tea (e.g., green tea, black tea, oolong tea, milk tea) with added-sugar and toppings (e.g., tapioca, mixed jelly, herbal jelly, pudding)".* The aforementioned food/beverage items were categorized into four groups, according to the food categories listed in the food frequency questionnaire employed in the NAHSIT (Lo et al., 2017). The four groups are: fried food/fast food, sweetened snacks (i.e., candy, chocolate, cookies, brownies, doughnuts, cakes, pastries, pies, jelly, puddings, sweetened shaved ice desserts, popcorn), salty snacks, and sugar-sweetened beverages (i.e., carbonated beverages, sugar-added processed juice, lactic acid drinks, sports drinks, instant powered drinks, chocolate beverages, tea with added-sugar or toppings). Given that less than 5% of EMA surveys were indicated as having any salty snacks, salty snacks and sweetened snacks were combined in the analysis as "sweet or salty snack."

Four momentary (i.e., up to four times daily) intake measures were used as outcomes in the analysis. Because consumption of each food/beverage category was relatively rare at any given signal, consumption of each of the three food/beverage categories was dichotomized as "0" and ">=1". Furthermore, overall empty calorie food/beverage intake at each signal was analyzed by summing the total count of consumed food/beverage items reported at an EMA prompt.

3.2.3.3 Sleep Quality and Sleep Duration

Sleep quality was assessed using a single question in the Core Consensus Sleep Diary (CSD) (Carney et al., 2012). At each EMA signal, participants were asked if they had reported their recent sleep behavior. If “no” was indicated, they were asked how they would rate the quality of their recent sleep, not including any nap, on a 5-point Likert scale (i.e., very poor, poor, fair, good, very good). Responses were dichotomized as poor sleep quality (i.e., very poor, poor) and without poor sleep quality (i.e., fair, good, very good).

Daily sleep duration was assessed objectively by the Actigraph GT3X (Pensacola, FL, USA), an accelerometer that was worn on the participants’ non-dominant wrist to capture TST (Migueles et al., 2017; Slater et al., 2015; Zinkhan et al., 2014). The Actigraph settings used in this study were: (1) sampling frequency at 30 Hz, (2) normal filter, and (3) epoch length at 60 seconds. Non-wear time was considered periods of time with zero activity counts recorded by the Actigraph for more than 60 consecutive minutes. A valid day was considered at least ten hours of daily wear time (Migueles et al., 2017). Several studies have shown that the Actigraph GT3X is a valid and reliable device for the objective assessment of sleep duration (i.e., TST) (Cellini, Buman, McDevitt, Ricker, & Mednick, 2013; Migueles et al., 2017; Quante et al., 2018; Sadeh & Acebo, 2002; Slater et al., 2015). Among an adult population, Cole’s algorithm is a valid (Cole, Kripke, Gruen, Mullaney, & Gillin, 1992) and reliable method for TST assessment (Cellini et al., 2013; Quante et al., 2018). To improve the accuracy, the TST measured by the Actigraph was adjusted based on each participant’s response to “time getting into bed” and “time getting out of the bed” (Ancoli-Israel et al., 2015).

In general, a sleep cycle including both rapid eye movement (REM) and non-REM (NREM) states for adults lasts for approximately 90 minutes (Carskadon & Dement, 2017). In this study, at least two hours of the calculated TST was considered a sleep episode. Because some participants reported more than one sleep episodes during a day, daily sleep duration was calculated by summing the total hours of sleep episodes within a day. The agreement between the objective and subjective daily sleep duration was examined. Using paired t-test, the mean difference between objective and subjective daily sleep duration was -0.09 hours (SD=1.4) with $p>0.05$ (two-tailed). This suggests that there are no differences between these two measures. Previous studies found that sleep duration of less than six hours was significantly associated with adverse health outcomes (e.g., obesity, metabolic syndrome) (Fernandez-Mendoza et al., 2017; Ford et al., 2014; Imaki et al., 2002; Wu, Zhai, & Zhang, 2014); therefore, sleep duration was dichotomized as at least six hours and less than six hours. Less than six hours of sleep was considered short sleep duration.

3.2.3.4 Covariates

3.2.3.4.1 Time-varying Covariates

Emotions, experienced stress, the number of complete EMA surveys per day, and the sequence of the EMA survey day (i.e., 1st, 2nd, …, 14th) were time-varying covariates in this study. Emotions were measured via 7-items of positive affect (PA) and 7-items of negative affect (NA). For both PA and NA, five items were retrieved from the International Positive and Negative Affect Schedule Short Form (I-PANAS-SF) (Thompson, 2007), which is the short-version of the 20-item Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988), and two items were retrieved from the affect subscale in the University of Wales Institute of Science and Technology (UWIST) mood scale (Johnston et al., 2016; Matthews, Jones, & Chamberlain, 1990).

The I-PANAS-SF has been known as a valid and reliable tool for emotions (Karim, Weisz, & Rehman, 2011; Merz et al., 2013; Thompson, 2007; Yoo, Burrola, & Steger, 2010). The results of the 20-item PANAS with the Taiwanese population also suggested good validity and reliability (Teng & Chang, 2006). Previous EMA studies have employed the PANAS for assessment of momentary (i.e., within-daily) or daily emotions (Berg et al., 2015; Lavender et al., 2013; Steptoe, Gibson, Hamer, & Wardle, 2007; Zenk et al., 2014); therefore, participants' emotions were assessed on the same interval as employed for empty calorie food/beverage consumption in this study. Participants' were requested to report how they had been feeling since the last EMA survey. Items from the I-PANAS-SF were rated on a 5-point Likert scale (i.e., 1=never, 5= always) (Thompson, 2007), and that of the UWIST were rated on a 4-point Likert scale (i.e., 1= definitely not, 4= definitely) (Johnston et al., 2016; Matthews et al., 1990). PA and NA were analyzed by summing the scores of PA (7-items) and NA (7-items) in each EMA survey (ranging from 7 to 33), respectively.

A single item (i.e., "*stressed*") in the UWIST tense arousal subscale (Johnston et al., 2016; Matthews et al., 1990) was used to assess experienced stress at each signal on a 4-point Likert scale (i.e., 1= definitely not, 4= definitely).

3.2.3.4.2 Time-invariant Covariates

Time-invariant covariates were assessed as part of the baseline survey. Participant demographics included age (in years), gender, educational attainment (i.e., high school, associate degree or diploma, bachelor's degree, master/doctoral degree), marital status (i.e., single, cohabitant, married, separated, divorced, widowed), family responsibility (i.e., identified as the main caregiver for kids or disable people in their family), and per capita household income. Due to the low prevalence of some responses in educational attainment (i.e., 5.2% had a master/doctoral degree) and marital status (i.e., 2.6% cohabitant, 1.3% divorced), in the analysis, I dichotomized these two variables as follows: (1) educational attainment: 1= bachelor's degree or above, 0= associate degree or below, (2) marital status: 1= married, 0= any status other than "married"). In terms of per capita household income, the criteria used by the Department of Social Assistance and Social Work, Ministry of Health and Welfare (2019) for evaluation of low-income and middle-to-low income household was employed: low (i.e., less than USD 4,955), middle (i.e., USD 4,955 to 7,433), and above middle (i.e., more than USD 7,433).

Other potential time-invariant covariates included the following items: body mass index (BMI) based on self-reported body height (cm) and weight (kg), health conditions (i.e., type 1 or type 2 diabetes/high blood sugar, heart disease, hypertension, stroke, high cholesterol /hyperlipidemia, thyroid problems, kidney diseases, cancer/a malignant tumor, digestive problems, mental illnesses, and sleep problems), occupational history (i.e., years of working as a registered nurse, years of working on rotating shift work), tobacco use, and hospital work unit (e.g., surgical, medical ward, or intensive care unit).

Given associations between eating style (e.g., emotional eating) with shift work (Wong, Wong, Wong, & Lee, 2010) and sweetened food intake (Camilleri et al., 2014) in previous studies, it is possible that eating style is a confounder in this study. To address this, eating style was assessed using the 33-item Chinese version of Dutch Eating Behavioral Questionnaire (C-DEBQ) (Wang, Ha, Zauszniewski, & Ross, 2018), which was derived from the Dutch Eating Behavioral Questionnaire (DEBQ) (van Strien, Frijters, Bergers, & Defares, 1986). There are three subscales in the DEBQ: (1) 13-item subscale for emotional eating, defined as eating in response to emotional events (e.g., a desire to eat when being cross), (2) 10-item subscale for external eating, defined as eating in response to food cues even when not being hungry (e.g., a desire to eat when passing by the baker), and (3) 10-item subscale for restrained eating, defined as restricting food intake in order to lose or control weight (e.g., eating less than usual when gaining weight) (van Strien et al., 1986). Each item subscale was assessed on a 5-point Likert scale (1=never, 5=very often). Final scores for each subscale were calculated by averaging the total scores for each domain (ranging from 1 to 5). Higher scores in a domain indicated higher frequency of behaviors of that domain. The DEBQ had been validated in a variety of populations (Barrada, van Strien, & Cebolla, 2016; Dakanalis et al., 2013; Nagl, Hilbert, de Zwaan, Braehler, & Kersting, 2016; van Strien et al., 1986; Wang et al., 2018). Among the Taiwanese population, the DEBQ has suggested adequate validity and reliability (Wang et al., 2018). In this study, the DEBQ scale demonstrated high internal consistency (Cronbach's α: 0.92 for emotional eating, 0.92 for external eating, and 0.88 for restrained eating).

Findings from previous studies also suggested that chronotype (i.e., individual differences in how a person synchronizes their circadian rhythm with the light-dark cycle) (Roenneberg, 2012; Roenneberg, Daan, & Merrow, 2003; Roenneberg, Hut, Daan, & Merrow, 2010) was significantly associated with shift work and empty calorie food/beverage consumption (Yoshizaki et al., 2016; Yoshizaki et al., 2018). This indicates that chronotype might be a potential confounder in this study. To address this, chronotype was assessed using the Chinese-version of the Munich ChronoType Questionnaire for shift workers ($\text{MCTQ}^{\text{shift}}$) (Cheng & Hang, 2018), which was modified from the $\text{MCTQ}^{\text{shift}}$ (Juda, Vetter, & Roenneberg, 2013). It was suggested that the habitual mid-sleep time (i.e., the time that is approximately half of daily sleep duration after the sleep onset) on off-duty days following the evening shifts (MSF^{E}) could best reflect a shift worker's chronotype (Juda et al., 2013); therefore, participants' chronotype was mainly assessed based on their MSF^{E}. Items employed for MSF^{E} assessment included time going to bed, time preparing to sleep, time needed to fall asleep, time of awakening, and using an alarm to wake up. If a participant set an alarm to wake up on off-duty days after their evening shifts, the reported time of awakening on those days was considered as invalid (Juda et al., 2013). It is possible that participants oversleep on off-duty days to compensate their sleep debt from the previous shift cycle. If a participant's habitual sleep duration on evening shifts was shorter than their habitual sleep duration on off-duty days after the evening shifts, the MSF^{E} would be corrected. The detailed information on the MSF^{E} and the corrected MSF^{E} ($\mathrm{MSF}_{\mathrm{SC}}^{\mathrm{E}}$) can be found in the original article (Juda et al., 2013). The Chinese-version of $\text{MCTQ}^{\text{shift}}$ has been employed in Taiwanese registered nurses with good validity (Cheng & Hang, 2018). Early, intermediate, and late chronotype were defined as $\mathrm{MSF}_{\mathrm{SC}}^{\mathrm{E}}$ earlier than 4:00 a.m., between 4:00 a.m. and 4:59 a.m., and 5:00 a.m. or later (Juda et al., 2013).

3.2.4 Analysis

3.2.4.1 Descriptive Statistics

All person-, day-, and moment-level variables were summarized using descriptive statistics. In addition, descriptive statistics of the four momentary empty calorie food/beverage intake measures were presented by sleep quality (i.e., with poor sleep quality, without poor sleep quality) and sleep duration (i.e., < 6 hours, >= 6 hours), respectively.

3.2.4.2 Inferential Statistics

I employed 3-level mixed-effects logistic regression models to estimate associations between shift work (day-level or person-level) and the three dichotomous measures of momentary empty calorie food/beverage consumption (moment level): fried food/fast food, sweet or salty snacks, and sweetened beverages. For the overall count of empty calorie food/beverage items reported at each EMA prompt, I employed 3-level mixed-effects negative binomial regression models to test the hypotheses because this variable's distribution was right-skewed, and its variance (i.e., 2.1) was twice as high as its mean (i.e., 1.1). Given that an analytic sample of 76 might not be large enough to detect the between-person effects, I mainly focused on the within-person effects. The within-person effects examined how variations in a time-varying predictor for a person (i.e., differences between the value for person i at time t and the average value/proportion for person i across time) related to variations in an outcome variable for that person, considering that person's average value/proportion of that predictor across time (Hedeker, Mermelstein, & Demirtas, 2008; Neuhaus & Kalbfleisch, 1998; Zenk et al., 2014).

Second, to identify the most parsimonious model given our sample size constraints at the person level, I employed backward selection based on results of a likelihood ratio test (LRT) to choose the final model. Specifically, I (1) included all the time-varying and time-invariant covariates in the same model for each outcome and, (2) consistent with a backward selection, selected covariates that were significant ($p<0.05$). If a variable met the criterion for inclusion as a covariate in any model, it was included in models for all four outcomes. In other words, I controlled the same set of time-varying and time-invariant covariates across all models. As a result of this process, the identified time-varying covariates included emotions and experienced stress at the moment level and the number of complete EMA surveys and the sequence of EMA survey day at the day level. The identified time-invariant covariates at the person level were age, BMI, educational attainment, family responsibility, and health conditions.

Third, I created multiplicative interaction terms between within- and between-person sleep measures (i.e., sleep quality, sleep duration) and respective within- and between-person measures of shift work (e.g., sleep quality$_{\text{within}}$*shift timing$_{\text{within}}$, sleep quality$_{\text{between}}$* shift intensity$_{\text{between}}$, sleep duration$_{\text{within}}$* shift intensity$_{\text{within}}$, sleep duration$_{\text{within}}$* shift speed, sleep duration$_{\text{between}}$* shift intensity$_{\text{between}}$) in order to test if associations between daily shift work and momentary empty calorie food/beverage consumption were moderated by daily poor sleep quality or short sleep duration. The roles of sleep quality and sleep duration were examined in separate models.

Fourth, I tested the hypotheses by adding the multiplicative interaction terms created in the previous step into the final models identified from step 2. Significant interaction terms suggested that associations between shift work and empty calorie food/beverage consumption differed by daily sleep quality or sleep duration.

3.2.4.2.1 Hypothesis 1

To test H1 (on days with poor sleep quality or short sleep duration, working evening or night shifts versus day shifts will have a stronger association with increased empty calorie food/beverage consumption), I regressed empty calorie food/beverage consumption on shift timing, daily sleep measures, and each within- and between-person multiplicative interaction term between shift timing and sleep measures as well as the identified covariates.

3.2.4.2.2 Hypothesis 2

To test H2 (on days with poor sleep quality or short sleep duration, working evening or night shifts versus day shifts on the previous day will be associated with higher empty calorie food/beverage consumption), I regressed each outcome on the prior-day shift timing, same-day sleep measures, multiplicative interaction terms between prior-day shift timing and same-day sleep measures, and the identified covariates. In addition, same-day shift timing was included in each final model.

3.2.4.2.3 Hypothesis 3

H3a (on days with poor sleep quality or short sleep duration, work shift intensity will be positively associated with increased empty calorie food/beverage consumption) and H3b (on days with poor sleep quality or short sleep duration, night shift intensity will be positively associated with increased empty calorie food/beverage consumption) were tested in separate models using the same approach. I first regressed each outcome on work (or night) shift intensity, daily sleep measures, and multiplicative interaction terms between work (or night) shift intensity and sleep measures, and the identified covariates. Then, I adjusted same-day shift timing in each final model.

3.2.4.2.4 Hypothesis 4

To test H4 (on days with poor sleep quality or short sleep duration, medium or rapid shift speed workers versus slow shift speed workers will have higher empty calorie food/beverage consumption), I regressed each outcome on shift speed, daily sleep measures, and multiplicative interaction terms between shift speed and sleep measures, as well as covariates. Similar to H2 and H3, same-day shift timing was included in the respective final models.

Data collected from the Actigraph was processed by the Actilife 6 Data Analysis Software first. Then, all the statistics were analyzed by STATA 15 (Statacorp, College Station, TX, USA). If a multiplicative interaction term between a sleep measure (e.g. sleep quality) and a shift work measure (e.g., shift timing) was significant, the association between that shift work measure and that outcome was plotted by different levels of that sleep measure (e.g., with and without poor sleep quality).

3.2.4.3 Sensitivity Analysis

Sleep duration was dichotomized as < 6 hours and >= 6 hours in this study; however, the cut-off points for short sleep duration are not consistent in the literature. Some studies defined short sleep duration as having less than 5-hour of sleep but some studies employed 7 hours as the cut-off point (Sperry, Scully, Gramzow, & Jorgensen, 2015; Wu et al., 2014). Several studies noted that having less than 5-hour of sleep duration was significantly associated with increased risk of obesity (Cappuccio et al., 2007; Gangwisch et al., 2006; James et al., 2017; Watanabe, Kikuchi, Tanaka, & Takahashi, 2010; Wu et al., 2014; Xiao, Arem, Moore, Hollenbeck, & Matthews, 2013).

Therefore, to test the sensitivity of my results for short sleep duration, I dichotomized daily sleep duration as <5 hours (i.e., short sleep duration) and >=5 hours first. Second, I created another set of multiplicative interactions between each within- and between-person short sleep duration (i.e., < 5 hours) and shift work measure pair (e.g., short sleep duration$_{\text{within}}$*shift timing$_{\text{within}}$, short sleep duration$_{\text{between}}$* shift intensity$_{\text{between}}$, short sleep duration$_{\text{within}}$* shift speed) and re-estimated the models again by replacing short sleep duration with these new multiplicative interaction terms.

3.3 Findings

3.3.1 Descriptive Statistics

A total of 2,157 EMA surveys completed on 829 person-days by 76 participants were included in the final analyses. As shown in Table 2-1, on average, participants were 27.8 years of age (SD=4.5). Most were female (94.7%) and had a bachelor's degree or above (85.5%). Less than one fifth were married (11.8%) or had primary family responsibilities (15.8%) (i.e., taking care of children or disabled persons). Approximately 23.7% of them had at least one chronic health condition. In terms of working conditions, the average tenure as a rotating shift worker was 5.4 (SD=4.3) years. Two fifths of participants were assigned a work schedule with either medium or rapid shift speed (42.1%).

Not shown in the table, out of the 829 person-day observations, 210 (25.3%), 194 (23.4%), 142 (17.1%), and 283 (34.1%) were collected on day shifts, evening shifts, night shifts, and off-duty days, respectively. On average, participants worked 1.7 consecutive work shifts (SD= 1.5) over the two weeks, ranging from 0 to 8. Over the two weeks, less than 10% of person-days were reported as high night shift intensity. Poor sleep quality and short sleep duration accounted for 16.2% and 32.1% of person-days, respectively. On average, participants slept 7.1 hours daily (SD=2.3).

As shown in Table 2-2, the prevalence rates of participants' momentary fried food/fast food consumption, sweet or salty snack food consumption, and sweetened beverage intake were 15.9%, 31.9%, and 34.5%, respectively. On average, participants reported consuming 1.1 (SD=1.5, ranging from 0 to 20) empty calorie food/beverage items on each EMA prompt.

As is shown in Table 2-2, on days with poor sleep quality, fried food/fast food consumption was more common when working evening shifts (21.2%) than when working day shifts (12.6%). In contrast, on days without poor sleep quality, the difference in the prevalence of fried food/fast food consumption was smaller: 14.7% when working evening shifts versus 12.2% when working day shifts. The patterns for the other non-day shifts were similar. Table 2-3 shows that consumption of empty calorie foods/beverages was more common on non-day shifts compared to that of day shifts regardless of sleep duration.

3.3.2 Inferential Statistics

3.3.2.1 Hypothesis 1

Table 2-4 displays associations between daily shift timing, daily sleep quality, their interactions and the four momentary measures of empty calorie food/beverage consumption. After controlling for covariates, I found only one statistically significant interaction. Specifically, on days with poor sleep quality, the likelihood of fried food/fast food consumption on night shifts was 4.3 times higher (OR=4.26, 95% CI [1.17, 15.57]) compared to day shifts, accounting for that person's usual daily sleep quality and usual shift timing. In contrast, on days without poor sleep quality, working on night shifts was also associated with the increased likelihood of fried food/fast food consumption (OR=1.60. 95% CI [1.03, 2.48]), but the magnitude of this association was weaker.

Figure 2-1 displays the predicted probability of fried food/fast food consumption at a signal on days with different shift timings by different levels of sleep quality. On days with poorer sleep quality for a person (i.e., the dashed line, which suggests poorer sleep quality than usual), the probability of fried food/fast food consumption on non-day shifts (i.e., evening, night shifts) was higher than working on day shifts. However, on days with habitual levels of sleep quality (i.e., the solid line) and days with better sleep quality than usual (i.e., the dotted line), the probability of reporting intake of fried food/fast food was slightly higher and lower on non-day shifts versus day shifts, respectively.

Table 2-5 shows associations between daily shift timing, daily sleep duration, their interactions, and the four momentary measures of empty calorie foods/beverages. As shown in Table 2-5, none of multiplicative interactions between shift timing and short sleep duration were significant, suggesting that associations between shift timing and empty calorie foods/beverages consumed were not moderated by short sleep duration.

3.3.2.2 Hypothesis 2

Table 2-6 presents associations between prior-day shift timing, daily sleep quality, their interactions, and the four momentary measures of empty calorie food/beverage consumption. As shown by the interaction terms in Model 1 (controlling for covariates) and Model 2 (controlling for both covariates and same-day shift timing), these associations did not differ between days with and without poor sleep quality.

Table 2-7 displays associations between prior-day shift timing, daily sleep duration, their interactions, and the four EMA diet-related outcomes. Similar to the results suggested in Table 2-6, as shown by the interaction terms in Model 1 (adjusting for covariates) and Model 2 (adjusting for both covariates and same-day shift timing), short sleep duration did not moderate associations between prior-day shift timing and same-day momentary empty calorie food/beverage consumption.

3.3.2.3 Hypothesis 3

Tables 2-8 through 2-11 show results for hypothesis 3: on days with poor sleep quality or short sleep duration, shift intensity (i.e., work shift intensity, night shift intensity) will be positively associated with empty calorie food/beverage consumption. Tables 2-8 and 2-9 show results for daily sleep quality; Tables 2-10 and 2-11 show results for daily sleep duration.

Table 2-8 presents associations between work shift intensity, daily sleep quality, their interactions and the four EMA diet-related outcomes. After adjusting for covariates (Model 1), for overall empty calorie food/beverage consumption, I found a significant interaction between work shift intensity and sleep quality. On days with poor sleep quality, each additional consecutive shift worked was associated with 0.11 (95% CI [0.00, 0.22]) more empty calorie foods or beverages reported, accounting for that person's usual levels of work shift intensity. However, on days without poor sleep quality, work shift intensity was negatively associated with overall count of empty calorie food/beverage items consumed (b=-0.04, 95% CI [-0.08. 0.00]). After adjusting for both covariates and same-day shift timing (Model 2), the interaction term between work shift intensity and daily sleep quality was attenuated and no longer statistically significant. For the other three outcomes (i.e., fried food/fast food, sweet or salty snacks, sweetened beverages), no significant interactions between work shift intensity and daily poor sleep quality were found.

Table 2-9 shows associations between night shift intensity, daily sleep quality, their interactions, and each EMA diet-related outcome variable. As shown in Table 2-9, daily poor sleep quality did not moderate associations between night shift intensity and any of the four outcome measures, before (Model 1) or after (Model 2) adjusting for same-day shift timing.

Table 2-10 and Table 2-11 present whether daily short sleep duration moderates associations between shift intensity and empty calorie food/beverage consumption. Table 2-10 presents the results for work shift intensity, and Table 2-11 presents the results for night shift intensity. As shown in Table 2-10 and Table 2-11, less than 6-hour of sleep duration on a day did not moderate associations between each outcome variable and daily work shift intensity or daily night shift intensity.

3.3.2.4 Hypothesis 4

Table 2-12 shows associations between a person's shift speed, daily sleep quality, their interactions, and the four momentary measures of empty calorie food/beverage consumption. As is presented Model 1, after adjusting for covariates, the association between shift speed and the likelihood of reporting fried food/fast food consumption at a signal differed by daily sleep quality (OR=2.34, 95% CI [1.14, 4.81]). After controlling for covariates and same-day shift timing (Model 2), the association was similar. On days with poor sleep quality, participants assigned either a medium or rapid shift speed schedule were 2.4 times more likely to report fried food/fast food consumption at a signal relative to their counterparts assigned a slow shift speed schedule (OR=2.38, 95% CI [1.16, 4.90]). In contrast, on days without poor sleep quality, there were no significant associations between shift speed and the likelihood of reporting intake of fried food/fast food (OR=0.87, 95% CI [0.58, 1.29]).

To illustrate this relationship, the predicted probability of fried food/fast food consumption by shift speed and sleep quality is displayed in Figure 2-2. As shown in Figure 2-2, on days with much worse sleep quality than usual (i.e., the dashed line), participants assigned a medium/rapid shift speed schedule had higher probability of fried food/fast food consumption than their counterparts. Among medium/rapid shift workers, participants' probability of reporting fried food/fast food consumption at a signal differed depending on their levels of sleep quality that day. In contrast, among slow shift speed workers, the probability of fried food/fast food consumption was not different on days with different levels of sleep quality.

Table 2-13 shows results for whether the association between a person's shift speed and momentary empty calorie food/beverage consumption is moderated by daily short sleep duration. Associations between shift speed and the four diet-related outcome variables did not differ between days with and without short sleep duration, before (Model 1) or after (Model 2) adjusting for same-day shift timing.

3.3.3 Sensitivity Analysis

For H1 and H2, results from the sensitivity analysis were consistent with what was presented in Table 2-5 and Table 2-7, respectively (see Supplemental Table 2-1 for H1; Supplemental Table 2-2 for H2). In terms of H3a, similar results were observed in the sensitivity analysis except the magnitude of the interaction between work shift intensity and short sleep duration on fried food/fast food consumption was increased slightly (see Supplemental Table 2-3). Regarding H3b, for the likelihood of reporting intake of fried food/fast food, the interaction between night shift intensity and short sleep duration was significant and the effect was stronger. Inconsistent with what was observed in Table 2-11, for the likelihood of sweetened beverage consumption, the interaction between night shift intensity and short sleep duration was significant and the direction of this association was opposite in the sensitivity test (see supplemental Table 2-4). For H4, results in the sensitivity analysis were consistent with findings presented in Table 2-13 (see Supplemental Table 2-5).

3.4 Discussion

This study examined whether associations between shift work and empty calorie food/beverage consumption were moderated by daily sleep quality or by daily sleep duration. In summary, I found associations between the likelihood of fried food/fast food consumption and both same-day shift timing and work shift intensity were moderated by daily sleep quality. As reported in Chapter 2, working night shifts was associated with an increased likelihood of fried food/fast food consumption relative to working day shifts. Here I found that the association between night shift work and fried food/fast food intake was stronger on days with poor sleep quality. Moreover, I found that participants assigned to either a medium or rapid shift speed schedule had a higher likelihood of fried food/fast food consumption on days with poor sleep quality. For participants assigned a slow shift speed schedule, the likelihood of fried food/fast food consumption did not differ on days with and without poor sleep quality. Associations between empty calorie food/beverage consumption and prior-day shift timing, work shift intensity, or night shift intensity did not differ by sleep quality or duration.

3.4.1.1 Hypothesis 1: on days with poor sleep quality or short sleep duration, working on non-day shifts would have a stronger association with empty calorie food/beverage intake

Providing some support for H1, the association between working night shifts versus day shifts and the likelihood of fried food/fast food intake was stronger on days with poor sleep quality than on days without poor sleep quality. Previous studies have suggested that nighttime work may contribute to circadian disruption (Bedrosian et al., 2016; Korkmaz et al., 2009; Wehrens et al., 2017), which may disturb the balance of appetite hormones (Bedrosian et al., 2016; Gautron & Elmquist, 2011; James et al., 2017; Korkmaz et al., 2009; Nakazato et al., 2001) and increase empty calorie food/beverage consumption (Souza, Sarmento, de Almeida, & Canuto, 2019). In prior work, poor sleep quality was linked to increased perceived hunger levels and more disinhibited eating behaviors (Blumfield et al., 2018). In addition, shift workers' daily sleep quality varies according to their assigned same-day shift timing (Tremaine et al., 2013). Thus, the combination of imbalanced appetite hormones from working night shifts and increased hunger levels and uncontrolled eating behaviors due to poor sleep quality may explain why I observed that the effect of night shifts was worse on days with poor sleep quality.

Contrary to my hypothesis, I did not find moderating effect of less than 6-hour of sleep duration on associations between shift work and empty calorie food/beverage consumption. There is still no universally accepted cut-off point for short sleep duration in the literature (Sperry, Scully, Gramzow, & Jorgensen, 2015; Wu et al., 2014). Given adverse health effects of less than 5-hour of sleep duration in prior studies (e.g. obesity) (Cappuccio et al., 2007; Gangwisch et al., 2006; James et al., 2017; Watanabe, Kikuchi, Tanaka, & Takahashi, 2010; Wu et al., 2014; Xiao, Arem, Moore, Hollenbeck, & Matthews, 2013), I used a 5-hour cut-off-point to test the sensitivity of short sleep duration. In the sensitivity analysis, I observed that interactions between work shift intensity and less than 5-hour of sleep duration were significant for the likelihood of reporting fried food/fast food consumption. The interaction between night shift intensity and less than 5-hour of sleep duration was significant in items of the likelihood of fried food/fast food intake and sweetened beverage consumption. This suggested that daily sleep duration might exacerbate associations between shift work and empty calorie food/beverage consumption and the result is subjective to the definition of short sleep duration. Therefore, the insignificant findings in less than 6-hour of sleep duration may be ascribed to misclassification of the daily short sleep duration.

3.4.1.2 Hypothesis 2: on days with poor sleep quality or short sleep duration, the effects of prior-day shift timing on empty calorie food/beverage consumption would be positive.

Providing no support for hypothesis 2, I found no evidence that daily sleep quality or short sleep duration moderated associations between prior-day shift timing and same-day empty calorie food/beverage consumption. It was reported that associations between changed levels of appetite hormones from circadian misalignment and dietary intakes could be short-term (Attele et al., 2002; Klok et al., 2007; Pico et al., 2003); thus, resulting in insignificant associations between shift timing on the prior day and the empty calorie food/beverage consumption.

To my knowledge, no prior studies tested prior-day shift timing and empty calorie food/beverage consumption. My findings make a unique contribution to the literature and are consistent with the biological possibility that the effects of shift timing on empty calorie food/beverage consumption are short-term.

3.4.1.3 Hypothesis 3: on days with poor sleep quality or short sleep duration, associations between shift intensity and empty calorie food/beverage consumption would be positive

Contrary to hypothesis 3, I found no evidence that the effect of work shift intensity on momentary empty calorie food/beverage consumption differed by daily sleep duration or quality (H3a). One possible explanation for this finding is different patterns being captured under the same-level of work shift intensity. For instance, (1) working five consecutive day shifts, (2) working five consecutive evening shifts, and (3) working two consecutive day shifts and three consecutive evening shifts were all recoded as “5” for work shift intensity. If the impacts of these three conditions differ, this could lead to null results for work shift intensity.

Second, several studies revealed that the direction of shift rotation (i.e., clockwise or forward rotation: day to evening to night, counter-clockwise or backward rotation: night to evening to day) was associated with shift workers’ health (e.g., better cardiovascular health for forward rotation) (Merkus et al., 2015; Viitasalo, Kuosma, Laitinen, & Harma, 2008) and behaviors (e.g., more sleep disturbance for backward rotation) (Shiffer et al., 2018; van Amelsvoort, Jansen, Swaen, van den Brandt, & Kant, 2004). It is possible that the role of sleep quality or duration differs depending on the direction of shift rotation within a consecutive work shift (e.g., forward rotation or no rotation).

In addition, although more than six consecutive work shifts in a row was defined as high levels of work shift intensity in the prior studies (Harma et al., 2018; Harma et al., 2015), there was still limited evidence in the adverse effects of high levels of work shift intensity on health (Harma et al., 2018). In this study, less than 2% of person-day observations were considered as high levels of work shift intensity based on this definition. Therefore, it is also possible that the low variability of this variable contributes to the insignificant results.

Providing no support for hypothesis (H3b), associations between night shift intensity and empty calorie food/beverage consumption were neither moderated by daily poor sleep quality nor daily short sleep duration. Less than 8% of person-days was reported as days with high night shift intensity in this study. Similar to work shift intensity, it is possible that the low variability of this variable results in the null findings.

3.4.1.4 Hypothesis 4: on days with poor sleep quality or short sleep duration, shift workers assigned a higher level of shift speed consumed more empty calorie foods/beverages

Providing partial support for hypothesis 4, particularly on days with poor sleep quality, participants assigned either a medium or rapid shift speed schedule had a higher momentary likelihood of fried food/fast food consumption compared to their counterparts on a slow shift speed schedule. Coffey, Skipper, and Jung (1988) explained that rotating shift work required shift workers to adjust themselves to different working conditions (e.g., different groups of colleagues, different patients, different schedules) more frequently, which may increase their work-related stress and consequently increase rotating shift workers' empty calorie food/beverage consumption (Power, Kiezebrink, Allan, & Campbell, 2017; Wardle, Steptoe, Oliver, & Lipsey, 2000). In addition, poor sleep quality had been linked to increased empty calorie food/beverage consumption (Ferranti et al., 2016; Katagiri et al., 2014). Hence, it is possible that the joint effects of increased stress from medium/rapid shift speed and poor sleep quality underlie this finding.

In addition, it is noteworthy that, on days without poor sleep quality, the likelihood of reporting fried food/fast food consumption was not different between slow and medium/rapid shift speed workers. This suggested that better sleep quality might attenuate the adverse effect of a higher level of shift speed.

3.4.2 Strengths and Limitations

This study has important strengths. First, four times daily EMA assessment helped to assess participants' real-time empty calorie food/beverage consumption, which decreased the chance of recall bias and increased ecological validity. Second, an intensive longitudinal study design prompted temporal ordering of shift work, sleep duration and quality, and empty calorie food/beverage consumption. Third, employing objective assessments of shift work (i.e., published work schedules) and sleep duration (i.e., Actigraph) enhanced validity of these measures. In addition, combining assessments from Actigraph and self-reported sleep information from the EMA surveys increased the validity of the sleep measures. Finally, this study examined within-person associations among shift work, daily sleep behaviors, and momentary empty calorie food/beverage intake concurrently and considered the complexity of shift work; these within-person associations have not been examined to date.

Several limitations should also be considered. First, the selection bias from convenience sampling and the potential healthy worker effect (McMichael, 1976; Shah, 2009) (e.g., only workers who can adjust to the shift work will work on rotating shifts) raise questions about the generalizability of my findings. Second, participants' empty calorie food/beverage consumption was assessed based on a food checklist, which may increase the chance of measurement error since other empty calorie food/beverage consumptions that were not included on the list may be missed. To reduce the likelihood of measurement error from the missing items, I created the food checklist based on the food frequency questionnaire employed in the NAHSIT (i.e., a national nutrition survey in Taiwan).

Third, the findings from this study should be explained with caution because, to reduce the respondents' burden, the portion size (i.e., number of servings) of empty calorie foods/beverages were not assessed in the EMA surveys, which may lead to misleading results. For example, two participants might report the same frequency of daily sweetened-snack intake. One might consume two servings per consumption; however, the other might consume half of the serving each time. The differences between these two participants are not captured in my measure. Nonetheless, this study mainly focused on the within-person effects; thus, reducing the effects from differences of habitual eating behaviors between persons.

Fourth, daily sleep quality was assessed by a single item in the CSD (i.e., a self-reported sleep diary) (Carney et al., 2012). Other dimensions of sleep quality such as sleep efficiency (SE), sleep onset latency (SOL), or wake time after sleep onset (WASO), derived from objective assessments could yield different results.

Finally, the EMA surveys were signal contingent. Prior EMA studies suggested that workers might not have time to complete an EMA survey due to work demand (McIntyre et al., 2016; Rutledge et al., 2009). Based on an EMA survey response rate of 56.3%, findings of this study could be biased as missing responses might not be missing at random. In addition, to capture participants' shift work schedules representatively, participants were requested to complete EMA surveys four times per day for 14 days. This might also increase participants' burden and result in their low response rate in this study. However, the outcome variables were measured by asking their empty calorie food/beverage consumption since the last EMA survey they responded on that day, which might help to capture their consumption at the missed EMA prompt.

3.4.3 Implications for Policy and Practice

This study suggested that poor sleep quality might exacerbate the adverse effects of night shift work and a work schedule with higher levels of shift speed on shift workers' fried food/fast food intake. Thus, interventions that help to reduce shift workers' poor sleep quality may not only improve their sleep hygiene, but also help to address the adverse impact of shift work on shift workers' daily empty calorie food/beverage consumption.

Multi-level interventions at the workplace (i.e., interventions on the organizational, interpersonal, and individual levels) have been reported as the better strategy to promote and improve workers' health behaviors (Levy et al., 2018; Risica et al., 2018; Ward et al., 2018). At the organizational level, prior research suggested that light exposure might influence shift workers' sleep behaviors (Bedrosian et al., 2016; Boivin et al., 2012; Jensen et al., 2016). Strategies targeting shift workers' light exposure during non-daytime shifts (e.g., changing lighting conditions in the working environment according to the time of the day: imitating daylight on day shifts and reducing the intensity of lighting during evening and night shifts) may be beneficial to workers' sleep hygiene and may further reduce the impacts of shift work on eating behaviors.

At both the organizational and interpersonal level, previous studies found that occupational stress (e.g., high job demand, low job control) (Li, Fang, & Zhou, 2019; Van Laethem, Beckers, Kompier, Dijksterhuis, & Geurts, 2013), low social support, low work time control (Salo et al., 2014), work-life imbalance or work-family conflict (Buxton et al., 2016; Chazelle, Chastang, & Niedhammer, 2016; Jacobsen et al., 2014; Magee, Robinson, & McGregor, 2018; Olson et al., 2015) were associated with poor sleep quality and short sleep duration. A randomized controlled trial of 580 full-time workers suggested that a 75% decrease in daily working hours significantly improved workers' sleep quality (Schiller et al., 2017). Assigned irregular rotating shifts is common among certain types of occupations (e.g., hospital registered nurses) (Asaoka et al., 2013; Harma et al., 2015; Shiao & Hu, 2015). Therefore, interventions to increase shift workers' work time control and social support, reduce their occupational stress and work-family conflict, and avoid long daily working hours may not only improve workers' sleep problems but may also weaken the adverse impacts of shift work on their empty calorie food/beverage consumption.

Shift work is unavoidable for workers in certain types of industries (e.g., healthcare). This study suggested that greater night shift intensity and a shift schedule with higher shift speed might contribute to shift workers' increased intake of empty calorie foods/beverages. Interventions that reduce the levels of night shift intensity and provide more stable shift work assignments (e.g., less changes in shift timing in the past two weeks) may prevent the adverse effects of shift work on shift workers' eating behaviors.

The food environment might also affect people's empty calorie food/beverage consumption (Elliston, Ferguson, Schuz, & Schuz, 2017; French et al., 2010; Zenk et al., 2014). With the exception of fast food restaurants and convenience stores, most food outlets in the working environment in Taiwan are closed while people are working on a night shift. Thus, creating a healthy eating working environment at night (e.g., higher accessibility of healthy foods during night shift work, providing incentives for healthy foods consumption) may also reduce the possibility of unhealthy food/beverage consumption on days when working a night shift.

Several studies also suggested the efficacy of technology-based interventions (e.g., information about healthy eating delivered by text messages or emails, tracking dietary intakes using a smartphone application, or a personalized interactive platform that provided timely feedback for food purchasing) on behavioral changes (Levy et al., 2018; Rayward et al., 2018; Schoeppe et al., 2016). Building upon this, besides the improvement of shift workers' working environment, to provide educational training programs with both conventional and technology-based methods may also be beneficial for workers' empty calorie food/beverage consumption.

3.4.4 Implications for Future Research

This study had several implications for future studies. First, the assessment of empty calorie food/beverage consumption was based on a food checklist in this study. Adding other dietary measurements (e.g., a few days of 24-hour dietary recalls) might help to capture the food/beverage items that were not included on the list and reduce the chance of measurement error.

Second, the EMA surveys in this study were administered based on a signal-based sampling method. It is possible that workers are not available to respond to the survey within an hour because of work demands. Time availability is suggested as the main reason for workers' food consumption on working days (Waterhouse, Buckley, Edwards, & Reilly, 2003). Therefore, combining time-based sampling with event-based sampling (i.e., participants respond when they eat) may better capture shift workers' food/beverage consumption on working days and reduce missed surveys during work.

Third, the definition of short sleep duration is still not consistent in the literature. Given the results of sensitivity test, it suggests that inappropriate cut-off points for short sleep duration may introduce bias from misclassification. Although some significant interactions between night shift intensity and less than 5-hour of sleep duration were observed, the 95% confidence interval of those estimates were relatively wide. This suggested that these estimations may not be very precise and the estimated effect may be exaggerated. Therefore, this finding should be interpreted with caution. Future studies with larger sample size to compare the results from different definitions of short sleep duration may help to better understand the moderating role of short sleep duration on dietary behaviors.

Finally, the direction of shift work may also impact shift workers' health (Fischer, Vetter, Oberlinner, Wegener, & Roenneberg, 2016; Karhula et al., 2016; Merkus et al., 2015; Viitasalo et al., 2008) and behaviors (Shiffer et al., 2018; van Amelsvoort et al., 2004). Future studies should consider the direction and speed of work shift rotation, the levels of shift intensity, and shift timing together by using sequence analysis, which may help cluster the most beneficial and hazardous shift work patterns.

3.5 Conclusion

This study found evidence that poor sleep quality exacerbated the adverse effects of night shift work and higher levels of shift speed on shift workers' fried food/fast food consumption. Relative to workers being assigned a higher level of shift speed, slow shift speed workers' fried food/fast food consumption did not differ on days with and without poor sleep quality. Strategies to improve shift workers' sleep hygiene (e.g., reducing occupational stress, adjusting light exposure during nighttime work) and promote less hazardous shift work assignments (e.g., a schedule with less changes in shift timings) may help to reduce empty calorie food/beverage consumption among rotating shift workers.

References

Akerstedt, T., Nordin, M., Alfredsson, L., Westerholm, P., & Kecklund, G. (2010). Sleep and sleepiness: impact of entering or leaving shiftwork--a prospective study. *Chronobiology International, 27*(5), 987-996. doi:10.3109/07420528.2010.489423

Ancoli-Israel, S., Martin, J. L., Blackwell, T., Buenaver, L., Liu, L., Meltzer, L. J., . . . Taylor, D. J. (2015). The SBSM guide to Actigraphy monitoring: Clinical and research applications. *Behavioral Sleep Medicine, 13 Suppl 1*, S4-S38. doi:10.1080/15402002.2015.1046356

Asaoka, S., Aritake, S., Komada, Y., Ozaki, A., Odagiri, Y., Inoue, S., . . . Inoue, Y. (2013). Factors associated with shift work disorder in nurses working with rapid-rotation schedules in Japan: The nurses' sleep health project. *Chronobiology International, 30*(4), 628-636. doi:10.3109/07420528.2012.762010

Attele, A. S., Shi, Z. Q., & Yuan, C. S. (2002). Leptin, gut, and food intake. *Biochemical Pharmacology, 63*(9), 1579-1583. doi:10.1016/S0006-2952(02)00883-3

Barrada, J. R., van Strien, T., & Cebolla, A. (2016). Internal structure and measurement invariance of the Dutch Eating Behavior Questionnaire (DEBQ) in a (nearly) representative Dutch community sample. *European Eating Disorders Review, 24*(6), 503-509. doi:10.1002/erv.2448

Bedrosian, T. A., Fonken, L. K., & Nelson, R. J. (2016). Endocrine effects of circadian disruption. *Annual Review of Physiology, 78*, 109-131. doi:10.1146/annurev-physiol-021115-105102

Berg, K. C., Crosby, R. D., Cao, L., Crow, S. J., Engel, S. G., Wonderlich, S. A., & Peterson, C. B. (2015). Negative affect prior to and following overeating-only, loss of control eating-only, and binge eating episodes in obese adults. *International Journal of Eating Disorders, 48*(6), 641-653. doi:10.1002/eat.22401

Blumfield, M. L., Bei, B., Zimberg, I. Z., & Cain, S. W. (2018). Dietary disinhibition mediates the relationship between poor sleep quality and body weight. *Appetite, 120*, 602-608. doi:10.1016/j.appet.2017.10.022

Boivin, D. B., Boudreau, P., James, F. O., & Kin, N. M. (2012). Photic resetting in night-shift work: Impact on nurses' sleep. *Chronobiology International, 29*(5), 619-628. doi:10.3109/07420528.2012.675257

Bolger, N., & Laurenceau, J. P. (2013). *Intensive longitudinal methods : An introduction to diary and experience sampling research*. New York, NY: Guilford Press.

Bonnell, E. K., Huggins, C. E., Huggins, C. T., McCaffrey, T. A., Palermo, C., & Bonham, M. P. (2017). Influences on dietary choices during day versus night shift in shift workers: A mixed methods study. *Nutrients, 9*(3). doi:10.3390/nu9030193

Broussard, J. L., Kilkus, J. M., Delebecque, F., Abraham, V., Day, A., Whitmore, H. R., & Tasali, E. (2016). Elevated ghrelin predicts food intake during experimental sleep restriction. *Obesity (Silver Spring), 24*(1), 132-138. doi:10.1002/oby.21321

Buxton, O. M., Lee, S., Beverly, C., Berkman, L. F., Moen, P., Kelly, E. L., . . . Almeida, D. M. (2016). Work-family conflict and employee sleep: Evidence from IT workers in the Work, Family and Health Study. *Sleep, 39*(10), 1871-1882. doi:10.5665/sleep.6172

Cain, S. W., Filtness, A. J., Phillips, C. L., & Anderson, C. (2015). Enhanced preference for high-fat foods following a simulated night shift. *Scandinavian Journal of Work, Environment and Health, 41*(3), 288-293. doi:10.5271/sjweh.3486

Camilleri, G. M., Mejean, C., Kesse-Guyot, E., Andreeva, V. A., Bellisle, F., Hercberg, S., & Peneau, S. (2014). The associations between emotional eating and consumption of energy-dense snack foods are modified by sex and depressive symptomatology. *Journal of Nutrition, 144*(8), 1264-1273. doi:10.3945/jn.114.193177

Cappuccio, F. P., Stranges, S., Kandala, N. B., Miller, M. A., Taggart, F. M., Kumari, M., . . . Marmot, M. G. (2007). Gender-specific associations of short sleep duration with prevalent and incident hypertension: The Whitehall II Study. *Hypertension, 50*(4), 693-700. doi:10.1161/HYPERTENSIONAHA.107.095471

Carney, C. E., Buysse, D. J., Ancoli-Israel, S., Edinger, J. D., Krystal, A. D., Lichstein, K. L., & Morin, C. M. (2012). The consensus sleep diary: Standardizing prospective sleep self-monitoring. *Sleep, 35*(2), 287-302. doi:10.5665/sleep.1642

Carskadon, M. A., & Dement, W. C. (2017). *Normal Human Sleep : An Overview* (Sixth ed., pp. 15-24.e13).

Cellini, N., Buman, M. P., McDevitt, E. A., Ricker, A. A., & Mednick, S. C. (2013). Direct comparison of two actigraphy devices with polysomnographically recorded naps in healthy young adults. *Chronobiology International, 30*(5), 691-698. doi:10.3109/07420528.2013.782312

Centers for Disease Control and Prevention. (2012). Short sleep duration among workers--United States, 2010. *MMWR: Morbidity and Mortality Weekly Report, 61*(16), 281-285.

Chang, S. J., & Liao, W. C. (2015). Prevalence of and risk factors associated with metabolic syndrome among nurses. *Taiwan Journal of Public Health, 34*(3), 268-283. doi:10.6288/TJPH201534104003

Chazelle, E., Chastang, J. F., & Niedhammer, I. (2016). Psychosocial work factors and sleep problems: Findings from the French national SIP survey. *International Archives of Occupational and Environmental Health, 89*(3), 485-495. doi:10.1007/s00420-015-1087-1

Cheng, W. J., & Cheng, Y. (2017). Night shift and rotating shift in association with sleep problems, burnout and minor mental disorder in male and female employees. *Occupational and Environmental Medicine, 74*(7), 483-488. doi:10.1136/oemed-2016-103898

Cheng, W. J., & Hang, L. W. (2018). Late chronotype and high social jetlag are associated with burnout in evening-shift workers: Assessment using the Chinese-version MCTQ(shift). *Chronobiology International*, 1-10. doi:10.1080/07420528.2018.1439500

Coffey, L. C., Skipper, J. K., & Jung, F. D. (1988). Nurses and shift work: Effects on job performance and job-related stress. *Journal of Advanced Nursing, 13*(2), 245-254. doi:10.1111/j.1365-2648.1988.tb01414.x

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, N.J.: L. Erlbaum Associates.

Cole, R. J., Kripke, D. F., Gruen, W., Mullaney, D. J., & Gillin, J. C. (1992). Automatic sleep/wake identification from wrist activity. *Sleep, 15*(5), 461-469. doi:10.1093/sleep/15.5.461

Dakanalis, A., Zanetti, M. A., Clerici, M., Madeddu, F., Riva, G., & Caccialanza, R. (2013). Italian version of the Dutch Eating Behavior Questionnaire. Psychometric proprieties and measurement invariance across sex, BMI-status and age. *Appetite, 71*, 187-195. doi:10.1016/j.appet.2013.08.010

Dashti, H. S., Scheer, F. A., Jacques, P. F., Lamon-Fava, S., & Ordovas, J. M. (2015). Short sleep duration and dietary intake: Epidemiologic evidence, mechanisms, and health implications. *Advances in Nutrition, 6*(6), 648-659. doi:10.3945/an.115.008623

de Assis, M. A., Kupek, E., Nahas, M. V., & Bellisle, F. (2003). Food intake and circadian rhythms in shift workers with a high workload. *Appetite, 40*(2), 175-183. doi:10.1016/S0195-6663(02)00133-2

Department of Social Assistance and Social Work, Ministry of Health and Welfare. (2019). *2019 Criteria for assistance in low and middle-to-low income household.* Retrieved from https://dep.mohw.gov.tw/DOSAASW/cp-566-45261-103.html

Elliston, K. G., Ferguson, S. G., Schuz, N., & Schuz, B. (2017). Situational cues and momentary food environment predict everyday eating behavior in adults with overweight and obesity. *Health Psychology, 36*(4), 337-345. doi:10.1037/hea0000439

Fernandez-Mendoza, J., He, F., LaGrotte, C., Vgontzas, A. N., Liao, D., & Bixler, E. O. (2017). Impact of the Metabolic Syndrome on Mortality is Modified by Objective Short Sleep Duration. *Journal of the American Heart Association, 6*(5), e005479. doi:10.1161/JAHA.117.005479

Ferranti, R., Marventano, S., Castellano, S., Giogianni, G., Nolfo, F., Rametta, S., . . . Mistretta, A. (2016). Sleep quality and duration is related with diet and obesity in young adolescent living in Sicily, Southern Italy. *Sleep Science, 9*(2), 117-122. doi:10.1016/j.slsci.2016.04.003

Fischer, D., Vetter, C., Oberlinner, C., Wegener, S., & Roenneberg, T. (2016). A unique, fast-forwards rotating schedule with 12-h long shifts prevents chronic sleep debt. *Chronobiology International, 33*(1), 98-107. doi:10.3109/07420528.2015.1113986

Flueckiger, L., Lieb, R., Meyer, A. H., Witthauer, C., & Mata, J. (2017). Day-to-day variations in health behaviors and daily functioning: Two intensive longitudinal studies. *Journal of Behavioral Medicine, 40*(2), 307-319. doi:10.1007/s10865-016-9787-x

Ford, E. S., Li, C., Wheaton, A. G., Chapman, D. P., Perry, G. S., & Croft, J. B. (2014). Sleep duration and body mass index and waist circumference among U.S. adults. *Obesity (Silver Spring), 22*(2), 598-607. doi:10.1002/oby.20558

French, S. A., Harnack, L. J., Hannan, P. J., Mitchell, N. R., Gerlach, A. F., & Toomey, T. L. (2010). Worksite environment intervention to prevent obesity among metropolitan transit workers. *Preventive Medicine, 50*(4), 180-185. doi:10.1016/j.ypmed.2010.01.002

Gangwisch, J. E., Heymsfield, S. B., Boden-Albala, B., Buijs, R. M., Kreier, F., Pickering, T. G., . . . Malaspina, D. (2006). Short sleep duration as a risk factor for hypertension: Analyses of the first National Health and Nutrition Examination Survey. *Hypertension, 47*(5), 833-839. doi:10.1161/01.HYP.0000217362.34748.e0

Garaulet, M., Ordovas, J. M., & Madrid, J. A. (2010). The chronobiology, etiology and pathophysiology of obesity. *International Journal of Obesity (2005), 34*(12), 1667-1683. doi:10.1038/ijo.2010.118

Gautron, L., & Elmquist, J. K. (2011). Sixteen years and counting: an update on leptin in energy balance. *Journal of Clinical Investigation, 121*(6), 2087-2093. doi:10.1172/JCI45888

Guenther, P. M., Casavale, K. O., Reedy, J., Kirkpatrick, S. I., Hiza, H. A., Kuczynski, K. J., . . . Krebs-Smith, S. M. (2013). Update of the Healthy Eating Index: HEI-2010. *Journal of the Academy of Nutrition and Dietetics, 113*(4), 569-580. doi:10.1016/j.jand.2012.12.016

Hall, A. L., Franche, R. L., & Koehoorn, M. (2018). Examining exposure assessment in shift work research: A study on depression among nurses. *Annals of Work Exposures and Health, 62*(2), 182-194. doi:10.1093/annweh/wxx103

Hansen, A. B., Stayner, L., Hansen, J., & Andersen, Z. J. (2016). Night shift work and incidence of diabetes in the Danish Nurse Cohort. *Occupational and Environmental Medicine, 73*(4), 262-268. doi:10.1136/oemed-2015-103342

Harma, M., Karhula, K., Puttonen, S., Ropponen, A., Koskinen, A., Ojajarvi, A., & Kivimaki, M. (2018). Shift work with and without night work as a risk factor for fatigue and changes in sleep length: A cohort study with linkage to records on daily working hours. *Journal of Sleep Research*. doi:10.1111/jsr.12658

Harma, M., Ropponen, A., Hakola, T., Koskinen, A., Vanttola, P., Puttonen, S., . . . Kivimaki, M. (2015). Developing register-based measures for assessment of working time patterns for epidemiologic studies. *Scandinavian Journal of Work, Environment and Health, 41*(3), 268-279. doi:10.5271/sjweh.3492

Heath, G., Coates, A., Sargent, C., & Dorrian, J. (2016). Sleep duration and chronic fatigue are differently associated with the dietary profile of shift workers. *Nutrients, 8*(12), 771. doi:10.3390/nu8120771

Heath, G., Dorrian, J., & Coates, A. (2019). Associations between shift type, sleep, mood, and diet in a group of shift working nurses. *Scandinavian Journal of Work, Environment and Health*. doi:10.5271/sjweh.3803

Heath, G., Roach, G. D., Dorrian, J., Ferguson, S. A., Darwent, D., & Sargent, C. (2012). The effect of sleep restriction on snacking behaviour during a week of simulated shiftwork. *Accident Analysis and Prevention, 45 Suppl*, 62-67. doi:10.1016/j.aap.2011.09.028

Hedeker, D., Mermelstein, R. J., & Demirtas, H. (2008). An application of a mixed-effects location scale model for analysis of Ecological Momentary Assessment (EMA) data. *Biometrics, 64*(2), 627-634. doi:10.1111/j.1541-0420.2007.00924.x

Hogenkamp, P. S., Nilsson, E., Nilsson, V. C., Chapman, C. D., Vogel, H., Lundberg, L. S., . . . Schioth, H. B. (2013). Acute sleep deprivation increases portion size and affects food choice in young men. *Psychoneuroendocrinology, 38*(9), 1668-1674. doi:10.1016/j.psyneuen.2013.01.012

Huth, J. J., Eliades, A., Handwork, C., Englehart, J. L., & Messenger, J. (2013). Shift worked, quality of sleep, and elevated body mass index in pediatric nurses. *Journal of Pediatric Nursing, 28*(6), e64-73. doi:10.1016/j.pedn.2013.02.032

Imaki, M., Hatanaka, Y., Ogawa, Y., Yoshida, Y., & Tanada, S. (2002). An epidemiological study on relationship between the hours of sleep and life style factors in Japanese factory workers. *Journal of Physiological Anthropology and Applied Human Science, 21*(2), 115-120. doi:10.2114/jpa.21.115

Jacobsen, H. B., Reme, S. E., Sembajwe, G., Hopcia, K., Stoddard, A. M., Kenwood, C., . . . Buxton, O. M. (2014). Work-family conflict, psychological distress, and sleep deficiency among patient care workers. *Workplace Health & Safety, 62*(7), 282-291. doi:10.3928/21650799-20140617-04

James, S. M., Honn, K. A., Gaddameedhi, S., & Van Dongen, H. P. A. (2017). Shift work: Disrupted circadian rhythms and sleep-implications for health and well-being. *Current Sleep Medicine Reports, 3*(2), 104-112. doi:10.1007/s40675-017-0071-6

Jensen, H. I., Markvart, J., Holst, R., Thomsen, T. D., Larsen, J. W., Eg, D. M., & Nielsen, L. S. (2016). Shift work and quality of sleep: Effect of working in designed dynamic light. *International Archives of Occupational and Environmental Health, 89*(1), 49-61. doi:10.1007/s00420-015-1051-0

Johnston, D., Bell, C., Jones, M., Farquharson, B., Allan, J., Schofield, P., . . . Johnston, M. (2016). Stressors, appraisal of stressors, experienced stress and cardiac response: A real-time, real-life investigation of work stress in nurses. *Annals of Behavioral Medicine, 50*(2), 187-197. doi:10.1007/s12160-015-9746-8

Juda, M., Vetter, C., & Roenneberg, T. (2013). The Munich ChronoType Questionnaire for Shift-Workers (MCTQ$^{\text{Shift}}$). *Journal of Biological Rhythms, 28*(2), 130-140. doi:10.1177/0748730412475041

Kant, A. K., & Graubard, B. I. (2014). Association of self-reported sleep duration with eating behaviors of American adults: NHANES 2005-2010. *American Journal of Clinical Nutrition, 100*(3), 938-947. doi:10.3945/ajcn.114.085191

Karhula, K., Harma, M., Ropponen, A., Hakola, T., Sallinen, M., & Puttonen, S. (2016). Sleep and satisfaction in 8- and 12-h forward-rotating shift systems: Industrial employees prefer

12-h shifts. *Chronobiology International, 33*(6), 768-775. doi:10.3109/07420528.2016.1167726

Karim, J., Weisz, R., & Rehman, S. U. (2011). International positive and negative affect schedule short-form (I-PANAS-SF): Testing for factorial invariance across cultures. *Procedia - Social and Behavioral Sciences, 15*, 2016-2022. doi:10.1016/j.sbspro.2011.04.046

Karlsson, B., Knutsson, A., & Lindahl, B. (2001). Is there an association between shift work and having a metabolic syndrome? Results from a population based study of 27,485 people. *Occupational and Environmental Medicine, 58*(11), 747-752. doi:10.1136/oem.58.11.747

Katagiri, R., Asakura, K., Kobayashi, S., Suga, H., Sasaki, S., & Diets, T.-G. S. W. (2014). Low intake of vegetables, high intake of confectionary, and unhealthy eating habits are associated with poor sleep quality among middle-aged female Japanese workers. *Journal of Occupational Health, 56*(5), 359-368. doi:10.1539/joh.14-0051-OA

Klok, M. D., Jakobsdottir, S., & Drent, M. L. (2007). The role of leptin and ghrelin in the regulation of food intake and body weight in humans: A review. *Obesity Reviews, 8*(1), 21-34. doi:10.1111/j.1467-789X.2006.00270.x

Ko, S. B. (2013). Night shift work, sleep quality, and obesity. *Journal of Lifestyle Medicine, 3*(2), 110-116.

Korkmaz, A., Topal, T., Tan, D. X., & Reiter, R. J. (2009). Role of melatonin in metabolic regulation. *Reviews in Endocrine & Metabolic Disorders, 10*(4), 261-270. doi:10.1007/s11154-009-9117-5

Lavender, J. M., De Young, K. P., Anestis, M. D., Wonderlich, S. A., Crosby, R. D., Engel, S. G., . . . Le Grange, D. (2013). Associations between retrospective versus ecological momentary assessment measures of emotion and eating disorder symptoms in anorexia nervosa. *Journal of Psychiatric Research, 47*(10), 1514-1520. doi:10.1016/j.jpsychires.2013.06.021

Levy, D. E., Gelsomin, E. D., Rimm, E. B., Pachucki, M., Sanford, J., Anderson, E., . . . Thorndike, A. N. (2018). Design of ChooseWell 365: Randomized controlled trial of an automated, personalized worksite intervention to promote healthy food choices and prevent weight gain. *Contemporary Clinical Trials, 75*, 78-86. doi:10.1016/j.cct.2018.11.004

Li, Y., Fang, J., & Zhou, C. (2019). Work-welated predictors of sleep quality in Chinese nurses: Testing a path analysis model. *Journal of Nursing Research*. doi:10.1097/jnr.0000000000000319

Li, Y., Sato, Y., & Yamaguchi, N. (2011). Shift work and the risk of metabolic syndrome: A nested case-control study. *International Journal of Occupational and Environmental Health, 17*(2), 154-160. doi:10.1179/107735211799030960

Lin, P. C., Chen, C. H., Pan, S. M., Pan, C. H., Chen, C. J., Chen, Y. M., . . . Wu, M. T. (2012). Atypical work schedules are associated with poor sleep quality and mental health in Taiwan female nurses. *International Archives of Occupational and Environmental Health, 85*(8), 877-884. doi:10.1007/s00420-011-0730-8

Lo, Y. L., Hsieh, Y. T., Hsu, L. L., Chuang, S. Y., Chang, H. Y., Hsu, C. C., . . . Pan, W. H. (2017). Dietary pattern associated with frailty: Results from Nutrition and Health Survey in Taiwan. *Journal of the American Geriatrics Society, 65*(9), 2009-2015. doi:10.1111/jgs.14972

Ma, Y., Wei, F., Nie, G., Zhang, L., Qin, J., Peng, S., . . . Zou, Y. (2018). Relationship between shift work schedule and self-reported sleep quality in Chinese employees. *Chronobiology International, 35*(2), 261-269. doi:10.1080/07420528.2017.1399902

Magee, C. A., Robinson, L. D., & McGregor, A. (2018). The work-family interface and sleep quality. *Behavioral Sleep Medicine, 16*(6), 601-610. doi:10.1080/15402002.2016.1266487

Manohar, S., Thongprayoon, C., Cheungpasitporn, W., Mao, M. A., & Herrmann, S. M. (2017). Associations of rotational shift work and night shift status with hypertension: A systematic review and meta-analysis. *Journal of Hypertension, 35*(10), 1929-1937. doi:10.1097/HJH.0000000000001442

Martinez, S. M., Tschann, J. M., Butte, N. F., Gregorich, S. E., Penilla, C., Flores, E., . . . Deardorff, J. (2017). Short sleep duration is associated with eating more carbohydrates and less dietary fat in Mexican American Children. *Sleep, 40*(2). doi:10.1093/sleep/zsw057

Mashhadi, N. S., Saadat, S., Afsharmanesh, M. R., & Shirali, S. (2016). Study of association between beverage consumption pattern and lipid profile in shift workers. *Diabetes & Metabolic Syndrome, 10*(4), 227-229. doi:10.1016/j.dsx.2016.06.011

Matthews, G., Jones, D. M., & Chamberlain, A. G. (1990). Refining the measurement of mood: The UWIST Mood Adjective Checklist. *The British journal of psychology, 81*(1), 17-42. doi:10.1111/j.2044-8295.1990.tb02343.x

McCarthy, S. N., Robson, P. J., Livingstone, M. B., Kiely, M., Flynn, A., Cran, G. W., & Gibney, M. J. (2006). Associations between daily food intake and excess adiposity in Irish adults: Towards the development of food-based dietary guidelines for reducing the prevalence of overweight and obesity. *International Journal of Obesity (2005), 30*(6), 993-1002. doi:10.1038/sj.ijo.0803235

McHill, A. W., Melanson, E. L., Higgins, J., Connick, E., Moehlman, T. M., Stothard, E. R., & Wright, K. P., Jr. (2014). Impact of circadian misalignment on energy metabolism during simulated nightshift work. *Proceedings of the National Academy of Sciences of the United States of America, 111*(48), 17302-17307. doi:10.1073/pnas.1412021111

McIntyre, T. M., McIntyre, S. E., Barr, C. D., Woodward, P. S., Francis, D. J., Durand, A. C., . . . Kamarck, T. W. (2016). Longitudinal study of the feasibility of using ecological momentary assessment to study teacher stress: Objective and self-reported measures. *Journal of Occupational Health Psychology, 21*(4), 403-414. doi:10.1037/a0039966

McMenamin, T. M. (2007). *A time to work: recent trends in shift work and flexible schedules*. Retrieved from https://www.bls.gov/opub/mlr/2007/12/art1full.pdf.

McMichael, A. J. (1976). Standardized mortality ratios and the "healthy worker effect": Scratching beneath the surface. *Journal of Occupational Medicine, 18*(3), 165-168. doi:10.1097/00043764-197603000-00009

McNeil, J., Doucet, E., Brunet, J. F., Hintze, L. J., Chaumont, I., Langlois, E., . . . Forest, G. (2016). The effects of sleep restriction and altered sleep timing on energy intake and energy expenditure. *Physiology and Behavior, 164*(Pt A), 157-163. doi:10.1016/j.physbeh.2016.05.051

McNeil, J., Forest, G., Hintze, L. J., Brunet, J. F., Finlayson, G., Blundell, J. E., & Doucet, E. (2017). The effects of partial sleep restriction and altered sleep timing on appetite and food reward. *Appetite, 109*, 48-56. doi:10.1016/j.appet.2016.11.020

Merkus, S. L., Holte, K. A., Huysmans, M. A., van de Ven, P. M., van Mechelen, W., & van der Beek, A. J. (2015). Self-reported recovery from 2-week 12-hour shift work schedules: A 14-day follow-up. *Safety and Health at Work, 6*(3), 240-248. doi:10.1016/j.shaw.2015.07.003

Merz, E. L., Malcarne, V. L., Roesch, S. C., Ko, C. M., Emerson, M., Roma, V. G., & Sadler, G. R. (2013). Psychometric properties of Positive and Negative Affect Schedule (PANAS) original and short forms in an African American community sample. *Journal of Affective Disorders, 151*(3), 942-949. doi:10.1016/j.jad.2013.08.011

Migueles, J. H., Cadenas-Sanchez, C., Ekelund, U., Delisle Nystrom, C., Mora-Gonzalez, J., Lof, M., . . . Ortega, F. B. (2017). Accelerometer data collection and processing criteria to assess physical activity and other outcomes: A systematic review and practical considerations. *Sports Medicine, 47*(9), 1821-1845. doi:10.1007/s40279-017-0716-0

Monk, T. H., Buysse, D. J., Billy, B. D., Fletcher, M. E., Kennedy, K. S., Begley, A. E., . . . Beach, S. R. (2013). Shiftworkers report worse sleep than day workers, even in retirement. *Journal of Sleep Research, 22*(2), 201-208. doi:10.1111/jsr.12003

Nagl, M., Hilbert, A., de Zwaan, M., Braehler, E., & Kersting, A. (2016). The German version of the Dutch Eating Behavior Questionnaire: Psychometric properties, measurement invariance, and population-based norms. *PloS One, 11*(9), e0162510. doi:10.1371/journal.pone.0162510

Nakazato, M., Murakami, N., Date, Y., Kojima, M., Matsuo, H., Kangawa, K., & Matsukura, S. (2001). A role for ghrelin in the central regulation of feeding. *Nature, 409*(6817), 194-198. doi:10.1038/35051587

National Center for Health Statistics. (2015). *National Health Interview Survey (NHIS), 2015 Data Release.* Retrieved from http://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_ Documentation/NHIS/2015/samadult_freq.pdf

Nedeltcheva, A. V., Kilkus, J. M., Imperial, J., Kasza, K., Schoeller, D. A., & Penev, P. D. (2009). Sleep curtailment is accompanied by increased intake of calories from snacks. *American Journal of Clinical Nutrition, 89*(1), 126-133. doi:10.3945/ajcn.2008.26574

Neuhaus, J. M., & Kalbfleisch, J. D. (1998). Between- and within-cluster covariate effects in the analysis of clustered data. *Biometrics, 54*(2), 638-645. doi:10.2307/3109770

Nicklas, T. A., & O'Neil, C. E. (2015). Development of the SoFAS (solid fats and added sugars) concept: The 2010 Dietary Guidelines for Americans. *Advances in Nutrition, 6*(3), 368S-375S. doi:10.3945/an.114.007021

Niu, S. F., Miao, N. F., Liao, Y. M., Chi, M. J., Chung, M. H., & Chou, K. R. (2017). Sleep quality associated with different work schedules: A longitudinal study of nursing staff. *Biological Research for Nursing, 19*(4), 375-381. doi:10.1177/1099800417695483

O'Connor, L., Imamura, F., Lentjes, M. A., Khaw, K. T., Wareham, N. J., & Forouhi, N. G. (2015). Prospective associations and population impact of sweet beverage intake and type 2 diabetes, and effects of substitutions with alternative beverages. *Diabetologia, 58*(7), 1474-1483. doi:10.1007/s00125-015-3572-1

Ohayon, M. M., Smolensky, M. H., & Roth, T. (2010). Consequences of shiftworking on sleep duration, sleepiness, and sleep attacks. *Chronobiology International, 27*(3), 575-589. doi:10.3109/07420521003749956

Olson, R., Crain, T. L., Bodner, T. E., King, R., Hammer, L. B., Klein, L. C., . . . Buxton, O. M. (2015). A workplace intervention improves sleep: Results from the randomized controlled Work, Family, and Health Study. *Sleep Health, 1*(1), 55-65. doi:10.1016/j.sleh.2014.11.003

Pan, A., Schernhammer, E. S., Sun, Q., & Hu, F. B. (2011). Rotating night shift work and risk of type 2 diabetes: Two prospective cohort studies in women. *PLoS Medicine, 8*(12), e1001141. doi:10.1371/journal.pmed.1001141

Papier, K., D'Este, C., Bain, C., Banwell, C., Seubsman, S., Sleigh, A., & Jordan, S. (2017). Consumption of sugar-sweetened beverages and type 2 diabetes incidence in Thai adults: Results from an 8-year prospective study. *Nutrition & Diabetes, 7*(6), e283. doi:10.1038/nutd.2017.27

Peplonska, B., Bukowska, A., & Sobala, W. (2015). Association of rotating night shift work with BMI and abdominal obesity among nurses and midwives. *PloS One, 10*(7), e0133761. doi:10.1371/journal.pone.0133761

Pico, C., Oliver, P., Sanchez, J., & Palou, A. (2003). Gastric leptin: A putative role in the short-term regulation of food intake. *British Journal of Nutrition, 90*(4), 735-741. doi:10.1079/BJN2003945

Pietroiusti, A., Neri, A., Somma, G., Coppeta, L., Iavicoli, I., Bergamaschi, A., & Magrini, A. (2010). Incidence of metabolic syndrome among night-shift healthcare workers. *Occupational and Environmental Medicine, 67*(1), 54-57. doi:10.1136/oem.2009.046797

Power, B. T., Kiezebrink, K., Allan, J. L., & Campbell, M. K. (2017). Understanding perceived determinants of nurses' eating and physical activity behaviour: A theory-informed qualitative interview study. *BMC Obesity, 4*, 18. doi:10.1186/s40608-017-0154-4

Quante, M., Kaplan, E. R., Cailler, M., Rueschman, M., Wang, R., Weng, J., . . . Redline, S. (2018). Actigraphy-based sleep estimation in adolescents and adults: A comparison with polysomnography using two scoring algorithms. *Nature and Science of Sleep, 10*, 13-20. doi:10.2147/NSS.S151085

Rayward, A. T., Murawski, B., Plotnikoff, R. C., Vandelanotte, C., Brown, W. J., Holliday, E. G., & Duncan, M. J. (2018). A randomised controlled trial to test the efficacy of an m-health delivered physical activity and sleep intervention to improve sleep quality in middle-aged adults: The refresh study protocol. *Contemporary Clinical Trials, 73*, 36-50. doi:10.1016/j.cct.2018.08.007

Risica, P. M., Gorham, G., Dionne, L., Nardi, W., Ng, D., Middler, R., . . . Gans, K. M. (2018). A multi-level intervention in worksites to increase fruit and vegetable access and intake: Rationale, design and methods of the 'Good to Go' cluster randomized trial. *Contemporary Clinical Trials, 65*, 87-98. doi:10.1016/j.cct.2017.12.002

Roenneberg, T. (2012). What is chronotype? *Sleep and Biological Rhythms, 10*(2), 75-76. doi:10.1111/j.1479-8425.2012.00541.x

Roenneberg, T., Daan, S., & Merrow, M. (2003). The art of entrainment. *Journal of Biological Rhythms, 18*(3), 183-194. doi:10.1177/0748730403018003001

Roenneberg, T., Hut, R., Daan, S., & Merrow, M. (2010). Entrainment concepts revisited. *Journal of Biological Rhythms, 25*(5), 329-339. doi:10.1177/0748730410379082

Rutledge, T., Stucky, E., Dollarhide, A., Shively, M., Jain, S., Wolfson, T., . . . Dresselhaus, T. (2009). A real-time assessment of work stress in physicians and nurses. *Health Psychology, 28*(2), 194-200. doi:10.1037/a0013145

Sadeh, A., & Acebo, C. (2002). The role of actigraphy in sleep medicine. *Sleep Medicine Reviews, 6*(2), 113-124. doi:10.1053/smrv.2001.0182

Salo, P., Ala-Mursula, L., Rod, N. H., Tucker, P., Pentti, J., Kivimaki, M., & Vahtera, J. (2014). Work time control and sleep disturbances: Prospective cohort study of Finnish public sector employees. *Sleep, 37*(7), 1217-1225. doi:10.5665/sleep.3842

Scheer, F. A., Hilton, M. F., Mantzoros, C. S., & Shea, S. A. (2009). Adverse metabolic and cardiovascular consequences of circadian misalignment. *Proceedings of the National Academy of Sciences of the United States of America, 106*(11), 4453-4458. doi:10.1073/pnas.0808180106

Schiavo-Cardozo, D., Lima, M. M., Pareja, J. C., & Geloneze, B. (2013). Appetite-regulating hormones from the upper gut: Disrupted control of xenin and ghrelin in night workers. *Clinical Endocrinology, 79*(6), 807-811. doi:10.1111/cen.12114

Schiller, H., Lekander, M., Rajaleid, K., Hellgren, C., Akerstedt, T., Barck-Holst, P., & Kecklund, G. (2017). The impact of reduced worktime on sleep and perceived stress - a group randomized intervention study using diary data. *Scandinavian Journal of Work, Environment and Health, 43*(2), 109-116. doi:10.5271/sjweh.3610

Schoeppe, S., Alley, S., Van Lippevelde, W., Bray, N. A., Williams, S. L., Duncan, M. J., & Vandelanotte, C. (2016). Efficacy of interventions that use apps to improve diet, physical activity and sedentary behaviour: A systematic review. *The International Journal of Behavioral Nutrition and Physical Activity, 13*(1), 127. doi:10.1186/s12966-016-0454-y

Shah, D. (2009). Healthy worker effect phenomenon. *Indian Journal of Occupational and Environmental Medicine, 13*(2), 77-79. doi:10.4103/0019-5278.55123

Shiao, S. C., & Hu, P. Y. (2015). *Mental health investigation and prevention strategies in nurses*. New Taipei City: Institute of Labor, Occupational Safety And Health, Ministry of Labor. Retrieved from https://labor-elearning.mol.gov.tw/co_report_detail.php?rid=842.

Shiffer, D., Minonzio, M., Dipaola, F., Bertola, M., Zamuner, A. R., Dalla Vecchia, L. A., . . . Barbic, F. (2018). Effects of clockwise and counterclockwise job shift work rotation on sleep and work-life balance on hospital nurses. *International Journal of Environmental Research and Public Health, 15*(9). doi:10.3390/ijerph15092038

Slater, J. A., Botsis, T., Walsh, J., King, S., Straker, L. M., & Eastwood, P. R. (2015). Assessing sleep using hip and wrist actigraphy. *Sleep and Biological Rhythms, 13*(2), 172-180. doi:10.1111/sbr.12103

Smith, L., Folkard, S., Tucker, P., & Macdonald, I. (1998). Work shift duration: A review comparing eight hour and 12 hour shift systems. *Occupational and Environmental Medicine, 55*(4), 217-229. doi:10.1136/oem.55.4.217

Smith, S. L., Ludy, M. J., & Tucker, R. M. (2016). Changes in taste preference and steps taken after sleep curtailment. *Physiology and Behavior, 163*, 228-233. doi:10.1016/j.physbeh.2016.05.002

Souza, R. V., Sarmento, R. A., de Almeida, J. C., & Canuto, R. (2019). The effect of shift work on eating habits: A systematic review. *Scandinavian Journal of Work, Environment and Health, 45*(1), 7-21. doi:10.5271/sjweh.3759

Sperry, S. D., Scully, I. D., Gramzow, R. H., & Jorgensen, R. S. (2015). Sleep duration and waist circumference in adults: A meta-analysis. *Sleep, 38*(8), 1269-1276. doi:10.5665/sleep.4906

Steptoe, A., Gibson, E. L., Hamer, M., & Wardle, J. (2007). Neuroendocrine and cardiovascular correlates of positive affect measured by ecological momentary assessment and by questionnaire. *Psychoneuroendocrinology, 32*(1), 56-64. doi:10.1016/j.psyneuen.2006.10.001

Stevens, R. G., Hansen, J., Costa, G., Haus, E., Kauppinen, T., Aronson, K. J., . . . Straif, K. (2011). Considerations of circadian impact for defining 'shift work' in cancer studies: IARC Working Group Report. *Occupational and Environmental Medicine, 68*(2), 154-162. doi:10.1136/oem.2009.053512

Sun, M., Feng, W., Wang, F., Li, P., Li, Z., Li, M., . . . Tse, L. A. (2018). Meta-analysis on shift work and risks of specific obesity types. *Obesity Reviews, 19*(1), 28-40. doi:10.1111/obr.12621

Tada, Y., Kawano, Y., Maeda, I., Yoshizaki, T., Sunami, A., Yokoyama, Y., . . . Togo, F. (2014). Association of body mass index with lifestyle and rotating shift work in Japanese female nurses. *Obesity (Silver Spring), 22*(12), 2489-2493. doi:10.1002/oby.20908

Teng, M.-H., & Chang, S.-H. (2006). A hierarchical model for the comorbidity of GAD and depressive disorder. *Chinese Journal of Psychology, 48*(2), 203-218. doi:10.6129/CJP.2006.4802.06

Thompson, E. R. (2007). Development and validation of an internationally reliable Short-Form of the Positive and Negative Affect Schedule (PANAS). *Journal of Cross-Cultural Psychology, 38*(2), 227-242. doi:10.1177/0022022106297301

Tremaine, R., Dorrian, J., Paterson, J., Neall, A., Piggott, E., Grech, C., & Pincombe, J. (2013). Actigraph estimates of the sleep of Australian midwives: The impact of shift work. *Biological Research for Nursing, 15*(2), 191-199. doi:10.1177/1099800411422249

Tsai, S. M., Wong, R. H., Hwang, S. L., Yang, H. C., Lin, Y. C., & Liao, W. C. (2014). A study relating shift work to the parameters of metabolic syndrome among nurses in a medical center. *Taiwan Journal of Public Health, 33*(2), 119-130. doi:10.6288/TJPH201433102110

van Amelsvoort, L. G., Jansen, N. W., Swaen, G. M., van den Brandt, P. A., & Kant, I. (2004). Direction of shift rotation among three-shift workers in relation to psychological health and work-family conflict. *Scandinavian Journal of Work, Environment and Health, 30*(2), 149-156.

Van Laethem, M., Beckers, D. G., Kompier, M. A., Dijksterhuis, A., & Geurts, S. A. (2013). Psychosocial work characteristics and sleep quality: A systematic review of longitudinal and intervention research. *Scandinavian Journal of Work, Environment and Health, 39*(6), 535-549. doi:10.5271/sjweh.3376

van Strien, T., Frijters, J. E. R., Bergers, G. P. A., & Defares, P. B. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behavior. *International lournal of Eating Disorders, 5*(2), 295-315. doi:10.1002/1098-108X(198602)5:23.0.CO;2-T

Vetter, C., Devore, E. E., Wegrzyn, L. R., Massa, J., Speizer, F. E., Kawachi, I., . . . Schernhammer, E. S. (2016). Association between rotating night shift work and risk of coronary heart disease among women. *JAMA, 315*(16), 1726-1734. doi:10.1001/jama.2016.4454

Viitasalo, K., Kuosma, E., Laitinen, J., & Harma, M. (2008). Effects of shift rotation and the flexibility of a shift system on daytime alertness and cardiovascular risk factors. *Scandinavian Journal of Work, Environment and Health, 34*(3), 198-205.

Waage, S., Pallesen, S., Moen, B. E., Mageroy, N., Flo, E., Di Milia, L., & Bjorvatn, B. (2014). Predictors of shift work disorder among nurses: A longitudinal study. *Sleep Medicine, 15*(12), 1449-1455. doi:10.1016/j.sleep.2014.07.014

Wang, F., Zhang, L., Zhang, Y., Zhang, B., He, Y., Xie, S., . . . Tse, L. A. (2014). Meta-analysis on night shift work and risk of metabolic syndrome. *Obesity Reviews, 15*(9), 709-720. doi:10.1111/obr.12194

Wang, Y. F., Ha, S., Zauszniewski, J. A., & Ross, R. (2018). Psychometric properties of the Chinese version of the Dutch Eating Behavior Questionnaire in a sample of Taiwanese parents. *Obesity Research & Clinical Practice, 12*(1), 129-132. doi:10.1016/j.orcp.2017.11.005

Ward, D. S., Vaughn, A. E., Hales, D., Viera, A. J., Gizlice, Z., Bateman, L. A., . . . Linnan, L. A. (2018). Workplace health and safety intervention for child care staff: Rationale, design, and baseline results from the CARE cluster randomized control trial. *Contemporary Clinical Trials, 68*, 116-126. doi:10.1016/j.cct.2018.02.018

Wardle, J., Steptoe, A., Oliver, G., & Lipsey, Z. (2000). Stress, dietary restraint and food intake. *Journal of Psychosomatic Research, 48*(2), 195-202. doi:10.1016/S0022-3999(00)00076-3

Watanabe, M., Kikuchi, H., Tanaka, K., & Takahashi, M. (2010). Association of short sleep duration with weight gain and obesity at 1-year follow-up: A large-scale prospective study. *Sleep, 33*(2), 161-167. doi:10.1093/sleep/33.2.161

Waterhouse, J., Buckley, P., Edwards, B., & Reilly, T. (2003). Measurement of, and some reasons for, differences in eating habits between night and day workers. *Chronobiology International, 20*(6), 1075-1092. doi:10.1081/CBI-120025536

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*(6), 1063-1070. doi:10.1037/0022-3514.54.6.1063

Wehrens, S. M. T., Christou, S., Isherwood, C., Middleton, B., Gibbs, M. A., Archer, S. N., . . . Johnston, J. D. (2017). Meal timing regulates the human circadian system. *Current Biology, 27*(12), 1768-1775 e1763. doi:10.1016/j.cub.2017.04.059

Westerlund, L., Ray, C., & Roos, E. (2009). Associations between sleeping habits and food consumption patterns among 10-11-year-old children in Finland. *British Journal of Nutrition, 102*(10), 1531-1537. doi:10.1017/S0007114509990730

Wong, H., Wong, M. C., Wong, S. Y., & Lee, A. (2010). The association between shift duty and abnormal eating behavior among nurses working in a major hospital: A cross-sectional study. *International Journal of Nursing Studies, 47*(8), 1021-1027. doi:10.1016/j.ijnurstu.2010.01.001

Wu, S. J., Pan, W. H., Yeh, N. H., & Chang, H. Y. (2011). Trends in nutrient and dietary intake among adults and the elderly: From NAHSIT 1993-1996 to 2005-2008. *Asia Pacific Journal of Clinical Nutrition, 20*(2), 251-265. doi:10.6133/apjcn.2011.20.2.15

Wu, Y., Zhai, L., & Zhang, D. (2014). Sleep duration and obesity among adults: A meta-analysis of prospective studies. *Sleep Medicine, 15*(12), 1456-1462. doi:10.1016/j.sleep.2014.07.018

Xiao, Q., Arem, H., Moore, S. C., Hollenbeck, A. R., & Matthews, C. E. (2013). A large prospective investigation of sleep duration, weight change, and obesity in the NIH-AARP Diet and

Health Study cohort. *American Journal of Epidemiology, 178*(11), 1600-1610. doi:10.1093/aje/kwt180

Yoo, H. C., Burrola, K. S., & Steger, M. F. (2010). A preliminary report on a new measure: Internalization of the Model Minority Myth Measure (IM-4) and its psychological correlates among Asian American college students. *Journal of Counseling Psychology, 57*(1), 114-127. doi:10.1037/a0017871

Yoshizaki, T., Komatsu, T., Tada, Y., Hida, A., Kawano, Y., & Togo, F. (2018). Association of habitual dietary intake with morningness-eveningness and rotating shift work in Japanese female nurses. *Chronobiology International, 35*(3), 392-404. doi:10.1080/07420528.2017.1410169

Zenk, S. N., Horoi, I., McDonald, A., Corte, C., Riley, B., & Odoms-Young, A. M. (2014). Ecological momentary assessment of environmental and personal factors and snack food intake in African American women. *Appetite, 83*, 333-341. doi:10.1016/j.appet.2014.09.008

Zhao, I., Bogossian, F., & Turner, C. (2012). Does maintaining or changing shift types affect BMI? A longitudinal study. *Journal of Occupational and Environmental Medicine, 54*(5), 525-531. doi:10.1097/JOM.0b013e31824e1073

Zinkhan, M., Berger, K., Hense, S., Nagel, M., Obst, A., Koch, B., . . . Stang, A. (2014). Agreement of different methods for assessing sleep characteristics: A comparison of two actigraphs, wrist and hip placement, and self-report with polysomnography. *Sleep Medicine, 15*(9), 1107-1114. doi:10.1016/j.sleep.2014.04.015

Table 2-1. Participants' Characteristics (N=76)

Variables	Mean (SD)	Range	n (%)
Person level			
Demographic data			
Age (in years)	27.8 (4.5)	22.5-41.9	
Female			72 (94.7)
Marital status			
Married			9 (11.8)
Educational attainment			
Bachelor's degree or above			65 (85.5)
Family responsibility			
Taking care of kids/disabled people			12 (15.8)
Per capita household income (n=74)[1]			
Low income (<USD 4,955)			22 (28.9)
Middle income (USD 4,955-7,433)			17 (22.4)
Above middle-income (>USD 7,433)			35 (46.1)
Other person level measures			
Body mass index (BMI)	23.1 (5.0)	17.2-39.1	
Having at least one health condition[2]			18 (23.7)
Eating style (DEBQ)			
Emotional	2.4 (0.7)	1.0-3.8	
Restrained	3.2 (0.5)	2.0-4.4	
External	2.7 (0.7)	1.1-4.3	
Chronotype (MCTQ$^{\mathrm{shift}}$) (MSF$^{\mathrm{E}}$/$\mathrm{MSF}_{\mathrm{SC}}^{\mathrm{E}}$)(n=53)[3]			
Early			11 (14.5)
Intermediate			6 (7.9)
Late			36 (47.4)
Current smoker			2 (2.6)
Occupational history			
Years of working as an RN (in years)	5.7 (4.2)	0.5-20.0	
History of rotating shift work (in years)	5.4 (4.3)	0.5-20.0	
Work characteristics			
Working units			
Intensive care units			40 (52.6)
Shift speed[4]			
Slow			44 (57.9)
Medium or rapid			32 (42.1)
Moment level (n$_{m}$=2,157)			
Emotions			
Positive affect	18.8 (6.4)	7-33	
Negative affect	11.1 (4.5)	7-32	
Experienced stress			821 (38.1)

N: number of participants, n_m: number of momentary observations, SD: standard deviation, DEBQ: Dutch Eating Behavior Questionnaire, $\text{MCTQ}^{\text{shift}}$: Munich ChronoType Questionnaire for shift workers, MSF^{E}: mid-sleep time on off-duty days after evening shifts, $\text{MSF}_{\text{SC}}^{\text{E}}$: corrected mid-sleep time on off-duty days after the evening shift, RN: registered nurse.

[1] Two participants refused to report their per capita household income.

[2] Health conditions included diabetes (type 1 or type 2) or high blood sugar, heart diseases (e.g., coronary artery disease, angina, congestive heart failure), hypertension, stroke, high cholesterol/hyperlipidemia, thyroid problems (e.g., hyperthyroidism, hypothyroidism), kidney diseases (e.g., chronic renal failure), cancer or a malignant tumor (excluding minor skin cancer), digestive problems (such as ulcer, colitis, or gallbladder disease), mental illnesses (e.g., depression, anxiety), and sleep problems (e.g., insomnia).

[3] Chronotype was assessed with $\text{MCTQ}^{\text{shift}}$ (Juda et al., 2013). Twenty-three participants' chronotype could not be defined because they set alarms to wake up even on off-duty days. Juda et al. (2013) defined early, intermediate, and late chronotype as $\text{MSF}_{\text{SC}}^{\text{E}}$ earlier than 4:00 a.m., between 4:00 a.m. and 4:59 a.m., and 5:00 a.m. or later, respectively.

[4] The respective definitions of slow, medium, and rapid shift speed were 0-1 change, 2-3 changes, and 4 or more changes in shift timing in the past two weeks prior to the first EMA survey.

Table 2-2. Momentary Empty Calorie Food/Beverage Consumption by Daily Sleep Quality and Shift Timing (N= 76 n_m= 2,153)[1]

		Daily poor sleep quality							
		Yes (n=371)				No (n=1,782)			
	Overall	D	E	N	O	D	E	N	O
		n= 111	n= 99	n= 67	n= 94	n= 434	n= 361	n= 297	n= 690
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Empty calorie food/beverage consumption (Any versus none)									
Fried food/fast food	342 (15.9)	14 (12.6)	21 (21.2)	15 (22.4)	22 (23.4)	53 (12.2)	53 (14.7)	53 (17.9)	111 (16.1)
Sweet or salty snacks	687 (31.9)	20 (18.0)	34 (34.3)	19 (28.4)	27 (28.7)	119 (27.4)	119 (33.0)	113 (38.1)	235 (34.1)
Sweetened beverages	743 (34.5)	33 (29.7)	33 (33.3)	22 (32.8)	37 (39.4)	136 (31.3)	117 (32.4)	109 (36.7)	255 (37.0)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Overall empty calorie food/beverage intake (count)	1.1 (1.5)	0.7 (1.0)	1.1 (1.2)	1.1 (1.3)	1.2 (1.3)	1.0 (1.5)	1.0 (1.1)	1.2 (1.3)	1.2 (1.8)

N: number of participants, n_m: number of momentary observations, D: Day shifts, E: Evening shifts, N: Night shifts, O: off-duty days, SD: standard deviation.

[1] The subjective measure of sleep quality was missed on one person-day; thus, resulting in 4 missing values out of 2,157 observations from 76 participants.

Table 2- 3. Momentary Empty Calorie Food/Beverage Consumption by Daily Sleep Duration and Shift Timing (N= 76, n_m= 2,157)

	Daily sleep duration							
	Less than 6 hours (n=778)				**At least 6 hours (n=1,439)**			
	D	**E**	**N**	**O**	**D**	**E**	**N**	**O**
	n= 170	**n= 99**	**n= 211**	**n= 238**	**n= 375**	**n= 365**	**n= 153**	**n= 546**
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Empty calorie food/beverage consumption (Any versus none)								
Fried food/fast food	26 (15.3)	17 (17.2)	44 (20.9)	43 (18.1)	41 (10.9)	57 (15.6)	24 (15.7)	90 (16.5)
Sweet or salty snacks	46 (27.1)	37 (37.4)	83 (39.3)	77 (32.4)	93 (24.8)	117 (32.1)	49 (32.0)	185 (33.9)
Sweetened beverages	50 (29.4)	29 (29.3)	76 (36.0)	102 (42.9)	119 (31.7)	122 (33.4)	55 (36.0)	190 (34.8)
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Overall empty calorie food/beverage intake (count)	0.9 (1.3)	1.1 (1.1)	1.2 (1.3)	1.2 (1.4)	0.9 (1.4)	1.0 (1.2)	1.1 (1.3)	1.2 (1.8)

N: number of participants, n_m: number of momentary observations, D: Day shifts, E: Evening shifts, N: Night shifts, O: off-duty days, SD: standard deviation.

Table 2-4. Associations between Shift Timing, Daily Sleep Quality, and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models[1] (N=76, $n_m = 2,153$)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Shift timing[2]								
Day (reference)								
Evening	1.15	(0.78, 1.71)	1.35	(0.98, 1.85)	1.20	(0.82, 1.75)	0.05	(-0.12, 0.22)
Night	1.60	(1.03, 2.48)*	1.28	(0.90, 1.81)	1.78	(1.16, 2.72)**	0.20	(0.01, 0.38)*
Off	1.42	(1.00, 2.03)	1.44	(1.08, 1.92)*	1.93	(1.37, 2.71)***	0.30	(0.14, 0.45)***
Poor sleep quality[3]								
No (reference)								
Yes	1.46	(1.02, 2.09)*	0.87	(0.64, 1.18)	0.81	(0.56, 1.17)	-0.03	(-0.20, 0.13)
Shift timing*sleep quality[4]								
Evening *poor	2.33	(0.75, 7.26)	1.40	(0.52, 3.76)	0.99	(0.30, 3.23)	0.39	(-0.14, 0.92)
Night *poor	4.26	(1.17, 15.57)*	1.22	(0.40, 3.73)	0.58	(0.15, 2.21)	0.41	(-0.20, 1.01)
Off*poor	2.62	(0.95, 7.27)	0.99	(0.40, 2.42)	0.78	(0.28, 2.21)	0.20	(-0.27, 0.67)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

[1] The respective models adjusted for the time-varying (i.e., emotions, experienced stress, number of complete EMA surveys per day, and the sequence of EMA survey day) and the time-invariant (i.e., age, BMI, educational attainment, family responsibility, health conditions) covariates.

[2] The within-person effects captured how changes in shift timing for a person contributed to that person's variations in empty calorie food/beverage consumption in each measure.

[3] The within-person effect captured how changes in poor sleep quality for a person related to that person's changes in momentary empty calorie food/beverage consumption.

[4] These multiplicative interactions tested if within-person associations between empty calorie food/beverage consumption and same-day shift timing were moderated by daily sleep quality.

$^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

Table 2-5. Associations between Shift Timing, Daily Sleep Duration, and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models[1] (N=76, n_m = 2,157)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Shift timing								
Day (reference)								
Evening	1.25	(0.84, 1.86)	1.41	(1.02, 1.95)*	1.13	(0.77, 1.65)	0.07	(-0.11, 0.24)
Night	1.60	(1.01, 2.54)*	1.11	(0.77, 1.61)	1.78	(1.14, 2.76)*	0.18	(-0.01, 0.37)
Off	1.49	(1.04, 2.15)*	1.45	(1.08, 1.93)*	1.92	(1.37, 2.70)***	0.30	(0.15, 0.46)***
Sleep duration[2]								
>= 6 hours (reference)								
< 6 hours	1.37	(1.02, 1.85)*	1.32	(1.03, 1.68)*	0.95	(0.71, 1.27)	0.08	(-0.05, 0.21)
Shift timing *sleep duration[3]								
Evening * < 6 hours	0.76	(0.27, 2.15)	1.50	(0.62, 3.60)	0.80	(0.28, 2.31)	0.03	(-0.43, 0.50)
Night *< 6 hours	0.86	(0.32, 2.32)	1.62	(0.71, 3.71)	0.96	(0.35, 2.65)	0.07	(-0.37, 0.51)
Off *< 6 hours	0.63	(0.29, 1.38)	1.02	(0.52, 1.98)	1.88	(0.85, 4.16)	0.06	(-0.29, 0.41)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

[1] Results presented in this table were adjusted for the time-varying (i.e., emotions, experienced stress, number of complete EMA surveys per day, and the sequence of EMA survey day) and the time-invariant (i.e., age, BMI, educational attainment, family responsibility, health conditions) covariates. Only within-person associations were presented in the table.

[2] The within-person effects examined how changes in short sleep duration for a person related to that person's fluctuations in empty calorie food/beverage consumption.

[3] The multiplicative interactions tested if within-person associations between shift timing and same-day empty calorie food/beverage consumption were moderated by daily sleep duration.

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 2-6. Associations between Prior-day Shift Timing, Daily Sleep Quality, and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N= 76, n_m = 2,153)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Model 1[1]								
Shift timing on previous day[2]								
Day (reference)								
Evening	1.10	(0.76, 1.60)	1.12	(0.82, 1.54)	0.91	(0.63, 1.33)	-0.05	(-0.21, 0.12)
Night	0.98	(0.64, 1.50)	1.29	(0.92, 1.80)	1.22	(0.81, 1.84)	0.05	(-0.13, 0.23)
Off	0.97	(0.69, 1.37)	1.08	(0.82, 1.43)	0.93	(0.67, 1.30)	-0.06	(-0.21, 0.08)
Poor sleep quality								
No (reference)								
Yes	1.48	(1.04, 2.12)*	0.84	(0.61, 1.14)	0.82	(0.55, 1.15)	-0.05	(-0.22, 0.11)
Shift timing on the previous day *sleep quality[3]								
Evening *poor	0.70	(0.22, 2.19)	1.41	(0.51, 3.86)	1.17	(0.36, 3.80)	0.23	(-0.31, 0.76)
Night *poor	2.30	(0.62, 8.57)	1.42	(0.46, 4.43)	0.82	(0.21, 3.24)	0.40	(-0.20, 1.01)
Off*poor	0.86	(0.32, 2.34)	0.88	(0.36, 2.16)	0.51	(0.18, 1.43)	-0.07	(-0.54, 0.40)
Model 2[4]								
Shift timing on previous day								
Day (reference)								
Evening	0.97	(0.63, 1.49)	0.96	(0.67, 1.36)	0.74	(0.48, 1.12)	-0.14	(-0.32, 0.05)
Night	0.74	(0.46, 1.20)	1.20	(0.83, 1.75)	0.95	(0.61, 1.50)	-0.04	(-0.24, 0.15)
Off	0.84	(0.58, 1.22)	1.02	(0.76, 1.37)	0.81	(0.58, 1.15)	-0.12	(-0.28, 0.03)
Poor sleep quality								
No (reference)								
Yes	1.50	(1.05,2.15)*	0.87	(0.63, 1.18)	0.85	(0.59, 1.22)	-0.02	(-0.19, 0.14)
Shift timing on previous day *sleep quality								
Evening *poor	0.69	(0.22, 2.15)	1.37	(0.50, 3.77)	1.15	(0.36, 3.73)	0.20	(-0.33, 0.73)
Night *poor	1.82	(0.49, 6.67)	1.44	(0.46, 4.52)	0.71	(0.18, 2.81)	0.33	(-0.27, 0.93)

Off*poor	0.90	(0.33, 2.45)	0.89	(0.36, 2.20)	0.49	(0.17, 1.38)	-0.12	(-0.58, 0.35)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

[1] Respective models adjusted for the time-varying (i.e., emotions, experienced stress, number of complete EMA surveys per day, and the sequence of EMA survey day) and the time-invariant (i.e., age, BMI, educational attainment, family responsibility, health conditions) covariates.

[2] The within-person effect captured how changes in prior-day shift timing given a person contributed to that person's variations in empty calorie food/beverage consumption.

[3] The multiplicative interactions tested if within-person associations between empty calorie food/beverage consumption and prior-day shift timing were modified by daily sleep quality.

[4] Besides covariates included in the Model 1, respective models adjusted for same-day shift timing.

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 2-7. Associations between Prior-day Shift Timing, Daily Sleep Duration, and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N= 76, n_m = 2,157)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Model 1[1]								
Shift timing on previous day								
Day (reference)								
Evening	1.08	(0.74, 1.57)	1.09	(0.80, 1.50)	0.90	(0.62, 1.32)	-0.04	(-0.21, 0.12)
Night	1.00	(0.65, 1.53)	1.23	(0.87, 1.73)	1.18	(0.78, 1.79)	0.05	(-0.13, 0.23)
Off	0.99	(0.70, 1.40)	1.03	(0.78, 1.36)	0.92	(0.66, 1.28)	-0.07	(-0.22, 0.08)
Sleep duration								
>= 6 hours (reference)								
< 6 hours	1.39	(1.06, 1.83)*	1.19	(0.95, 1.50)	1.04	(0.79, 1.37)	0.08	(-0.04, 0.20)
Shift timing on previous day *sleep duration[2]								
Evening * < 6 hours	1.26	(0.47, 3.08)	0.92	(0.40, 2.11)	1.16	(0.43, 3.11)	0.22	(-0.21, 0.66)
Night *< 6 hours	0.86	(0.32, 2.30)	0.84	(0.37, 1.93)	1.36	(0.51, 3.65)	0.18	(-0.26, 0.62)
Off *< 6 hours	0.92	(0.40, 2.09)	1.02	(0.50, 2.07)	1.00	(0.44, 2.29)	0.24	(-0.13, 0.61)
Model 2[3]								
Shift timing on previous day								
Day (reference)								
Evening	0.94	(0.61, 1.45)	0.89	(0.62, 1.28)	0.71	(0.47, 1.08)	-0.15	(-0.34, 0.04)
Night	0.77	(0.48, 1.24)	1.15	(0.79, 1.68)	0.92	(0.58, 1.45)	-0.04	(-0.24, 0.16)
Off	0.87	(0.60, 1.25)	0.97	(0.72, 1.30)	0.80	(0.57, 1.13)	-0.13	(-0.29, 0.03)
Sleep duration								
>= 6 hours (reference)								
< 6 hours	1.34	(1.00, 1.79)*	1.28	(1.00, 1.63)*	1.05	(0.79, 1.39)	0.09	(-0.04, 0.21)
Shift timing on previous day *sleep duration								
Evening * < 6 hours	1.18	(0.46, 3.03)	0.90	(0.39, 2.06)	0.99	(0.37, 2.65)	0.14	(-0.29, 0.58)
Night *< 6 hours	0.83	(0.30, 2.25)	0.83	(0.36, 1.94)	1.19	(0.44, 3.19)	0.11	(-0.33, 0.54)

Off *< 6 hours	0.94	(0.41, 2.14)	1.05	(0.52, 2.12)	0.96	(0.42, 2.19)	0.21	(-0.15, 0.58)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

[1] Respective models adjusted for the time-varying (i.e., emotions, experienced stress, number of complete EMA surveys per day, and the sequence of EMA survey day) and the time-invariant (i.e., age, BMI, educational attainment, family responsibility, health conditions) covariates.

[2] The multiplicative interactions tested if within-person associations between empty calorie food/beverage consumption and prior-day shift timing were moderated by daily sleep duration.

[3] Besides covariates adjusted in the Model 1, same-day shift timing was controlled in respective models.

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 2-8. Associations between Work Shift Intensity, Daily Sleep Quality, and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N= 76, n_m = 2,153)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Model 1[1]								
Work shift intensity[2]	0.97	(0.89, 1.06)	0.93	(0.87, 1.00)*	0.98	(0.90, 1.07)	-0.04	(-0.08, 0.00)*
Poor sleep quality								
No (reference)								
Yes	1.48	(1.04, 2.11)*	0.84	(0.62, 1.14)	0.77	(0.53, 1.10)	-0.06	(-0.22, 0.11)
Work shift intensity*sleep quality[3]								
Work shift intensity*poor	1.13	(0.88, 1.44)	1.06	(0.85, 1.30)	1.27	(0.99, 1.63)	0.11	(0.00, 0.22)*
Model 2[4]								
Work shift intensity	1.00	(0.90, 1.11)	0.93	(0.85, 1.02)	1.08	(0.97, 1.19)	-0.01	(-0.05, 0.04)
Poor sleep quality								
No (reference)								
Yes	1.49	(1.05, 2.13)*	0.86	(0.63, 1.16)	0.80	(0.55, 1.15)	-0.05	(-0.21, 0.12)
Work shift intensity*sleep quality								
Work shift intensity*poor	1.09	(0.86, 1.39)	1.03	(0.83, 1.27)	1.20	(0.93, 1.54)	0.09	(-0.02, 0.20)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

[1] The time-varying (i.e., emotions, experienced stress, number of complete EMA surveys per day, and the sequence of EMA survey day) and the time-invariant (i.e., age, BMI, educational attainment, family responsibility, health conditions) covariates were controlled in the respective models.

[2] The within-person effects examined how one unit increased in work shift intensity related to that person's variations in empty calorie food/beverage consumption.

[3] The multiplicative interactions tested if associations between empty calorie food/beverage consumption and work shift intensity were moderated by daily sleep quality.

[4] In addition to covariates included in the Model 1, same-day shift timing was also controlled each model.

$^*p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

Table 2-9. Associations between Night Shift Intensity, Daily Sleep Quality, and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N= 76, n_m = 2,153)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Model 1[1]								
Night shift intensity[2]								
Low (reference)								
High	1.64	(1.00, 2.69)*	1.02	(0.69, 1.53)	1.82	(1.12, 2.97)*	0.14	(-0.07, 0.35)
Poor sleep quality								
No (reference)								
Yes	1.37	(0.95, 1.96)	0.84	(0.61, 1.14)	0.73	(0.50, 1.05)	-0.08	(-0.25, 0.08)
Night shift intensity*sleep quality[3]								
High*poor	2.01	(0.60, 6.70)	0.78	(0.25, 2.46)	1.42	(0.36, 5.56)	0.25	(-0.34, 0.85)
Model 2[4]								
Night shift intensity								
Low (reference)								
High	1.43	(0.80, 2.56)	1.03	(0.85, 1.05)	1.96	(1.09, 3.50)*	0.16	(-0.10, 0.41)
Poor sleep quality								
No (reference)								
Yes	1.40	(0.98, 2.02)	0.87	(0.64, 1.19)	0.78	(0.54, 1.12)	-0.06	(-0.22, 0.11)
Night shift intensity*sleep quality								
High*poor	2.05	(0.61, 6.87)	0.73	(0.23, 2.32)	1.25	(0.32, 4.85)	0.19	(-0.40, 0.78)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

[1] Respective models adjusted for the time-varying (i.e., emotions, experienced stress, number of complete EMA surveys per day, and the sequence of EMA survey day) and the time-invariant (i.e., age, BMI, educational attainment, family responsibility, health conditions) covariates.

[2] The within-person effects examined if changes in levels of night shift intensity for a person were associated with that person's variations in empty calorie food/beverage consumption.

[3] The multiplicative interactions tested if daily sleep quality moderated associations between empty calorie food/beverage consumption and night shift intensity.

[4] In addition to the covariates adjusted in Model 1, same-day shift timing was also adjusted in the respective models.

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 2-10. Associations between Work Shift Intensity, Daily Sleep Duration, and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N= 76, n_m = 2,157)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Model 1[1]								
Work shift intensity	0.95	(0.87, 1.04)	0.92	(0.86, 0.99)*	0.98	(0.90, 1.07)	-0.05	(-0.08, -0.01)*
Sleep duration								
>= 6 hours (reference)								
< 6 hours	1.43	(1.09, 1.88)*	1.25	(1.00, 1.57)	1.04	(0.79, 1.37)	0.10	(-0.03, 0.22)
Work shift intensity*sleep duration[2]								
Work shift intensity *< 6 hours	1.19	(0.98, 1.44)	1.13	(0.95, 1.33)	0.94	(0.77, 1.14)	0.05	(-0.04, 0.13)
Model 2[3]								
Work shift intensity	0.98	(0.88, 1.09)	0.93	(0.85, 1.02)	1.09	(0.98, 1.20)	-0.01	(-0.06, 0.04)
Sleep duration								
>= 6 hours (reference)								
< 6 hours	1.37	(1.03, 1.83)*	1.29	(1.01, 1.64)*	1.01	(0.76, 1.35)	0.08	(-0.04, 0.21)
Work shift intensity*sleep duration								
Work shift intensity *< 6 hours	1.17	(0.96, 1.41)	1.12	(0.95, 1.33)	0.91	(0.75, 1.10)	0.03	(-0.05, 0.11)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

[1] The time-varying (i.e., emotions, experienced stress, number of complete EMA surveys per day, and the sequence of EMA survey day) and the time-invariant (i.e., age, BMI, educational attainment, family responsibility, health conditions) covariates were controlled in the respective models.

[2] The multiplicative interactions tested if sleep duration on a day moderated the associations between work shift intensity and each outcome.

[3] Besides the covariates adjusted in Model 1, same-day shift timing was also included in the respective models.

$^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

Table 2-11. Associations between Night Shift Intensity, Daily Sleep Duration, and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N= 76, n_m = 2,157)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Model 1[1]								
Night shift intensity								
Low (reference)								
High	1.63	(0.96, 2.77)	0.98	(0.63, 1.52)	1.84	(1.07, 3.15)*	0.14	(-0.09, 0.37)
Sleep duration								
>= 6 hours (reference)								
< 6 hours	1.33	(1.01, 1.75)*	1.22	(0.97, 1.54)	0.99	(0.75, 1.30)	0.07	(-0.05, 0.19)
Night shift intensity*sleep duration[2]								
High *< 6 hours	1.24	(0.41, 3.75)	0.81	(0.31, 2.15)	0.95	(0.30, 3.01)	-0.05	(-0.55, 0.45)
Model 2[3]								
Night shift intensity								
Low (reference)								
High	1.56	(0.83, 2.93)	1.06	(0.63, 1.78)	1.99	(1.05, 3.79)*	0.19	(-0.08, 0.47)
Sleep duration								
>= 6 hours (reference)								
< 6 hours	1.32	(0.99, 1.75)	1.27	(1.00, 1.61)	1.02	(0.77, 1.35)	0.08	(-0.05, 0.20)
Night shift intensity*sleep duration								
High *< 6 hours	1.14	(0.38, 3.43)	0.76	(0.28, 2.02)	0.88	(0.28, 2.80)	-0.12	(-0.62, 0.37)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

[1] Each model adjusted for the time-varying (i.e., emotions, experienced stress, number of complete EMA surveys per day, and the sequence of EMA survey day) and the time-invariant (i.e., age, BMI, educational attainment, family responsibility, health conditions) covariates.

[2] The multiplicative interactions examined if sleep duration moderated the effects of night shift intensity on empty calorie food/beverage consumption.

[3] In addition to variables controlled in Model 1, respective models adjusted for same-day shift timing.

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 2-12. Associations between Shift Speed, Daily Sleep Quality and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N=76, n_m= 2,153)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Model 1[1]								
Shift speed[2]								
S (reference)								
M/R	0.81	(0.54, 1.23)	0.70	(0.43, 1.13)	0.63	(0.31, 1.26)	-0.14	(-0.37, 0.10)
Poor sleep quality								
No (reference)								
Yes	1.05	(0.66, 1.67)	0.88	(0.59, 1.31)	0.65	(0.40, 1.06)	-0.14	(-0.36, 0.08)
Shift speed* sleep quality[3]								
M/R* poor	2.34	(1.14, 4.81)*	0.87	(0.47, 1.60)	1.44	(0.69, 2.98)	0.18	(-0.15, 0.51)
Model 2 [4]								
Shift speed								
S (reference)								
M/R	0.87	(0.58, 1.29)	0.73	(0.45, 1.18)	0.68	(0.34, 1.35)	-0.09	(-0.31, 0.14)
Poor sleep quality								
No (reference)								
Yes	1.06	(0.66, 1.68)	0.91	(0.60, 1.36)	0.68	(0.42, 1.11)	-0.13	(-0.34, 0.09)
Shift speed* sleep quality								
M/R* poor	2.38	(1.16, 4.90)*	0.88	(0.47, 1.62)	1.45	(0.70, 2.99)	0.19	(-0.14, 0.51)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions, S: slow shift speed, M/R: medium or rapid shift speed.

[1] The time-varying (i.e., emotions, experienced stress, number of complete EMA surveys per day, and the sequence of EMA survey day) and the time-invariant (i.e., age, BMI, educational attainment, family responsibility, health conditions) covariates were controlled in the respective models.

[2] Shift speed was a person level measure. The between-person effects estimated whether differences in shift speed between persons were associated with their differences in a dependent variable (Hedeker et al., 2008; Neuhaus & Kalbfleisch, 1998; Zenk et al., 2014).

[3] The multiplicative interactions between sleep quality and shift speed were cross-level. These cross-level interactions tested if associations between empty calorie food/beverage consumption and shift speed were moderated by daily sleep quality.

[4] In addition to the covariates adjusted in Model 1, same-day shift timing was also controlled in each model.

$^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

Table 2-13. Associations between Shift Speed, Daily Sleep Duration and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N= 76, n_m = 2,157)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Model 1[1]								
Shift speed								
S (reference)								
M/R	0.99	(0.58, 1.69)	0.82	(0.42, 1.60)	1.14	(0.56, 3.51)	0.14	(-0.17, 0.46)
Sleep duration								
>= 6 hours (reference)								
< 6 hours	1.43	(1.00, 2.06)	1.39	(1.03, 1.89)*	1.07	(0.74, 1.54)	0.08	(-0.08, 0.25)
Shift speed*sleep duration[2]								
M/R*< 6 hours	0.93	(0.54, 1.60)	0.74	(0.47, 1.17)	0.96	(0.56, 1.65)	<0.01	(-0.24, 0.24)
Model 2[3]								
Shift speed								
S (reference)								
M/R	1.03	(0.61, 1.73)	0.75	(0.38, 1.46)	1.36	(0.54, 3.40)	0.10	(-0.21, 0.40)
Sleep duration								
>= 6 hours (reference)								
< 6 hours	1.38	(0.96, 2.00)	1.46	(1.07, 1.99)*	1.06	(0.73, 1.54)	0.08	(-0.08, 0.25)
Shift speed*sleep duration								
M/R*< 6 hours	0.91	(0.53, 1.57)	0.73	(0.46, 1.16)	0.93	(0.54, 1.59)	-0.01	(-0.25, 0.23)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions, S: slow shift speed, M/R: medium or rapid shift speed.

[1] The time-varying (i.e., emotions, experienced stress, number of complete EMA surveys per day, and the sequence of EMA survey day) and the time-invariant (i.e., age, BMI, educational attainment, family responsibility, health conditions) covariates were controlled in the respective models.

[2] The multiplicative interactions between sleep duration and shift speed were cross-level. These cross-level interactions examined if associations between empty calorie food/beverage consumption and shift speed were moderated by daily sleep duration.

[3] In addition to variables adjusted in Model 1, same-day shift timing was also adjusted.

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

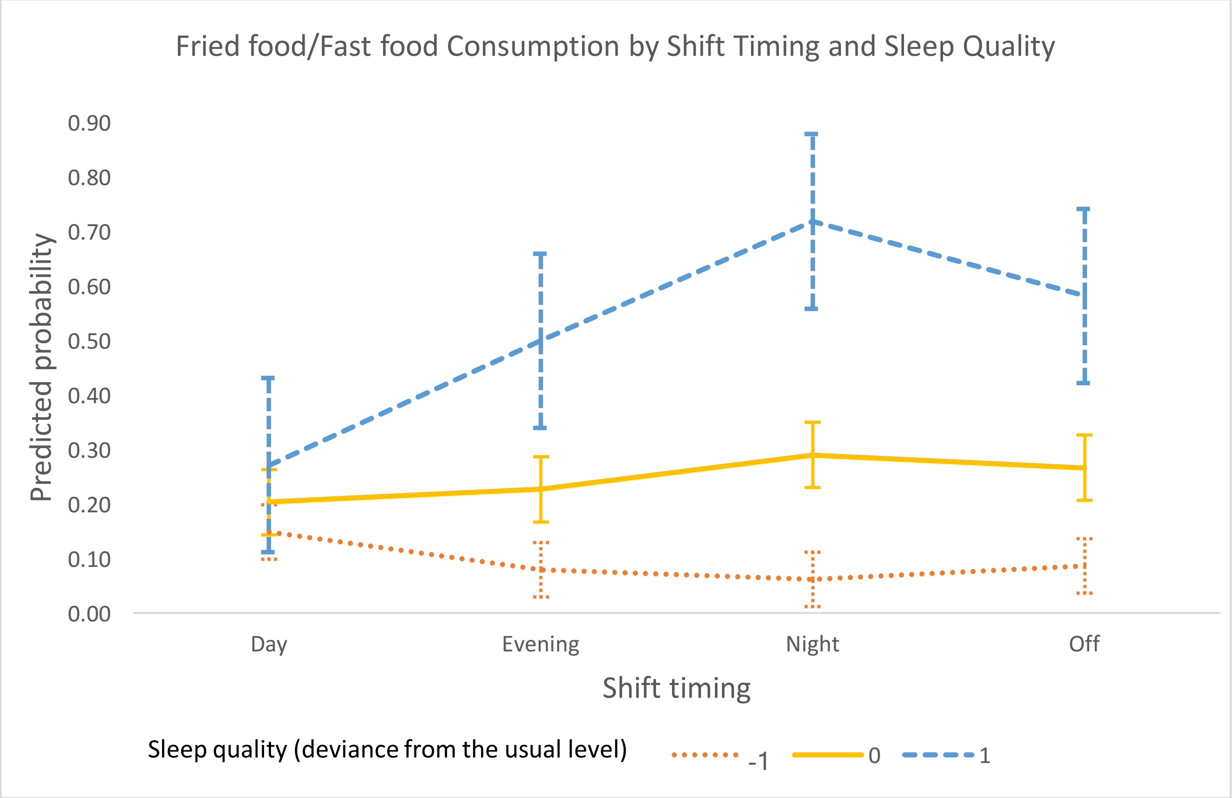


Figure 2- 1. Predicted probability of fried food/fast food consumption by within-person shift timing and sleep quality. Error bars represent standard errors. The number of “-1” refers to days with sleep quality far better than their usual level, “0” refers to days with usual levels of sleep quality, and “1” refers to days with much poorer sleep quality.

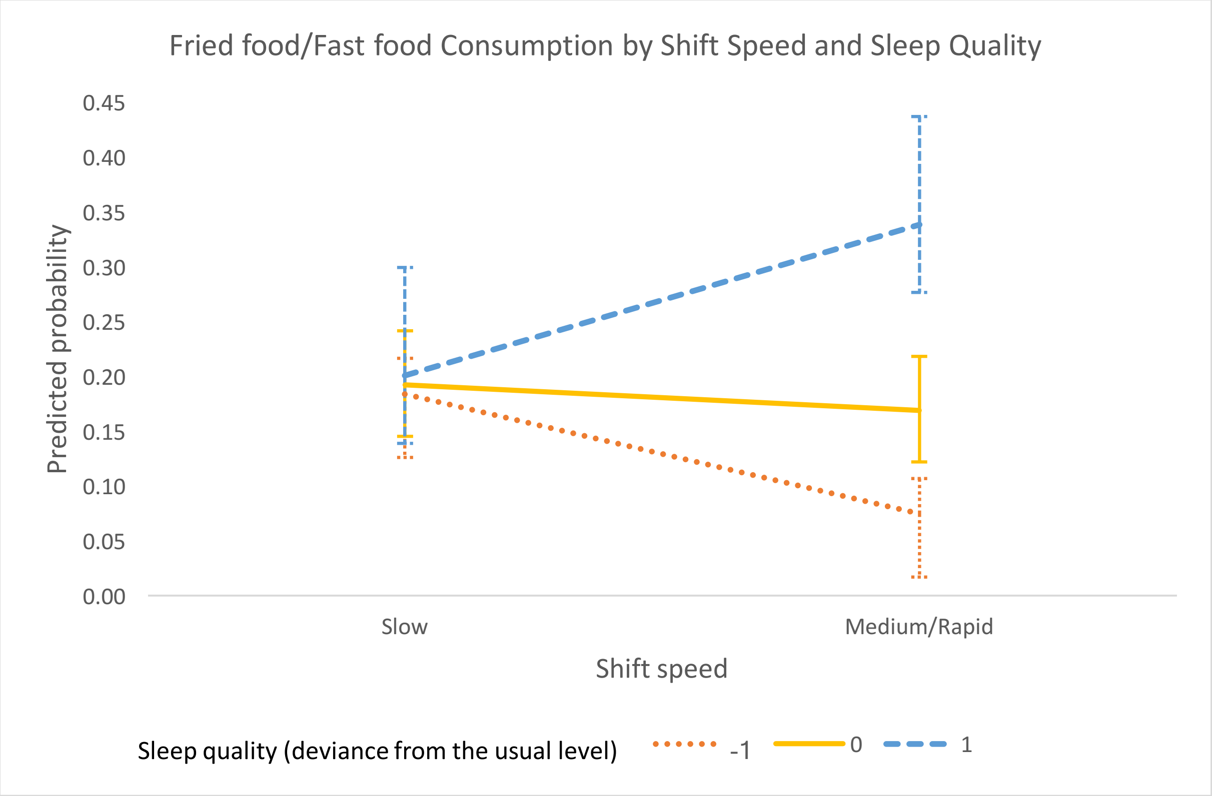


Figure 2- 2. Predicted probability of fried food/fast food consumption by shift speed and within-person variation in sleep quality. The number of "-1" refers to days with sleep quality far better than their usual level, "0" refers to days with usual levels of sleep quality, "1" refers to days with much poorer sleep quality.

APPENDICES

Appendix A

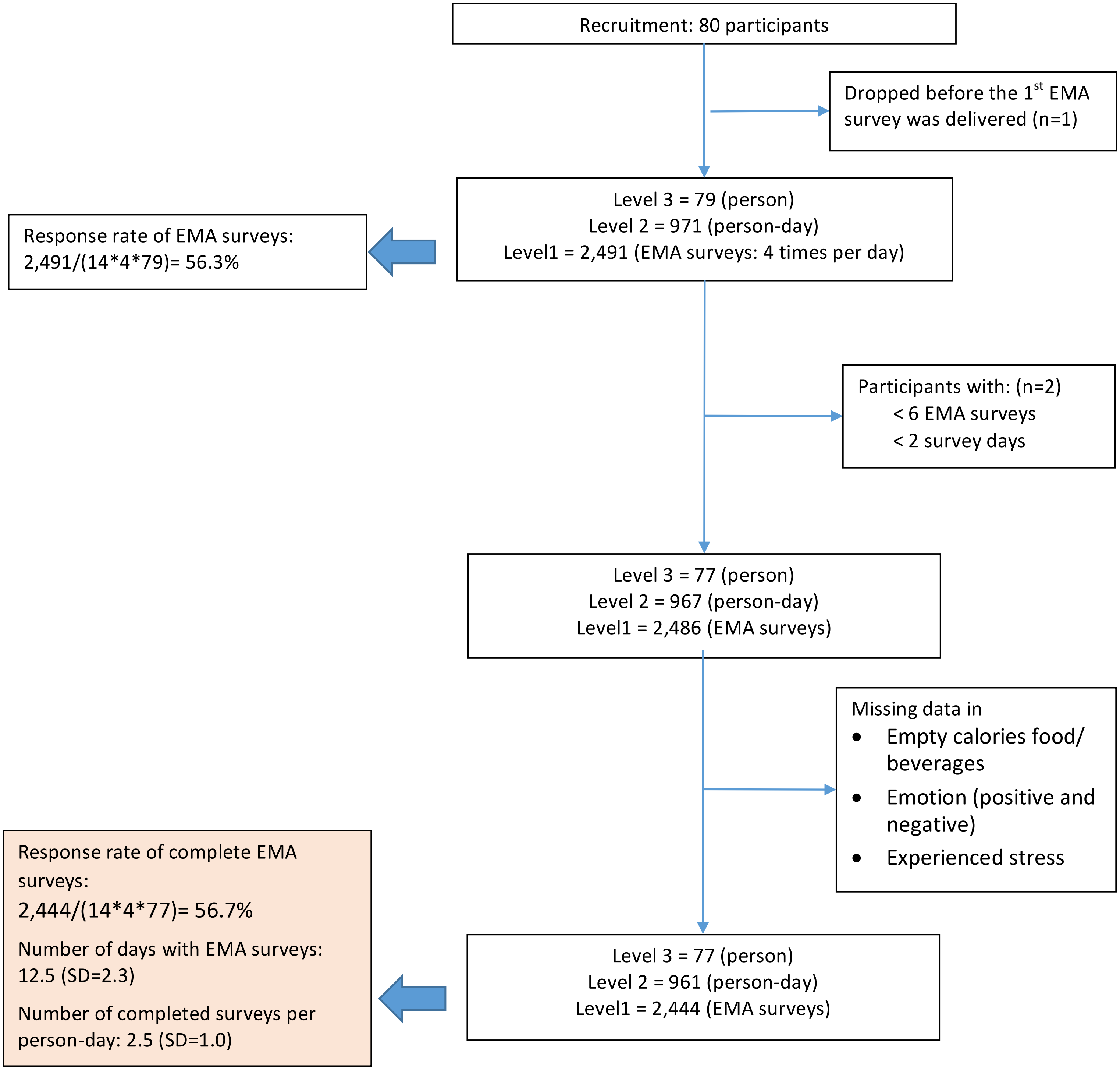


Figure A-1. Process of data reduction (Chapter 2)

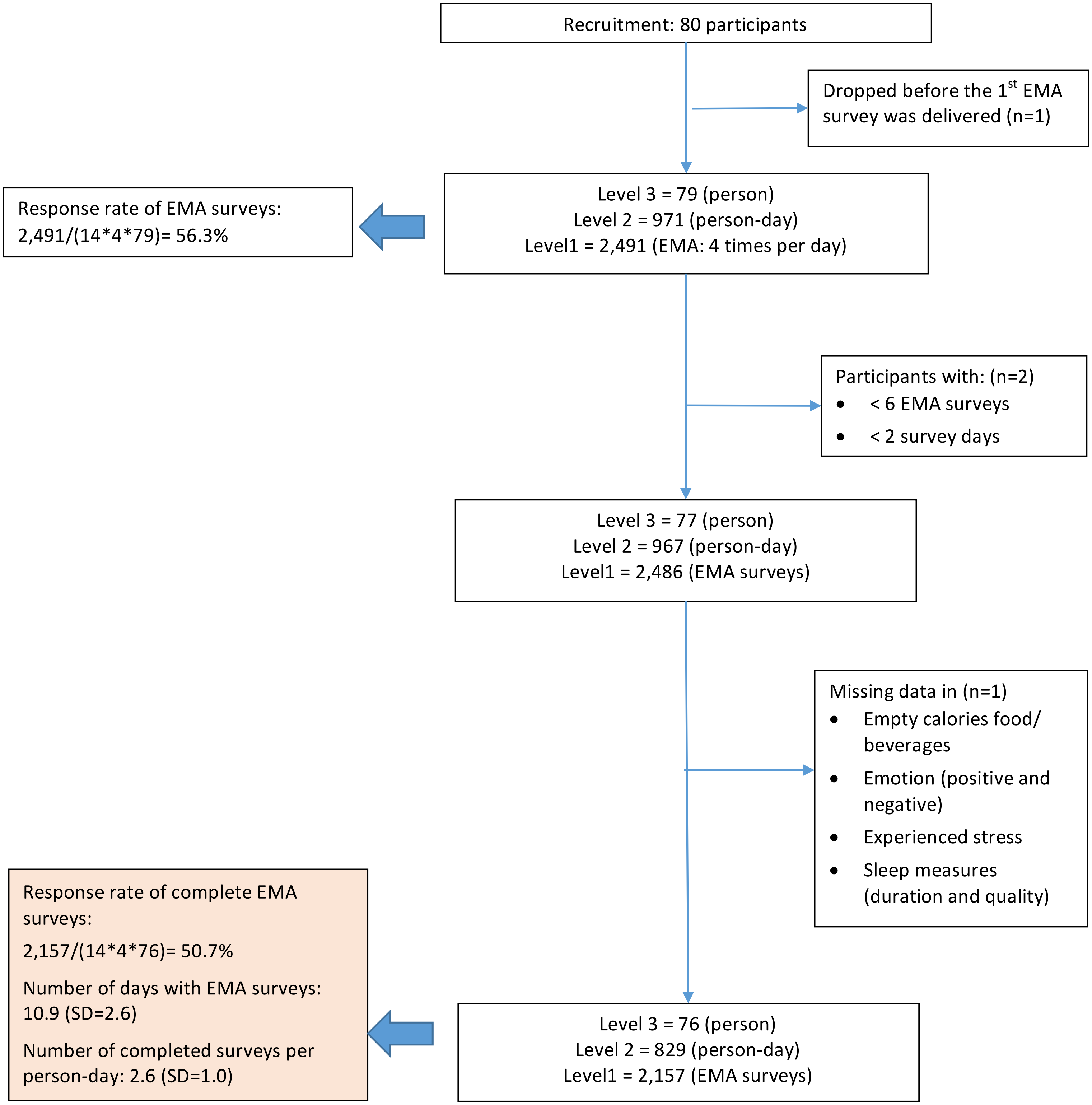


Figure A-2. Process of data reduction (Chapter 3)

Appendix B

Supplemental Table 1-1. Associations between Shift Timing and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N=77, n_m= 2,031)[1]

	Fried food/fast food		**Sweet or salty snacks**		**Sweetened beverages**		**Overall consumption**	
	OR	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Hypothesis 1								
Shift timing								
Day (reference)								
Evening	1.34	(0.91, 1.99)	1.27	(0.92, 1.74)	1.29	(0.90, 1.83)	0.09	(-0.07, 0.25)
Night	1.86	(1.22, 2.82)**	1.30	(0.94, 1.80)	1.66	(1.14, 2.43)**	0.23	(0.06, 0.39)**
Off	1.71	(1.14, 2.58)**	1.65	(1.20, 2.28)**	2.00	(1.38, 2.89)***	0.41	(0.26, 0.57)***
Hypothesis 2								
Shift timing on the previous day (n_m= 1,418)[1]								
Day (reference)								
Evening	1.07	(0.60, 1.90)	0.85	(0.52, 1.40)	0.70	(0.41, 1.18)	-0.10	(-0.33, 0.14)
Night	0.78	(0.42, 1.43)	1.37	(0.82, 2.30)	0.71	(0.40, 1.24)	-0.09	(-0.34, 0.16)
Off	0.88	(0.56, 1.39)	0.80	(0.55, 1.15)	0.59	(0.40, 0.87)***	-0.22	(-0.40, -0.04)*

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

[1] A total of 2,031 observations and 1,418 observations were included in the sensitivity test for H1 and H2, respectively. Respective outcome variables were tested by the same analytical models as for H1 and H2.

$^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

Supplemental Table 1-2. Associations between Shift Timing, Shift Speed and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N=77, n_m= 2,031)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
	OR	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Hypothesis 4								
Shift timing								
Day (reference)								
Evening	1.57	(0.96, 2.58)	1.28	(0.85, 1.92)	0.85	(0.46, 1.14)	0.04	(-0.17, 0.25)
Night	1.72	(0.95, 3.09)	1.11	(0.69, 1.77)	1.37	(0.88, 2.53)	0.17	(-0.07, 0.40)
Off	1.98	(1.18, 3.33)**	1.51	(0.99, 2.30)	1.57	(1.06, 2.46)*	0.41	(0.20, 0.62)***
Shift speed								
S (reference)								
M/R	0.34	(0.10, 1.17)	1.32	(0.31, 5.66)	1.43	(0.17, 12.25)	0.22	(-0.48, 0.91)
Shift speed*shift timing								
M/R*Evening	0.64	(0.28, 1.45)	0.94	(0.49, 1.79)	2.77	(1.35, 5.66)**	0.12	(-0.20, 0.44)
M/R*Night	1.10	(0.48, 2.51)	1.32	(0.70, 2.51)	1.56	(0.74, 3.28)	0.12	(-0.20, 0.45)
M/R*Off	0.66	(0.29, 1.46)	1.18	(0.63, 2.21)	1.74	(0.86, 3.50)	<0.01	(-0.31, 0.31)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions, S: slow shift speed, M/R: medium or rapid shift speed.

[1] Respective outcome variables were tested by the same analytical models as for H4.

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Supplement Table 2-1. Associations between Shift Timing, Daily Sleep Duration and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N=76, n_m= 2,157)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Shift timing								
Day (reference)								
Evening	1.15	(0.78, 1.70)	1.37	(0.99, 1.88)	1.20	(0.82, 1.75)	0.06	(-0.11, 0.23)
Night	1.37	(0.86, 2.17)	1.21	(0.84, 1.73)	1.73	(1.12, 2.69)*	0.16	(-0.04, 0.35)
Off	1.39	(0.97, 1.99)	1.46	(1.09, 1.95)*	1.96	(1.39, 2.76)***	0.30	(0.15, 0.45)***
Sleep duration								
>= 5 hours (reference)								
< 5 hours	1.62	(1.12, 2.33)*	1.08	(0.79, 1.47)	0.99	(0.68, 1.43)	0.09	(-0.07, 0.25)
Shift timing *sleep duration								
Evening * < 5 hours	0.64	(0.17, 2.46)	1.61	(0.49, 5.34)	1.24	(0.30, 5.21)	0.10	(-0.53, 0.73)
Night *< 5 hours	1.49	(0.44, 5.00)	2.01	(0.68, 5.98)	1.43	(0.39, 5.27)	0.37	(-0.20, 0.95)
Off *< 5 hours	0.77	(0.25, 2.33)	1.66	(0.59, 4.64)	1.96	(0.58, 6.56)	0.21	(-0.33, 0.74)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

$^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

Supplement Table 2-2. Associations between Prior-day Shift Timing, Daily Sleep Duration and Momentary Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N=76, n_m= 2,157)

	Fried food/fast food		**Sweet or salty snacks**		**Sweetened beverages**		**Overall consumption**	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Shift timing on previous day								
Day (reference)								
Evening	0.93	(0.60, 1.44)	0.94	(0.65, 1.34)	0.74	(0.48, 1.13)	-0.12	(-0.32, 0.07)
Night	0.75	(0.46, 1.21)	1.18	(0.81, 1.73)	0.94	(0.60, 1.49)	-0.02	(-0.22, 0.18)
Off	0.86	(0.60, 1.25)	1.00	(0.74, 1.35)	0.83	(0.59, 1.18)	-0.10	(-0.26, 0.06)
Sleep duration								
>= 5 hours (reference)								
< 5 hours	1.69	(1.18, 2.41)**	1.13	(0.83, 1.53)	1.01	(0.70, 1.46)	0.10	(-0.06, 0.26)
Shift timing on previous day *sleep duration								
Evening * < 5 hours	1.84	(0.50, 6.73)	1.15	(0.36, 3.66)	1.21	(0.30, 4.98)	0.38	(-0.23, 0.99)
Night *< 5 hours	1.54	(0.40, 5.91)	1.25	(0.39, 3.98)	3.26	(0.81, 13.19)	0.61	(<0.01, 1.22)
Off *< 5 hours	1.42	(0.42, 4.82)	1.20	(0.41, 3.53)	1.51	(0.42, 3.50)	0.58	(0.01, 1.14)*

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

$^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

Supplemental Table 2-3. Associations between Work Shift intensity, Daily Sleep Duration and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N=76, n_m= 2,157)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Work shift intensity	0.97	(0.87, 1.08)	0.94	(0.86, 1.02)	1.08	(0.97, 1.20)	-0.01	(-0.05, 0.04)
Sleep duration								
>= 5 hours (reference)								
< 5 hours	1.74	(1.23, 2.45)**	1.12	(0.83, 1.51)	1.04	(0.72, 1.48)	0.12	(-0.03, 0.28)
Work shift intensity*sleep duration								
Work shift intensity*< 5 hours	1.28	(1.03, 1.59)*	1.03	(0.85, 1.26)	1.00	(0.79, 1.26)	0.02	(-0.08, 0.12)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

$^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

Supplemental Table 2-4. Associations between Night Shift intensity, Daily Sleep Duration and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N=76, n_m= 2,157)

	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Night shift intensity								
Low (reference)								
High	1.19	(0.62, 2.28)	1.01	(0.61, 1.66)	1.48	(0.80, 2.74)	0.11	(-0.16, 0.37)
Sleep duration								
>= 5 hours (reference)								
< 5 hours	1.55	(1.09, 2.20)	1.13	(0.83, 1.52)	0.95	(0.66, 1.35)	0.11	(-0.05, 0.26)
Night shift intensity*sleep duration								
High *< 5 hours	3.60	(1.14, 11.30)*	0.99	(0.37, 2.60)	4.02	(1.24, 13.00)*	0.31	(-0.20, 0.82)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions.

$^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

Supplemental Table 2-5. Associations between Shift Speed, Daily Sleep Duration and Empty Calorie Food/Beverage Consumption Using Mixed-effects Regression Models (N=76, n_m= 2,157)

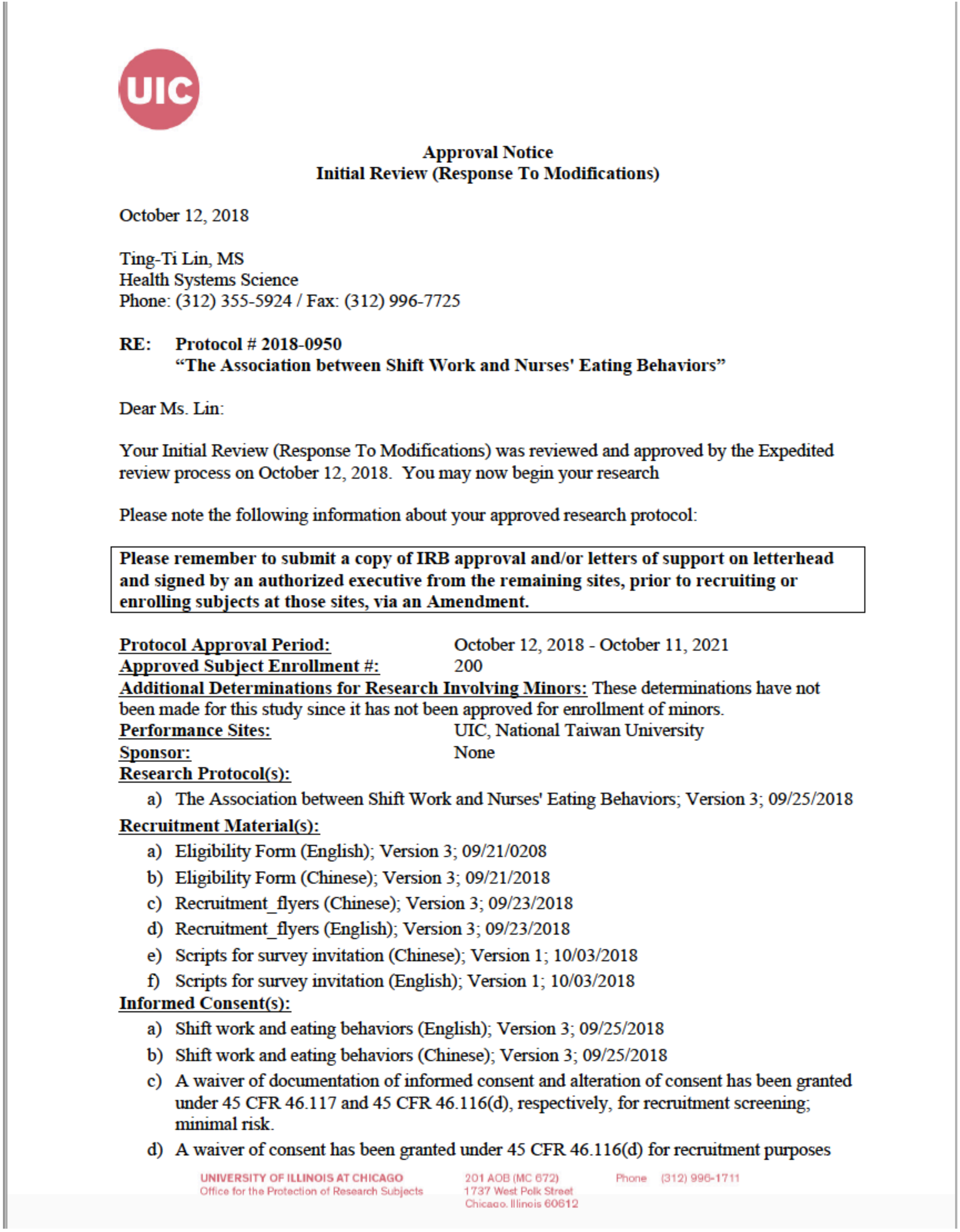
	Fried food/fast food		Sweet or salty snacks		Sweetened beverages		Overall consumption	
Variables	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**b**	**(95% CI)**
Shift speed								
S (reference)								
M/R	1.01	(0.67, 1.51)	0.70	(0.42, 1.18)	1.05	(0.51, 2.15)	0.02	(-0.22, 0.26)
Sleep duration								
>= 5 hours (reference)								
< 5 hours	1.75	(1.14, 2.70)*	1.26	(0.85, 1.85)	1.11	(0.70, 1.76)	0.15	(-0.05, 0.35)
Shift speed*sleep duration								
M/R*< 5 hours	0.91	(0.47, 1.78)	0.77	(0.43, 1.38)	0.83	(0.41, 1.66)	-0.06	(-0.36, 0.25)

N: number of participants, n_m: number of momentary observations, OR: odds ratio from 3-level mixed-effects logistic regression models, CI: confidence interval, b: beta coefficient from 3-level mixed-effects negative binomial regressions, S: slow shift speed, M/R: medium or rapid shift speed.

$^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

Appendix C

IRB Approval (English)



Approval Notice
Initial Review (Response To Modifications)

October 12, 2018

Ting-Ti Lin, MS
Health Systems Science
Phone: (312) 355-5924 / Fax: (312) 996-7725

RE: Protocol # 2018-0950
"The Association between Shift Work and Nurses' Eating Behaviors"

Dear Ms. Lin:

Your Initial Review (Response To Modifications) was reviewed and approved by the Expedited review process on October 12, 2018. You may now begin your research

Please note the following information about your approved research protocol:

Please remember to submit a copy of IRB approval and/or letters of support on letterhead and signed by an authorized executive from the remaining sites, prior to recruiting or enrolling subjects at those sites, via an Amendment.

Protocol Approval Period: October 12, 2018 - October 11, 2021
Approved Subject Enrollment #: 200
Additional Determinations for Research Involving Minors: These determinations have not been made for this study since it has not been approved for enrollment of minors.
Performance Sites: UIC, National Taiwan University
Sponsor: None
Research Protocol(s):

a) The Association between Shift Work and Nurses' Eating Behaviors; Version 3; 09/25/2018

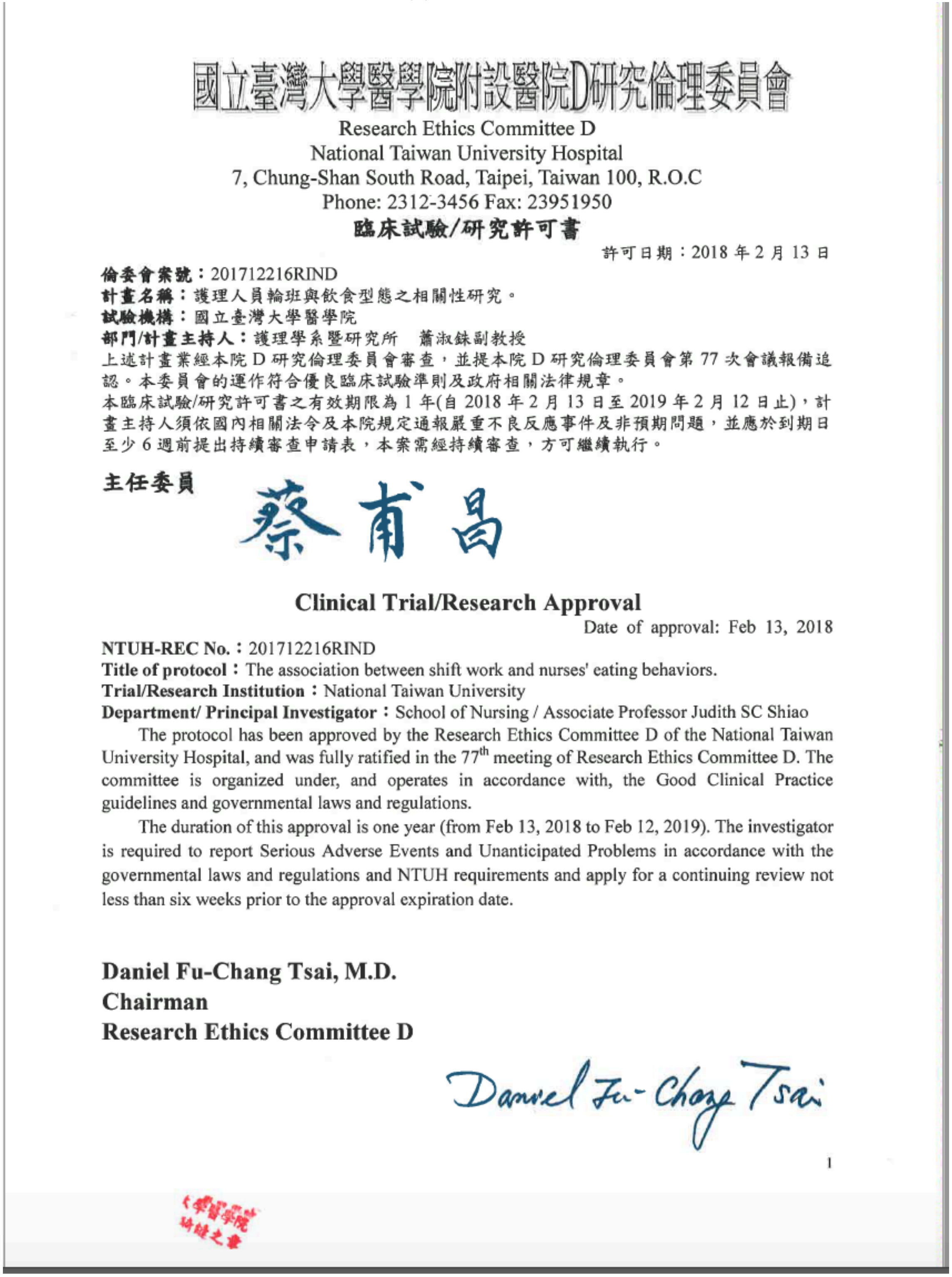
Recruitment Material(s):

a) Eligibility Form (English); Version 3; 09/21/0208
b) Eligibility Form (Chinese); Version 3; 09/21/2018
c) Recruitment_flyers (Chinese); Version 3; 09/23/2018
d) Recruitment_flyers (English); Version 3; 09/23/2018
e) Scripts for survey invitation (Chinese); Version 1; 10/03/2018
f) Scripts for survey invitation (English); Version 1; 10/03/2018

Informed Consent(s):

a) Shift work and eating behaviors (English); Version 3; 09/25/2018
b) Shift work and eating behaviors (Chinese); Version 3; 09/25/2018
c) A waiver of documentation of informed consent and alteration of consent has been granted under 45 CFR 46.117 and 45 CFR 46.116(d), respectively, for recruitment screening; minimal risk.
d) A waiver of consent has been granted under 45 CFR 46.116(d) for recruitment purposes

IRB Approval (Chinese)



國立臺灣大學醫學院附設醫院D研究倫理委員會
Research Ethics Committee D
National Taiwan University Hospital
7, Chung-Shan South Road, Taipei, Taiwan 100, R.O.C
Phone: 2312-3456 Fax: 23951950

臨床試驗/研究許可書

許可日期：2018年2月13日

倫委會案號：201712216RIND
計畫名稱：護理人員輪班與飲食型態之相關性研究。
試驗機構：國立臺灣大學醫學院
部門/計畫主持人：護理學系暨研究所　蕭淑銖副教授

上述計畫業經本院D研究倫理委員會審查，並提本院D研究倫理委員會第77次會議報備追認。本委員會的運作符合優良臨床試驗準則及政府相關法律規章。

本臨床試驗/研究許可書之有效期限為1年(自2018年2月13日至2019年2月12日止)，計畫主持人須依國內相關法令及本院規定通報嚴重不良反應事件及非預期問題，並應於到期日至少6週前提出持續審查申請表，本案需經持續審查，方可繼續執行。

主任委員　蔡甫昌

Clinical Trial/Research Approval

Date of approval: Feb 13, 2018

NTUH-REC No.：201712216RIND
Title of protocol：The association between shift work and nurses' eating behaviors.
Trial/Research Institution：National Taiwan University
Department/ Principal Investigator：School of Nursing / Associate Professor Judith SC Shiao

The protocol has been approved by the Research Ethics Committee D of the National Taiwan University Hospital, and was fully ratified in the 77th meeting of Research Ethics Committee D. The committee is organized under, and operates in accordance with, the Good Clinical Practice guidelines and governmental laws and regulations.

The duration of this approval is one year (from Feb 13, 2018 to Feb 12, 2019). The investigator is required to report Serious Adverse Events and Unanticipated Problems in accordance with the governmental laws and regulations and NTUH requirements and apply for a continuing review not less than six weeks prior to the approval expiration date.

Daniel Fu-Chang Tsai, M.D.
Chairman
Research Ethics Committee D

Daniel Fu-Chang Tsai

VITA

NAME Ting-Ti Lin

EDUCATION

2015-present University of Illinois at Chicago (Chicago, IL, USA)
- Doctor of Philosophy in Nursing Science

2012 National Taiwan University (Taipei, Taiwan)
- Master of Science in Nursing

2007 National Defense Medical Center (Taipei, Taiwan)
- Bachelor of Science in Nursing

PROFESSIONAL EXPERIENCE

2007-2015 Tri-Services General Hospital (Taipei, Taiwan)
- Assistant Head Nurse in the General Surgical Ward (2014.07 – 2015.06)
- Registered Nurse in the Burns Center and Critical Care Unit (2008.08 – 2014.06)
- Registered Nurse in the Cardiovascular Surgical Ward (2007.08 – 2008.07)

TEACHING EXPERIENCE

2013-2015 National Defense Medical Center (Taipei, Taiwan)
- Clinical Lecturer in Community Health Nursing Practice
- Lecturer in Community Health Nursing and Emergency and Critical Care Nursing

RESEARCH EXPERIENCE

2016-present	Research Assistant, UIC Neighborhoods and Health Research Group
2016-2018	Research Assistant, Promoting Seniors' Health with Home Care Aides
2011-2012	Research Assistant, Working conditions of nursing personnel at district-level hospitals and below in Taiwan - the 3rd year (DOH098-TD-M-113-098006)
2010	Research Assistant, Working conditions of nursing personnel at district-level hospitals and below in Taiwan - the 2nd year (DOH098-TD-M-113-098006)

HONOR/AWARD/SCHOLARSHIP

2015-2019	Military Personnel Scholarship from National Defense Medical Center, Ministry of National Defense

2013 TSGH Excellence in Nursing Award

FUNDED RESEARCH GRANT

2018-2019 College of Nursing PhD Student Research Awards

- "Associations between shift work and empty calorie food/beverage consumption"
- Direct Expenses: $800

2018-2019 Sigma Theta Tau International Alpha Lambda Chapter Award

- "Associations between shift work and empty calorie food/beverage consumption"
- Direct Expenses: $500

PUBLICATIONS

Journal Articles

Muramatsu, N., Yin, L., & **Lin, T. T.** (2017). Building Health Promotion into the Job of Home Care Aides: Transformation of the Workplace Health Environment. *International Journal of Environmental Research and Public Health, 14*(4), 384. doi: 10.3390/ijerph14040384.

Book Chapter

Shiao, J. S. C. & **Lin, T. T.** (2013). Occupational and Environmental Health Nursing in the Past, Present, and Future. In Shiao, J. S. C. (Ed.), *Occupational and Environmental Health Nursing: Concepts and Practice,* (1st ed., pp. 1-32). Taipei City, Taiwan, ROC: Farseeing (Chinese)

Under Review

Kraft, A., Jones, K. K., **Lin, T. T**., Matthews, S., & Zenk, S. N. Stability of Activity Space Footprint and Features over Six Months. *Spatial and Spatio-temporal Epidemiology* (under review)

In Preparation

Lin, T. T., Jones, K. K., Martyn-Nemeth, P., Roy, P. G., & Zenk, S. N. Associations between Daily Work Hassles and Energy Balance-Related Behaviors in Female African American Workers: An Ecological Momentary Assessment Study.

Wing, C., Tarlov, E., Gwarnicki, C., Eldeirawi, K., **Lin, T. T.**, & Zenk, S. N. Cumulative and Lagged Effects of the Residential Environment on Blood Pressure in a Nationwide Sample.

Hashad, R., **Lin, T. T.**, Ezell, S., Phan, J., & Zenk, S. N. Daily Experiences of Discrimination and Well-Being in African American Women.

PRESENTATIONS

Lin, T. T., Shiao, J. S. C., Chen, Y. C., Lin, Y. T., & Guo, Y. L. (2018, August). Associations between psychosocial working environments and nurses' eating behaviors in Taiwan: A pilot study. ISES-ISEE 2018 Joint Annual Meeting, Ottawa, Canada. (Poster)

Lin, T. T., Shiao, J. S. C., Guo, Y. L., Wu, H. C., & Ho, J. J. (2017, August). The association between psychosocial factors and needle stick injuries among nurses working in different healthcare settings. 26th EPICOH Conference, Edinburgh, United Kingdom. (Poster)

Lin, T. T., Shiao, J. S. C., Guo, Y. L., Chen, Y. C., Lee, Y. J., Ho, J. J. (2017, August). The Association between Work Schedule Control and Nurses' Burnout in Taiwan. 26th EPICOH Conference, Edinburgh, United Kingdom. (Oral)

Lin, T. T., Shiao, J. S. C., Hung, Y. J., & Guo, Y. L. (2016, September). The Association between Psychosocial Factors and Musculoskeletal Disorders Among Nursing Home Nurses in Taiwan. *25th EPICOH | X2016 | RHICOH 2016 Conference*, Barcelona, Spain. (Poster)

Lin, T. T., Shiao, J. S. C., & Guo, Y. L., (2015, June). Impact of psychosocial hazards on nursing personnel in Taiwan nursing homes. *31st International Congress on Occupational Health*, Seoul, Korea. (Oral)

Lin, T. T., Shiao, J. S. C., Guo, Y. L., & Hsu, J. H. (2013, June). The correlation between working conditions and health status of nursing personnel in nursing homes in Taiwan. *23rd Conference on Epidemiology in Occupational Health,* Utrecht, Netherlands. (Poster)

Lin, T. T. (2010, November). Nursing Care of a Buccal Cancer Patient Receiving Wide Excision and Free Flap Coverage. *Symposium on Nursing Case Report Writing and Presentation*, Taipei, Taiwan. (Oral)

PROFESSIONAL AFFILIATION

2007 – Present	Member, Taiwan Nurse Association
2013 – Present	Member, Taiwan Association of Critical Care Nurse
2015 – Present	Member, Occupational Health Nursing and Education Association of Taiwan