



**Design Specs of the Human Machine:
*Minimizing Fatigue-Related Human
Error in Medical Environments***

SHIFTWORK AND EXTENDED HOURS



- 24 million shiftworking Americans
- Shiftwork: Body of work performed by groups, or shifts, of workers who succeed each other over a recurring time interval
- Extended hours employees are those who work beyond their regularly schedule intervals. Typically outside the hours of 8am to 5pm.
- Extended Hours: Term often used synonymously with shiftwork
- Shiftworkers found in almost all major industries, including health care, law enforcement, manufacturing and processing, customer service, and financial services
- Over 2 million shiftworking nurses alone in healthcare segment

HUMAN DESIGN SPECS



Humans were not designed for peak performance at night.

Then...



...and Now

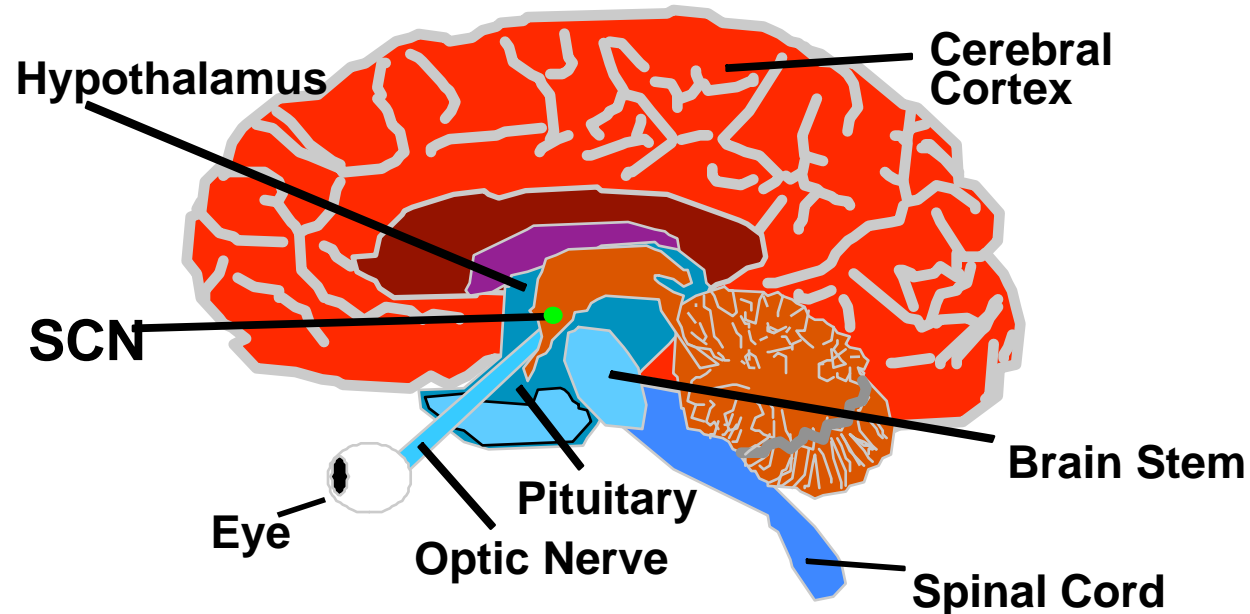


- Adjustment to night work creates health problems for shiftworkers
- Performance decreases during overnight and post-lunch dip hours
- Training and experience is compromised by fatigue
- Behavior becomes erratic/deviant
- Human error is more often a physiological problem – not behavioral
- Fatigue is the major cause of human error

ADVENT OF CIRCADIAN RHYTHMS

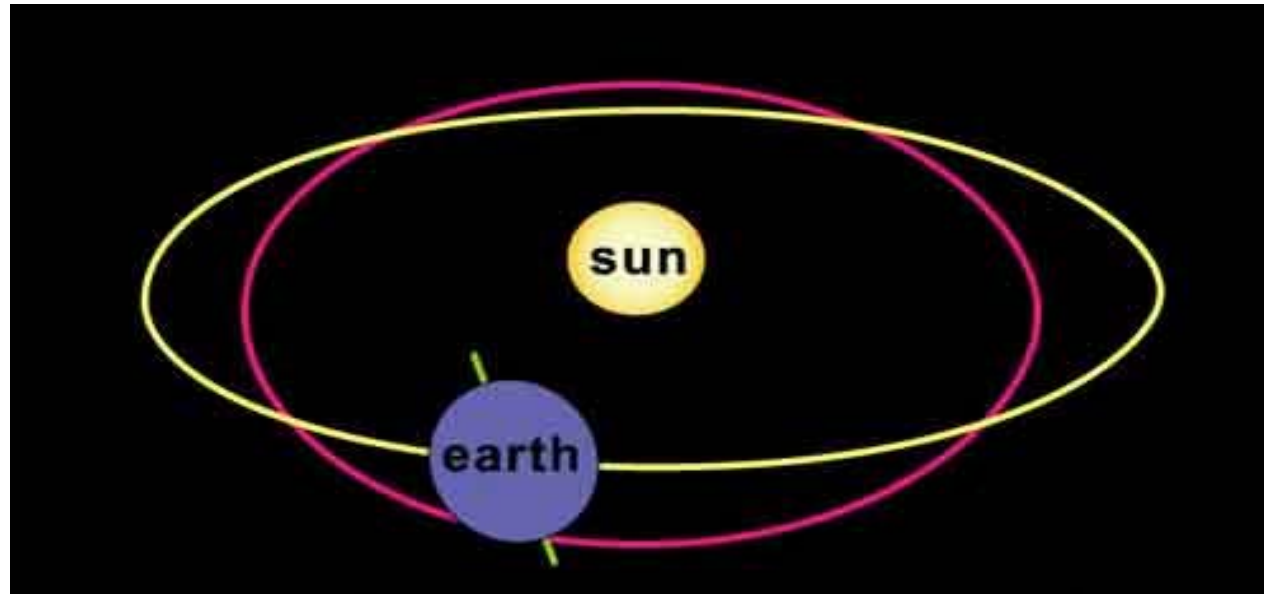


PHYSIOLOGY: THE BIOLOGICAL CLOCK (SCN)



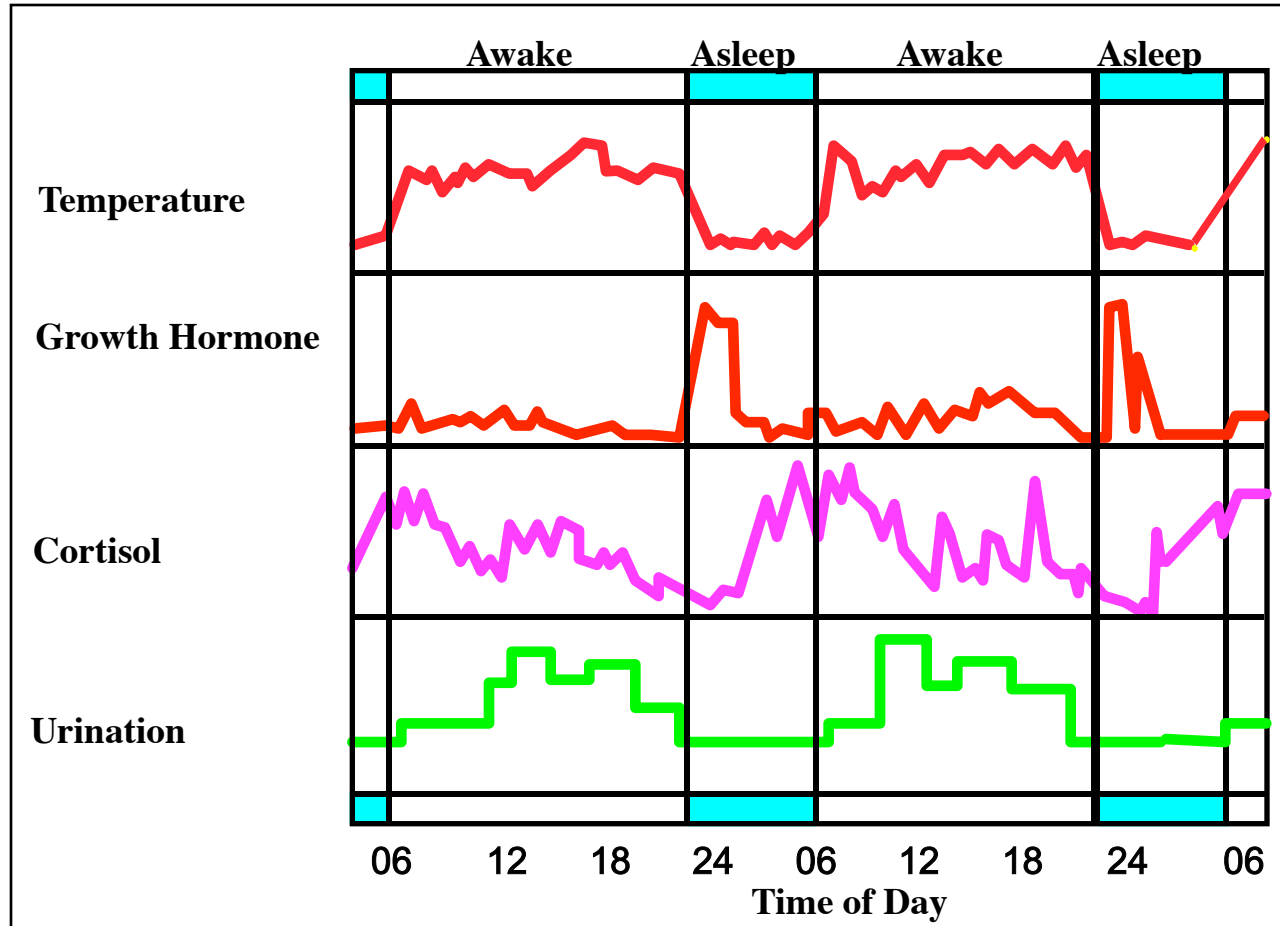
- SCN controls hundreds of biological rhythms, including alertness, digestion, hormone production, blood pressure, mood, etc.
- Light has the greatest effect in controlling the biological clock
- The rhythms of the SCN are a basic physiological function – It is difficult to fool or “tough it out”
- Understanding physiology is critical to successful shiftwork management

THE BIOLOGY OF SHIFT ROTATIONS



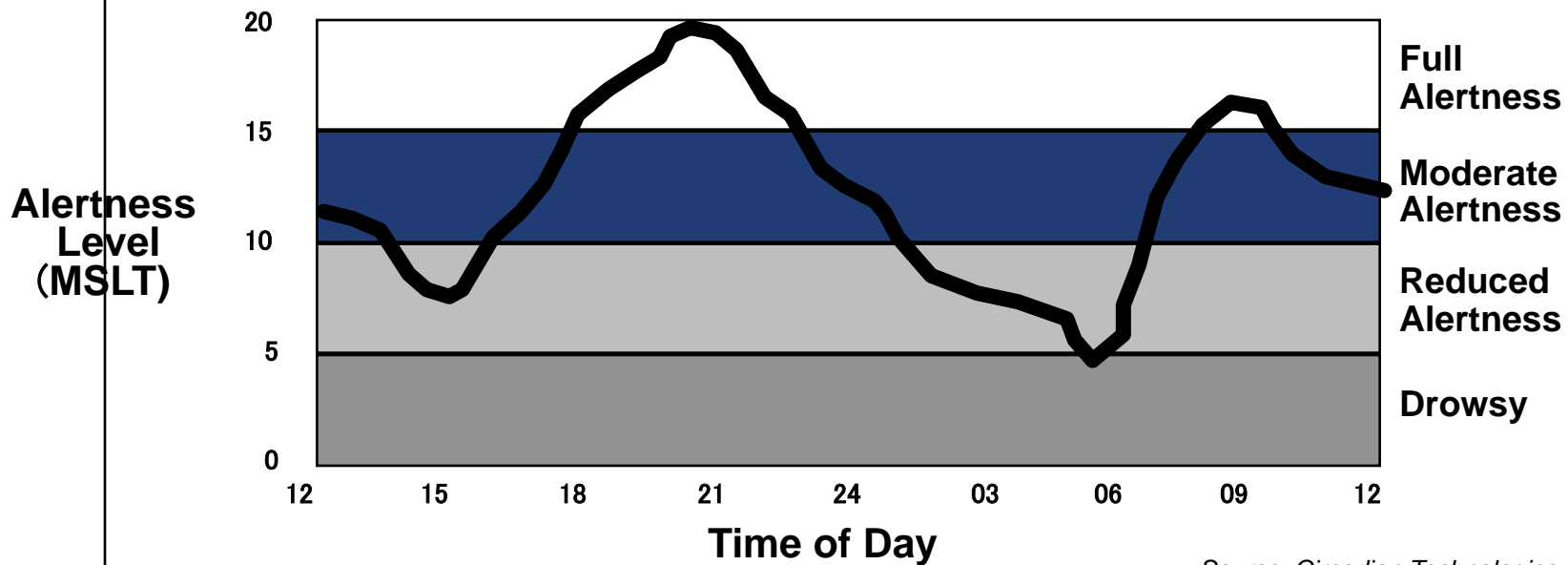
- Forward rotation (East to West) around the sun
- Change in earth's orbit now out of sync with biological clock
- Created 24-hour orbital rotation vs. 25+ hour biological clock

PROCESS CONTROL CHART OF HUMAN CIRCADIAN RHYTHMS



CIRCADIAN RHYTHM OF HUMAN ALERTNESS

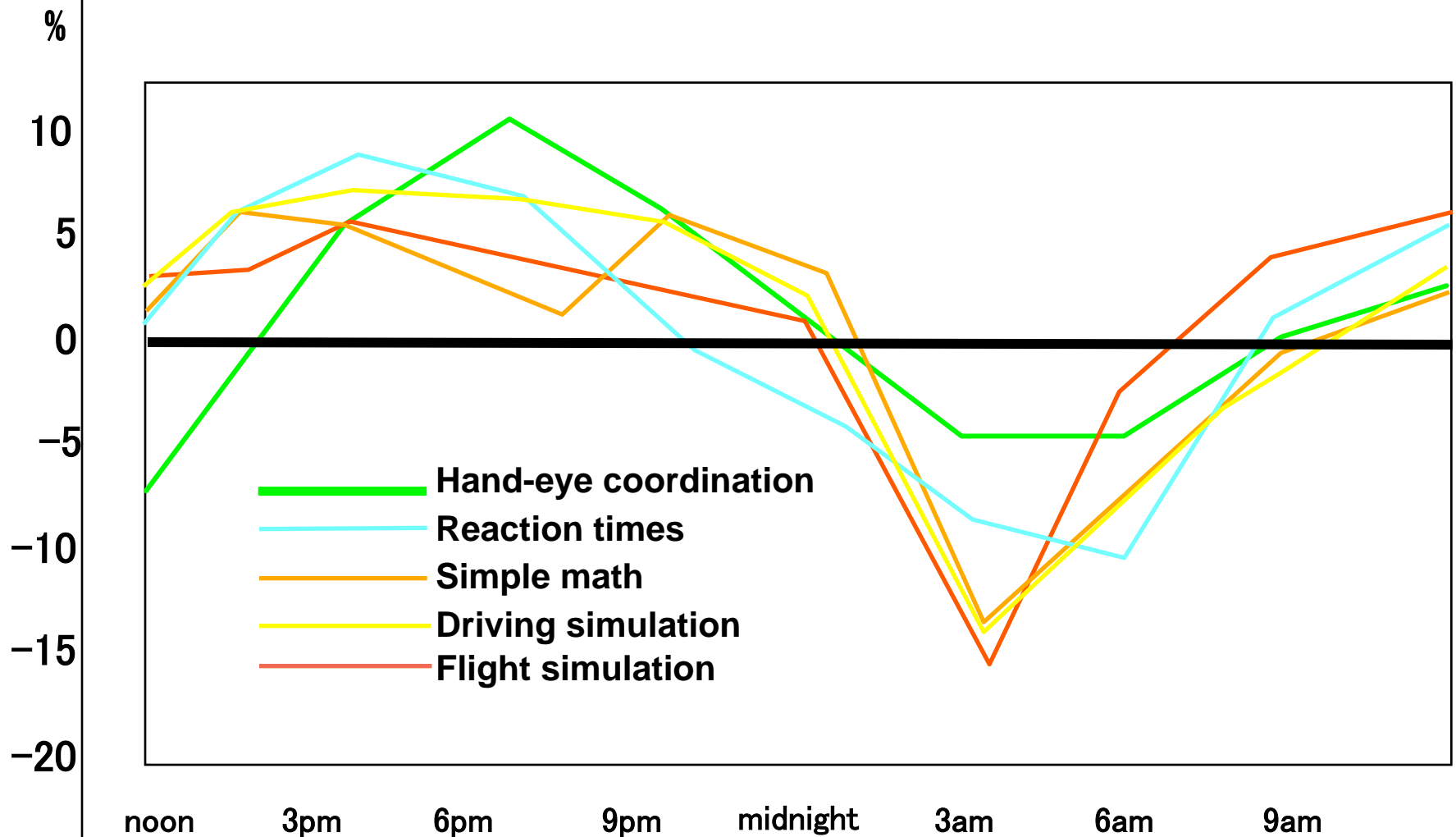
(With Normal Quantity / Quality of Nighttime Sleep)



Source: Circadian Technologies, Inc. (1993)

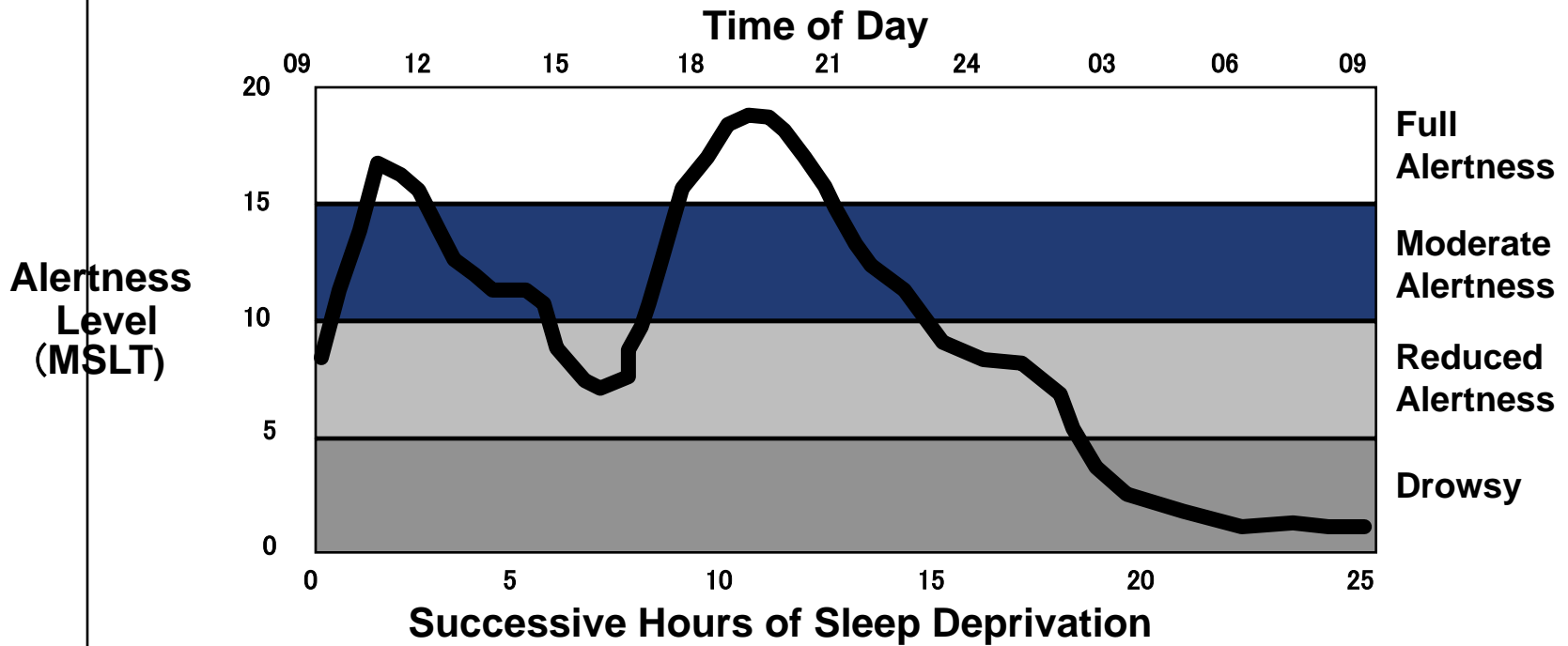
This is an average composite for all Circadian types. The curve can be shifted 1-2 hours in either direction depending on whether one is an early or late riser, etc.

PERFORMANCE VARIABILITY IN A 24-HR PERIOD



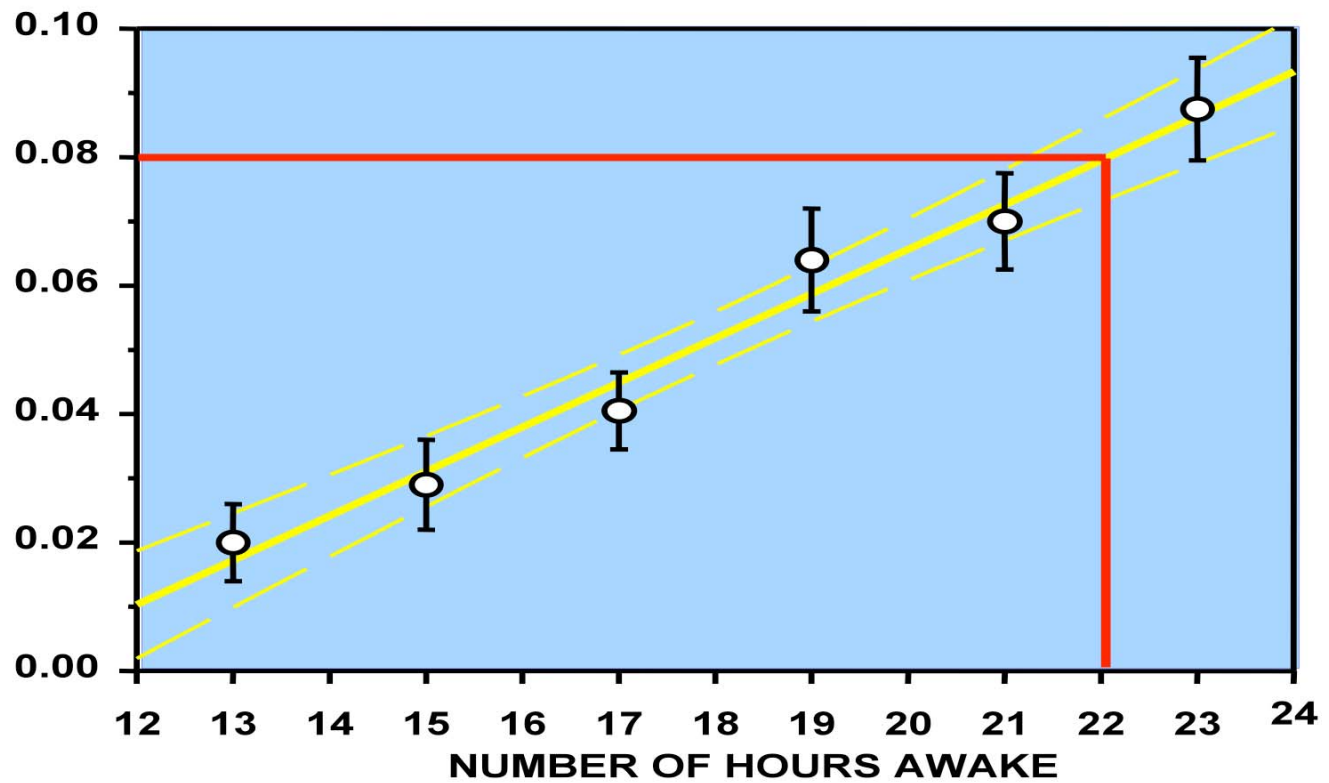
Time of Day

DETERMINANTS OF HUMAN ALERTNESS: EXTENDED HOURS WITHOUT SLEEP



Source: Circadian Technologies, Inc. (1993)

FATIGUE VS. ALCOHOL IMPAIRMENT



Adapted from Dawson and Reid, 1997

BIOLOGICAL BASIS OF FATIGUE



- Fatigue is fundamentally a Physiological Problem
- Not fundamentally a Behavioral Problem
- While lifestyle training and personal discipline are valuable, they only address part of the problem
- No matter how diligent, well trained, or motivated, most people will have difficulty sleeping during the daytime and staying awake at night
- No matter how good incident reporting systems, they are not capturing data needed to determine fatigue as a causal factor
- Thus, contribution of fatigue to safety/operating incidents is grossly under-reported

SHIFTWORK

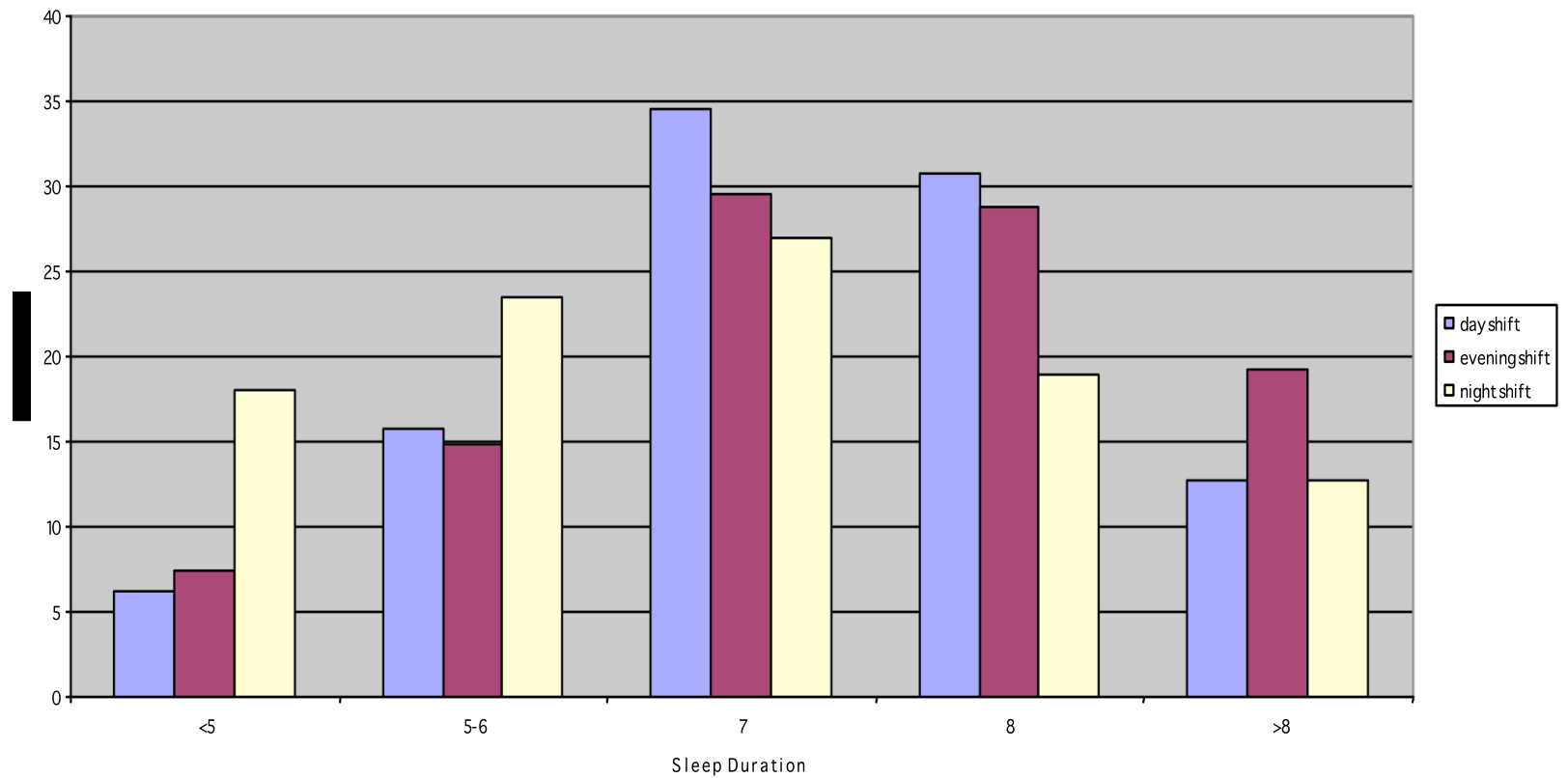


- Shiftwork and extended hours disrupt human biological functions
- Negatively impact health and well being, performance and safety
- Well documented issues due to:
 - Desynchronization of circadian rhythms
 - Lifestyle changes in relation to diet, sleep disruption, coping substances, lack of exercise, etc.
- Increased stress

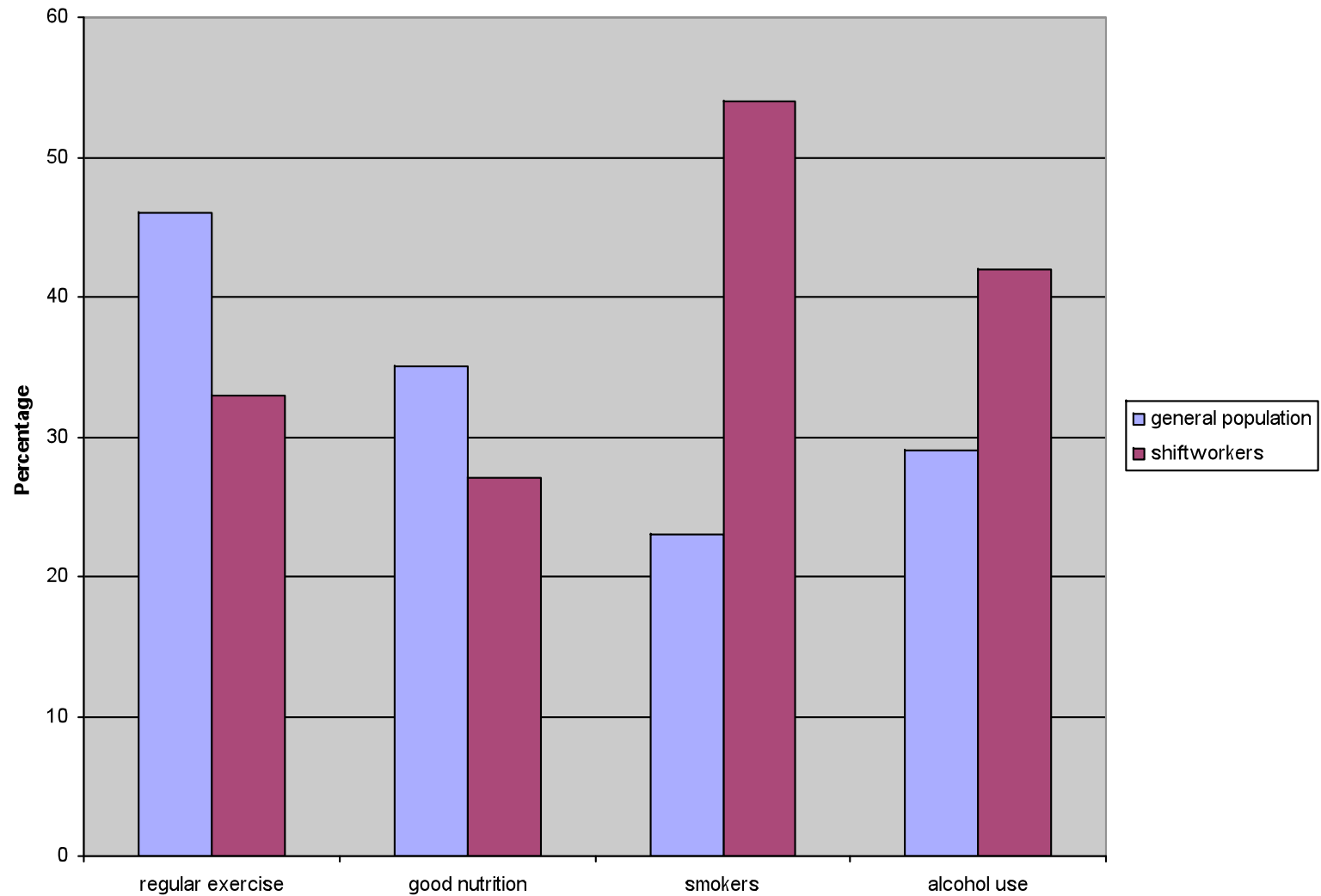
DISRUPTION OF CIRCADIAN RHYTHMS: SLEEP



Sleep duration in different shifts



LIFESTYLE CHANGES IN EXTENDED HOURS



DISRUPTION OF SOCIAL RHYTHMS



- Shiftworkers experience more conflicts between work, family, and social activities than dayworkers
- Problems related to working evenings, weekends and holidays
- Shiftwork affects the workers role as spouse and parent

EXTENDED HOURS AND NURSING



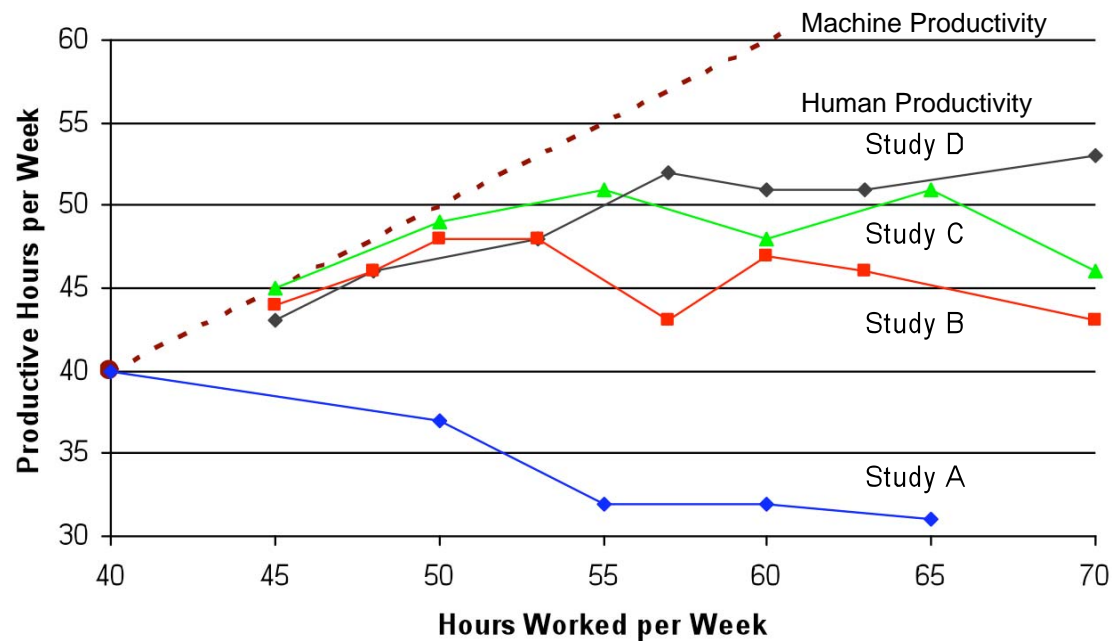
- Nurses work long hours
 - Most nurses work more than 40 hours per week, with many working more than 12 hours per day
 - On average RNs work 8.5 weeks of overtime per year
 - The limit on residents' work hours may increase the workload for RNs
- Most nurses work shifts and face the same difficulties as any other shiftworker:
 - Health Problems
 - Accidents and Injuries
 - Work/Life Balance

HEALTH ISSUES: LONG HOURS



- Nurses face the same challenges as all of the 24 million Americans who work shiftwork
- Long hours and/or night work can contribute to poorer health
- Working in excess of 60 hours per week has been related to:
 - Increased risk of heart attack
 - Impaired performance
 - Reduced productivity

OVERTIME VS. PRODUCTIVITY



- Study A shows productive hours when a person is excessively fatigued (burnout). Study B is after working 4 weeks of long hours. Studies C and D are from just 1 week of long hours.
- Dotted line represents lineal machine productivity (i.e. hours of work = Productive Hours)

Source: Nevison, J., *Overtime Hours: The Rule Of 50*

OVERTIME AND WORK HOURS



- 40% nurses working longer than 12-hour (Rogers, 2004)
- 40% nurses on call (Trinkoff, 2006)
- Direct correlation between work duration/overtime on nursing errors (ONA, 2005)
- Risk increases when overtime follows 12-hour shifts (ONA, 2005)
- Interns/residents (Lockley 2007)
 - 36% more serious errors
 - 300% more fatigue related errors leading to patient deaths
- Extended shift durations increase fatigue and impair safety and performance
- Current hours unsafe

HEALTH ISSUES: SHIFTWORK



- Shiftwork has been associated with:
 - Sleep disorders
 - Gastrointestinal diseases
 - Cardiovascular disease
 - Obesity and diabetes
 - Reproductive health problems (women)
 - Mental health problems
 - Immune system depression and higher risk of getting common infections

- Increased morbidity associated with higher use of medication

HEALTH ISSUES: MUSCULOSKELETAL DISORDERS

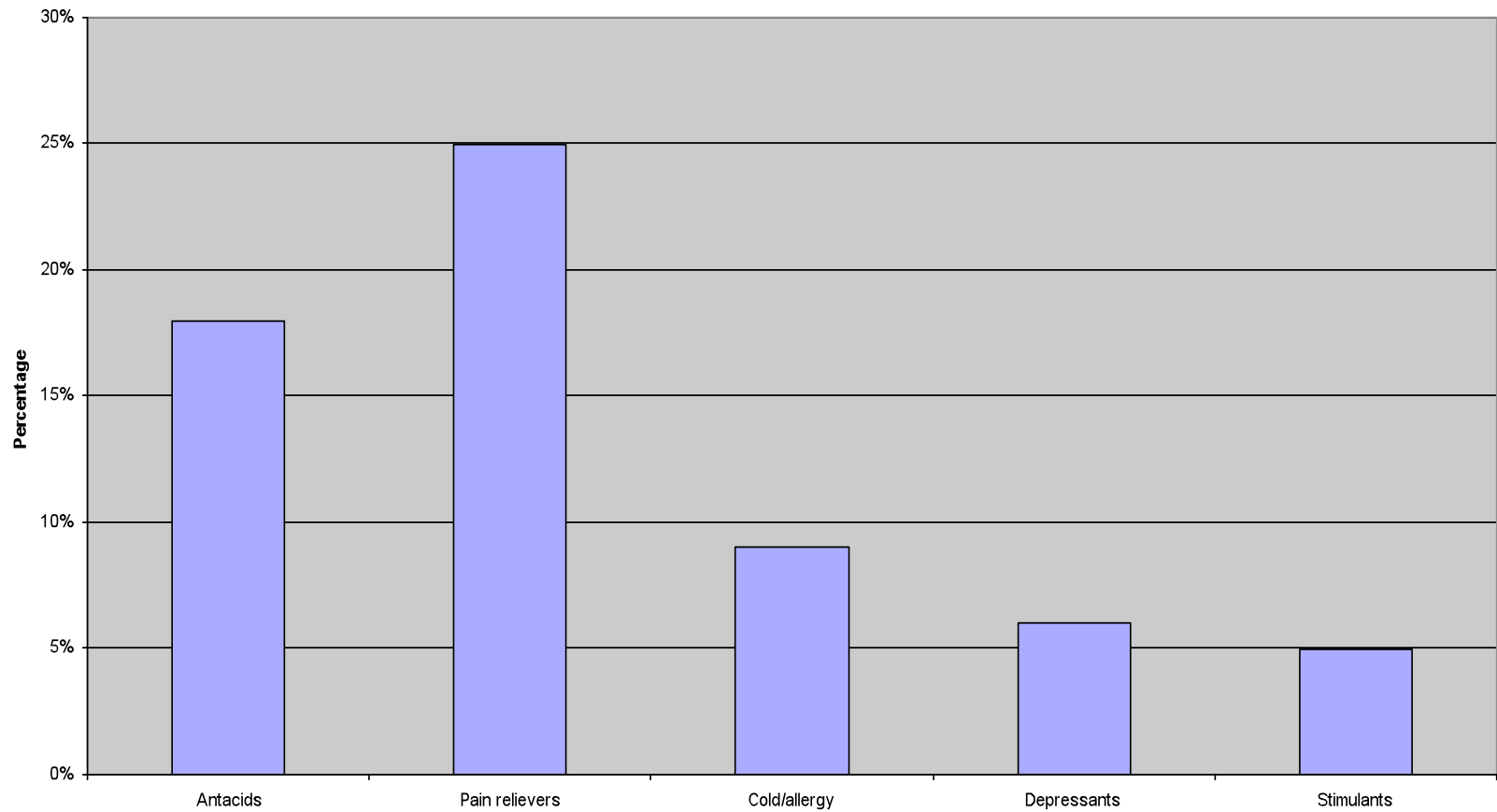


- Prevalence of MSD is high among nurses:
 - Back pain: 30-60%
 - Neck: 30-48%
- Physical work demands are associated with MSD (lifting, moving patients, work in awkward postures)
- Night work is a risk factor for MSD:
 - Ergonomics guidelines are based on daytime research studies
 - Ability to generate muscle force decreases during the night
 - Sleep deprivation reduces accuracy of movements
 - Sleep deprivation increases time needed for healing

HEALTH ISSUES: MEDICATION



Percentage of shiftworkers using medication at least several times per week



SAFETY: WORK-RELATED INJURIES



- Nursing is one of the 10 occupations with the highest levels of occupational injury or illness requiring days away from work
- Non-fatal occupational injury and illness rate is 7.4 cases per 100 health care workers, vs. 4.6 in the service sector and 5.3 overall in private sector
- ANA reports that 40% of its members are injured annually
- Most common problems: MSD and needlestick injuries

SAFETY AND STAFFING LEVELS



- Fatigue-related accidents and injuries are more common among extended hours workers
- Inadequate staffing levels result in higher stress and fatigue levels causing higher rates of injuries
 - When RN positions in a hospital study decreased by 9.2%, the number of work-related injuries for RN's increased by 65.2%
- Increased fatigue levels are related to increased Workers' Compensation costs

WORKPLACE CONSEQUENCES: QUALITY OF CARE



- Fatigue, resulting from long work hours, shiftwork and low staffing levels affect quality of care:
 - Insufficient number of nurses linked to increased problems (infections, etc)
 - Hospitals with low nurse staffing levels have higher rates of poor patient outcomes
 - Each additional patient over four in an RN's workload, increases the risk of death by 7% for hospital patients

WORK AND FAMILY LIFE



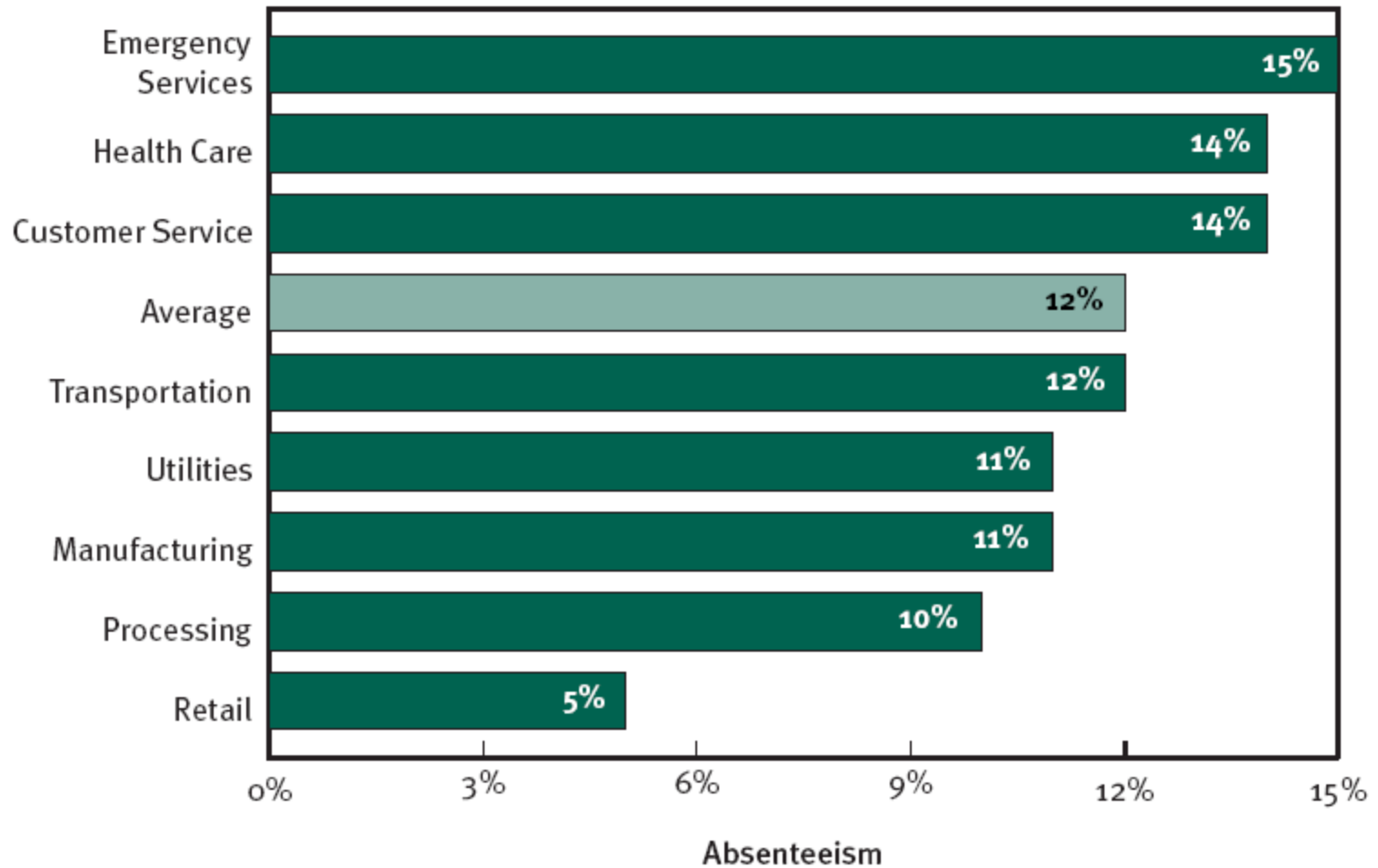
- Increased difficulty participating in family/social activities for those working evenings, nights, or irregular schedules
 - Feelings of social isolation and stress
- Spouse and parenting role can be affected.
 - Divorce more likely when young children are present and one spouse works shiftwork
- Childcare, and elderly care are major problems
 - Split shift parenting
 - Leaving workforce, turning down promotions
 - 500,000 registered nurses no longer working in healthcare

SAFETY: COMMUTING

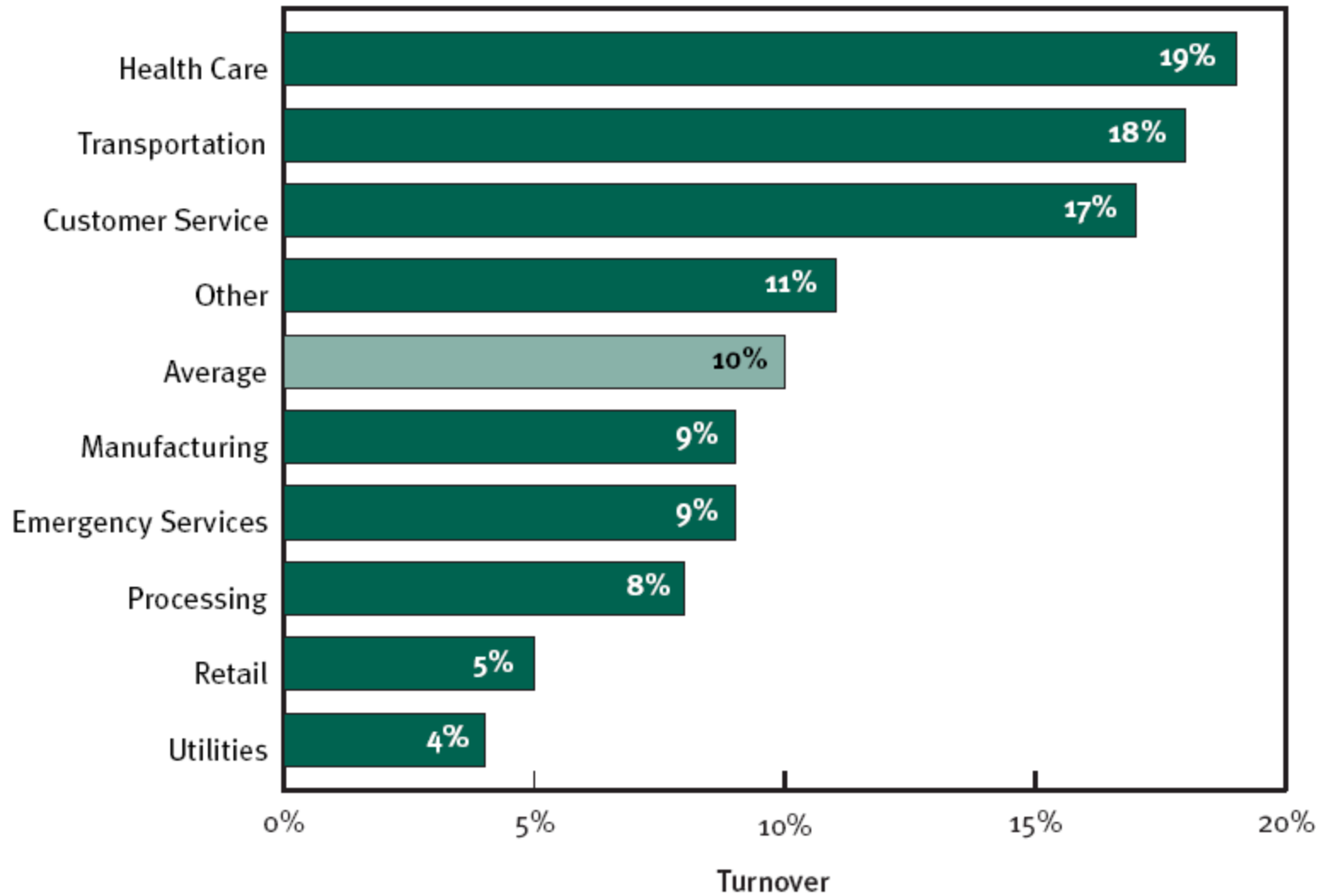


- Relationship between shiftwork and increased traffic accidents
 - 41% of shiftworkers report fighting sleep/nodding off while driving, 28% of day workers (NSF)
- Probability of falling asleep at the wheel is doubled with rotating shifts, and 6 times higher with fixed night shifts (AAA)
- 19% of nurses report “having a commuting accident driving back home” as one of three top health/safety job-related risks (ANA)

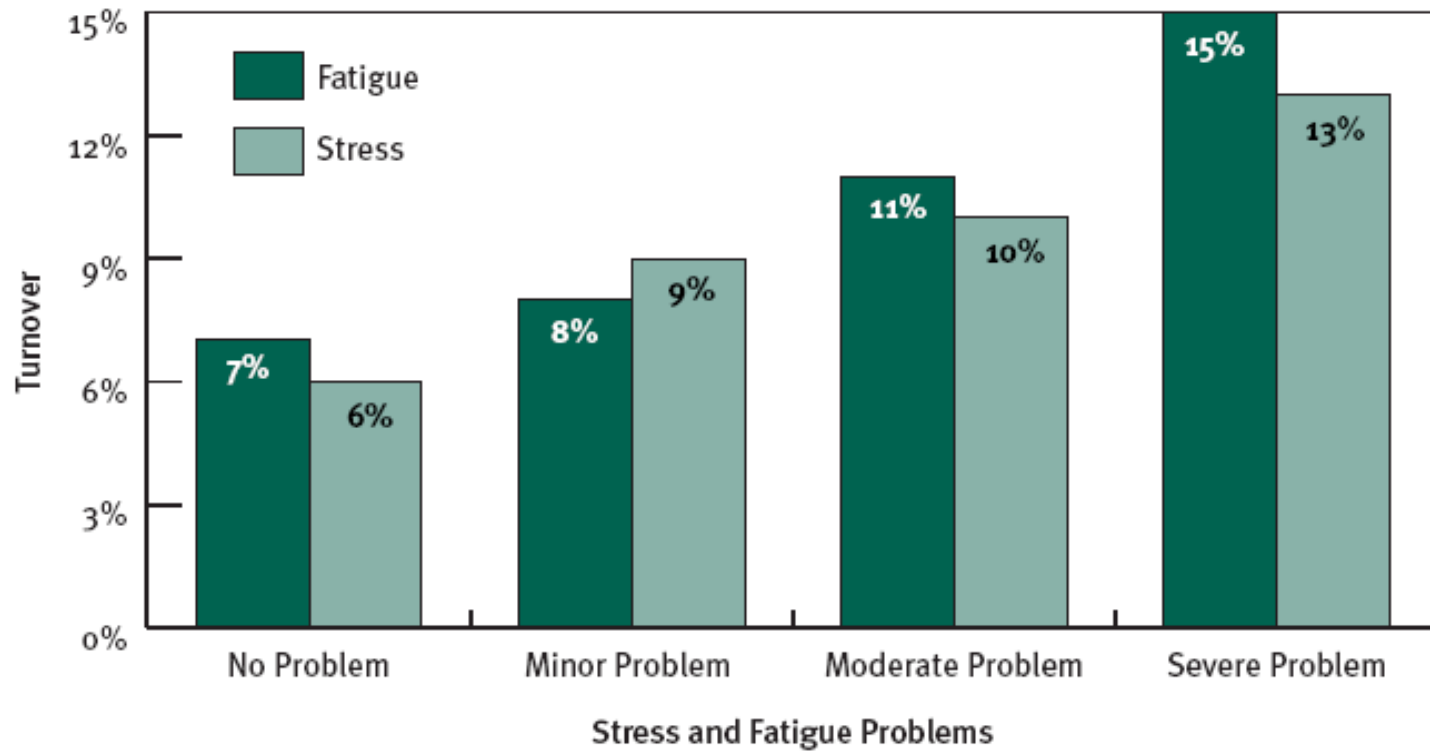
ABSENTEEISM



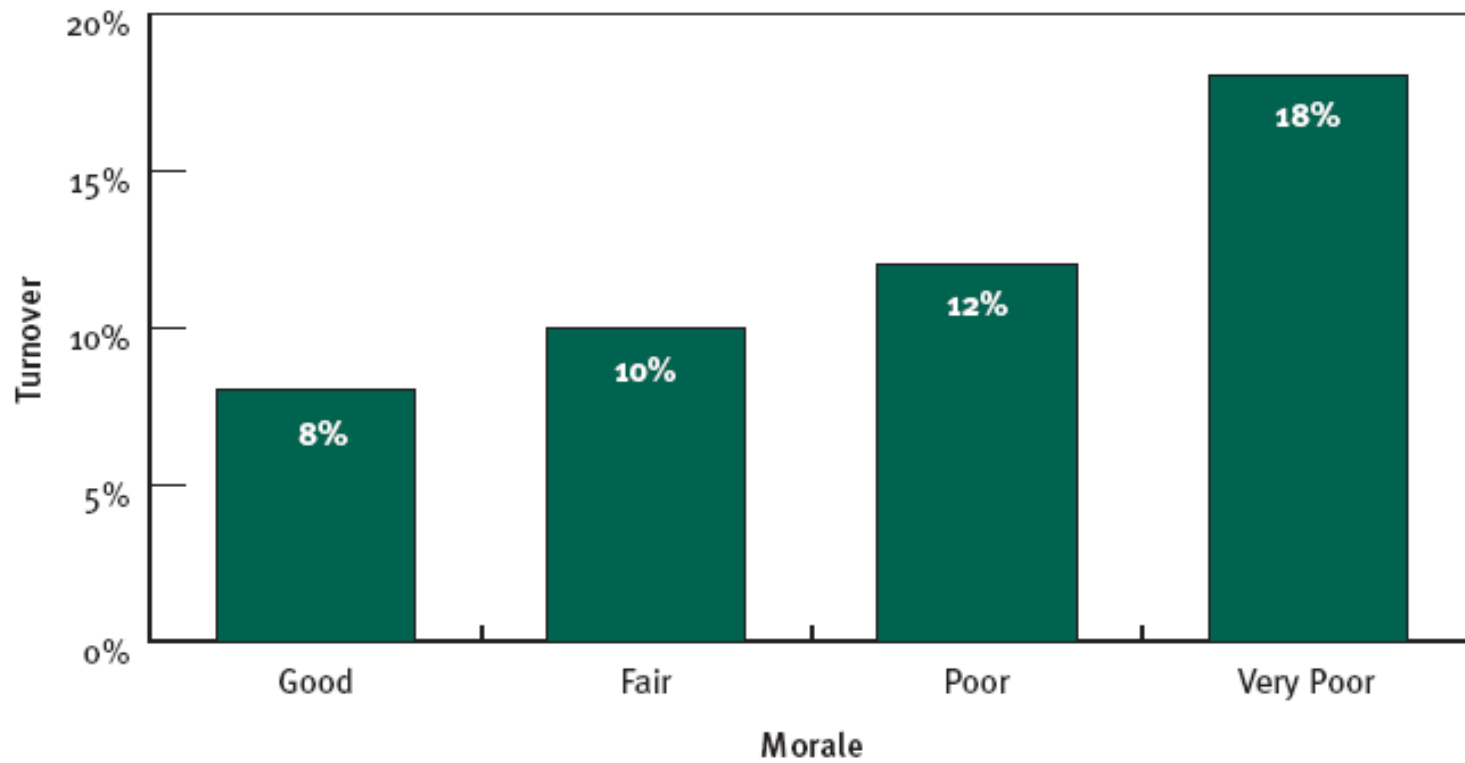
TURNOVER



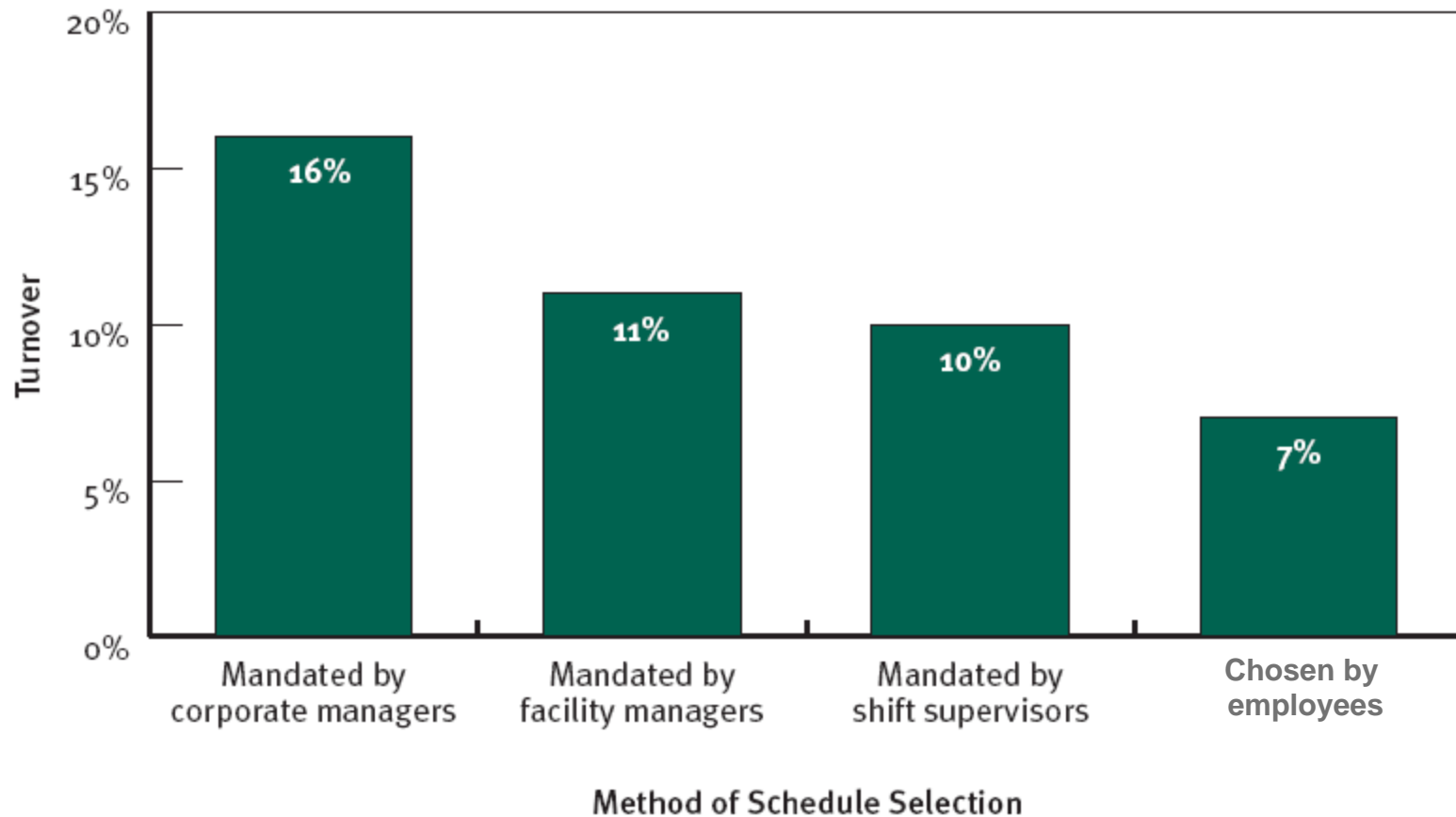
TURNOVER, STRESS, AND FATIGUE



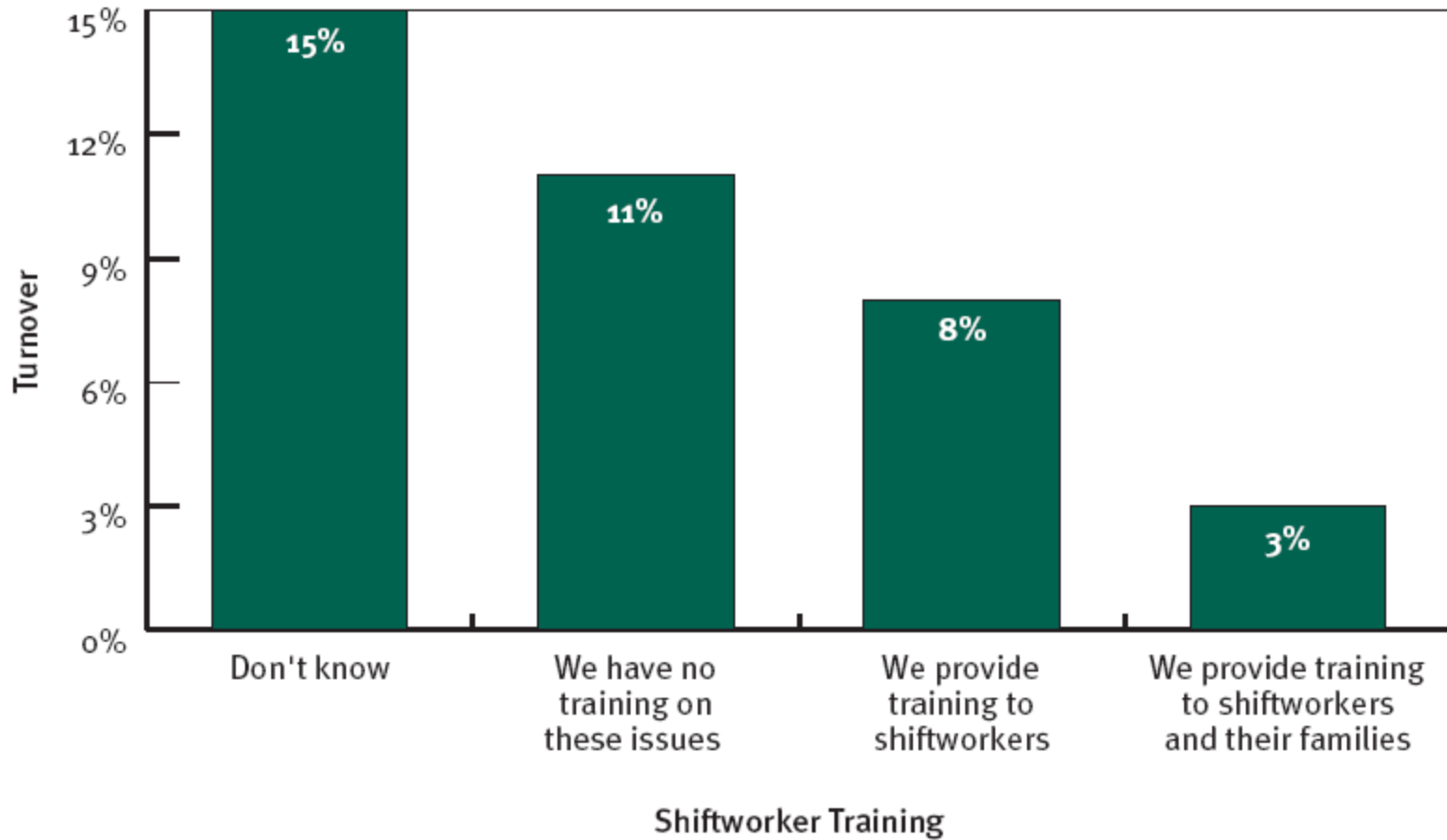
TURNOVER AND MORALE



TURNOVER AND SCHEDULE SELECTION PROCESS



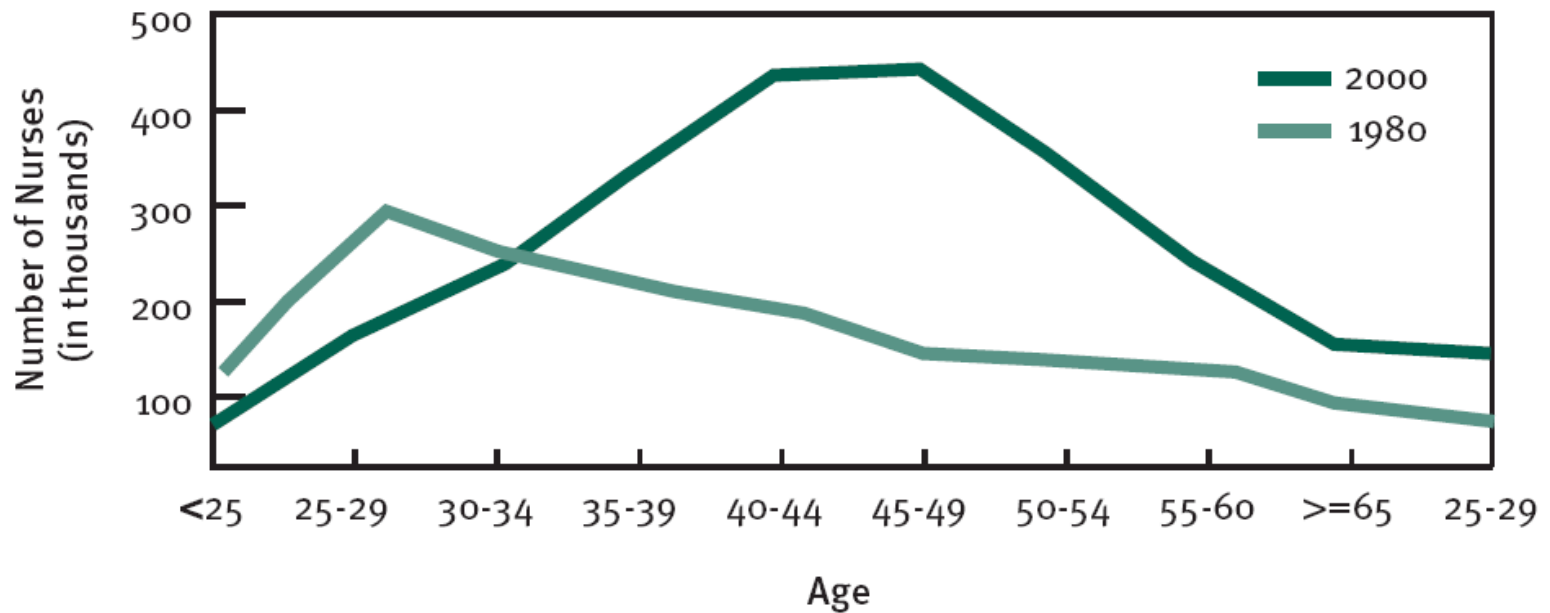
TURNOVER AND TRAINING ON COPING WITH SHIFTWORK



SHORTAGES AND AGING



- Fewer people are entering the profession
- By 2010, 40% of nurses will be > 50 years old
- Half of today's nurses will be at retirement age by 2020



SOLUTIONS: SOLVING STAFFING SHORTAGE



- Create Organizational Cultures of Retention
- Bolster the Nursing Educational Infrastructure
- Establish Financial Incentives for Investing in Nursing
- Improve overtime situation and work/life balance (difficult to do without hiring)
- Agency for Healthcare Research and Quality study
 - Increasing nurse staffing levels does not significantly decrease a hospital's profits, in contrast to increases in non-nurse staffing

SOLUTIONS: IMPROVING NURSES' SAFETY AND WELL-BEING



- Educate the organizational infrastructure
 - Build consensus for change
 - Obtain needed support for change
- Scheduling and work hours
 - Implement biocompatible work schedules
 - Set limits on the number of hours that can be worked
 - Eliminate mandatory overtime
 - Add predictability to overtime
 - Within confines of hospital needs, allow care groups to choose their own schedules (fairly, not politically)
- Train nurses to better cope with the demands of shiftwork

SOLUTIONS: POLICIES



- Promote legislation that addresses workplace safety (i.e., “Needlestick Safety and Prevention Act”, lifting policies)
- Overtime regulations
- Work conditions improvement (Magnet Hospital Program)
- Replace a “culture of blame” by a “culture of safety”
- Re-evaluate work policies, practices and procedures
- Implement alertness recovery procedures
- Screen and treat sleep disorders
- Install fatigue analytics/reporting system to monitor progress

CONCLUSIONS



- Critical shortages in nursing positions
- Immigration is controversial/political solution
- The nursing population is aging – over 50 by 2010
- Absenteeism and turnover continues to be high
- Many injuries and accidents linked to fatigue from working long or irregular hours
- Nurses, patients, and profits suffer if too few nurses are employed
- Nurses experience the same problems as other shiftworkers, and need to be trained on how to better cope
- Need to optimize scheduling and staffing levels



THANK YOU