




Slide 4

### Sleep and Health

- Sleep deficits (and excess) may lead to adverse outcomes with changes in endocrine, metabolic and immune pathways (Cappuccio et al., 2010)
  - Mortality (U-shaped), cardiovascular disease, hypertension, diabetes, and depression (Ayas et al., 2003; Gangwisch et al., 2008; Goffeys et al., 2005; Patel et al., 2008)
  - Obesity (measured as BMI) in cross-sectional and longitudinal studies (Singh et al., 2005; Marshall et al., 2008; Schoenborn and Adams, 2008; Landerdale et al., 2009; Di Milla & Mummary, 2009; Theorell-Haglow et al., 2010)
  - Traffic "accidents", work-related injuries and "accidents" (Connor et al., 2002; Dembe et al., 2006; Folkard and Lombardi, 2005; Lombardi et al., 2010)

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Slide 5

### BMI and Safety

- Higher BMI and obesity have been shown to increase injury risk in vehicle drivers (Whitlock et al., 2003) and in occupational settings
  - Obese workers (BMI  $\geq$  30) were reported to have a higher risk of falls, sprains and strains, and general occupational injury (Chau et al., 2004)
- However:
  - Systematic reviews of the literature have reported mixed findings

Suggesting further examination of the association between obesity and injury risk using studies with **sufficient sample size and control for confounding variables** (Polack & Cheskin, 2007)

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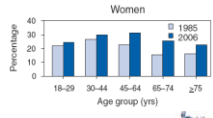
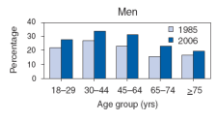

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Slide 6


### Trends in Sleep Duration in the US

- Percentage of Adults Aged  $>18$  Years Who Reported an **Average of  $\leq 6$  Hours of Sleep per 24-Hour Period**, by Sex and Age Group — National Health Interview Survey, United States, 1985 and 2006



Source: MMWR, February 29, 2008 / 57(08):209.

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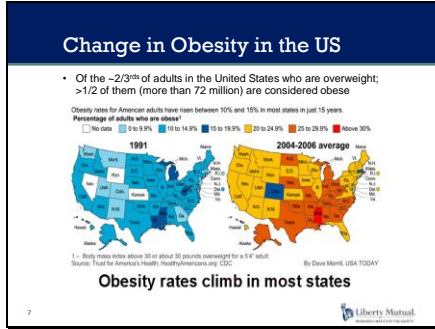
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Slide 7




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Slide 8

**Study Objective**

- Short sleep and high BMI have been associated with an increase in work-related injury risk in separate studies, however,
  - it has not been examined whether these two factors independently affect work injury risk? (e.g., exhibit an additive effect) or
  - if BMI modifies the effect of short sleep on injury risk or vice-versa (e.g., interactive effect)

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Slide 9

**Study Design**

- Seven years of pooled data (2004-2010) from US National Health Interview Survey (NHIS)
- Since 1957, annual, nationwide, cross-sectional sample survey of ~33,300\* households and ~86,000\* persons (varies by year/budget)
  - Multistage area probability design creates a representative sampling of all US households (Vital Health Stat 2, 2000; Moriarty, 2002)
    - Each person has a known non-zero probability of selection
    - Weighted for over-sampling adjustments for gender, age, race/ethnicity, and non-response
    - Sum of the weights is the size of the US civilian non-institutionalized population

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Slide 13

### Statistical Analysis

- Analytic SAS Survey procedures
  - Adjusting for complex sampling design: weighting, stratification, and clustering
- Weighted annualized work-related injury rates estimated across *a priori* defined categories of daily sleep
  - Stratified by BMI categories: healthy weight (BMI <24.99)<sup>1</sup>, overweight (BMI 25 - 29.99), and obese (BMI ≥30) \*includes underweight (-1% of data)
- Weighted logistic regression modeling used to estimate adjusted injury risk across categories of daily sleep hours and BMI
  - Controlling for age, gender, education, race/ethnicity, working hours, industry, occupation, and type of pay

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Slide 14

### Study Sample and Response Rate: National Health Interview Survey (2004-2010)

NHIS Survey Year	Households	Persons	Workers <sup>1</sup>	Interviewed for Usual Sleep Hours and BMI <sup>2</sup>	Overall Response Rate <sup>3</sup>
2004	36,579	94,460	40,808	17,304	72.5
2005	38,509	98,649	43,274	17,450	69.0
2006	29,204	75,716	33,265	13,484	70.8
2007	29,266	75,764	33,556	12,871	67.8
2008	28,790	74,236	32,589	11,934	62.6
2009	33,856	88,446	36,651	14,692	65.4
2010	34,329	89,976	36,958	14,156	60.8
<b>Total</b>	<b>230,533</b>	<b>597,247</b>	<b>257,101</b>	<b>101,891</b>	<b>67.0</b>

<sup>1</sup>Persons, age 18-74 years who reported "working at paid job" in the previous week.  
<sup>2</sup>Sample Adults, age 18-74 who reported both average sleep hours in a 24-hour period and height and weight to calculate BMI.  
<sup>3</sup>Abstracted from NHIS documentation for each respective year.

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### Interviewed Worker Characteristics: NHIS (2004 – 2010)

Characteristic	Number of Workers Interviewed	Weighted Percent
<b>Gender</b>		
Male	51,584	51.71
Female	50,307	48.29
<b>Age (Years)</b>		
18-29	22,892	23.80
30-54	61,271	58.45
55+	17,728	17.75
Mean ± S.E.M. 41.06 ± 0.08		
<b>Work-Related Injury</b>		
Injured <sup>1</sup>	723	0.73
Non-injured	101,168	99.27
<b>Weekly Work Hours<sup>1</sup></b>		
30 h or Less	17,834	17.95
31-40 h	54,586	52.18
41-50 h	16,893	17.74
51+ h	11,589	12.13
<b>Total</b>	<b>101,891</b>	<b>100.00</b>

<sup>1</sup>Most frequent injuries were overexertion (24.4%), fall (22.8%), and cut/laceration (15.0%). 1989 subjects missing weekly work hours.

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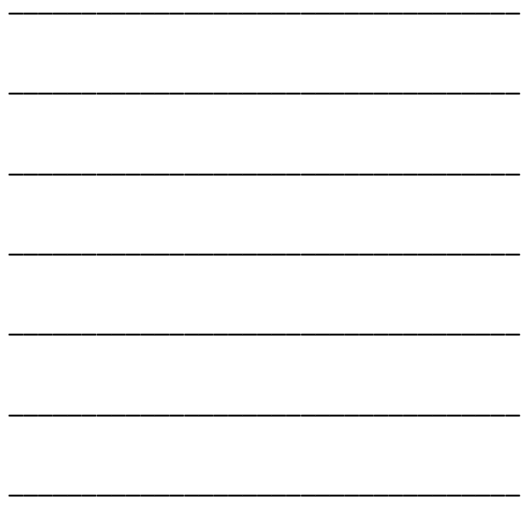
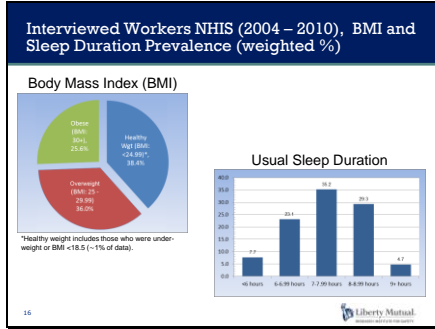
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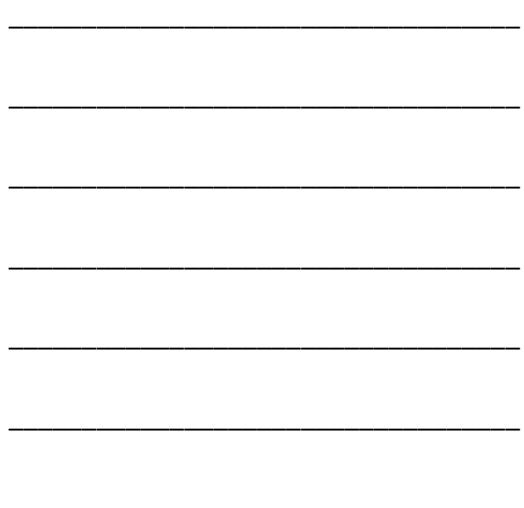
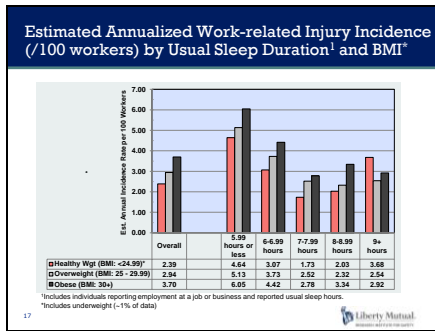
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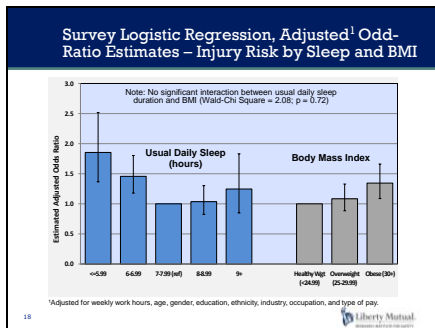
Slide 16



Slide 17




Slide 18



Slide 19

**Study Strengths**

- Pooling 7 years of NHIS injury data
  - Significantly increased statistical power
  - Reduced standard error of estimate
  - Ability to analyze smaller sub-groups
- Strong external validity
  - Response rate 67% among sampled adults
- Overcomes many shortcomings of other national based systems
  - Increased recall accuracy (severity defined as seeking medical treatment)

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
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Slide 20

**Study Limitations**

- 3 month recall of injuries may under-estimate rate of injury (unlikely to be differential across BMI or sleep categories)
- Components of BMI (height, weight) are self-reported → potential information bias (unlikely to be differential across categories of sleep or injury)
- Usual sleep patterns may not be representative of sleep time or sleep quality at the time of injury
  - Daily variability may make it difficult to integrate into "usual" and may also be differential across sleep length
- Cross-sectional design → should be confirmed within a large cohort study, where a causal relationship can be established

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Slide 21

**Summary**

- These results from a large representative sample of US workers suggest:
  - a significant *increase* in work-related injury risk for reduced daily sleep duration (<7 h), regardless of body mass
  - a significant *increase* in work-related injury risk for obese (BMI 30+) workers, regardless of daily sleep duration (co-morbidities, more hazardous work, healthy worker effect?)

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Slide 22

**Conclusions**

The independent additive risk of these factors on work-related injury is *potentially modifiable*!

- Given the high prevalence of workers reporting,
  - high BMI (36.0% overweight and 25.6% obese)
  - low sleep durations (23.1% <7 h, 7.7% <6 h)
- ✓ Work-related safety and health prevention programs should consider approaches to reducing fatigue and encourage healthy weight

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Slide 23

**Publication**

Information Sciences Institute

**Independent Effects of Sleep Duration and Excess Weight on the Risk of a Work-Related Injury: Evidence From the US National Health Interview Survey (2006-2010)**

**David A. Lombardi<sup>1</sup>, Alexander M. Smith<sup>1</sup>, and Dennis L. Scharf<sup>2</sup>**

1. Liberty Mutual Research Institute for Safety, Liberty Mutual Group, 100 Worldway Dr., Needham Heights, MA 02459; 2. National Institute for Occupational Safety and Health, 1015 North Meridian St., Cincinnati, OH 45204

*[Abstract text follows]*

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Slide 24

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