# What do petrochemical workers, healthcare workers, and truck drivers have in common? Evaluation of sleep and alertness in Brazilian shiftworkers

# O que têm em comum os trabalhadores da indústria petroquímica, profissionais de saúde e caminhoneiros? Sono e vigília entre trabalhadores em turnos no Brasil

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## Abstract

*The article reports briefly on some effects of shiftwork and the work environment on health and wellbeing of shiftworkers. Studies of Brazilian shiftworkers (healthcare workers, petrochemical workers, and truck drivers) are described. A similar methodology was used to evaluate sleep and alertness in all these studies. The evaluation of sleep duration and quality and alertness showed similar results in the three studies. Although the workers were in different work settings, performing different jobs, the results are similar: daytime sleep is reduced and perceived as having worse quality than nighttime sleep; alertness decreases as the night work progresses. The study highlights the importance of shiftwork schedules' features and work organization for workers' health, wellbeing, and safety.*

*Shift Work; Sleep; Occupational Health*

## Shiftwork and its relation to workers' health and wellbeing

### Shiftwork around the world

Shift and night work are part of the 24-hour society worldwide. Large numbers of industrial and services settings provide operations during continuous working days and/or nights, including weekends. Work that proceeds twenty-four hours a day and seven days a week is commonplace in many industrial operations, such as petroleum, chemical, petrochemical, fertilizer, steel, cement, glass, coal, and energy production, distribution, and maintenance, water and sewage treatment, etc., due to the nature of these industrial processes. Continuous day and night services are increasing in number and in recent decades cover an important range of activities including telecommunications (telephone, radio, TV, internet providers), public safety/security, public transportation, education, health services, financial markets, supermarkets, drugstores, gas stations, etc. According to statistics published in 1985 by the International Labor Organization [1], developing countries have 15.0-30.0% of their labor force working in shiftwork. The proportion varies according to economic sectors, countries, and regions within the same country. Rural and urban shiftworkers are involved in quite different jobs. Their daily activities can be performed year-

round or seasonally, during non-traditional diurnal hours, in regular or irregular work schedules, and during fixed or alternating work times [1,2]. In many countries the deregulation of labor laws has allowed the implementation of irregular and flexible work schedules, often unfavorable to workers [3]. In the United States, a recent national study showed that only 29.1% of workers were working 5 days a week (Monday-Friday) with a fixed work day and no longer than 40 hours a week [4].

Ilmarinen [5] presented an overall picture of the workforce status among the aging (≥ 45 years) workforce in 15 European Union countries. Heavy shiftwork (more than five nightshifts/month and irregular day work (often including weekends) are quite different across the countries. These characteristics were more common in Ireland, Portugal, Finland, and Austria, where 18.0% of men over 45 years of age reported working heavy shifts.

According to a comprehensive study conducted in 15 countries of the European Union (SALTSA Report) with a sample of 21,505 workers, only a minority of the labor force (24.0%) was free from working on Saturdays, Sundays, on night shifts, part-time, or more than 10 hours per day while having a workweek of 40 hours or less [6].

## Brazilian nightshift and shiftwork legislation

In 1988, when the new (and currently prevailing) Brazilian Constitution [7] was enacted, the Brazilian nightshift and shiftwork legislation was already quite advanced. For approximately 40 years, night work had involved shorter work hours and higher wages compared to daytime work [8]. According to Article 7, paragraph 14, of the 1988 Brazilian Constitution, workers on continuous shifts should have no more than a six-hour workday or the possibility of implementing work arrangements through collective bargaining [7]. This significant reduction in daily working time, compared to the former practice of 42 to 44 hours a week, certainly can have an important impact on workers' health and wellbeing, as well as on extra-occupational activities.

According to Social Security Ruling 3,038 of May 1999 [9], shift and night work were recognized as etiologic agents associated with work-related diseases such as sleep disorders due to non-organic factors (F 51.2 Group V ICD 10) and disorders of the sleep-wake cycle (G 47.2, ICD 10).

## Work environment and shiftwork effects on health

Since the early 1960s several articles have demonstrated the relations between shiftwork organization and negative outcomes for workers' performance, health, and lives [10].

Epidemiological studies have shown that several diseases are associated with night work and shiftwork, including sleep, gastrointestinal, cardiovascular, and mental disorders [11], while other chronic illnesses such as breast cancer and colorectal cancer are currently being investigated [12,13].

Complex work environments where shiftwork prevails impose a myriad of hazards on workers' health. Shiftwork combined with multiple risks in the workplace, associated with heavy physical and/or cognitive demands, lack of work control, and other psychosocial stressors have a major negative impact on workers' health and wellbeing [14,15,16].

Such risks include the disruption of biological rhythms, aggravation of several physiological functions leading to higher morbidity of various types, and earlier retirement, all interacting with family and social relations. Since shiftwork per se and/or combined with unsafe working conditions and unhealthy life styles can trigger the development of important chronic diseases, early aging is a matter of concern [17].

A more detailed description of the biological mechanisms as well as perceived symptoms and diagnosed diseases aggravated by night and shiftwork can be found in Moreno & Louzada [18] in the current issue of this journal.

## Shiftwork organization and its effects on sleep and alertness

Shiftwork timetables should be evaluated by several parameters in order to obtain a picture of their potential harm to workers. These include the length of workdays and workweeks, the beginning and end of working hours for each day/week, the direction of rotation among shifts, the number of shifts/hours worked per month/year, the number of teams working in shifts, the consecutive number of work days and off-days off in each shift, off-days in each shift cycle, possibilities for switching work hours among coworkers, etc.

Numerous publications have described negative effects on sleep and performance in shiftworkers, non-diurnal workers, and those with

irregular work schedules. Recent and older studies have shown accumulated sleep deficits, excessive sleepiness during and after work, biological disorders, difficulties in performing work, increased rates of accidents and other ailments caused by unsafe/unhealthy working conditions (occupational and environmental stressors, including shiftwork organization), unhealthy lifestyles (such as smoking, alcohol consumption, sedentary habits, and poor nutrition), lack of social support, and other negative psychosocial factors [14,19,20,21,22,23,24].

Studies conducted in Brazil by Fischer et al. [16,25,26], Borges & Fischer [27], and Moreno et al. [28] evaluated perceived sleep and alertness across shift cycles in a number of companies working continuous shifts.

The objective of this report is to discuss the results on sleep duration and quality and alertness from studies conducted in a petrochemical company, a university hospital, and two trucking companies.

A similar methodology was used to evaluate sleep duration and quality and alertness across the shift cycles. Studies were conducted with shiftworkers working in rotating and fixed shifts, as well as in irregular work schedules.

## Analysis of sleep (duration and quality) and alertness among shiftworkers: some examples from Brazilian companies

### Data on shiftworkers with continuous schedules in a petrochemical plant

The study by Fischer et al. [25] aimed to evaluate sleep duration, quality, and alertness during day and night 12-hour shifts among petrochemical workers. Twenty-two male workers participated in the study. The shiftwork schedule followed a so-called "rapid shift rotation": two or three dayshifts were followed by three or two nightshifts, and followed by four to five days off. Workers filled out activity diaries, as well as alertness levels measured by 10cm analog scales in the second, sixth, and tenth hours of each shift, during the full shift cycle. Sleep duration varied significantly between the work shifts and off-days. The shortest mean sleeping time occurred after the second nightshift (mean = 311.4 minutes, SD 101.7 minutes), followed by sleep after the third night of work (335.3 minutes, SD 151.2 minutes). All but one shift (sleep after the first work night) was significantly different ($p < 0.002$) from sleep after the first two workdays. The magnitude of the standard deviation highlights the importance of individual differences among coworkers within the same shifts. The same phenomenon was observed in the study at the University Hospital (see *University Hospital data*), described below.

Reported quality of sleep was not significantly different when comparing day and nightshifts, with the exception of sleep after the third day compared to sleep after nightshifts. The former was reported to be better than the latter.

Reported alertness levels measured by 10cm analog scales showed worse alertness as the nightshift progressed (2nd at 21:00 hours, 6th at 01:00, and 10th at 05:00). When comparing alertness during the day shifts, the 2nd hour of the first day was better than the 10th hour of all dayshifts. These results may have been influenced by the monotony of the control rooms, particularly at night.

### University Hospital data

Fischer et al. [26] conducted a study in a University Hospital (Central Institute) in São Paulo, Brazil, in 1997-1999 as part of a comprehensive study on working and living conditions and early aging. Healthcare workers followed a traditional work schedule known as 12 hours "on" followed by 36 hours "off", either fixed day or nightshifts. One hundred seventy-six healthcare workers agreed to participate in the study. Of these, 26 (24 women and 2 men) filled out daily protocols and 10cm analog scales to evaluate perception of sleeping/waking times and alertness during two consecutive weeks. As is commonplace in the healthcare sector, they work 12-hour shifts on alternating days or nights. Mean sleep duration during the day after night work was significantly shorter than nighttime sleep during the off-day (208.7 minutes versus 497.0 minutes). There were also significant differences between the duration of night sleep after and before 12-hour working days (458.9 minutes versus 333.2 minutes). This is probably because workers have to be awake quite early (about 05:00 AM) to go to work before the dayshift, which starts at 07:00 AM. As a result, their night sleeping time is interrupted.

Perceived sleeping quality was also reported using a 10cm analog scale during working days and off-days for two consecutive weeks. Night workers (who slept their main period of sleep during the day) reported worse quality of sleep than day workers.

Day workers perceived worse sleep during working days as compared to off-days. The reason was the same as mentioned above: day workers interrupted their sleep too early in the

morning. Among night workers, circadian mechanisms interfere with the maintenance of sleep, shortening the main daytime sleeping period and thus affecting duration and quality of sleep. For further details, see results in *Data on Trucking Companies* and the study by Moreno & Louzada [18].

Perception of alertness was evaluated four times during day shifts (at 09:00, 13:00, and 17:00 hours) and night shifts (21:00, 01:00, and 05:00 hours). As the night progressed, alertness was significantly lower than earlier, reaching the lowest point during the dawn hours (05:00) ($p < 0.05$). Perceived alertness during dayshifts did not show significant differences ($p > 0.05$).

Interesting results were observed in the standard deviation (SD) of alertness during night shifts: the SD increased from the 2nd to the 10th hour, showing a conspicuous difference among individuals able to cope with sleepiness throughout the 12-hour work night as compared to others barely able to resist taking snoozes.

A further study was carried out by Borges & Fischer [27] at the same University Hospital mentioned earlier, but in two other departments (the Institute of Cardiology and the Institute of Orthopedics and Traumatology, respectively) with 20 healthcare workers who also worked 12-hour nightshifts. The workers used a continuous monitoring wrist device in a non-dominant hand-actigraph (Ambulatory Monitoring) [29] to evaluate rest (sleep) and activity times during two consecutive weeks on workdays and off-days. They also filled out a standardized scale (the Karolinska Sleepiness scale) [30] to evaluate alertness at work. Results showed significantly shorter day sleeping times compared to night sleep, as well as decreased alertness during nightshifts. Reported quality of sleep also showed similar results to those mentioned in the first study with healthcare workers. The study by Borges & Fischer confirmed the results of the previous one [26].

Sleep duration and alertness are dependent on sleeping times (see Moreno & Louzada [18]) and length of the work night. Both studies showed that workers reported worse quality of sleep during daytime sleep as compared to nighttime sleep.

This leads us to the conclusion on the importance of shiftwork schedules to maintain workers alert and to allow them to have enough sleep, particularly when they are exposed to long working hours. Healthcare workers have significant physical and mental demands at work, and 12-hour shifts can be a burden to them. Their traditional work schedule (12 hours on followed by 36 hours off), allowing them to have a day off after a single night shift (or day shift), helps workers recover their sleep deficit. Even so, when they return to work after 36 hours off, their alertness showed a major decline, particularly comparing the 7th and 10th hour after the beginning of the 12-hour night shift.

## Data on Trucking Companies

Moreno et al. [28] carried out a study with truck drivers from two trucking companies located in São Paulo and Campinas, São Paulo State. Thirty-seven male truck drivers participated in the study. They worked either fixed schedules ($n1 = 13$) or irregular shifts ($n2 = 24$). The latter worked at any time according to task demands or hauls ordered by the trucking companies.

Evaluation of active and rest times used an actigraph (Ambulatory Monitoring, USA) for 10 days. During the same period, workers also filled out activity diaries to confirm whether they were awake or sleeping during the data collection days.

In relation to sleep during time off, truck drivers working on fixed schedules showed significantly longer time in bed and sleep duration (mean times of 397.6 and 312.0 minutes, respectively) compared to drivers on irregular work schedules (199.6 and 213.7 minutes in Campinas and São Paulo, respectively).

Frequently neglected or overlooked points relate to breaks and rest during work, including sleep, particularly during critically sleepy times at work. Such oversights can be associated with poor performance involving mistakes, work incidents, and accidents and do not go unnoticed in many work settings. A good example is the increased rate of traffic accidents involving car/truck crashes associated with drivers' excessive sleepiness at certain hours of the day or night and their irregular work schedules and long working hours. Biguetti et al. [31] conducted a large study of thousands of drivers on highways in the State of São Paulo: while overall road accidents were more frequent during the day, fatal accidents were more frequent at night (60.0% of all accidents).

According to Moreno et al. [28], truck drivers with regular work schedules experienced monophasic sleep, whereas those with irregular schedules showed polyphasic sleep patterns. Such results can be viewed as a strategy to cope with irregular work schedules. The ability to be more flexible in falling asleep can be an advantage that helps workers to tolerate non-diurnal working hours [32]. Other practices in addition to going to sleep are often cited: listening to loud music, opening windows to let in cool air, wash-

ing one's face, eating, and drinking beverages containing caffeine. Unhealthy practices can involve breaking the law: truck drivers cite substance abuse to keep awake during long hauls and/or irregular schedules [31,33].

Such negative consequences of long and irregular work schedules involve significant human and financial costs for society.

## Final remarks

The above section presents results from four studies in distinct work settings (two of the studies were conducted in the same hospital complex). The shiftworkers performed very different tasks and had to cope with different physical and mental stressors. However, in the evaluation of alertness and duration/quality of sleep, particularly after night work, the effects of shiftwork showed common outcomes: reduced sleep, worse quality of sleep, and decreased alertness.

Previous studies in petrochemical plants in Cubatão and Santo André, São Paulo State, in 1988 and 1989 [34] showed similar results for duration of sleep: shorter duration of sleep when working 8-hour morning and nighttime shifts as compared to afternoon shifts in weekly and fast-rotating shift schedules. However, reported quality of sleep was worse for weekly than for fast-rotating schedules. At the time of these studies, workers on continuous shifts were not provided with shorter daily/weekly working schedules, contrary to provisions in the 1988 Brazilian Constitution. All these results are consistent with recommendations for reducing the number of consecutive nights of shiftwork [35].

Occupational risk levels, safety patterns, and work schedules are defined and managed by administrative and/or operational personnel who work during the day. However, serious risk factors and health hazards are aggravated during non-diurnal work. Employers and employees should be aware of the higher risks associated with long work schedules and non-diurnal shifts. They should also not overlook individual differences that are aggravated when unfavorable working conditions fail to help maintain alertness. This is especially important when some or all of the following work stressors are present: long working hours, boredom in monitoring/ surveillance tasks, and heavy cognitive demands.

Several work schedule characteristics have raised concern among managers and shiftwork consultants. A review recently published by the U.S. National Institute of Occupational Safety and Health [36] on overtime and extended work shifts showed that a more in-depth evaluation is still needed in the ways by which long working hours are associated with health and safety. A careful analysis of shiftwork organization should extend beyond the above-mentioned features, looking at the physical and mental demands of the work environment, the nature of the tasks, the control workers have over their work schedules and tasks, commuting time, the organizational atmosphere, occupational health and safety procedures, and prevention programs. This list should include other factors that are also important to detect critical, unhealthy, and uncomfortable working conditions. The so-called "shiftwork timetables" provide an initial view of how shiftworkers are tied to their work schedules, but hide an important number of variables that influence workers' health, safety, and wellbeing.

Successful coping with shiftwork schedules demands interaction among variables, including those related to occupational and extra-occupational factors, workers' demographic characteristics (age, marital status, family support, housing quality, and quality of transportation to and from work), and balanced free time, allowing sufficient rest and leisure activities, etc. [37].

As part of a "risk management program", customized educational programs for workers and employers can assist all parties in taking a closer look at shiftwork and reevaluating schedules, as well as implementing best safety practices at work. One such program is the assessment of sleepiness during daytime or nighttime work, particularly when propensity to sleepiness can seriously jeopardize safety and productivity. A recent report [38] showed that satisfaction with work schedules appears to be related to less sleepiness at work and better quality of sleep, besides helping workers tolerate and cope better with shiftwork.

Appropriate work schedules using ergonomic principles can be implemented with the help of specific software programs. The implementation and enforcement of measures to support occupational health can help workers harmonize their lives and overcome difficulties both during work and in their time off.

## Resumo

*Este artigo apresenta de forma resumida os efeitos do trabalho em turnos na saúde e bem-estar dos trabalhadores. São apresentados estudos conduzidos em hospitais, indústria petroquímica e companhias de caminhões de carga. Foi utilizada metodologia semelhante nos estudos descritos para avaliação da duração e qualidade do sono, assim como do alerta durante o trabalho. Apesar dos trabalhadores realizarem tarefas bastante distintas, os resultados das avaliações de sono e alerta foram semelhantes: os trabalhadores após turnos noturnos apresentaram sono mais curto do que após outros turnos, comparados consigo mesmos e/ou com seus colegas de turnos diurnos. É enfatizada a importância da escala em turnos, assim como da organização do trabalho, para auxiliar os trabalhadores a manterem sua saúde, bem-estar e segurança no trabalho.*


*Trabalho em Turnos; Sono; Saúde Ocupacional*


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