NASA Applied Sciences Program
Public Health Review

Nowcast of Atmospheric Ionizing Radiation for Aviation Safety (NAIRAS) Model

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Flight Crew Research at NIOSH

- 200,000 US workers in commercial aircraft cabins and 500,000 workers worldwide
- NIOSH’s mission is to generate new knowledge in the field of worker safety and health and to transfer that knowledge into practice
- Study of the health effects arising from aircraft cabin work is a significant area of research for NIOSH
- www.cdc.gov/niosh/topics/flightcrew
Air Cabin Exposures

- Atmospheric Ionizing Radiation
- Circadian Rhythm Disruption
- Airborne Contaminants
- Ergonomic Factors
- Stress
NIOSH Flight Crew Studies

Health Effects

Reproductive
• Ovulatory Function
• Pregnancy Outcomes

Cancer
• Incidence/mortality in FAs and pilots
• Breast cancer among FAs
• Cytogenetic effects in pilots

Other
• Respiratory Symptoms
• Downsizing and mortality

Exposure

Radiation
• Measure
• Model

Circadian Disruption
• Desynchronization
• Sleep disturbance

Other
• Physical work demands
• Psychosocial factors
• Cabin air quality
• Bioaerosol levels
Background for Flight Crew Regulation of Radiation Exposures: ICRP 60 (1991)

- ICRP 60 (1991): first time that flight crew and space workers exposed to natural background radiation were considered *occupationally exposed*
- ICRP is *the* authoritative international scientific body for health effects of radiation
- EU responded with legislation in 1996, effective in 2000
- No US response as yet
Radiation Exposure

• Occupationally Exposed Flight Crew
  - Scheduled airlines ~ 500,000 workers worldwide
  - Unscheduled business jets?
  - Air couriers?
• Ionizing radiation is an IARC carcinogen
• Biologic role of energetic particles is important, especially neutrons
• Annual radiation dose exposure
  - 0.2 - 9.1 milliSieverts per year (mSv/yr)
  - Sources: NIOSH & 8 other sources worldwide
Radiation Dose Estimation

- How best to measure cosmic radiation doses to individual?
  - Function of altitude, latitude & flight distance

- Compare measured doses with FAA CARI-6 in 38 flights

- Study will be use NAIRAS to compute more accurate dosages
Implications for Flight Crew

- Dose equivalent rates
  - 0.9 - 6 uSv/block hour

- Flight Attendants work 600 - 900+ block hrs/yr

- Annual doses at 900 block hrs/yr for our study
  - 0.8 - 5.4 milliSieverts (mSv)

- **Compare:** ICRP Occupational Limit: 20mSv/year
  - ICRP Limit: 1 mSv/term of pregnancy
Radiation Biomarker Study in Pilots

- Pilots may be exposed to biologically significant doses of cosmic radiation
- 83 airline pilots, 50 referents; age 36-56, male, current non-smokers
- Pilot lifetime flight histories from records
- Questionnaire: health, non-occupational radiation, lifestyle factors, and family history of cancer
- Blood sample for analysis of chromosomal aberrations as a marker of cumulative cosmic radiation exposure & damage
- 1st publication, 2008: Pilot translocation frequency increased significantly with increasing flight years
- Expected 2010: Reanalysis with assessment of individual flight histories
Cohort Mortality Study of Pilots

- Personnel/medical records of 6,000 former Pan Am pilots, 1953-91

- Determine if pilots are at an increased risk of mortality (all causes, cardiovascular disease & cancer)

- Evaluate relationship between mortality and exposures, including cosmic radiation and circadian rhythm disruption

- Major study findings expected in 2010
Flight Attendant Cancer Incidence Study

- Conducted among female flight attendants
- Focus is breast cancer
- No national cancer registry in U.S.
- Identifying cancers from interviews & state cancer registries
- Collected data on potential confounders from respondents
- Data analysis planned in 2010
Flight Attendant Reproductive Risks

- Flight attendants may experience increased risk of:
  - Miscarriage
  - Menstrual disorders
  - Other adverse reproductive outcomes

- Is work as a female flight attendant associated with adverse reproductive effects?
Ovulatory Function Study

• Characterize menstrual function in 45 flight attendants and 26 teachers (comparison group) in two major cities

• ~50 indices of menstrual/hormonal function

• Markers of infertility or sub-fertility

• Links with adverse reproductive outcomes and adverse exposure

• Major study findings expected in 2011
Reproductive Outcomes Questionnaire Study

- 2,273 FAs and 381 teachers, age 18-40

- Exposure:
  - 2 million individual flight records
  - Exposures in critical reproductive time windows for each FA
  - Cosmic radiation dose (including travel through solar particle events), circadian disruption and sleep disturbance

- Reproductive Outcomes:
  - Spontaneous abortions, all major birth defects, menstrual function, time to pregnancy (fertility), low birthweight and preterm birth
Reproductive Health Studies

• **Significant strengths:**
  - Detailed flight history records
  - Exposure assessment developed for flight exposures
  - Multiple health outcomes

• **Unique contribution to understanding health effects**

• **Major study findings expected in 2010+**
Summary in the Literature

- **Biomonitoring methods** worked well in this mobile study population (JOEM, 2002).

- **Cosmic radiation dose** to flight crew can be determined from individual flight segments (AJIM, 2000).

- Use of detailed company **flight histories** may give different results than questionnaire data (Aviat Space Environ Med 2004).

- Relations between flight attendant **job stressors**, psychological distress, and job satisfaction have been characterized (JOEM 2003).

- Flight attendant **workload** was characterized and measured with methods developed (Proc Hum Factors Ergo Soc Conf 2004).

- Flight attendants experience increased **circadian disruption** and it can be measured in larger studies (Scand J Environ Health, 2003; Am J Epi 2000)
NIOSH Flight Crew Studies

• Significant strengths:
  – Detailed flight history records
  – Exposure assessment developed for flight exposures
  – Multiple health outcomes
• Improving the “dose” in “dose response”

• Unique contribution to understanding health effects
  – Major study findings published 2009+