

Galactic radiation exposure during commercial flights: Is there a risk?

Background: High-energy subatomic particles emitted from outside our solar system continuously bombard the Earth. On the Earth's surface, we are relatively shielded from this "galactic radiation" by the atmosphere. However, during high-altitude commercial flights, people are at risk of increased exposure to primary and secondary galactic ionizing radiation and to solar ionizing radiation (see Box 1). The impact of acute and chronic exposure to such forms of radiation has been studied for 4 decades,¹⁻⁵ and safe exposure limits have been recommended.^{6,7}

Management: Occupational and lifetime risk-exposure limits are derived from constantly evolving data from the fields of radiation biology, epidemiology, and astrophysics and atmospheric physics.

In general, the greater the altitude of a flight, the greater the exposure to ionizing particles. As well, cosmic particles

are deflected to a significant extent by the magnetic field accompanying the solar wind. Thus, flights at lower latitudes (nearer the equator) typically involve less radiation exposure. Furthermore, the strength of the solar wind increases and decreases over cycles of about 11 years, and the galactic radiation entering the atmosphere varies inversely with these cycles of solar activity.⁷ Estimates of the solar wind intensity (the "heliocentric potential") can be determined for any given month and are monitored regularly by the SOHO (Solar and Heliospheric Observatory) spacecraft (sohowww.nascom.nasa.gov).

Software developed at the US Federal Aviation Administration (FAA) Civil Aerospace Medical Institute allow computations of in-flight galactic radiation exposures going back to January 1958. The current version of the software, known as CARI-6 (www.cami.jccbi.gov/AAM-600/Radiobiology/600radio.html), uses data on heliocentric potential as well as data provided by the user such as flight date, altitude, duration and points of departure and arrival, to provide a rapid estimate of the ionizing radiation dose received during a specific flight. The current SI unit for the dose of absorbed equivalent ionizing radiation is the sievert (Sv). The older unit sometimes still reported is the "rem" ("roentgen equivalent man"), with 1 Sv = 100 rem.

Typical exposures range from 0.0001 mSv to 0.0644 mSv per flight.⁵ Table 1 shows examples of galactic radiation exposure calculated for people on 2 commercial flights that took place in January 2003. The annual maximum exposure proposed by the US FAA is 5 mSv.⁸ Even at the exposure level of 0.0644 mSv, it would take about 78 flights to reach the annual maximum.

Studies have estimated that the risk of dying of cancer from all causes is about 220 per 1000 population in the United States.⁸ Among crew members, radiation



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exposure from 20 years of high-altitude flight may increase this risk to 225 cancer-related deaths per 1000.⁸ Thus, aided by more specific estimates of galactic radiation exposure (e.g., those obtained using the CARI-6 software), physicians can counsel their patients that the actual risk of radiation harm from flying is low, lower in fact than the typical annual exposure to radiation from medical diagnostic equipment, which is usually in the range of 0.1–10 mSv.⁹

Tissues with large numbers of dividing cells are most susceptible to ionizing radiation. These include blood-forming tissues and gonads.⁶ Embryos, fetuses and children are at higher risk.⁶ Elderly people with mature tissues are at lower risk, because death from various causes would probably occur before radiation-induced cancer would. For pregnant women, the FAA recommends that they be limited to a total exposure of 1 mSv from the reported time of pregnancy, with no monthly dose exceeding 0.5 mSv.⁶ Health Canada recommends that pregnant women who expect to fly more than 200 hours during their pregnancy seek further information from the Radiation Protection Bureau of Health Canada (www.hc-sc.gc.ca/ehp/ehd/rpb/viron/cosmic.htm).

Prevention: In general, passengers on commercial flights would have less exposure to ionizing radiation than would crew members, although typically the exposures of crew members are still within the recommended safe limits. Some limited epidemiologic data suggest increased rates of disease such as cancer and leukemia among flight crews relative to the general popula-

Box 1: Types of radiation from outer space

- *Primary galactic ionizing radiation* consists of high-energy protons and alpha particles (helium nuclei) originating from supernovae or "exploding stars." Some heavier nuclei (e.g., tin and iron nuclei) are usually also interspersed with the primary galactic radiation particles.
- *Secondary galactic radiation* occurs when particles of primary galactic and solar ionizing radiation strike oxygen and nitrogen molecules in the Earth's atmosphere and dislodge "secondary" particles of neutrons, protons, electrons, muons and gamma rays.
- *Solar ionizing radiation* contains low-energy protons, alpha particles and electrons originating from the sun.

Table 1: Examples of levels of exposure to galactic radiation calculated for people on 2 commercial flights that took place in January 2003

Flight	Climb time, min	Cruise altitude, ft (m)	Cruise time, min	Descent time, min	Calculated level of exposure to galactic radiation
Ottawa to Miami	19	31 000 (9 450)	130	21	7.35 μ Sv (0.00735 mSv)
Halifax to Toronto	23	37 000 (11 280)	54	17	6.11 μ Sv (0.00611 mSv)

Note: μ Sv = microsieverts, mSv = millisieverts. Levels of exposure were calculated using the CARI-6 software program developed at the US Federal Aviation Administration's Civil Aerospace Medical Institute (available at www.camii.jccbi.gov/AAM-600/Radiobiology/600radio.html).

tion.^{10,11} There is no practical way to shield oneself from galactic radiation on flights. People who wish to seek the lowest levels of ionizing radiation should consider choosing flights at lower latitudes.⁶ In addition, avoidance of especially high-altitude flights, as are capable on supersonic jets such as the Concorde, could be considered. (Most commercial airliners cruise at altitudes of 20 000–45 000 ft [6100–13 715 m], but the Concorde is capable of flying at altitudes of 60 000 ft [18 290 m].) That being said, the Concorde has monitoring equipment and radiation-sensing equipment on board, which normally record radiation levels of 0.005–0.01 mSv/h.¹² An alert sounds if the level reaches 100 mSv/h, and a lower cruising altitude can be assumed to reduce exposure levels. In general, the shorter flight times of the Concorde yield lower total radiation exposures per trip than those experienced by crews on typical airliners flying the same trip.

Overall, the risks of exposure to

galactic ionizing radiation during high-altitude flights are small, but international exposure limits have been established to minimize the potential for harm. The science of estimating one's true exposure and its potential impact is complex and constantly evolving. Thus, clinicians should remain apprised of periodic updates on the topic in key publications such as *Health Physics* and *Aviation, Space, and Environmental Medicine*.

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