American Journal of Epidemiology
Vol. 156, No. 6
Printed in U.S.A.
DOI: 10.1093/aje/kwf083

Mortality from Cancer and Other Causes among Airline Cabin Attendants in Germany, 1960–1997

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Received for publication January 31, 2002; accepted for publication May 1, 2002.

Airline cabin attendants are exposed to several potential occupational hazards, including cosmic radiation. Little is known about the mortality pattern and cancer risk of these persons. The authors conducted a historical cohort study among cabin attendants who had been employed by two German airlines in 1953 or later. Mortality follow-up was completed through December 31, 1997. The authors computed standardized mortality ratios (SMRs) for specific causes of death using German population rates. The effect of duration of employment was evaluated with Poisson regression. The cohort included 16,014 women and 4,537 men (approximately 250,000 person-years of follow-up). Among women, the total number of deaths (n = 141) was lower than expected (SMR = 0.79, 95% confidence interval (CI): 0.67, 0.94). The SMR for all cancers (n = 44) was 0.79 (95% CI: 0.54, 1.17), and the SMR for breast cancer (n = 19) was 1.28 (95% CI: 0.72, 2.20). The SMR did not increase with duration of employment. Among men, 170 deaths were observed (SMR = 1.10, 95% CI: 0.94, 1.28). The SMR for all cancers (n = 21) was 0.71 (95% CI: 0.41, 1.18). The authors found a high number of deaths from acquired immunodeficiency syndrome (SMR = 40; 95% CI: 28.9, 55.8) and from aircraft accidents among the men. In this cohort, ionizing radiation probably contributed less to the small excess in breast cancer mortality than reproductive risk factors. Occupational causes seem not to contribute strongly to the mortality of airline cabin attendants. *Am J Epidemiol* 2002;156:556–65.

aircraft; aviation; cohort studies; mortality; neoplasms; occupational exposure; radiation

Abbreviations: AIDS, acquired immunodeficiency syndrome; CI, confidence interval; SIR, standardized incidence ratio; SMR, standardized mortality ratio.

Investigation of specific health risks associated with working in commercial aviation has gained more importance now that air travel has developed into a widespread means of transportation. Results of several epidemiologic studies investigating cancer incidence and mortality among flight crews, mainly in pilots, have been published (1). For cabin crews, results of cancer incidence studies have been reported from three Nordic countries (2–4). Limited data on Danish cabin attendants (5) and on retired cabin employees of a US airline (6) have been published in research letters. The main findings of these studies were slightly increased standardized incidence ratios (SIRs) for all cancers combined (SIRs between 1.2 and 1.4) and significantly increased SIRs for breast cancer among female flight attendants from Finland (SIR = 1.7), Denmark (SIR = 1.6), Iceland (SIR = 1.5), and the United States (SIR = 2.0) but not from Norway (SIR = 1.1). In addition, the SIR for melanoma among cabin crew was increased in all published studies. Other significantly increased SIRs in individual studies were those for bone cancer, thyroid cancer, and nonmelanoma skin cancer. In Norway, there were significantly raised SIRs for upper respiratory tract and gastric tract cancers and liver cancers among male cabin crew (SIR = 6.0). For most other cancers, no significant differences from the reference population were noted in the reported studies.

Occupational factors that are potentially relevant for studies of cancer among cabin attendants include exposure to cosmic radiation (7), exposure to environmental tobacco smoke (8, 9), circadian rhythm changes (10), and exposure to onboard pesticides (6). Neutrons contribute a large propor-

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tion (up to 60 percent) to the effective dose from cosmic radiation and are considered to have greater biologic effectiveness than gamma radiation. However, there are few available data on the carcinogenic effect of neutrons in humans (11). It would be pertinent to investigate whether this kind of radiation is more effective in causing cancer than other types of radiation.

The excess annual radiation received by a flight crew varies as a function of cumulative flight hours, flight routes, and solar activity. Typically, airline crews flying 700–900 hours per year have been estimated to receive effective radiation doses of 2–5 mSv per year (12–14), in addition to approximately 2–3 mSv from natural background radiation. Flight crews were recently included in European radiation protection regulations (15), which implies a need for further research on cancer risk in this occupational group. Nonoccupational risk factors, among them reproductive factors and particular lifestyles involving increased leisure-time exposure to ultraviolet radiation, additionally influence the cancer patterns of flight personnel.

To evaluate the mortality of male and female cabin attendants in the German airline industry, we conducted a cohort study among cabin attendants employed by two major German airlines between 1953 and 1997. The main topic of interest was patterns of cancer mortality and other important causes of mortality in this occupational group. To our knowledge, this is the first cohort study that has reported mortality patterns among airline cabin crews.

MATERIALS AND METHODS

We conducted a retrospective cohort mortality study of all cabin attendants employed by either Lufthansa German Airlines or LTU International Airways between January 1, 1953, and December 31, 1997, for a minimum of 6 months and whose vital status was last known on or after January 1, 1960. At Lufthansa German Airlines, cohort members were identified through a manual review of company files up to 1992 and through data retrieval from electronic personnel files thereafter. Differentiation between flying and nonflying personnel, as well as between cockpit and cabin personnel, was based on each person's job code, assigned according to detailed lists compiled from airline records. Although it was rare in practice, a person could theoretically have had several different kinds of employment periods—for example, by changing from ground crew to cabin crew. In such cases, the personnel files included several job periods for each person and several job codes. Duration of employment was calculated as the sum of periods spent in jobs coded as cabin employment. No adjustment was made for part-time employment. At LTU International Airways, cohort members were identified through a manual review of all company personnel files. For persons with a "cabin crew" job code in the records, the complete job history was abstracted and duration of employment was calculated as above. Thus, "duration of employment" in this paper refers to employment as cabin crew. We abstracted relevant biographic information, including last known address, employment periods, and job code. Enumeration of the cohort was completed by a cross-check with the electronic files of the Federal Aviation Authority (Luftfahrtbundesamt), available for the years 1988–1997.

Follow-up of vital status

The cohort included 20,895 cabin attendants. From company files, 11,285 cabin attendants were identified as still employed on December 31, 1997, and no follow-up was necessary. For the remaining 9,610 persons, including all those with a last known address in Germany, Switzerland, Austria, or the Netherlands, we conducted follow-up for vital status via the compulsory population registry of the municipality of last known residence. This procedure revealed a further 542 persons who were still employed on December 31, 1997. This process was continued until vital status was confirmed as alive on December 31, 1997, or later or until death or emigration was reported. Persons were occasionally lost during the process; however, this happened most often immediately after the end of employment because of insufficient address information. In general, name changes due to marriage did not cause a loss to follow-up. Persons who were lost or who had emigrated were censored at the date of last known vital status.

In cases of death, we requested a copy of the death certificate from the local health authority of the place of death. Since these certificates are kept for different periods of time in various federal states, not all causes of death could be obtained in this way. Wherever possible, we contacted the treating physician or the next of kin of the deceased for information on the underlying cause of death. Death certificates were available for 62.4 percent of female cabin crew and 71.8 percent of male cabin crew, while information from physicians was used for 15.6 percent and 6.5 percent, respectively. For three women (2.1 percent) and five men (2.9 percent), only data from relatives were accessible. In approximately 19 percent of deaths, no information on the underlying cause of death could be established. All causes of death were coded according to the *International Classification of Diseases*, Ninth Revision, by trained codification staff from the Statistical State Office Saarland. National reference rates were obtained from the World Health Organization mortality database for most causes of death and from the National Statistical Office for causes not available from the World Health Organization.

Exposure assessment

Because company files did not contain information on past individual flights for cabin crew, we used duration of employment as cabin crew as the main variable to assess occupational exposure. In the framework of our study, we showed that duration of employment is highly correlated ($r \geq 0.8$) with exposure to cosmic radiation—at least for pilots for whom more detailed information on job history was available (16). Employment periods were grouped into three categories: 6 months–<10 years, 10–<20 years, and ≥20 years. For female staff, the first category was additionally subdivided into 6 months–<5 years and 5–<10 years, because the majority of women were employed for less than 10 years. Slightly different categories were used for breast cancer to

TABLE 1. Cohort size and results of follow-up in a retrospective cohort study of German airline cabin attendants, 1960–1997

	Total		Women		Men	
	No.	%	No.	%	No.	%
Total cohort	20,895	100				
Not employed on December 31, 1997	9,068	43.4				
Still employed on December 31, 1997*	11,827	56.6				
Excluded from analysis†	344	1.6				
Cohort available for analysis	20,551	100	16,014	100	4,537	100
Lost to follow-up	1,020	5.0	820	5.1	200	4.4
Emigrated	640	3.1	488	3.1	152	3.4
Included in analysis	18,891	91.9	14,706	91.8	4,185	92.2
Vital status on December 31, 1997						
Alive	18,580	90.4	14,565	91.0	4,015	88.5
Deceased	311	1.5	141	0.9	170	3.8

* Includes 542 persons identified during follow-up as still employed on December 31, 1997.

† Exclusions were due to missing or incorrect information on date of birth, sex, or date of cohort entry.

avoid categories with fewer than five cases. Since nonjet planes were gradually phased out in the early 1970s, we conducted separate analyses for the subcohort of cabin crew who had first been employed in 1971 or later. Stratification details were laid out beforehand in the study protocol.

Statistical methods

Standardized mortality ratios (SMRs) for predefined causes of death were computed according to person-years methods (17). According to the protocol, we restricted the SMR analysis to the period 1960–1997. We calculated person-years for each subject, commencing on the first day of employment or on January 1, 1960, whichever was later, and ending on the date of last known vital status, emigration, or death or on December 31, 1997, whichever came first. Expected numbers of deaths in 5-year age and calendar intervals were calculated on the basis of German population mortality rates. In analyses conducted according to duration of employment, person-years were dynamically allocated to the respective employment time categories.

To account for missing causes of death, we corrected the observed number of deaths for specific causes with a proportional correction factor, $\hat{p}$ (18). Basically, the "corrected observed" number of deaths, O_c, was calculated as $O_c = O/\hat{p}$, where $\hat{p}$ is the proportion of known causes among all causes, stratified by sex (and SMR = uncorrected SMR/$\hat{p}$ = O_c/E). The 95 percent confidence interval of the SMR was calculated by approximate methods (16) for 100 or more observed cases or by exact methods if the number of observed cases was smaller. If p were known, the confidence interval of the corrected SMR could be calculated by dividing the upper and lower limits of the uncorrected SMR by p. Since $\hat{p}$ is an estimate of p, we used the confidence limits of $\hat{p}$ (19) to calculate appropriate 95 percent confidence intervals for the corrected SMR. This means that our confidence intervals are rather wide. In addition to the SMR analysis, we used Poisson regression models to further evaluate the role of length of employment for all-cause mortality, all-cancer mortality, and breast cancer mortality. Age-adjusted parameter estimates for categories of employment time were calculated, with the lowest category used as the reference group. We used SAS, version 6.12 (SAS Institute, Inc., Cary, North Carolina) for all statistical analyses.

RESULTS

The total cabin-crew cohort consisted of 20,895 persons. Of these, 344 had to be excluded from the analysis because of missing data on sex, date of birth, or date of entry into the cohort. The remaining 16,014 female and 4,537 male cabin attendants yielded 188,218 and 60,665 person-years of follow-up, respectively. Our cohort was rather young: 81 percent of person-years among women and 73 percent among men were accumulated in the age groups below 41 years. The mean duration of follow-up was 11.8 years among women and 13.4 years among men.

A total of 311 deaths were confirmed in the total cohort, of which 141 occurred among women and 170 among men. A total of 1,020 persons (820 female, 200 male) were lost to follow-up in the population registries, while 640 cohort members (488 female, 152 male) emigrated to foreign countries. Table 1 gives an overview of the cohort size and follow-up results.

The median duration of employment was lower among female cabin attendants than among male cabin attendants (8.4 years vs. 10.3 years). Most cohort members were first employed after 1970 (88 percent of female cabin attendants, 81 percent of male cabin attendants).

Tables 2 and 3 show observed numbers of deaths and calculated expected numbers of deaths by cause of death for women and men, respectively. Among female cabin attendants, the SMR for all causes of death was significantly decreased (SMR = 0.79, 95 percent confidence interval (CI): 0.67, 0.94), while the decrease in the all-cancer SMR was of the same size but not statistically significant (SMR = 0.79, 95 percent CI: 0.54, 1.17). The SMR for breast cancer mortality was 1.28 (95 percent CI: 0.72, 2.20). SMRs were decreased for most other cancers. Among noncancer deaths, the very low SMR for cardiovascular disease was statistically significant. The observed number of deaths caused by aircraft accidents was 13 (16.2 corrected). Since comparison rates were available only from 1980 onwards, the expected number of deaths and the SMR for aircraft accidents must be interpreted with particular caution.

Male cabin attendants had a nonsignificantly raised all-cause mortality (SMR = 1.10, 95 percent CI: 0.94, 1.28) that can mainly be explained by the high number of deaths from acquired immunodeficiency syndrome (AIDS). The SMR for all cancers was 0.71 (95 percent CI: 0.41, 1.18), which was very close to that observed for women. For specific cancer sites, no patterns were obvious, but the numbers of cases were small. We found a high SMR for AIDS-related deaths (SMR = 40, 95 percent CI: 28.9, 55.8); the SMR for infectious diseases was also elevated. The number of AIDS deaths peaked in the early 1990s and has since declined. Among external causes of death, eight deaths due to aircraft accidents were observed (9.9 corrected).

A separate evaluation of cabin crew first employed after 1970 (table 4) revealed no deviation from the overall cohort SMRs, with the exception that the SMR for all-cause mortality among men was significantly increased (SMR = 1.56, 95 percent CI: 1.26,1.91). We performed SMR analyses according to duration of employment for all causes of death and for the two major causes of cancer death (breast cancer for women and lung cancer for men) for which at least five deaths were recorded (tables 5 and 6). No differences in the SMRs were seen for all causes or for all cancers in the different employment categories. For breast cancer among women, there was no pattern by duration of employment: The SMR was nonsignificantly increased among women employed for less than 10 years (both categories) but not for those with a longer duration of employment. Results from the Poisson regression analysis (table 7) indicated nonsignificant decreases in all-cause and all-cancer mortality with increasing length of employment among women. The age-adjusted rate ratio for breast cancer among women employed for 5–<10 years versus those employed for 0.5–<5 years was 1.05 (95 percent CI: 0.42, 2.62); among women employed for 10 or more years, the rate ratio was 0.60 (95 percent CI: 0.21, 1.65). For all causes of death, the highest SMR in men was observed among those who had been employed for 10–20 years (see table 6), while no pattern with duration of employment was seen for either all cancer or lung cancer. Results were similar for the Poisson regression.

DISCUSSION

To our knowledge, this study is among the first to have reported mortality risk estimates for cabin crews working in commercial aviation. It included approximately 16,000 female and 4,500 male cabin attendants and was larger than all previous studies of cabin attendants combined. Overall, we observed a slightly lower SMR among female cabin crew, while male cabin crew had a slightly increased SMR for all causes of death compared with the general population in Germany. Aviation-related accidental deaths in the total cohort and AIDS deaths among male cabin attendants contributed largely to the overall number of deaths in our cohort. In terms of specific causes, we noted reduced risks for all cancer deaths and for cardiovascular disease deaths. For women, a strong healthy worker effect could be seen. When AIDS deaths were removed from the overall mortality data, a similar effect was observed among men.

Cancer mortality

Our mortality data showed a decrease in all-cancer mortality, which contrasts with the findings from studies of Nordic cabin crews (2–4), where the SIR for cancer was slightly increased. However, the precision of published SIR and SMR estimates (including ours) is still rather low. It currently seems premature to conclude that cabin crews have an overall cancer risk which is materially different from that of the general population, since this cohort is very young and further follow-up is needed.

In the Finish (2) and Icelandic (3) cohort studies, as well as in the Danish (5) and US (6) data reported in letters, an excess incidence of breast cancer was observed. Results from the larger Norwegian cohort study (4) did not confirm this finding. Our SMR was slightly lower than the risk estimates from the incidence studies. However, the low number of deaths resulted in a wide confidence interval for the SMR. We did not observe any pattern of mortality increase across categories of duration of employment, which contrasts with data from Finland (2) and Iceland (3), where elevated risks (expressed as SIRs) were seen with increasing duration of employment. The influence of risk factors associated with duration of employment remains unclear.

Possible explanations for the observed small increase in breast cancer risk among female cabin attendants (in comparison with the general population) have focused thus far on cosmic radiation, differences in reproductive factors, and the contribution of socioeconomic differentials. Although data on individual radiation measurements or flight hours were not available, it can be calculated that cabin crews flying for an average of 700 hours per year are exposed to an average of 2–5 mSv annually (20), resulting in a lifetime occupational dose that is usually below 100 mSv. Ionizing radiation is an established risk factor for breast cancer (21); however, a relative risk of 1.0–1.1 for a 100-mSv exposure obtained between ages 20 and 40 years would be expected if BEIR V risk estimates were applied (22). Our

TABLE 2. Observed and expected numbers of deaths and standardized mortality ratios for various causes of death among female airline cabin attendants in Germany, 1960–1997

Cause of death*	ICD-9† code(s)	Observed no. of deaths (*O*)	Corrected‡ observed no. of deaths (O_c)	Expected no. of deaths (*E*)	SMR†	95% CI†
All causes	001–999	141	141	177.8	0.79	0.67, 0.94
All infectious diseases (except acquired immunodeficiency syndrome)	001–139	2	2.5	1.9	1.30	0.15, 5.16
Acquired immunodeficiency syndrome	042.9	1	1.2	1.2	1.07	0.03, 6.57
All cancers	140–208	44	54.9	69.2	0.79	0.54, 1.17
Individual cancer sites						
Stomach	151	2	2.5	3.4	0.73	0.08, 2.90
Large intestine	153	2	2.5	3.3	0.75	0.08, 2.97
Biliary tree/liver	155–156	1	1.2	1.5	0.86	0.02, 5.26
Bronchial tree and lung	162–163	2	2.5	4.4	0.57	0.06, 2.28
Breast	174	19	23.7	18.5	1.28	0.72, 2.20
Cervix uteri	180	2	2.5	4.4	0.57	0.06, 2.27
All other uterine cancer	179, 181–182	2	2.5	1.4	1.80	0.20, 7.17
Ovary	183	3	3.7	4.3	0.86	0.17, 2.77
Brain and central nervous system	191–192	2	2.5	3.1	0.82	0.09, 3.25
All lymphoma	200–202	4	5.0	2.7	1.88	0.48, 5.29
Non-Hodgkin's lymphoma	200, 202	2	2.5	1.5	1.66	0.19, 6.60
Hodgkin's lymphoma	201	2	2.5	1.2	2.15	0.24, 8.57
All leukemia	204–208	2	2.5	3.2	0.79	0.09, 3.13
All other cancer	Rest, 140–208	3	3.7	4.9	0.76	0.15, 2.45
Diabetes mellitus	250	1	1.2	1.9	0.66	0.02, 4.03
Cerebrovascular disease	430–438	3	3.7	7.5	0.50	0.10, 1.60
All cardiovascular disease	390–429	3	3.7	16.3	0.23	0.04, 0.74
Other ischemic heart disease	411–414	1	1.2	1.7	0.75	0.02, 4.62
Hypertension	401–405	1	1.2	1.1	1.17	0.03, 7.15
All other cardiovascular disease	Rest, 390–429	1	1.2	7.8	0.16	0.00, 0.98
Nonmalignant respiratory disease	460–479, 488–519	1	1.2	3.6	0.35	0.01, 2.12
Liver cirrhosis	571	1	1.2	10.1	0.12	0.00, 0.76
Motor vehicle accidents	E810–E825	16	20.0	12.4	1.61	0.86, 2.88
Aircraft accidents§	E840–E844	13	16.2	0.2	96.3	47.8, 181.3
All external causes except aircraft accidents	E800–E999, except E840–E844	34	42.4	36.8	1.15	0.74, 1.77
Suicide	E950–E959	11	13.7	15.7	0.87	0.41, 1.72
Homicide	E960–E999	4	5.0	4.3	1.16	0.29, 3.26
All other external causes	Rest, E899–E999	3	3.7	4.4	0.85	0.16, 2.75

* Causes of death are listed if at least one case was reported.

† ICD-9, *International Classification of Diseases*, Ninth Revision; SMR, standardized mortality ratio; CI, confidence interval.

‡ Corrected for missing specific information on cause of death (18).

§ Expected numbers were based on comparison rates available only from 1980 onwards.

study had little power to detect a small excess relative risk of this magnitude.

Reproductive factors such as a late first birth and a lower-than-average number of children increase the risk of breast cancer (23). The risk increases observed in the Icelandic cohort did not seem to be explainable by confounding due to reproductive factors (3), while in Finland, a risk difference of 23 percent was attributed to reproductive factor differentials (2). No information on reproductive history is currently available for German cabin crews. It seems reasonable to assume, however, that postponement of childbearing is common in this occupational group, since child-rearing is

TABLE 3. Observed and expected numbers of deaths and standardized mortality ratios for various causes of death among male airline cabin attendants in Germany, 1960–1997

Cause of death*	ICD-9† code(s)	Observed no. of deaths (O)	Corrected‡ observed no. of deaths (O_c)	Expected no. of deaths (E)	SMR†	95% CI†
All causes	001–999	170.0	170	154.5	1.10	0.94, 1.28
All infectious diseases (except acquired immunodeficiency syndrome)	001–139	4	4.9	1.5	3.31	0.85, 9.21
Acquired immunodeficiency syndrome	042.9	61	76.4	1.9	40.04	28.87, 55.83
All cancers	140–208	21	25.9	36.4	0.71	0.41, 1.18
Individual cancer sites						
Buccal cavity/pharynx	140–149	4	4.9	2.5	1.97	0.50, 5.48
Large intestine	153	1	1.2	1.9	0.63	0.02, 3.85
Rectum	154	1	1.2	1.2	1.04	0.02, 6.33
Biliary tree/liver	155–156	1	1.2	1.0	1.26	0.03, 7.61
Pancreas	157	2	2.5	1.5	1.62	0.18, 6.36
Bronchial tree and lung	162–163	5	6.2	8.0	0.77	0.24, 1.97
Other skin cancer	173	1	1.2	0.1	14.89	0.35, 90.23
Testis/other male genital organ	186–187	1	1.2	0.9	1.30	0.03, 7.86
All lymphoma	200–202	1	2.5	1.7	1.46	0.17, 5.73
Non-Hodgkin's lymphoma	200, 202	2	2.5	1.0	2.41	0.27, 9.45
All leukemia	204–208	1	1.2	1.6	0.78	0.02, 4.74
All other cancer	Rest, 140–208	2	2.5	3.1	0.81	0.09, 3.17
Cerebrovascular disease	430–438	1	1.2	4.8	0.26	0.01, 1.56
All cardiovascular disease	390–429	9	11.1	26.7	0.41	0.18, 0.86
Other ischemic heart disease	411–414	2	2.5	3.7	0.67	0.08, 2.63
Acute myocardial infarction	410	2	2.5	13.6	0.18	0.02, 0.71
All other cardiovascular disease	Rest, 390–429	5	6.2	8.3	0.75	0.23, 1.89
Liver cirrhosis	571	3	3.7	10.5	0.35	0.07, 1.12
Nephritis and nephrosis	580–589	1	1.2	0.7	1.71	0.04, 10.34
Motor vehicle accidents	E810–E825	7	8.6	15.6	0.55	0.21, 1.24
Aircraft accidents§	E840–E844	8	9.9	0.2	47.9	19.5, 102.7
All external causes except aircraft accidents	E800–E999, except E840–E844	22	27.1	43.7	0.62	0.37, 1.02
Suicide	E950–E959	11	13.6	16.5	0.82	0.39, 1.60
Homicide	E960–E999	4	4.9	3.1	1.61	0.41, 4.49

* Causes of death are listed if at least one case was reported.

† ICD-9, *International Classification of Diseases*, Ninth Revision; SMR, standardized mortality ratio; CI, confidence interval.

‡ Corrected for missing specific information on cause of death (18).

§ Expected numbers were based on comparison rates available only from 1980 onwards.

not easily combinable with the work patterns of airline cabin attendants. The higher social class of this group may also contribute partly to the increase compared with the general population. Since detailed data are not available for this cohort, we are planning a survey to further explore issues concerning reproductive and socioeconomic factors in this population. Given the limits of the available data, our study could not specifically address the influence of other occupational factors, such as exposure to electric and magnetic fields, engine fumes, or pesticides used for insect vector control on selected flights. It is likely that there are circadian rhythm disturbances with associated changes in melatonin homeostasis among airline cabin crews (10), but their importance for breast cancer development is still unclear (24–26).

Since one of the main exposures of interest in our study was ionizing radiation, the results for leukemia are of special importance. The study had sufficient power to detect an approximate twofold increase in mortality. The additional lifetime exposure of most cabin crew members is below 100 mSv based on standard weighting factors for neutrons (27). Although these weighting factors for neutrons may not be accurate for the evaluation of leukemia risk, a rough estimate

TABLE 4. Standardized mortality ratios for selected causes of death (through 1997) among German airline cabin attendants first employed after 1970

Cause of death	ICD-9* code(s)	Observed no. of deaths (*O*)	Corrected† observed no. of deaths (O_c)	Expected no. of deaths (*E*)	SMR*	95% CI*
Women						
All causes	001–999	80	80.0	99.9	0.80	0.63, 1.00
All cancers	140–208	21	26.2	34.8	0.75	0.43, 1.27
Breast cancer	174	9	11.2	8.9	1.27	0.54, 2.65
Aircraft accidents‡	E840–E844	9	11.2	0.1	85.9	36.7, 179.5
Men						
All causes	001–999	92	92.0	59.0	1.56	1.26, 1.91
All cancers	140–208	7	8.6	10.0	0.87	0.33, 1.94
Acquired immunodeficiency syndrome	042.9	44	54.2	1.5	36.7	25.1, 53.6
Aircraft accidents‡	E840–E844	5	6.2	0.1	57.1	17.4, 144.8

* ICD-9, *International Classification of Diseases*, Ninth Revision; SMR, standardized mortality ratio; CI, confidence interval.

† Corrected for missing specific information on cause of death (18).

‡ Expected numbers were based on comparison rates available only from 1980 onwards.

of lifetime risk can be calculated on the basis of epidemiologic studies carried out in populations exposed to gamma radiation. For example, from studies of nuclear power workers, a 22 percent increase in risk has been reported for a 100-mSv lifetime dose (28). In our cohort, no mortality increases were seen for all types of leukemia combined. Subdivision of leukemia cases into chronic lymphoid leukemia and nonchronic lymphoid leukemia was not consistently possible from the death certificates. Given the power of our study and the relative rarity of hematologic tumors in the population, informatively raised leukemia rates in the cohort could only be expected if large deviations from previous risk estimates were to occur. This was not the case.

An increased risk of melanoma has been the most consistent finding in cancer studies conducted among airline crews (29). However, there were no deaths attributed to melanoma

TABLE 5. Standardized mortality ratios for selected causes of death among female airline cabin attendants, by duration of employment, Germany, 1960–1997

Cause of death	ICD-9* code(s)	Duration of employment (years)	Observed no. of deaths (*O*)	Corrected† observed no. of deaths (O_c)	Expected no. of deaths (*E*)	SMR*	95% CI*
All causes	001–999	0.5–<5	57	57	71.8	0.79	0.60, 1.03
		5–<10	48	48	53.7	0.89	0.66, 1.19
		10–<20	27	27	37.6	0.72	0.47, 1.05
		≥20	9	9	14.8	0.61	0.28, 1.15
All cancers	140–208	0.5–<5	30	37.4	45.4	0.82	0.52, 1.30
		5–<10	14	17.5	21.2	0.83	0.42, 1.52
		10–<20	9	11.2	16.3	0.69	0.29, 1.44
		≥20	5	6.2	7.5	0.83	0.25, 2.14
Breast cancer	174	0.5–<5	7	8.7	5.6	1.56	0.59, 3.54
		5–<10	7	8.7	5.7	1.53	0.57, 3.47
		≥10	5	6.2	7.2	0.87	0.26, 2.22

* ICD-9, *International Classification of Diseases*, Ninth Revision; SMR, standardized mortality ratio; CI, confidence interval.

† Corrected for missing specific information on cause of death (18).

TABLE 6. Standardized mortality ratios for selected causes of death among male airline cabin attendants, by duration of employment, Germany, 1960–1997

Cause of death	ICD-9* code(s)	Duration of employment (years)	Observed no. of deaths (*O*)	Corrected† observed no. of deaths (O_c)	Expected no. of deaths (*E*)	SMR*	95% CI*
All causes	001–999	0.5–<10	62	62	71.4	0.87	0.67, 1.11
		10–<20	68	68	34.8	1.96	1.52, 2.48
		≥20	40	40	48.4	0.83	0.59, 1.13
All cancers	140–208	0.5–<10	8	9.9	12.8	0.77	0.31, 1.65
		10–<20	5	6.2	7.6	0.81	0.25, 2.06
		≥20	8	9.9	16.0	0.61	0.25, 1.32
Cancer of bronchial tree and lung	162–163	0.5–<10	1	1.2	2.0	0.61	0.01, 3.67
		10–<20	1	1.2	1.5	0.84	0.02, 5.09
		≥20	3	3.7	4.5	0.83	0.16, 2.64

* ICD-9, *International Classification of Diseases*, Ninth Revision; SMR, standardized mortality ratio; CI, confidence interval.

† Corrected for missing specific information on cause of death (18).

in our cabin-crew cohort (number expected: 1.6 in women, 0.9 in men). One possible explanation for the difference between our results and those of the incidence studies is early diagnosis due to regular medical checkups and subsequent more successful treatment in this occupational group. The question of whether ionizing radiation may also be an

TABLE 7. Age-adjusted rate ratios from Poisson regression for all-cause, all-cancer, and breast cancer mortality among airline cabin attendants, by duration of employment, Germany, 1960–1997

Cause of death	Duration of employment (years)	No. of deaths	Rate ratio	95% CI*,†
		Women		
All causes	0.5–<5‡	57	1	
	5–<10	48	1.21	0.78, 1.89
	10–<20	27	1.06	0.61, 1.83
	≥20	9	0.96	0.42, 2.20
All cancers	0.5–<5‡	30	1	
	5–<10	14	1.00	0.50, 1.99
	10–<20	9	0.85	0.39, 1.88
	≥20	5	0.87	0.32, 2.32
Breast cancer	0.5–<5‡	7	1	
	5–<10	7	1.05	0.42, 2.62
	≥10	5	0.60	0.21, 1.65
		Men		
All causes	0.5–<10‡	62	1	
	10–<20	68	1.87	1.33, 2.63
	≥20	40	1.11	0.71, 1.75
All cancers	0.5–<10‡	8	1	
	10–<20	5	0.94	0.44, 1.99
	≥20	8	0.86	0.40, 1.86

* *p* for trend > 0.1 for all listed causes of death.

† CI, confidence interval.

‡ Reference category.

independent risk factor for melanoma (30, 31) or may modify the risk associated with exposure to ultraviolet radiation (32) requires further investigation.

We found a rather remarkably low SMR for lung cancer among female cabin attendants and no increase for male cabin attendants, indicating that smoking and exposure to passive smoking may not play an important role in mortality in this group. Smoking during airplane flights was permitted in Germany until the mid-1990s, and smoking is still not banned on all charter flights.

Noncancer mortality

The risk of cardiovascular disease mortality for male and female air crew was surprisingly low (reaching statistical significance among women). This is a clear indication of a healthy worker effect, wherein selection for employment and ongoing monitoring lead to a very low prevalence of cardiovascular disease risk factors such as obesity and hypertension. Since the expected number of deaths was also small, this finding should be confirmed in cohorts with a higher proportion of older persons. On the other hand, current evidence can serve to inform cabin attendants of their advantageous cardiovascular mortality profile and increase their motivation to maintain a healthy lifestyle.

Among male cabin attendants, we found a high number of AIDS deaths. Airline personnel and employers in Germany were aware of this situation prior to our study. The number of AIDS deaths peaked in the early 1990s and has decreased steadily since then. Pukkala et al. (2) reported two cases of Kaposi's sarcoma—presumably AIDS-associated—among the three cancers observed in their small male cabin-crew cohort in Finland. Our data and further in-depth analyses of this issue could be used to promote AIDS prevention among cabin attendants.

Aviation accidents are a specific hazard for airline crews, not only as an occupational risk factor but also because airline employees frequently fly for nonoccupational reasons. A considerable number of accidents reported to us were not occupational accidents but rather were small private airplane crashes that occurred during leisure tours. It would be informative to further analyze these data so that airline companies could adequately advise their employees.

Strengths and limitations

To our knowledge, the present study was the largest cohort study performed among airline cabin crews to date. Mortality data for male cabin attendants have not been reported previously. Enumeration of our cohort was based on company files that were carefully checked and validated with Federal Aviation Authority data. We consider it nonselective and highly complete. Unfortunately, the company files did not contain any information on health-related factors, including reproductive history, or on individual annual flight hours, which have only been systematically registered in recent years. Therefore, dose-response analyses could only be carried out using duration of employment. This may have introduced some misclassification, since we could not take into account the fact that some persons were employed only part-time.

Limitations of this study also include loss to follow-up and missing information on causes of death. The occupational group studied here is highly mobile, and these workers may temporarily or permanently migrate to foreign countries. This led to some losses in the population registration system on which the follow-up of cohort members relied. Since we censored persons at the date of loss or migration, the person-year calculations in our study were correct; the main consequence of the losses was a decrease in statistical power.

Because our study included all deaths that had occurred since 1960, a number of original death certificates were not available at the offices of local health authorities. In a few cases, we were able to obtain information on cause of death from physicians or relatives, but a considerable gap in the completeness of cause-specific death data remained. On the basis of the assumption that cause-of-death information was missing at random, we believe that the extrapolation method used for the SMR analysis provides a valid estimate of the SMR if the numbers are not too small. However, this imputation may yield incorrect values for categories with only a few cases. Missing only one case of leukemia among male cabin crew, for example, would change the SMR from 0.78 to 1.25. This uncertainty is partly accounted for in the enlarged confidence intervals. Nevertheless, SMRs based on small numbers should be interpreted with great caution.

Overall, our results regarding cancer mortality among cabin attendants correspond well with the findings of the few other studies published so far (2–6), whose main finding was increased breast cancer mortality among women. Our study provides new data on noncancer mortality in this population. Notable findings include low mortality from cardiovascular causes and a high risk of death from AIDS among men employed as airline cabin attendants. Our data are being included in an ongoing pooled analysis of nine European cohort studies (33), which will provide more stable risk estimates for specific causes of death. Information from the current study can be used to educate airline staff and employers and to devise appropriate strategies to reduce occupational and individual health risks for airline cabin attendants.

ACKNOWLEDGMENTS

This work was partially supported by grants from the Berufsgenossenschaft für Fahrzeughaltungen, Lufthansa German Airlines, LTU International Airlines, the trade unions Deutsche Angestellten-Gewerkschaft and Gewerkschaft Öffentliche Dienste, Transport, und Verkehr, the German Academy for Aviation Medicine, and the Unabhängige Flugbegleiter Organisation.

The authors are grateful to all Lufthansa and LTU staff, particularly Barbara Reck (Lufthansa). The authors also thank Dorothea Niehoff for data management in the early phases of the study.

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