

# Self-Reported Flight Hours vs. Company Records for Epidemiologic Studies of Flight Attendants

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**Introduction:** Although there is increased interest in health effects studies of aircrew members, the differences between self-reported work history and company records, including effects on exposure assessment, are poorly characterized. **Methods:** We collected both self-reported work history and company records as part of a National Institute for Occupational Safety and Health biomonitoring study of reproductive hormones in 45 female flight attendants. These two sources of work history information were compared to identify differences which might impact the assessment of work exposures. **Results:** There appeared to be consistent overreporting of self-reported block time and number of flight segments compared with company record-based estimates. Overreporting in turn inflated the assessment of two important exposures: cosmic ionizing radiation estimated dose and time zones crossed. Factors including domicile, block hours per year of work, and length of employment affected the amount and direction of overreporting. Comparison to compensated credit hours, including nonflight hours, did not fully account for the overreporting. **Discussion:** Self-report of block time may or may not include compensated nonflight hours, resulting in differences when compared to company records. Exposure bias is likely to result if the complexities of self-report are not considered when writing questionnaires. Aircrew members should be asked for additional occupational information, and a comparison of self-report block time to a sample of company records should be considered prior to exposure assessment and epidemiologic analysis.

**Keywords:** aerospace medicine, epidemiologic methods, exposure assessment.

UNIQUE WORK EXPOSURES in the air cabin environment, including cosmic ionizing radiation and circadian rhythm disruption from travel through multiple time zones, have increased interest in health effects studies among aircrew members. In the last 2–3 yr, 10 new studies of aircrew mortality and cancer incidence have been published (5). Currently, the National Institute for Occupational Safety and Health (NIOSH) is conducting several reproductive health studies as well as a breast cancer incidence study among female flight attendants, and a cosmic radiation biodosimetry study among pilots.

The quality of aircrew epidemiologic studies depends on an accurate work exposure assessment. Company records containing flight histories suitable for detailed epidemiologic exposure assessment are generally maintained by United States airlines for periods ranging from 1–5 yr. This period of record availability is adequate for cross-sectional health effects studies and reproductive history studies, but records covering much

longer study periods (e.g., 20 or more yr) are necessary for cancer mortality and incidence studies. If company records are not available, another option is to administer a questionnaire which asks for self-report of work history over a period of years. However, the differences between self-reported work history and company records, including effects on exposure assessment, have not been characterized. We collected both self-reported work history and company records as part of a NIOSH biomonitoring study of reproductive hormones in female flight attendants. This presented an opportunity to compare these two sources of work history information and identify differences which might impact the assessment of work exposures.

## METHODS

The study protocol was approved in advance by the NIOSH Human Subjects Review Board. Each subject provided written informed consent before participating. Study methods for this biomonitoring study of flight attendants and teachers have been described previously (2,3,6). Two major airline companies were selected for this study, one with a domicile in Miami and the other with a domicile in Seattle. A total of 45 full-time flight attendants, ages 18–45 yr, were enrolled from company rosters in the 2 cities (21 from Miami, 24 from Seattle) for a study period of 4 mo. The Miami domicile and its flight attendants were international; 21 of the Seattle flight attendants flew primarily domestic routes. An interviewer-administered baseline questionnaire contained questions on occupational factors.

For aircrew members in epidemiologic studies, exposures to cosmic radiation and other work exposures are typically based on cumulative block time. In our study, baseline questionnaire occupational questions were used to estimate annual block time, time zones crossed,

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and number of flight segments. "Block" time is the time from block removal from behind the aircraft wheels at the origin city gate to block placement behind the aircraft wheels at the destination city gate, and generally can be derived from airline payroll records. Block hours per month were asked as "How many block hours do you usually fly per month as a requirement of your job? Include any company-required deadheading, positioning flights, or commuting, but not personal air travel." Additional questions were asked to estimate separate totals for commuting hours flown per month, usual number of time zones per segment, and usual block time per segment. A segment is an individual nonstop flight between two cities.

Individual flight history records ("company records") were also obtained for each flight attendant from the airlines. The company records contained the origin city, destination city, date, and local departure and arrival times for each bid and deadheading (positioning) flight segment flown during the study period. Cumulative block time, time zones crossed, and number of flight segments in the study period were calculated from each segment's local departure and arrival times adjusted for time zones and daylight savings time, and were used to calculate annual estimates.

"Pass" or "nonrevenue" employee-discounted recreational travel was also estimated from questionnaire and company record data, although both of these sources of information were less detailed than company records of work-related travel. The baseline questionnaire included questions on number of recreational segments, total block time, length of typical flight, and number of time zones crossed per typical flight in the last 6 mo; travel cities were not recorded. Recreational travel records obtained from the airlines included dates and travel cities, and included commuting flights for some flight attendants. Block time was estimated from these company records on the basis of existing city pair data.

Radiation dose estimates for each flight segment in the company flight histories were derived from the CARI-6 program. CARI is a computer model developed by the Federal Aviation Administration (1) which estimates the effective dose of cosmic radiation received by an individual on an aircraft flying between any two geographic locations. Data on city pair, date, and calculated block time for each flight segment were input to CARI-6 using an algorithm developed for this purpose (3). These dose estimates, cumulated for the 4-mo study period, were used to derive annual estimates. For self-reported questionnaire data, because only average block time per usual flight segment was reported, radiation dose was estimated from a continuous regression model based only on average self-reported segment block time [Estimated dose for a flight segment =  $-1.931 + 0.048 \times (\text{average block time}) + 0.0000389 \times (\text{average block time})^2$ ]. The regression model ( $R^2 = 0.88$ ) was derived from a set of 6,785 flights in August 1997, which included data from the study companies for the Miami and Seattle domiciles (3). The annualized dose estimate was the product of this segment estimated

dose and the self-reported estimated number of segments flown.

For 22 of the 24 Seattle-based flight attendants, company records of credit hours for each month of the study period were also available. Credit hours are the basis of flight attendant compensation, and may include work hours which are not actual flying hours (e.g., training time). Length of employment was also available for these flight attendants. SAS (4) was used for all statistical procedures, including descriptive statistics, tests of group differences, and correlation coefficients.

## RESULTS

In our study, based on company records, flight attendants traveled an average of  $253 \pm 125$  flight segments per year, totaling  $640 \pm 262$  block hours per year, including unofficial (commuter and recreational) travel. **Table I** compares self-reported questionnaire estimates to those derived from company records for official travel. There appears to be consistent overreporting of self-reported block time (**Fig. 1**) and number of flight segments compared with company record-based estimates. In turn, these sources of overreporting inflate the assessment of two important exposures (**Table I**): cosmic ionizing radiation estimated dose and time zones crossed [a measure or indicator of circadian disruption (2)]. Annual estimated radiation dose estimates, for example, were increased by 47–87%. The overreporting was most pronounced for official travel. Relatively minor differences with no overall directionality were observed between flight attendant estimates of recreational travel and our estimates from company records (data not shown).

Flight attendants at the two study domiciles had very different patterns of block time overestimation (**Fig. 2**). In Seattle, most flight attendants were flying relatively short routes, and overreporting was relatively constant (mean  $277 \pm 113 \text{ h} \cdot \text{yr}^{-1}$ ) regardless of how many block hours per year were flown. In Miami, with typically fewer but longer flights, overreporting decreased with increasing block hours per year.

To examine one possible source of the observed overestimation of block time, we compared the 22 Seattle flight attendants' estimate of block time with company-recorded compensable credit time, which includes block hours worked plus extra hours of credit for certain nonflying activities. **Fig. 3** shows that self-reported block time estimates by flight attendants are higher than their company-recorded credit time, which includes block and nonflight activities (mean estimated difference between self-report and company-recorded credit time,  $153 \pm 121 \text{ h} \cdot \text{yr}^{-1}$ ;  $p < 0.0001$ ). There was a weak positive correlation between length of employment and overreporting of block time ( $r = 0.37$ ;  $p = 0.09$ ).

## DISCUSSION

The design of our feasibility study allowed us to compare self-reported flight attendant flight hours to company flight records, which are the basis of compensation and thus unlikely to be under- or overreported.

TABLE I. BLOCK HOUR AND RELATED ESTIMATES FOR OFFICIAL TRAVEL FROM FLIGHT ATTENDANT SELF-REPORT AND COMPANY RECORDS AT TWO DOMICILES.\*

| Estimate  | Seattle       |                 |  | Miami          |                 |  |
|---|---------------|-----------------|--|----------------|-----------------|--|
|   | Self-reported | Company records | Self-reported minus company records <sup>†</sup> | Self-reported  | Company records | Self-reported minus company records <sup>†</sup> |
| Block hours/year (mean ± SD)                              | 906 ± 224     | 629 ± 186       | 277 ± 113 <sup>‡</sup>                           | 992 ± 149      | 605 ± 304       | 387 ± 276 <sup>‡</sup>                           |
| Number of flight segments flown/year (mean ± SD)          | 391 ± 113     | 316 ± 94        | 75 ± 91 <sup>‡</sup>                             | 301 ± 142      | 149 ± 100       | 152 ± 123 <sup>‡</sup>                           |
| Time zones crossed/year [median (interquartile range)]    | 352 (0, 428)  | 66 (39, 92)     | 235 (-42, 356) <sup>§</sup>                      | 451 (189, 705) | 183 (86, 275)   | 259 (3, 438) <sup>‡</sup>                        |
| Estimated annual cosmic radiation dose, mSv (mean ± SD)** | 2.2 ± 0.7     | 1.5 ± 0.4       | 0.7 ± 0.4 <sup>‡</sup>                           | 2.8 ± 0.5      | 1.5 ± 0.9       | 1.3 ± 0.8 <sup>‡</sup>                           |

\* N varied from 22–24 in Seattle and 19–20 in Miami due to missing data. Annual estimates are based on 4 mo of company records or a single questionnaire self-report.

<sup>†</sup>Mean (median for time zones crossed per year) calculated from individual differences between self-reported questionnaire and company record.

<sup>‡</sup>p < 0.001, t-test for the difference between self-reported and company records.

<sup>§</sup>Seattle distribution of difference is nonnormal. For Seattle, sign test p = 0.29, signed rank test p = 0.0014 for the difference between self-reported and company records.

\*\*Dose estimate for self-report was calculated for a typical segment from a quadratic equation which included estimated block time per self-reported work segment. The annualized estimate was the product of this segment-estimated dose and the self-reported estimated number of segments flown. Dose was estimated from company records with the Federal Aviation Administration’s CARI-6 software with input based on a published algorithm (see text for details).

Official travel block time was overestimated by flight attendants studied at two U.S. airline domiciles. Overestimation of block time, in turn, increased estimates of work exposures. Patterns of overestimation varied between the two airline/domicile cities, and due to study design it is unclear whether the pattern variation is due to airline or domicile differences. At one of the two domiciles (Miami), overreporting decreased with increasing block hours flown per year. This overestimation of block time does not appear to affect recreational travel, which accounted for a relatively small fraction of flight attendant air travel in our study, and is responsible for 2–6% of flight attendants’ total estimated radiation dose (3). Recreational travel was discretionary, tracked separately from work-related travel at the airlines we studied, and was not impacted by the nonflying work activities reflected in credit hours.

We compared Seattle flight attendants’ credit hours, which include official travel and nonflight activities, to

their self-report of block time. Because credit hours are familiar to flight attendants as the basis of their compensation, and because credit hours include some nonflying work hours, we expected that the reason for the self-reported overestimate of block time was the erroneous self-report of credit hours. If this were true, self-reported block times would be similar to credit hours. However, self-reported block time still exceeded recorded credit hours (Fig. 3) by an estimated median of 188 h · yr<sup>-1</sup>. Overall, about 40% of overreported block time corresponded with recorded credit hours, while the remainder of overreported block time was overreported for unknown reasons.

Real bias could contribute to overestimation from rounding of self-reported block time and assignment of segment length values from self-reported categories. For block time, the range of self-reported values is from

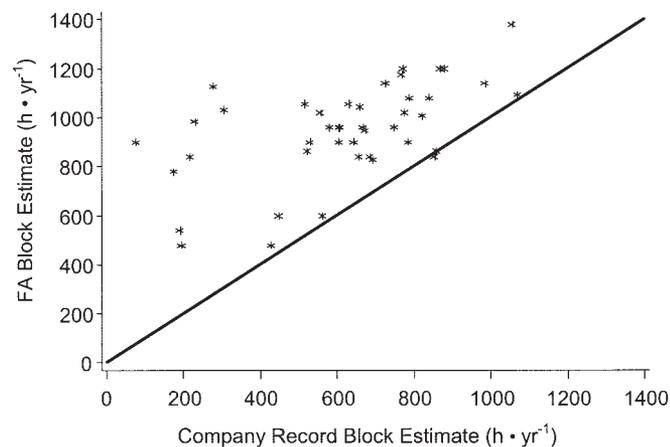


Fig. 1. Flight attendant (FA) estimate of cumulative block time vs. company record based estimate of block time for 43 flight attendants (\*), indicating consistent overreporting of self-reported block time. The identity line (—) is provided as a reference of equality.

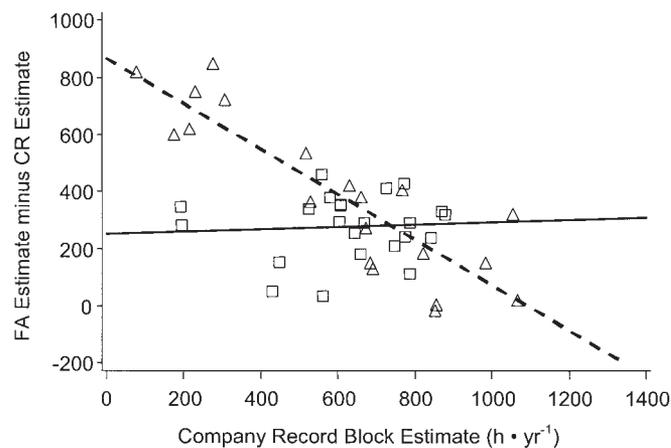
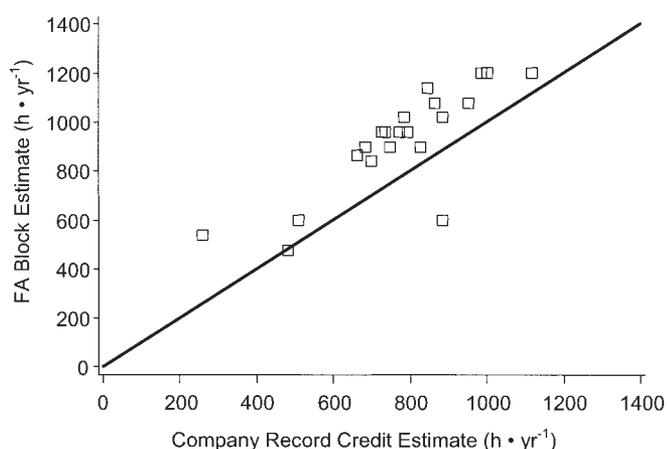


Fig. 2. The difference between the flight attendant (FA) and company record (CR) based estimates of block time vs. the CR-based estimate of block time with least-squares regression line for 20 Miami-based flight attendants (Δ; dotted line) and 23 Seattle-based flight attendants (□; solid line). Seattle flight attendants’ overreporting was relatively constant regardless of number of block hours, while Miami flight attendants’ overreporting decreased with increasing block hours per year.



**Fig. 3.** Flight attendant (FA) estimate of block time vs. company record based estimate of credit hours (paid hours including block time and other compensable activities) for 23 Seattle-based flight attendants ( $\square$ ). Self-reported block time estimates are generally higher than the company's credit time records for unknown reasons. The identity line ( $\rightarrow$ ) is provided as a reference of equality.

40–115  $\text{h} \cdot \text{mo}^{-1}$ . In our data, 81% of self-reported block times ended in “0” or “5,” suggesting rounding of these block time estimates. To look at possible rounding effects, we conducted a sensitivity analysis to determine the effect of subtracting 5 h from each flight attendant's self-reported monthly total block time. Other variables were recalculated without changing original assumptions. Overreporting remained at levels near those reported in Table I. Values for exposure variables corrected for rounding decreased 1.2–7% from their comparable unrounded values reported in Table I. Annual radiation dose per year estimates each dropped by 0.1 mSv (3.6–4.5%). The contribution of rounding errors to overestimation is likely to be small compared with nonflying credit time compensation.

We also examined how close self-reported segment length was to that calculated from actual company work history records, since overreporting of the number of flight segments had occurred at both domiciles (Table I). A “typical segment” length was used to create other variables. This typical length was the median value for the category of segment length chosen by the flight attendant for self-report. Differences between self-report and company records of typical segment length varied from 2% underestimation to 20% overestimation by domicile and segment length, but the effects are not consistent. Finally, we compared segment length values assigned from self-reported categories to those from an external source, our database of 6,785 study airline flights from 1997. Differences from the 1997 database medians ranged from 4.7% underestimation to 29% overestimation of the true median for a given domicile/flight length category. It is not clear from these comparisons that there is one “best” choice of median segment length. Some misclassification is inevitable when median values are assigned to self-reported segment categories.

Although a few study participants' estimates of block time were close to our calculations from company records, most flight attendants in our study overestimated their block time. “Usual block time” may also

have differed from our 4-mo sample of actual records because the sample was taken at a time when less flying occurred, although this is unlikely. Our results suggest that factors such as annual hours worked and length of employment or seniority may affect the estimation of block hours. Federal Aviation Regulations (FARs) and airline guidelines or collective bargaining union rules are also likely to affect flight attendant responses to a work history question, and may account for some of the airline and domicile differences observed in our data. FARs stipulate flight attendant staffing levels and locations on board the aircraft, recurrent training and testing intervals, and flight duty time limitations and rest requirements. Airline compensable credit time may include credit for nonflight time, deadheading (traveling as a passenger at the request of the airline to another city to perform flight attendant duties), night and holiday work, required training or meetings, delays, or holding on the ground with passengers on board. Flight attendants may also have the opportunity to receive additional pay for their ability to speak an alternate language or for leadership roles. Minimum flight pay credit guarantees are designed to ensure adequate compensation for situations such as extra long duty periods, extra short duty periods, and trips that have little flight time but a long time away from base. Recently hired flight attendants are often required to fly at short notice or “reserve,” rarely knowing where they will be headed from day to day. For reserve flight attendants, minimum pay credits typically ensure that they obtain a certain salary per month regardless of actual flight hours.

Responses from flight attendants about block time may be difficult to interpret. The number of flight attendants studied was too small to examine reporting patterns stratified by demographic or occupational factors. Our study was limited to current company records and self-report of block hours worked for a current 4-mo period at two domiciles of two different airlines. A change in domicile or airline may have produced different results. However, data from even these limited domicile/airline combinations generate several possibilities for exposure bias. Flight attendants in Seattle flying any number of block hours per year overreported block time by a constant (mean 277  $\text{h} \cdot \text{yr}^{-1}$ ), which would generate nondifferential bias in radiation dose estimates (that is, the proportion of flight attendants misclassified does not depend on health outcome; the result of this bias is generally toward no association between exposure and health outcome). Flight attendants in Miami who flew a high number of block hours generally overestimated their total very little; those who flew few block hours overestimated total block time by almost a factor of 4. This differential bias would overestimate radiation dose for the flight attendants who flew the least, but dose estimates for flight attendants with high total block time would be minimally affected. The most likely effect of this differential bias on a monotonic dose-response curve would be a steeper response slope, and risk of an outcome related to dose could be underestimated at lower doses.

For the NIOSH flight attendant reproductive bio-

monitoring and reproductive history studies, exposure estimates are derived from company records of flights. The accuracy of self-reported block hours over the longer periods of recall of cancer mortality and incidence studies is unknown, and for most U.S. airlines, work records are not available to address this question. From our comparison, we conclude that differential exposure bias may result when survey questions for aircrew work history do not account for the complexities of self-report. Rounding by study participants and assignment of values from self-reported categorical responses are two sources of error which should be minimized where possible when the survey instrument is designed. More importantly, for future studies in which company records are not available, survey questions which distinguish between compensable (credit flight) pay and block hours may be advisable. Investigators may also wish to explore whether compensation issues including seniority, length of employment, international/domestic status, number of segments per trip, type of equipment flown, domicile, and changes in airline policies over time are related to overreporting prior to exposure assessment and epidemiologic analysis.

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