Influence of circadian rhythms on safety at work

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Fatigue is a contributing factor of industrial incidents

Many studies analyzed the distribution of incidents throughout the 24h-day
- Vehicular accidents
- Medical incidents
- Human errors in technical operations

Major findings:
- Increased sleep tendency during 2-7 a.m.
- To a lesser degree between 2-5 p.m.
- Pattern of sleepiness has been replicated in clinical studies
- Can be explained by „two process model of sleep regulation“ (Borbély 1982)

Hypothesis

- Light is the most important zeitgeber for the circadian system
- Many studies show that the human clock synchronizes to sun time
- Changes in the daylight pattern occur on a seasonal and geographical basis
- Roenneberg (2007):
  - Adaptation of the chronotype to the time of sunrise
  - In accordance with the later time of sunrise in western regions of Germany the chronotype shifts to a later time from east to west
- Our hypothesis:
  - Seasonal and geographical changes in the daylight pattern influence the time of industrial incidents
- **Combination of two databases from German Environment Agency:**
  - ZEMA
  - ZP-Info
- **Collection of incidents focuses on release of chemical substances**
- **Serious industrial incidents must be reported to the authorities pursuant to the 12th Federal Immission Control Ordinance**
- **The Central Reporting and Evaluation Office for Major Accidents and Incidents in Process Engineering Facilities (ZEMA) records events**
- **Incident notification is sent to the BAuA for information purposes**
  - Notification form
  - Cause analysis
  - Expert reports
Method

- **Number of incidents:**
  - 2884
- **Period of investigation:**
  - 1990-2015
- **Variables taken into account:**
  - Date
  - Time
  - Geographical position (longitude/latitude)
  - Season
  - Cause of incident
- **Modification:**
  - Correction for Central European Time
- **Filter/Restrictions:**
  - Germany
  - Human error
  - Daytime (8 a.m.- 4 p.m.)
- **Incidents left:**
  - 252
Results – seasonal pattern

- Data was divided according to four seasons
- Sunrise times differ significantly between the seasons (earlier sunrise in summer, later sunrise in winter)
- In compliance with our hypothesis we found:
  - Shift in the median of incident time that corresponds to the shift in sunrise time
  - Significant difference between summer and winter
  - No difference between spring and autumn
  - No seasonal pattern in medians of technical or organizational errors
Results – geographical pattern

- **Natural difference in sunrise time between east and west Germany:**
  - $6^\circ$-$15^\circ$ longitude = 36 min.
  - Slope: -0.0667

- **In compliance with our hypothesis we found (not significant):**
  - Shift in incident time from east to west
  - $6^\circ$-$10^\circ$ longitude = 20 min.
  - Slope: -0.083
  - $10^\circ$-$15^\circ$ longitude = 10 min.
  - Slope: -0.042
  - $6$-$15^\circ$ longitude = 30 min.

- **Only 6 minutes deviation from hypothesis**
Discussion

Limitations:

- **Unconsidered confounder:**
  - Time spend on the job / working breaks
  - Shift schedule
  - Type of task / work
  - Individual factors: sleep deprivation, chronotype, light history etc.

- **Dangerous assumptions:**
  - Constant amount of people working from 8 a.m. to 4 p.m.
  - Small database

Conclusion:

- Preliminary results
- Incident time shows a seasonal pattern with a shift to earlier times in summer and later times in winter
- Incident time shows a geographical pattern with a shift to later times from east to west

Outlook:

- Would be interesting to analyze workplace accident data
- Circadian influences are not considered in risk assessment so far
Thank you for listening... 😊