

# 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](http://www.cdc.gov/niosh/topics/flightcrew)



# Air Cabin Exposures

- **Atmospheric Ionizing Radiation**
  - **Circadian Rhythm Disruption**
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- **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  $\mu\text{Sv}/\text{block hour}$
- 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
- 1<sup>st</sup> 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+