Comparing Objective and Subjective Measures of Sleep Loss with Balance Performance in Farmers

Research Brief

D. Sedlacek, M. Beacom, S. Bista,
R. Rautiainen, K.-C. Siu

HIGHLIGHTS

- The farming population is at risk of injury due to sleep deprivation.
- Loss of sleep during previous night affects balance performance in farmers.
- Objective measures of sleep are more reliable than subjective measures for predicting balance performance.

ABSTRACT. *This study aimed to investigate the ability of both subjective and objective sleep measures to predict balance difficulty in agricultural workers. Seven male farmers from rural Nebraska were analyzed for static balance performance following a bout of sleep. Actiwatches were used to measure objective sleep hours and subjective questionnaires, including the Epworth Sleepiness Scale and the Pittsburgh Sleep Quality Index, were used to measure subjective hours of sleep and sleep quality. The participants were observed for 12 sessions, with six in planting season and six in harvest season. Static balance testing consisted of measuring the area, total displacement, and maximum range in the anteroposterior and mediolateral directions of the individual's center of pressure with Tekscan pressure mats. Overall, it was found that objective measures had a higher correlation with the magnitude of balance deviations than subjective measures.*

Keywords. *Actiwatch, Agricultural worker, Injury, Sleep deprivation.*

Agricultural workers have been shown to have higher death and disability rates due to injury compared to other physically demanding professions (Reece, 2018). In 2018, the Bureau of Labor Statistics (BLS) reported 574 fatal injuries per 100,000 agricultural workers. In 2020. BLS statistics showed that the agricultural industry had the highest rates of deaths from preventable injuries per hours worked (Smith and Pegula, 2020). A study in 2010 of farmers in Saskatchewan revealed that average weekly work hours for farm owners were 70 in spring, 60 in summer, 70 in fall, and 28 in winter (Marlenga et al., 2010). Long hours in certain seasons make it difficult to obtain adequate sleep, which could contribute to the high rates of injury.

Submitted for review on 21 July 2020 as manuscript number JASH 14217; approved for publication as a Research Brief by the Ergonomics, Safety, & Health Community of ASABE on 27 December 2020.

The authors are **Devan Sedlacek,** Doctoral Student of Physical Therapy, College of Allied Health Professions, University of Nebraska Medical Center, Omaha, Nebraska; **Matthew Beacom,** M.D., Beacom Health, Fremont, Nebraska; **Sabin Bista,** M.B.B.S., Associate Professor, College of Medicine, **Risto Rautiainen,** Ph.D., Professor, College of Public Health, and **Ka-Chun Siu,** Ph.D., Associate Professor, College of Allied Health Professions, University of Nebraska Medical Center, Omaha, Nebraska. **Corresponding author:** Ka-Chun Siu, 984420 Nebraska Medical Center, Omaha, NE 68198; phone: 402-559-8464; e-mail: kcsiu@unmc.edu.

  ISSN 1074-7583 https://doi.org/10.13031/jash.14217

Sleep schedules that align with the circadian rhythm are very important for quality rest, especially for those working long hours (Valdez, 2019). Cognitive performance deficits are associated with poor alignment to the circadian rhythm (Valdez, 2019). Clinical decision-making during bouts of sleep deprivation is an issue for many medical professionals (Kramer, 2010; Couyoumdjian et al., 2010; Scott et al., 2014; Ganesan et al., 2019). Nurses and doctors have been shown to have significantly slower psychomotor reaction times after working an 8 h night shift (Ganesan et al., 2019; Di Muzio et al., 2019). They have also been shown to make significantly more errors at the end of an 8 h night shift (Ganesan et al., 2019). Sleep deprivation also impedes the performance of other types of work, such as machine operation (Dinges, 1995; Orzel-Gryglewska, 2010) and vehicle driving (Peters et al., 1999). Extended work hours reduced productivity due to inadequate sleep, fatigue, and irregular shift scheduling for operators of forest harvesting machinery (Nicholis, 2003). Increasing events of near-miss injury were found in forest industry workers with long work hours, reduced sleep, and compromised recovery time (Lilley et al., 2002).

In a study of 20 military cadets who were deprived of sleep for 60 h, the submaximal cardiovascular performance was impaired after sleep loss, and detriments were seen in balance testing after 24 h of sleep deprivation. Specifically, increases in medial-to-lateral and anterior-to-posterior displacement were seen for both the eyes-open and eyes-closed conditions with a tandem stance (Vaara et al., 2018). Physical performance is vital to the demands of agricultural work. Poor physical health (e.g., impaired balance or reduced postural stability) increases the likelihood of occupational injuries in both young and old workers (Frone, 1998; Zwerling et al., 1996). Detriments in this area may contribute to the high injury rates associated with the agricultural population (Smith and Pegula, 2020).

The prevalence of chronic diseases and musculoskeletal injuries is high among farmers, affecting their quality of life (Rostamabadi et al., 2019). Heart disease, vision problems, depression, arthritis, and sleep deprivation result in high sleep medication use, which is associated with an increased injury risk and poor quality of life (Voaklander et al., 2009). The daily worry about cash flow has also been shown to influence the lack of sleep in peak seasons (LaBrash et al., 2008). Further, several studies have indicated a connection between sleep-related problems and injury for part-time farmers (Spengler et al., 2004), for older farmers (Heaton et al., 2010), and for farmers in China (Zhu et al., 2014). Therefore, sleep likely plays an important role in the risk of injury in farming populations.

Traditionally, subjective sleep questionnaires have been used to determine sleep quality (Di Muzio et al., 2019; Kaplan et al., 2017). However, these subjective measures do not correlate well with objective measures, such as polysomnographic recording or the use of an Actiwatch (Ganesan et al., 2019; Kaplan et al., 2017), and subjective beliefs about the quality of sleep do not indicate if the sleep was of physiological quality (Kaplan et al., 2017). In this study, we hypothesized that objective measures of sleep quality will be more strongly correlated to poor balance performance than subjective measures.

Materials and Methods

Farmers were recruited in east-central Nebraska and west-central Iowa by flyers, phone calls, or referral from previous participants (Siu et al., 2015). The inclusion criteria were: (1) the farm is located in Dodge, Saunders, Washington, Douglas, Sarpy, Harrison, Shelby, Pottawattamie, Cass, Mills, or Montgomery county; (2) the farm is a family operation; (3) farming is the farm operator's main occupation (more than half of total work time) and the farmer must own, live, or work on a farm in one of the above Nebraska and Iowa counties; (4) the farm operator plans to farm for at least the duration of the study; (5) the farm operator is able to follow instructions, track working hours, wear test equipment, conduct balance tests, and conduct computerized vigilance tests; and (6) the farm operator has normal or corrected vision and hearing.

The exclusion criteria were: (1) a diagnosis of a severe mental health problem (e.g., depression or anxiety) that impacts sleep; (2) a pathology that directly affects the musculoskeletal system, such as an artificial joint, neurodegenerative disease, neurological compromise, cognitive decline, or peripheral neuropathy; (3) an amputation; (4) an uncorrected vision problem; (5) significant cardiopulmonary disease that affects balance; and (6) major surgery in the last six months. Subjects who met all the criteria were informed about the research protocol, and they signed a consent form before starting the study.

This study consisted of 12 sessions of testing, six during planting season and six during harvest season. Each set of six sessions consisted of the same protocol. For the first session, we scheduled to meet with the subjects at their home or workplace. The subjects first completed a questionnaire to report their demographics, farm conditions, caffeine intake, hours of sleep, hours of work, and balance performance. We then measured the subjects' balance performance using a portable pressure mat system (Tekscan Inc., South Boston, Mass.) that monitors the change in the center of pressure (CoP) of the foot. The subjects performed two balance tests three times for 10 s each: (1) standing on both feet with eyes open and closed, and (2) standing on one foot with eyes open and closed. Several balance biomarkers were calculated, including the area, total displacement, and maximum range in the anteroposterior and mediolateral directions of the CoP. After the balance tests, the subjects completed two questionnaires, including the Pittsburgh Sleep Quality Index, (PSQI) (Buysse et al., 1989) and the Epworth Sleepiness Scale (ESS) (Johns, 1991), to self-report their sleepiness level and sleep quality. At the end of the first session, the subjects received an Actiwatch (Philips Healthcare, Andover, Mass.) to monitor their daily activity. The subjects were instructed to wear the device all day long (except when showering) for seven days and complete a daily log of their activities.

One week later, during the second session, we met with the subjects at the same locations as the first session. The subjects first returned the Actiwatch for analysis of their daily activity during the previous seven days. They then completed the same questionnaires as in the first session, with an additional report of any complications with the Actiwatch. The same protocol used for the first two sessions was repeated for the remaining sessions throughout the year of the study, but the farm and demographic information were removed from the questionnaires for the remaining sessions. Acute sleep loss was computed as net sleep, which equals the hours of sleep the night before testing minus the average hours of sleep during the previous seven days. The average total sleep time was computed as the average sleep time over seven days.

The sleep loss data were compared against the balance data. The data were analyzed using Pearson correlations in SPSS (IBM, Armonk, N.Y.) to examine the associations between sleep measures and balance biomarkers. The level of significance was set at 0.05.

Results

In this study, we initially had eight subjects, but one subject was excluded due to a health issue. Thus, a total of seven farmers were included (table 1). All were men with a mean

Table 1. Demographics and participation.

Subject[a]	Age[b]	Gender	Farm Size[c] (acres)	Type of Farm Work[d]	Hired Help	Sessions Completed
A	55/56	Male	80	Corn and soybeans	None	5
B	69/70	Male	1040	Corn, soybeans, hay, cattle, and hogs	One or two (<150 days)	5
C	-	-	-	-	-	0
D	42/43	Male	1200 to 1250	Seed corn, soybeans, poultry, and other	Two (<150 days)	3
E	48	Male	320 to 396	Corn, soybeans, alfalfa, hay, horses, and other livestock	None	1
F	-	-	-	-	-	0
G	45/46	Male	1170 to 1290	Corn and soybeans	One (<150 days)	2

[a] Subjects C and F were excluded from the data analysis due to withdrawal from the study.
[b] If the subject's age changed from the beginning to the end of the study, both ages are indicated.
[c] Farm sizes varied based on season.
[d] Other farm work included vegetables, potatoes, sweet corn, and melons.

age of 58 years (range from 42 to 70). Only five of the seven subjects were included in the statistical analysis (table 1). Two subjects were excluded due to either lack of data from losing contact or inability to participate. Table 2 shows how the objective and subjective sleep measures were correlated with balance performance.

Overall, the objective sleep measurements using the Actiwatch generated more statistically significant correlations with balance performance than the subjective sleep measures, most notably in the total area and total distance displaced with eyes open. Only one correlation was found to be significant with eyes closed, both legs on the mat, and the total area of displacement. Overall, the net sleep measurements using objective data showed more association with balance deviation. The average total sleep time (TST) was not well correlated with balance deficits, as shown by only two statistically significant findings. The subjective measures showed more correlation with increased velocity in an individual's changing CoP, specifically with the ESS.

Discussion

The results of this study support the hypothesis that objective sleep measures, such as the Actiwatch, correlate much better with balance performance than subjective sleep measures, such as the PSQI. Actiwatches have been used in previous research to achieve objective sleep measurements (Di Muzio et al., 2019; Harrison et al., 2019; Slightam et al., 2018). Subjects can exaggerate a poor quality of sleep compared to Actiwatch measurements (Slightam et al., 2018).

Our results also indicate that net sleep loss is more strongly associated with balance deficits than total sleep time. As noted by Kaplan et al. (2017), actual sleep quality and subjective beliefs about sleep quality differ, likely because the net sleep loss equation considers what each participant's "normal" is. A normal amount of sleep can vary between persons and may not be the 7 to 9 h standard. Vaara et al. (2018) studied military personnel who were subjected to 60 h of sleep deprivation. Interestingly, reaction times improved significantly after 36 h without sleep.

In contrast, Sadaat et al. (2017) found significantly worse reaction times in anesthesiologists after a 17 h night shift. Military personnel may be subject to sleep deprivation more

Table 2. Correlations between sleep measures and balance performance.[a]

Balance Performance[b]	Objective Sleep Measures		Subjective Sleep Measures	
	Net Sleep	Average TST	PSQI	ESS
LOA	-0.488*	0.096	0.104	-0.149
ROA	-0.481*	0.094	0.081	-0.157
TOA	-0.515*	0.078	0.088	-0.199
RCA	-0.422	0.124	0.199	-0.079
TCA	-0.508*	0.027	0	-0.197
LCA	0.119	-0.319	-0.003	.521*
ROD	-0.628**	-0.388	-0.221	-0.142
LOD	-0.705**	-0.323	-0.176	-0.09
TOD	-0.667**	-0.249	-0.184	-.472*
LCD	-0.385	-0.367	0.05	-0.068
RCD	-0.401	-0.41	0.228	-0.271
TCD	-0.362	-0.331	-.564*	-0.214
LOAP	-0.264	-0.455	-0.119	0.233
ROAP	-0.172	-.474*	-0.389	0.267
TOAP	-0.490*	0.042	-0.076	-0.181
LCAP	-0.02	-0.398	-0.261	.624**
RCAP	-0.095	-0.176	0.239	0.412
TCAP	-0.148	-0.233	-0.466	0.146
LOLR	-0.442	-0.142	-0.113	0.273
ROLR	-0.095	-.602**	-.614**	0.325
TOLR	-0.636**	-0.249	-0.283	-0.176
LCLR	0.082	-0.185	0.121	0.423
RCLR	0.11	-0.256	0.272	0.146
TCLR	-0.465	-0.145	-0.355	-0.124
LOV	-0.09	-0.291	-0.12	.664**
ROV	-0.142	-0.396	-0.286	.626**
TOV	-0.127	0.005	0.247	0.067
LCV	0.093	-0.294	-0.013	.569*
RCV	0.01	-0.139	0.383	0.334
TCV	-0.032	-0.171	-.637**	0.444

[a] TST = total sleep time, PSQI = Pittsburgh Sleep Quality Index (Buysse et al., 1989), and ESS = Epworth Sleepiness Scale (Johns, 1991). Asterisks indicate significance: * = $p < 0.05$, and ** = $p < 0.01$.

[b] TL = left leg, R = right leg, T = total or both legs, O = eyes open, C = eyes closed, A = total area of center of pressure (CoP, cm^2), D = total displacement of CoP (cm), AP = deviation of CoP in anteroposterior direction (cm), LR = deviation of CoP in mediolateral direction (cm), V = velocity of CoP change ($cm\ s^{-1}$).

often than individuals in other professions, so they may have adapted to it. The farm population that we studied can be deprived of sleep during planting and harvest seasons; however, this deprivation is not constant, as in the military population. Therefore, the farming population could be considered more at risk for reaction time deficits because they are unable to acclimate to a consistent sleep schedule throughout the year. Reaction times are important for recovering after a momentary loss of balance; therefore, the significant findings of this study indicate an area of risk reduction for this population.

The more significant findings with eyes open are concerning. Farming tasks require coordination with vision and proprioception. The ability to efficiently maintain balance throughout dual-task scenarios has been shown to deteriorate with age (Kahya et al., 2019). Farm work often requires multi-tasking, and vision may be impaired during the late hours during harvest. Our population was middle-aged, and they are at increasing risk for balance-related injuries as they continue to work in these environments.

Although the objective measures seemed to be well correlated with the CoP changes in the static balance testing, the subjective measures were more correlated with the velocity of those changes with eyes open. This is consistent with the reaction time results reported by Ganesan et al. (2019) based on psychomotor vigilance testing. In that study, healthcare workers who consistently worked a night shift had slower visual reactions than those who worked the day shift. In our study, our subjects had higher velocity changes in the CoP with their eyes open, indicating a reduced ability to use their visual system to regulate their static balance, and thus slower visual reactions. There is not enough evidence to draw the conclusion that the subjective ratings truly indicated slower reactions; however, it is something to explore further. If further evidence confirms this correlation, subjective questionnaires could be useful for predicting reaction times in study populations.

The limitations of this study were as follows: a limited sample size (n = 5), all male subjects with a wide age range (43 to 70), and no subject was able to complete all six sessions of data collection due to fluctuating availability or unexpected health issues (table 1). There were also confounding factors, such as the size of the farm, caffeine use, hours worked, and hired help. As shown in table 1, the farm size, type of work, and hired help varied among the farmers, along with caffeine or medication use, which can contribute to fatigue levels and could impact our results.

Conclusions

In this study, we demonstrated that objective measures, such as the Actiwatch, as well as a calculation of net sleep loss provided better correlations with balance performance than subjective recall of sleep quality alone. We recommend that objective measures from an activity monitoring device are considered or supplemented with other subjective sleep measures when assessing sleep deprivation in a farming population.

Acknowledgements

This study was supported by NIOSH (Grant No. U54OH010162), the Central States Center for Agricultural Safety and Health (CS-CASH) at the University of Nebraska Medical Center (UNMC), and the UNMC College of Nursing for the use of the Actiwatch devices and related software.

References

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Res., 28*(2), 193-213. https://doi.org/10.1016/0165-1781(89)90047-4

Couyoumdjian, A., Sdoia, S., Tempesta, D., Curcio, G., Rastellini, E., De Gennaro, L., & Ferrara, M. (2010). The effects of sleep and sleep deprivation on task-switching performance. *J. Sleep Res., 19*(1 PART.1), 64-70. https://doi.org/10.1111/j.1365-2869.2009.00774.x

Di Muzio, M., Reda, F., Diella, G., Di Simone, E., Novelli, L., D'Atri, A., ... De Gennaro, L. (2019). Not only a problem of fatigue and sleepiness: Changes in psychomotor performance in Italian nurses across 8-h rapidly rotating shifts. *J. Clin. Med., 8*(1), 47. https://doi.org/10.3390/jcm8010047

Dinges, D. F. (1995). An overview of sleepiness and accidents. *J. Sleep Res., 4*(s2), 4-14. https://doi.org/10.1111/j.1365-2869.1995.tb00220.x

Frone, M. R. (1998). Predictors of work injuries among employed adolescents. *J. Appl. Psychol., 83*(4), 565-576. https://doi.org/10.1037/0021-9010.83.4.565

Ganesan, S., Magee, M., Stone, J. E., Mulhall, M. D., Collins, A., Howard, M. E., ... Sletten, T. L. (2019). The impact of shift work on sleep, alertness, and performance in healthcare workers. *Sci. Rep., 9*(1), 1-13. https://doi.org/10.1038/s41598-019-40914-x

Harrison, E. M., Yablonsky, A. M., Powell, A. L., Ancoli-Israel, S., & Glickman, G. L. (2019). Reported light in the sleep environment: Enhancement of the sleep diary. *Nat. Sci. Sleep, 11*, 11-26. https://doi.org/10.2147/NSS.S193902

Heaton, K., Azuero, A., & Reed, D. (2010). Obstructive sleep apnea indicators and injury in older farmers. *J. Agromed., 15*(2), 148-156. https://doi.org/10.1080/10599241003636020

Johns, M. W. (1991). A new method for measuring daytime sleepiness: The Epworth sleepiness scale. *Sleep, 14*(6), 540-545. https://doi.org/10.1093/sleep/14.6.540

Kahya, M., Moon, S., Ranchet, M., Vukas, R. R., Lyons, K. E., Pahwa, R., ... Devos, H. (2019). Brain activity during dual task gait and balance in aging and age-related neurodegenerative conditions: A systematic review. *Exp. Gerontol., 128*, article 110756. https://doi.org/10.1016/j.exger.2019.110756

Kaplan, K. A., Hirshman, J., Hernandez, B., Stefanick, M. L., Hoffman, A. R., Redline, S., ... Zeitzer, J. M. (2017). When a gold standard isn't so golden: Lack of prediction of subjective sleep quality from sleep polysomnography. *Biol. Psychol., 123*, 37-46. https://doi.org/10.1016/j.biopsycho.2016.11.010

Kramer, M. (2010). Sleep loss in resident physicians: The cause of medical errors? *Front. Neurol., 1*, 128. https://doi.org/10.3389/fneur.2010.00128

LaBrash, L. F., Pahwa, P., Pickett, W., Hagel, L. M., Snodgrass, P. R., & Dosman, J. A. (2008). Relationship between sleep loss and economic worry among farmers: A survey of 94 active Saskatchewan noncorporate farms. *J. Agromed., 13*(3), 149-154. https://doi.org/10.1080/10599240802371862

Lilley, R., Feyer, A.-M., Kirk, P., & Gander, P. (2002). A survey of forest workers in New Zealand: Do hours of work, rest, and recovery play a role in accidents and injury? *J. Saf. Res., 33*(1), 53-71. https://doi.org/10.1016/S0022-4375(02)00003-8

Marlenga, B., Pahwa, P., Hagel, L., Dosman, J., & Pickett, W. (2010). Impact of long farm working hours on child safety practices in agricultural settings. *J. Rural Health, 26*(4), 366-372. https://doi.org/10.1111/j.1748-0361.2010.00304.x

Nicholls, A. R. (2003). Some aspects of the human factors associated with extended hours of work and the operation of forest harvesting machinery. MS thesis. Melbourne, Australia: University of Melbourne.

Orzel-Gryglewska, J. (2010). Consequences of sleep deprivation. *Intl. J. Occup. Med. Environ. Health, 23*(1), 95-114. https://doi.org/10.2478/v10001-010-0004-9

Peters, R. D., Wagner, E. K., Alicandri, E., Fox, J. E., Thomas, M. L., Thorne, D. R., ... Balwinski, S. M. (1999). Effects of partial and total sleep deprivation on driving performance. *Public Roads, 62*(4), 2-8.

Reece, S. C., Thiruchelvam, D., & Redelmeier, D. A. (2018). Medical emergencies in farmers. *J. Rural Health, 35*(4), 429-435. https://doi.org/10.1111/jrh.12336

Rostamabadi, A., Jahangiri, M., Naderi Mansourabadi, B., Javid, M., Ghorbani, M., & Banaee, S. (2019). Prevalence of chronic diseases and occupational injuries and their influence on the health-related quality of life among farmers working in small-farm enterprises. *J. Agromed., 24*(3), 248-256. https://doi.org/10.1080/1059924X.2019.1592047

Saadat, H., Bissonnette, B., Tumin, D., Raman, V., Rice, J., Barry, N., & Tobias, J. (2017). Effects of partial sleep deprivation on reaction time in anesthesiologists. *Pediatric Anesthesia, 27*(4), 358-362. https://doi.org/10.1111/pan.13035

Scott, L. D., Arslanian-Engoren, C., & Engoren, M. C. (2014). Association of sleep and fatigue with decision regret among critical care nurses. *American J. Crit. Care, 23*(1), 13-23. https://doi.org/10.4037/ajcc2014191

Siu, K.-C., Huang, C.-K., Beacom, M., Bista, S., & Rautiainen, R. (2015). The association of sleep loss and balance stability in farmers. *J. Agromed., 20*(3), 327-331. https://doi.org/10.1080/1059924X.2015.1042615

Slightam, C., Petrowski, K., Jamison, A. L., Keller, M., Bertram, F., Kim, S., & Roth, W. T. (2018). Assessing sleep quality using self-report and actigraphy in PTSD. *J. Sleep Res., 27*(3), e12632.

https://doi.org/10.1111/jsr.12632
Smith, S. M., & Pegula, S. M. (2020). Fatal occupational injuries to older workers. Washington, DC: U.S. Bureau of Labor Statistics. https://doi.org/10.21916/mlr.2020.2
Spengler, S. E., Browning, S. R., & Reed, D. B. (2004). Sleep deprivation and injuries in part-time Kentucky farmers: Impact of self-reported sleep habits and sleep problems on injury risk. *AAOHN J., 52*(9), 373-382. https://doi.org/10.1177/216507990405200905
Vaara, J. P., Oksanen, H., Kyrolainen, H., Virmavirta, M., Koski, H., & Finni, T. (2018). 60-hour sleep deprivation affects submaximal but not maximal physical performance. *Front. Physiol., 9*, article 1437. https://doi.org/10.3389/fphys.2018.01437
Valdez, P. (2019). Circadian rhythms in attention. *Yale J. Biol. Med., 92*(1), 81-92.
Voaklander, D. C., Umbarger-Mackey, M. L., & Wilson, M. L. (2009). Health, medication use, and agricultural injury: A review. *American J. Ind. Med., 52*(11), 876-889. https://doi.org/10.1002/ajim.20749
Zhu, H., Han, Y., Sun, Y., Xie, Z., Qian, X., Stallones, L., ... Wang, L. (2014). Sleep-related factors and work-related injuries among farmers in Heilongjiang Province, People’s Republic of China. *Intl. J. Environ. Res. Public Health, 11*(9), 9446-9459. https://doi.org/10.3390/ijerph110909446
Zwerling, C., Sprince, N. L., Wallace, R. B., Davis, C. S., Whitten, P. S., & Heeringa, S. G. (1996). Risk factors for occupational injuries among older workers: An analysis of the health and retirement study. *American J. Public Health, 86*(9), 1306-1309. https://doi.org/10.2105/ajph.86.9.1306