

Cosmic Radiation and Its Effect on Pregnancy

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A. Cosmic Radiation

- Radiation is the transfer of heat energy by electromagnetic waves.
- Form of ionizing radiation.
- Charged particles from the solar system interact with atmospheric gases.
- Alpha (α) particles (He) and Protons (H).
- Secondary radiation in the form of neutrons.
- Deflected by Earth's geomagnetic field.

a. Radiation Units

- Rate of radioactive decay: Curie (Ci) measures activity of a source.
- Air exposure: Roentgen (R)
 - I R - ability to deliver 8.78 mJ/kg of dry air.
- Absorbed dose: measured in rad or Gray (Gy) Indicates energy absorbed.
 - 1 Rad = 0.01 J/kg. 100 rad = 1 Gray (Gy)
- Biological effectiveness: rem or Sievert (Sv)
 - Rem (roentgen equivalent in man) - rads x RBE' factor,

b. Permissible Radiation

- Baseline radiation: 0.06 μSv/b-r (0.006 mrem/hr)
- General public: 1 mSv/yr (100 mrem)
- Radiation Worker: 20 mSv/yr
- Aircrew: 50 mSv/yr
- Fetus: 0.5 mSv/mo or 2 mSv
- Pregnant Woman: 2 mSv (in 9 mo period)
- Based on current knowledge and experience with Hiroshima, Nagasaki, Chernobyl

c. In-Flight Radiation

- Altitudes
 - ground level : 0.06 μSv/hr
 - 35,000 ft (10.6 km) : 6 μSv/hr
- Latitudes
 - Equator vs polar regions
- Flight time
- Commercial airline vs charter executive jet.
- Solar flares

d. Solar Flares

- Charged particles ejected from the Sun rarely contribute to cosmic radiation.
- Solar flares occur in roughly 11 year cycles.
- Greatest record flare was in 1956 and produced high levels of radiation. (10 mSv/hr @ 42,000 ft).

Sample Flights (One-Way)

Origin – Destination	Highest altitude	Air time (hrs)	μSv (mrem)	Annual mSv
Miami -Tampa	24,000	0.6	0.4	0.4
Houston-Austin	20,000	0.5	0.1	0.2
NYC-San Juan	37,000	3.0	13 (1.3)	3.5
NYC-Chicago	39,000	1.8	12	5.0
London - LA	39,000	10.5	80	6.9
NYC – Athens	41,000	9.4	93	9.1
NYC-Tokyo	43,000	13	99 (9.9)	7.0

e. Radiation and the Fetus

- Current knowledge based on animal studies and survivors of Hiroshima, Nagasaki, Chernobyl.
- Actively dividing cells are susceptible to radiation.
- Exposure during early organogenesis may lead to growth retardation. (e.g., microcephaly)
- Crucial time for human fetus is between 8 and 15 weeks - neural cells proliferate and migrate. Estimated drop of 0.03 IQ points per mSVT!
- Atomic bomb survivors have demonstrated
 - increased lifetime risk for leukemia
 - dose-related decreases in cognitive function.

B. Effect of Cosmic Radiation**• Question**

- Does in-flight cosmic radiation have an effect on pregnancy and its outcome?

• Hypothesis

- In-flight cosmic radiation has a significant effect on pregnancy and its outcome.

a. Risks of Prenatal Irradiation

- In utero
 - 1st wk -death
 - 3rd to 8th wk - structural abnormalities
 - 9th to 26th wk - cognitive dysfunction
- Radiation-induced genetic defects
 - General population 600 in 10,000 (6%)
- Childhood cancer
 - Leukemias in the setting of marrow irradiation

b. Outcomes

Primary

- Birth Defects
- Late Fetal Deaths
- Miscarriages
- Pregnancy Termination

Secondary

- Cognitive function (Mental retardation, IQ testing)
- Childhood cancers

C. Overall Study Design

- Observational Prospective Cohort Study
- Female crewmembers in childbearing age are followed to identify exposure and its effect. Recruited by airport/Ob-Gyn office based ads. Flight logbooks and monthly web-based/telephone questionnaires. Primary care and Ob/GYN follow-up at NYPH.
- Events are compared to NYC/national database on birth rates / cancer incidence.

a. Cohort Entry Criteria

i. Inclusion

- Female in childbearing
- age (18-39 y/o)
- Currently employed crewmember in commercial or private airline
- NY/NJ based

ii. Exclusion

- On known teratogenic medications
- Previous radiation
- Substance abuse

b. Cosmic Radiation and Its Effect on Pregnancy

i. Introduction

ii. Hypothesis (HA)

In-flight cosmic radiation affects pregnancy outcome by increasing the rate of spontaneous abortions and birth defects.

iii. Methods

1. Outcomes

Primary

Pregnancy Outcome

- Spontaneous abortion
- Fetal Growth Retardation
- Birth defects

Secondary

Childhood cancers

Cognitive function

Mental Retardation

IQ testing

2. Study Design

Prospective Cohort Study, Observational Female flight attendants in the childbearing age are interviewed and followed during a five year period. Radiation exposure would be quantified by frequency and nature of travel. Controls would consist of age-matched women from New York/New Jersey who have contacted the Teratogen Information Service. Monthly follow-up regarding general health, perinatal, neonatal, and developmental statistics.

3. Data collected

- MD conducts a structured interview Demographics, Maternal age, Gravidity, Parity, Maternal tobacco/alcohol/illicit drug use, Medication exposure, Maternal medical conditions, Maternal maintenance medications, Family history.
 - Monthly Web-based / telephone follow-up questionnaires.
 - Review of flight logbooks.
 - Primary Care and Ob-Gyn Care at NYPH

- Record perinatal/neonatal complications, gestational age at delivery, birth weight, presence and identity of any birth defects, postnatal growth and development

iv. Statistical Analysis

- Chi-square test will be used to determine the statistical significance of any difference between the groups (exposed/not exposed).
- Stratification of population into subgroups of radiation exposure according to flight logs.
- Logistic Regression of potential confounders (parity, induced abortions, age)
 - Maternal age
 - Gravidity/Parity
 - Smoking status

v. Sample Size

Incidence of SAB / growth retardation in the population: 6%

Literature reports a possible 9% rate of these events in flight attendants.

vi. Power Analysis

Projected proportions Group 1 : 0.6, Group 2 : 0.9 result in N per group 1275

(For 90% CI to a 5% significance level)

vii. Subjects Selection

Population

- Female flight attendants in the childbearing age
- New York/New Jersey based
- Cohort Entry criteria
- Inclusion - female, childbearing age, employed, NY/NJ based
- Exclusion - teratogen exposure, previous radiation exposure, substance abuse

viii. Informed consent

Recruitment of flight attendants via advertisements placed in airlines, airports, and Ob-Gyn offices. Controls would be recruited from NY/NJ teratogen information service and registry. Women selected would have been cleared from a potential teratogen exposure with the structure interview above. Patients in the TIS have contacted the agency with questions regarding possible exposures.

ix. Exposure assessment

Direct: personnel-monitoring device (film badge)

Indirect: questionnaire, logbook

D. References

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