VERKEHR UND INFRASTRUKTUR

65

Gesundheitliche Belastungen des fliegenden Personals

Endbericht

Hans Peter Hutter, Florian Heger, Kathrin Lemmerer,
Hanns Moshammer, Michael Poteser, Peter Wallner

AK WIEN

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VORWORT

Das vergleichsweise junge Berufsbild des fliegenden Personals hat sich in den letzten Jahrzehnten in seinen Anforderungen stetig und zuletzt massiv gewandelt. So wurde etwa der Beruf der FlugbegleiterIn in seiner Anfangszeit und lange darüber hinaus als Traumberuf mit zahlreichen Vorteilen wahrgenommen. Spätestens mit dem Wandel der gesamten Luftfahrtbranche Richtung Massentourismus haben sich auch die Berufsprofile massiv verändert. Heute handelt es sich beim fliegenden Personal um ArbeitnehmerInnen mit einem höchst anspruchsvollen und herausfordernden Tätigkeitsfeld einhergehend mit vergleichsweise hohen Gesundheitsrisiken und zunehmend prekären Beschäftigungsbedingungen und Gehältern.

Angetrieben werden die gegenwärtigen Entwicklungen durch die technologischen Fortschritte in der Luftfahrtindustrie und dem massiv angestiegenen Wettbewerb unter den Fluggesellschaften aufgrund des Eintritts zahlreicher Billig-Airlines in den Markt. Sie ermöglichen immer längere Flüge mit immer mehr Menschen und das auf immer komprimierteren Platzverhältnissen. Anders als die Flugzeuge ist der menschliche Körper aber nicht für das Zurücklegen extrem langer Wegstrecken in so kurzer Zeit angepasst, was letztlich sowohl zu psychischen als auch körperlichen Problemen führen kann. Während Flugzeuge, mit erheblichem finanziellen Aufwand sorgsam kontrolliert, gewartet und gepflegt werden, verschlechtert sich die Situation des fliegenden Personals immer mehr. Zu Unrecht werden beispielsweise FlugbegleiterInnen immer öfter als reine Servicedienstleister ohne systemerhaltende Relevanz angesehen.

Die Arbeitsbedingungen des fliegenden Personals sind mit sehr speziellen und unterschiedlichen gesundheitlichen Belastungen verbunden, welche sie von anderen ArbeitnehmerInnengruppen deutlich unterscheidet. Dazu zählen vor allem Einflüsse auf die Chronobiologie durch oftmalige Zeitzonenwechsel, die Einwirkung von Höhen- bzw. ionisierender Strahlung, die Lärm- und Innenraumluftbelastung in der Kabine, räumlich beengte sowie körperlich belastende Arbeitsbedingungen und steigender Zeitdruck.

Bisher fehlte es an einer fundierten arbeits- und umweltmedizinischen Darstellung der Problematik. Ziel der Studie war daher, die aktuelle wissenschaftliche Evidenz hinsichtlich der gesundheitlichen Belastungsfaktoren des fliegenden Personals in einer detaillierten Übersichtsarbeit auf Grundlage der gegenwärtig vorliegenden medizinisch-wissenschaftlichen Literatur zu analysieren und zusammenzufassen. Anhand dieser Studie werden die einzelnen Belastungsfaktoren und die gesundheitliche Gesamtbelastung dieser Berufsgruppe erfasst und abgebildet. Die Ergebnisse sollen Handlungsfelder für Maßnahmen im Sinne eines präventiven ArbeitnehmerInnenschutzes aufzeigen und damit konkrete Verbesserungen an den Arbeitsplätzen anstoßen. Zudem sollen sie als Basis für zukünftige Ansatzpunkte bei der Anerkennung von Berufskrankheiten und der Schwerarbeit dienen.

Doris Artner-Severin (AK Wien) und Harald Bruckner (AK Wien)

Wien, im März 2021

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1 HINTERGRUND

Das vergleichsweise junge Berufsbild der Flugbegleiterin/des Flugbegleiters ist einem stetigen Wandel unterworfen, sodass sich Aufgaben, Herausforderungen und Zuständigkeiten, aber auch Risiken, welche dieser Beruf mit sich bringt, seit seinen Anfängen in den frühen 1920er Jahren stark verändert haben.

Die Wahrnehmungen des Berufsbildes der FlugbegleiterInnen schwanken zwischen Traumberuf mit zahlreichen Vorteilen und einem höchst anspruchsvollen Tätigkeitsfeld mit vergleichsweise hohen Gesundheitsrisiken. Angetrieben werden die gegenwärtigen Entwicklungen durch die technologischen Fortschritte in der Luftfahrtindustrie, die immer längere Flüge mit immer mehr Menschen ermöglichen. Anders als die Flugzeuge ist der menschliche Körper aber nicht für das Zurücklegen extrem langer Wegstrecken in so kurzer Zeit angepasst, was letztlich sowohl zu mentalen als auch körperlichen Problemen führen kann.

Die Belegschaft eines Flugzeuges ist somit einer erheblichen dauerhaften Belastung ausgesetzt und es ist ein bekanntes Phänomen, dass die gesundheitlichen Gefahren dabei wenig Beachtung finden, sei es aus Gründen des Drucks aus den jeweiligen Unternehmen, eigener Fehlwahrnehmung oder allgemeiner Unterschätzung der Folgen.

Ein wesentlicher Faktor, welcher zu einer Verschlechterung der Arbeitsbedingungen in diesem Sektor beigetragen hat, ist der Umstand, dass seit den frühen 1980er Jahren zunehmend Billigfluglinien auf den Flugmarkt drängen, was einerseits zu steigenden Passagierzahlen und dadurch verursacht steigenden Flugzahlen führte, andererseits aber die Fluglinien auch aufgrund der steigenden Konkurrenz unter finanziellen Druck und Zugzwang stellte. Auch das Flugpersonal ist durch die zunehmenden Passagierzahlen, aber auch die steigenden Ansprüche der Fluggäste in immer stärkerem Ausmaß Stressoren ausgesetzt.

Anders als die Flugzeuge selbst, die als technische Elemente mit erheblichem finanziellen Aufwand sorgsam kontrolliert, gewartet und gepflegt werden, gelten die Flugbegleiter als reine Serviceleister, die oft als nicht systemerhaltend angesehen werden, wobei deren wesentlicher Beitrag zu Flugsicherheit und allgemeiner Ablaufstabilität nicht berücksichtigt wird.

Hinweise aus Studien legen nahe, dass FlugbegleiterInnen im Vergleich zur Gesamtbevölkerung ein höheres Gesundheitsrisiko aufweisen (McNeely et al. 2014).

VertreterInnen der Belegschaft bzw. der MitarbeiterInnen der AUA beobachteten in den letzten Jahren eine Zunahme an (schweren) Erkrankungen (z.B. Tumore), speziell beim fliegenden Personal. Diese Beobachtungen wurden auch auf die Arbeitsbedingungen des fliegenden Personals zurückgeführt.

Die Arbeitsbedingungen sind generell mit teils für diesen Beruf sehr speziellen gesundheitlichen Belastungen (u.a. Einflüsse auf die Chronobiologie, Höhen- bzw. ionisierende Strahlung, Lärm- und Innenraumluftbelastung in der Kabine, Zeitdruck usw.) verbunden, die diese Berufsgruppe („Fliegendes Personal“) von anderen ArbeitnehmerInnengruppen sehr deutlich unterscheidet.

2 ZIEL DER VORLIEGENDEN STUDIE

Bisher fehlt es an einer fundierten arbeits- und umweltmedizinischen Darstellung der Problematik. Ziel der Studie ist es daher, die aktuelle wissenschaftliche Evidenz hinsichtlich der gesundheitlichen Belastungsfaktoren des fliegenden Personals in einer detaillierten Übersichtsarbeit auf Grundlage der gegenwärtig vorliegenden medizinisch-wissenschaftlichen Literatur zu analysieren und zusammenzufassen.

Auf Basis dieser Zusammenstellung sollen entsprechende Argumente für die Kommunikation an Verantwortliche bzw. die Öffentlichkeit sowie in weiterer Folge auch Grundlagen für Maßnahmen im Sinne eines präventiven ArbeitnehmerInnenschutzes ableitbar werden.

3 METHODE

Es erfolgte eine ausführliche systematische Literaturrecherche zu Belastungsfaktoren des Flugpersonals. Dabei wurde auf die folgenden Themenkomplexe fokussiert: Krebs, Zirkadianer Rhythmus, Infektionen, Stress, Erschöpfung, Fehlgeburten und COVID-19. Grundlage des Reviews sind überwiegend Veröffentlichungen in der Datenbank „Pubmed“, vereinzelt in anderen Datenbanken.

Die entsprechenden Begriffe – Flight attendants, cabin crew u.v.m – wurden bei der Literatursuche mit den interessierenden gesundheitlichen Endpunkten und Ähnlichem kombiniert.

Alle gefundenen Einträge wurden anhand von Titel und Abstract auf ihre jeweilige Relevanz geprüft und entsprechend ausgewählt.

Im Rahmen der Ergebnispräsentation soll, sofern vorhanden, v.a. auf aktuelle Studien (Publikationszeitraum 2010-2020), speziell auf Metaanalysen eingegangen und die wichtigsten Daten sollen überblicksmäßig und kompakt zusammengefasst werden.

4 ERGEBNISSE

Die Liste der hier behandelten gesundheitlichen Endpunkte mit gehäufter Prävalenz bei FlugbegleiterInnen ist zweifellos nicht vollständig, sondern stellt eine Auswahl dar, die auf der Grundlage der Schwere der Beeinträchtigung (Krebs, Fehlgeburt) oder aber der Häufigkeit (Infektionen etc.) erfolgte. Im Folgenden werden typische gesundheitliche Endpunkte der beruflichen Belastung von FlugbegleiterInnen dargestellt.

4.1 Krebserkrankungen

Es fanden sich 219 Einträge in der Datenbank, wovon 69 als relevant für die Arbeit eingestuft wurden. Die Mehrzahl der Studien beschäftigte sich mit der Frage eines erhöhten Risikos für Hautkrebs (Melanom und Nicht-Melanom) und Brustkrebs.

Metaanalysen zeigen ein grundsätzlich erhöhtes Risiko für Krebs bei FlugbegleiterInnen im Vergleich zur Normalbevölkerung (siehe Tabelle 1). Dabei treten die Häufigkeiten von Brust- und Hautkrebs besonders hervor. Das Risiko für Krebs der Schilddrüsen oder des Gehirns war bei Flugbegleitern nicht erhöht. Während man beim Brustkrebs von einem direkten Zusammenhang mit den Arbeitsbedingungen ausgeht, vor allem bedingt durch Strahlenbelastung und Verlust des Tagesrhythmus, dürfte die Häufung von Hautkrebsfällen indirekt berufliche Ursachen haben. Sie ist wohl darauf zurückzuführen, dass FlugbegleiterInnen oft ihre Freizeit in Regionen mit hoher Sonneneinstrahlung verbringen bzw. verbringen müssen (dos Santos Silva et al. 2013).

Auch Liu et al. (2016) ordneten in ihrer Metaanalyse aus 10 analysierten Studien und insgesamt 31697 Teilnehmerinnen sowie 821 neuen Fällen 40% aller Brustkrebsfälle unter Flugbegleiterinnen einer beruflichen Exposition zu (SIR 1.40; 95% CI: 1.30, 1.50). Als einer der Hauptfaktoren wird vor allem die kosmische ionisierende Strahlung (Höhenstrahlung) angeführt, wobei hier eine doppelt so hohe Dosis verglichen zur Normalbevölkerung nachgewiesen werden konnte. Dennoch lag dieser Wert immer noch unter dem Dosislimit von 20 mSv/Jahr.

Eine Kohortenstudie mit 6.093 US Flugbegleiterinnen ergab ein erhöhtes Risiko für Brustkrebs (Schuberger-Berigan et al. 2015) Dieses Risiko konnte jedoch weder alleine der stärkeren Strahlenbelastung noch einem gestörten Tagesrhythmus zugeordnet werden. Es war vielmehr durch die Anzahl der Geburten sowie vom Alter bei der ersten Geburt beeinflusst.

Besonders hervorzuheben ist eine Studie von McNeely et al. (2018), welche eine höhere Prävalenz von Brustkrebs (Standardized Prevalence Ratio 1.51; 95% Konfidenzintervall CI: 1,02; 2,24), schwarzem Hautkrebs (SPR 2,27; 95% CI: 1,27, 4.06) und weißem Hautkrebs (SPR 4.09; 95%CI: 2.70; 6.20) unter Flugbegleitern feststellte.

Meta-Analyse	Jahr	RR/pSIR *RR = Relatives Risiko* *pSIR = pooled standard incidence rate*	Internet-Link
Tokumaru et al. (Melanom + Brustkrebs)	2006	RR 2.13	https://doi.org/10.1111/j.1708-8305.2006.00029.x
Buja et al. (Alle Krebsarten)	2006	SIR 1.11	https://www.liebert-pub.com/doi/abs/10.1089/jwh.2006.15.98
Ballard et al. (Brustkrebs)	2000	RR 1.35	https://pubmed.ncbi.nlm.nih.gov/10716165/
Miura et al. (Melanom)	2019	pSIR 2.12	https://online-library.wiley.com/doi/full/10.1111/bjd.17586
Gassmann et al. (Brustkrebs)	2015	SIR 1.04-5.24	https://pubmed.ncbi.nlm.nih.gov/25442820/
He et al. (Brustkrebs)	2015	RR 1.56	https://pubmed.ncbi.nlm.nih.gov/25261318/
Liu et al. (Brustkrebs)	2016	pSIR 1.40	https://academic.oup.com/jtm/article/23/6/taw055/2750995
Sanlorenzo et al. (Melanom)	2015	pSIR 2.09	https://jamanetwork.com/journals/jamadermatology/article-abstract/1899248
Liu et al. (Schilddrüsenkrebs)	2018	pSIR 1.00	https://cancersheadneck.biomedcentral.com/articles/10.1186/s41199-018-0034-8
Liu et al. (Gehirn)	2017	pSIR 1.01	http://www.ijtmgh.com/article_43359.html

Tabelle 1: Meta-Analysen zum Thema Krebs bei FlugbegleiterInnen

4.2 Störung des zirkadianen Rhythmus

Zu den Suchbegriffen fanden sich 106 Resultate, wobei 20 davon Relevanz beigemessen werden konnte.

Unter dem zirkadianen Rhythmus versteht man in der Chronobiologie (siehe Exkurs 1) die Fähigkeit eines Organismus seine physiologischen Vorgänge auf eine bestimmte Periodenlänge (im Fall des Menschen ca. 24 Stunden) zu synchronisieren. Es konnte gezeigt werden, dass gerade dieser Rhythmus bei FlugbegleiterInnen, aber auch der restlichen Flugcrew aufgrund von Nachtarbeit und schnellem und häufigem Wechsel der Zeitzone häufig unterbrochen ist. Studien belegen, dass der menschliche Organismus 4 bis 6 Tage benötigt um nach einem Flug durch mehrere Zeitzonen seinen zirkadianen Rhythmus wieder zu synchronisieren (Grajewski et al. 2003). Gerade bei FlugbegleiterInnen werden diese Ruhe- und Erholungsphasen nur sehr selten eingehalten. In der Folge kommt es zu Veränderungen der Ausschüttung von Melatonin und Cortisol und damit einhergehenden Schlafstörungen.

Eine Metaanalyse von He et al. (2015) aus insgesamt 28 Studien assoziiert eine Unterbrechung der zirkadianen Rhythmik mit einem erhöhten Brustkrebsrisiko bei Frauen (RR 1.14; 95% CI: 1.08, 1.12). Dabei stellte sich heraus, dass das Risiko für Brustkrebs für jedes Jahrzehnt, das man in Schichtarbeit tätig ist, um 16% zunimmt (95% CI: 1.06, 1.27). Im Vergleich zu (anderen) Schichtarbeiterinnen haben Flugbegleiterinnen ein höheres Risiko (RR 1.56 vs. 1.19).

Auch konnte in einer Studie von Heidecker et al. (2017) eine erhöhte Rate an Fehlgeburten von 26% bei Flugbegleiterinnen verglichen zur Normalbevölkerung (17,1%) festgestellt werden, welche ebenfalls in Verbindung mit der Unterbrechung der zirkadianen Rhythmik stehen könnte.

Zumindest hinsichtlich des subjektiven Empfindens von Jetlag zeigten sich in einigen Studien positive Wirkungen von Melatonin. In einer Studie von Petrie et al. (1993) hatte die Einnahme von Melatoninpräparaten nach einem Rückflug einen positiven Effekt, nicht jedoch eine frühere Einnahme. Dies unterstreicht die Rolle des richtigen Timings bei der Einnahme derartiger Präparate.

EXKURS 1: Grundlagen zur Chronobiologie

1 Homöostase

Der menschliche Organismus ist in der Lage, das innere „Milieu“ auch bei stark wechselnden äußeren Umständen annähernd konstant zu halten. Ein bekanntes Beispiel betrifft die Körpertemperatur. Schon geringe Abweichungen von der optimalen Temperatur, zum Beispiel bei Fieber, beeinträchtigen Leistungsfähigkeit und Wohlbefinden. Bei mehr als 4 bis 5°C über der Normaltemperatur kommt es zu Bewusstlosigkeit, bei längerem Anhalten zu irreparablen Schäden, und letztlich tritt der Tod ein. Aber auch viele andere physiologische Funktionen werden in engen Grenzen reguliert. Diesen Vorgang nennt man Homöostase. Dabei werden jedoch die meisten Körperfunktionen nicht ständig auf einem fixen Wert gehalten, sondern schwanken in einer vorhersagbaren Weise.

2 Rhythmische Änderungen

Viele Körperfunktionen weisen einen Tagesgang mit charakteristischem Verlauf auf. Den Rhythmus, dem diese Funktionen unterliegen, nennt man zirkadian. Rhythmen mit längerer Zyklusdauer nennt man infradian (z.B. Menstruationszyklus), solche mit kürzerer Dauer ultradian (z.B. Herzrate). Diese periodischen Schwankungen dienen der Anpassung an geänderte Bedingungen bzw. Anforderungen und entsprechen einem gesunden Wechselspiel insbesondere zur besseren Regulierung und zur rascheren Reaktion auf Stimuli von außen.

3 Endogen oder exogen?

Wird der zirkadiane Rhythmus von der Außenwelt vorgegeben oder wird er vom Organismus selbst produziert? Diese grundlegende Frage der Biorhythmusforschung wurde in den 50er und 60er Jahren intensiv untersucht. In aufwändigen Isolations-experimenten wurden Probanden zum Teil wochenlang in unterirdischen Bunkern usw. untergebracht, um möglichst alle äußeren Einflüsse, die den Rhythmus „takten“ könnten, auszuschalten. Auch unter diesen Bedingungen sowie in Experimenten in der Polarnacht blieben die Zirkadianrhythmen bestehen, so dass eine körpereigene, innere Uhr vermutet wurde, die die verschiedenen Rhythmen übergeordnet steuerte. Allerdings begannen die einzelnen Rhythmen bei Ausschaltung äußerer Zeitgeber, wie vor allem dem natürlichen Hell-Dunkel-Wechsel, „frei“ zu laufen mit einer Zyklusdauer von etwas mehr als 24 Stunden (durchschnittlich etwa 25 Stunden). Offenbar ist es für den Organismus leichter, einen vollständigen Zyklus abzubremsen, als ihn auszudehnen.

4 Biologische Vorgänge

Obwohl die Metapher der Uhr in die Alltagssprache eingegangen ist, ist die Annahme einer einzigen biologischen Uhr, die die biologischen Prozesse kontrolliert, zu kurz gefasst. Grundsätzlich existiert eine übergeordnete „innere Uhr“, die im Nucleus suprachiasmaticus (SCN) im Gehirn als Kernstück liegt. und an periphere Organe, über wahrscheinlich das vegetative Nervensystem und Hormone wie insbesondere Melatonin, chronobiologisch relevante Informationen vermittelt.

Auf zellulärer Ebene gibt es jedoch auch ein „Uhrwerk“, das in Form von sogenannten Uhrengenen auch unabhängig von der „inneren Uhr“ schlägt und rhythmische Belange der Zelle kontrolliert. Zusammengefasst gibt es demnach die „Hauptuhr“ im Gehirn und kleine „Uhren“ auf zellulärer Ebene in praktisch allen Organen.

5 Bedeutung für die Arbeitsleistung

Die Bedeutung des physiologischen Tagesganges wurde zunächst für die Arbeitsleistung ermittelt. Schon 1953 wurde durch die Analyse von Ablesefehlern in einem Gaswerk in Schweden erkannt, dass die Leistung nicht nur von der Arbeitszeit (der Zeit seit Arbeitsbeginn), sondern auch von der Tageszeit abhängt. Die Abhängigkeit der Zahl der Fehlleistungen von der Tageszeit wird in Abbildung 1 dargestellt.

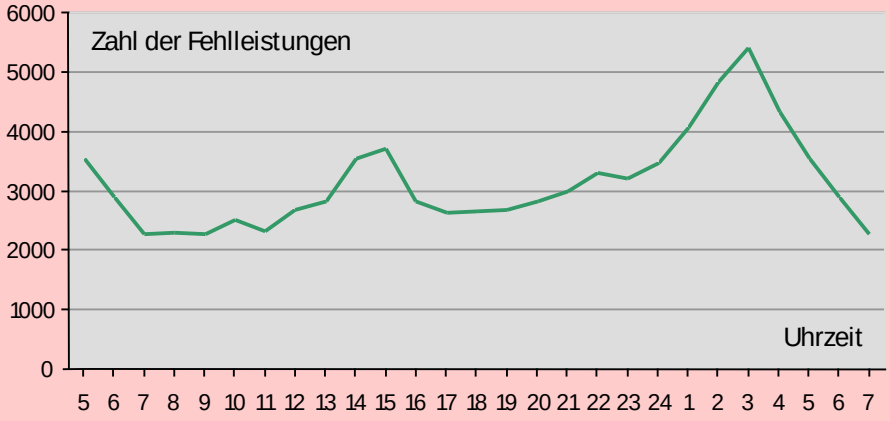

Abbildung 1: Zahl der Fehlleistungen in Abhängigkeit von der Tageszeit (n. Bjerner et al. 1955)

Dieser Tagesgang der Fehlerquoten entspricht spiegelbildlich dem Funktionsverlauf vieler physiologischer Funktionen wie der Körpertemperatur, dem Blutdruck oder der Lungenfunktion. Alle diese rhythmischen Funktionsabläufe sind Ausdruck einer fundamentalen Zeitorganisation: dem Wechsel zwischen der so genannten ergotropen und der trophotropen Phase. In der ergotropen Phase ist der Organismus auf Tätigkeit und Leistung „programmiert“, in der trophotropen auf Erholung und Schlaf.

Die Problematik von Nacht- und Schichtarbeit liegt u.a. darin, dass diese Grundorganisation im Allgemeinen durch Arbeit zu abweichenden Zeiten nicht geändert werden kann. Auch wenn in der Nacht gearbeitet wird, ist der Organismus eigentlich auf Erholung und Schlaf eingerichtet. Unter normalen Umständen findet selbst nach beliebig vielen Nachtschichten hintereinander keine wirkliche Anpassung statt. Einige der Zirkadianrhythmen verflachen nach einigen Tagen Nachtschicht, ohne sich aber vollständig umzukehren. Es kommt daher zu einer Desynchronisation zwischen verschiedenen rhythmischen Funktionen und dem Aktivitätsrhythmus. Dieses Auseinanderklaffen zwischen der biologischen Orientierung des Körpers und dem durch das Arbeitszeitregime geforderten Leistungszyklus ist für eine Reihe von Problemen der Schichtarbeiter verantwortlich. Das bekannteste Problem besteht in Schlafschwierigkeiten.

4.3 Fehlgeburten

Die Literatursuche erbrachte 14 Treffer, von denen acht als relevant für die vorliegende Arbeit eingestuft wurden.

In der bereits erwähnten Studie von Heidecker et al. (2017) wurde eine erhöhte Rate an Fehlgeburten von 26% bei Flugbegleiterinnen verglichen zur Normalbevölkerung (17,1%) festgestellt. Grajewski et al. (2015) zeigten in einer Studie mit 673 Flugbegleiterinnen auf mehr als zwei Millionen Flügen, dass vor allem die allgemeine hohe Beanspruchung während der Arbeit in der Kabine sowie die Störung des zirkadianen Rhythmus mit einem erhöhten Fehlgeburtsrisiko verbunden ist. Yang et al. (2013) fanden eine deutlich schlechtere reproduktionsbezogene Gesundheit bei Flugbegleiterinnen im Vergleich zu nicht-fliegendem Personal derselben chinesischen Fluglinien. Die Häufigkeit einer Fehlgeburt war mit 6,8% deutlich höher als in der Kontrollgruppe (3,0%).

Zu einem ähnlichen Schluss kam eine finnische Studie von Aspholm et al. (1999), wo ein mit den Jahren zunehmendes Risiko für Spontanaborte bei Flugbegleiterinnen festgestellt wurde (Odds Ratio OR 1.6; 95% CI 1.1-2.4). Zu einem ähnlichen Ergebnis kamen auch Megann et al. (2010), die in einer Übersichtsarbeit zeigten, dass Flugbegleiterinnen ein erhöhtes Risiko für Fehlgeburten aufweisen (OR 1.62; 95% CI 1.29-2.04).

Eine Studie von dos Santos Silva et al. aus dem Jahr 2009 zeigte weiters einen Hinweis auf eine erhöhte kongenitale Fehlbildungsrate bei Kindern von Flugbegleiterinnen (OR: 2.37; 95%CI 0.43-13.06).

Zusammenfassend kann man festhalten, dass das Risiko von Flugbegleiterinnenn für eine Fehlgeburt bzw. vorzeitigen Schwangerschaftsabbruch erhöht ist. Die kausalen Zusammenhänge mit bestimmten beruflichen Faktoren sowie der Einfluss allgemeiner berufsbedingter Lebensumstände sind aber bisher nur unzureichend erforscht.

4.4 Infektionen

Die Suchbegriffe lieferten 1.036 Ergebnisse, von denen 41 für diese Arbeit ausgewählt wurden. Das erhöhte Infektionsrisiko für Flugpersonal wurde durch zahlreiche Studien nachgewiesen. An erster Stelle sind hier respiratorische Infekte zu nennen. Faktoren, welche diese im Flugzeug begünstigen, sind unter anderem der vorherrschende niedrige Luftdruck, Hypoxie und trockene Umgebungsluft im Flugzeuginneren (Leder u. Newman 2005). Dabei spielt weniger die Luftzirkulation der raumlufttechnischen Anlage innerhalb des Flugzeugs eine Rolle, sondern vielmehr der direkte Kontakt zu infizierten Passagieren.

Episoden von Influenza-ähnlichen Erkrankungen waren bei ungeimpftem Flugpersonal gegenüber geimpftem Flugpersonal um 39,5% häufiger (Mixéu et al. 2002). Das Risiko für die Ansteckung mit respiratorischen Infektionen dürfte in Passagierflugzeugen für die Passagiere, mit Ausnahme bei unmittelbarer Sitzplatz-Nachbarschaft zu infizierten Personen, allgemein nicht deutlich erhöht sein (Hertzberg et al. 2018). Eine Übertragung von Tuberkulose wird sogar als unwahrscheinlich eingestuft und das Flugzeug entsprechend als Niedrig-Inzidenz-Setting klassifiziert (Thibeault et al. 2012, Byrne 2007).

In einer Übersichtsarbeit von Edelson aus dem Jahr 2012 konnte hinsichtlich Masern gezeigt werden, dass eine Übertragung über einen Abstand von siebzehn Sitzreihen möglich ist und im Durchschnitt im Bereich von bis zu sechs Sitzreihen auftritt. Diese Beobachtungen stellen die Definition der Hochrisiko-Exposition/Ansteckungszone von zwei Reihen („2-Row Rule“), welche vor allem für respiratorische Erkrankungen verwendet wird, infrage. Zu einem ähnlichen Ergebnis kam auch eine Literaturübersicht von Hertzberg und Weiss aus dem Jahr 2016, bei welcher für 40% aller untersuchten Infektionen in Flug-

zeugen die Übertragung außerhalb der 2-Reihen-Zone stattfand und dabei vor allem die Bewegungsmuster der Passagiere und Flugbegleiter im Flugzeug eine wichtige Rolle spielen könnten. Hier wird das Risiko für eine Ansteckung innerhalb von zwei Reihen Abstand zum Infizierten mit 6% und über die zwei Reihen hinaus mit 2% kalkuliert. So ist vor allem der Nahbereich unter einem Meter Abstand relevant, welcher nicht nur den Nachbarsitz einschließt, sondern auch infizierte Passagiere, die während des Fluges an Sitzplätzen vorbeigehen bzw. sitzende Passagiere, an denen während des Fluges vorbeigegangen wird (Hertzberg et al. 2018). Aus diesem Grund werden auch in zwei weiteren Studien Gangplätze (der direkte Arbeitsbereich der Flugbegleiter) als besondere Risikobereiche genannt (Kirking et al. 2010, Lei et al. 2018).

Zu weiteren Infektionen, welche sich im Flugzeugsetting verbreiten können, zählen unter anderem solche mit Meningokokken (Leder u. Newman 2005).

In einer Studie von Schwartz et al. (2012) gaben 52% der Flugbegleiter an trotz spürbarer Krankheitssymptome zu arbeiten. Die Bereitschaft zur Selbstisolation zeigte sich jeweils stark von der diesbezüglichen Einstellung des Arbeitgebers bzw. Unternehmens abhängig. In Bezug auf Piloten konnte eine Studie aus dem Jahr 2017 nachweisen, dass sich innerhalb von 10 Jahren der Prozentsatz der Piloten, die trotz Infektionen der oberen Atemwege zur Arbeit erschienen, signifikant erhöhte (Boel u. Klokker 2017). Als Grund dafür wird u.a. der bereits erwähnte gesteigerte Wettbewerb innerhalb der Flugbranche genannt. Infolge dessen erleiden auch immer mehr Piloten Barotraumen im Bereich der Ohren mit entsprechenden Folgeerkrankungen, welche wiederum Auswirkung auf die Flugsicherheit haben können (Rosenkvist et al. 2008). Analoge Folgen sind auch für FlugbegleiterInnen anzunehmen, wenn auch dazu die Daten aus Studien fehlen.

COVID-19

Die Literatursuche erbrachte 120 Treffer, wovon 6 Arbeiten weiter betrachtet wurden. Aufgrund der Brisanz und Aktualität der Pandemie nimmt die Anzahl der Arbeiten zum Übertragungsrisiko von COVID-19 stetig zu. Etliche Studien (z.B. Yang et al. 2020) sehen ein gewisses Übertragungsrisiko in Flugzeugen und empfehlen daher auch entsprechende Schutzmaßnahmen während des Flugs. Nir-Paz (2020) stuft das Übertragungsrisiko als gering ein, speziell wenn alle Anwesenden höherwertige Masken (FFP2 bzw. N95) tragen.

Prinzipiell ist der Wissensstand hinsichtlich der Übertragung von SARS-CoV-2 in Flugzeugen und des Risikos einer Infektion mit COVID-19 allerdings noch nicht ausreichend, um hier wissenschaftlich fundierte Schlüsse zu ziehen.

4.5 Stress und Erschöpfung

Die Literatursuche bezüglich Stress brachte 59 Resultate, von denen sechs Publikationen in die vorliegende Arbeit aufgenommen wurden. Hinsichtlich Erschöpfung waren es vier Arbeiten von 20.

In einer Studie aus dem Jahr 2017 von Omholt et al. konnte gezeigt werden, dass hohe Level von berufsbedingtem Stress mit einer höheren Zahl an Gesundheitsbeschwerden assoziiert waren. Fünfundzwanzig Prozent der Kabinencrew empfanden subjektiv hohe Stresslevel, wogegen es bei der Cockpitcrew 15% waren. Als Folge davon berichtete das Kabinenpersonal signifikant häufiger ($p < 0,05$) über Gesundheitsbeschwerden als die Cockpitbesatzung. Am häufigsten wurden von der Kabinencrew Müdigkeit, Kopfschmerzen, Darmprobleme, Schlafstörungen sowie Nacken- und Schulterschmerzen angegeben. Nicht selten waren auch gastrointestinale Beschwerden, Depressionen und Schwindel.

Die erhöhte Stresssituation der Kabinencrew führten die Studienautoren (Omholt et al. 2017) auf die physisch belastende und monotone Arbeit, Zeitzonen-Shifts, Lärm (Schallpegel in der Kabine bis zu 110

Dezibel; Zevitas et al. 2018), Vibrationen, die erhöhte Arbeitsbelastung durch Sicherstellung der Sicherheit und des Passagier-Services durch das Flugpersonal und schließlich auch auf aggressives Verhalten und sexuelle Belästigungen durch Passagiere zurück. Sie unterstreichen, dass mehr Forschung zu spezifischen psychosozialen Stressoren, die auf FlugbegleiterInnen einwirken, notwendig ist.

Als weitere wesentliche Stressoren wurden von MacDonald et al. (2003) außerdem ein Ungleichgewicht zwischen Job und Freizeitaktivitäten, Gefühle von Isolation und Einsamkeit, verursacht durch längere Abwesenheit von zu Hause und mangelnde Unterstützung etwa in Form von Supervisionen genannt. Zudem fühlt sich bis zu einem Drittel aller FlugbegleiterInnen vor dem Abheben ängstlich.

MacDonald et al. (2003) zeigten, dass diese Umstände zu einem Erschöpfungsgefühl („Fatigue“) bei Flugbegleitern führen. Als erste und offensichtlichste Ursache für einen erhöhten Erschöpfungsgrad von FlugbegleiterInnen nannten die Betroffenen den berufsbedingte Schlafmangel und die Unterbrechung der zirkadianen Rhythmik. Aber auch weitere Faktoren, wie etwa ungenügende Ruhezeiten, hohe Arbeitsbelastung, Arbeitsumgebung, fehlende Unterstützung durch den Arbeitgeber und ungenügende Fortbildungen hinsichtlich Ermüdungsmanagement wurden in einer aktuellen Studie von van den Berg et al. (2020) identifiziert.

In dieser qualitativen Erhebung nannten FlugbegleiterInnen unter anderem auch Gewichtszunahme und ein schlechteres Immunsystem mit häufigeren Erkrankungen als Folgen der Erschöpfung. Aber auch Auswirkungen auf Sicherheit und Service während der Arbeit, aufgrund von erhöhter Reizbarkeit, herabgesetzter Aufmerksamkeit, Vergesslichkeit und Veränderungen in der Leistungsbereitschaft wurden als Gefahren der Erschöpfung angeführt.

Besonders belastend dürften hierbei die sogenannten Inbound-Flüge, also die Rückflüge, sein, auf denen sich Müdigkeit und Erschöpfung mehr auf die Job-Performance auswirken als auf Outbound-Flügen. Auch konnte im Rahmen der Arbeit von van den Berg et al. (2020) festgestellt werden, dass das Flugpersonal am ersten Tag nach einem Trip erhöhten Schlafbedarf hat und aufgrund dessen der Heimweg per Auto aufgrund von erhöhter Müdigkeit eine erhebliche Gefahrenquelle darstellt.

Als Lösungsvorschläge nannten die Teilnehmer der Studie primär Änderungen des Dienstplans mit einer Maximierung der Pausenzeiten zwischen den Diensten sowie eine Verkürzung zu langer Turnaround-Zeiten. Auch wurde hier auf die Wichtigkeit des Vorhandenseins entsprechender Ruheräume (fernab von Passagieren) hingewiesen. Eine Aufstockung der Crew während des Fluges hätte zudem eine Abnahme der Arbeitsbelastung zur Folge, was wiederum mehr Zeit zur Erholung auch während des Flugs biete.

Zu Erschöpfung kann auch die Emotionsarbeit (Chang 2009) und das hohe Maß an selbstkontrolliertem Verhalten, das von Flugbegleitern erwartet wird, führen.

Einen weiteren Stressfaktor, der in den letzten Monaten hinzugekommen ist, stellt die Corona-Pandemie dar.

4.6 Weitere Belastungsfaktoren und ihre Folgen

Wie oben angeführt (Kapitel 4.4) stellt die Lärmexposition einen weiteren ernstzunehmenden Belastungsfaktor dar. Generell ist Lärm am Arbeitsplatz ein Problem und kann u.a. zu physiologischem Stress, erhöhtem Blutdruck und verminderter Leistungsfähigkeit führen. Dauerlärm ist mit einem erhöhten Risiko für kardiovaskuläre Erkrankungen verbunden, aber auch mit immunologischen Effekten und Stoffwechselproblemen. Diesbezügliche spezifische Studien zu den Auswirkungen der Lärmexposition innerhalb von Flugzeugen liegen bisher kaum vor.

Seit etlichen Jahren diskutiert werden auch „fume and smell events“ und das sogenannte aerotoxische Syndrom, das zum Teil auf Chemikalien in Triebwerksölen zurückgeführt wird (de Boer et al. 2015).

Zahlreiche Studien zeigen zudem eine allgemein hohe Prävalenz für Beschwerden des Bewegungsapparates bei Flugbegleitern (Lee et al. 2006: 50-86%, Rau et al. 2020: 86%, Posch et al. 2019: 48%, Mulay et al. 2019: 82%). Mulay et al. (2019) befragten 33 FlugbegleiterInnen im Detail und konnten Probleme der Füße und Fußgelenke, des Lendenbereiches, des Nackens und der Schulter als häufigste genannte Beschwerden finden.

Die Betroffenen führten diese Beschwerden hauptsächlich auf das lange Stehen mit wenigen Pausen zurück, aber auch auf die berufliche Notwendigkeit Schuhe mit hohen Absätzen zu tragen, wie auch auf erhöhten mentalen Stress. Ein weiterer Faktor für Beschwerden im Muskel- und Skelettbereich ist zweifelsohne das wiederholte Heben schwerer Koffer etc., oft verbunden mit dafür ungeeigneten Körperhaltungen oder Drehbewegungen.

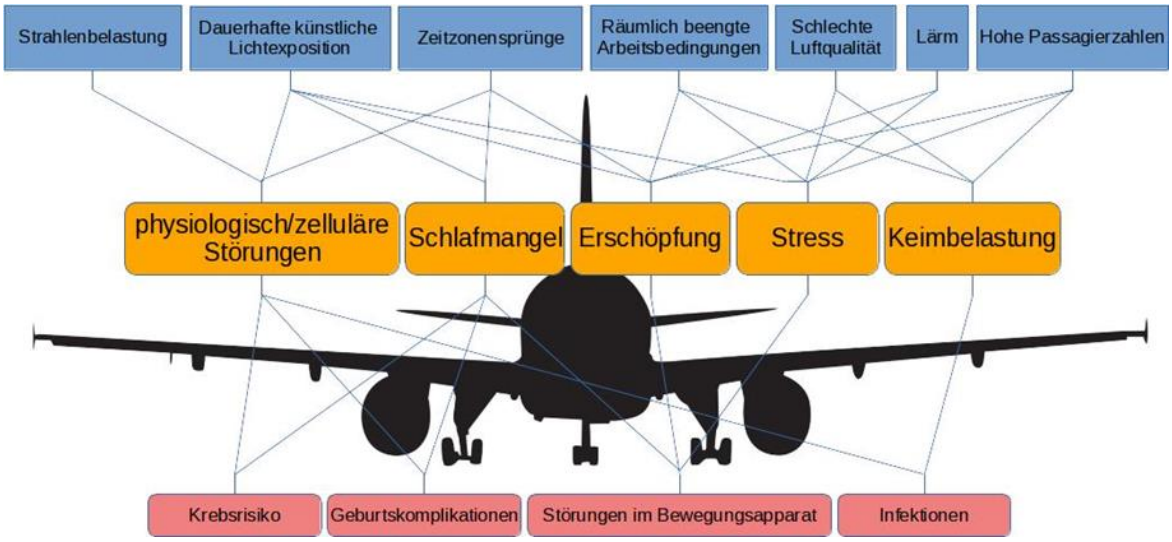

Abbildung 2: Spezifische äußere Faktoren beim Flugpersonal (blau) führen zu erhöhter Belastung (orange) und entsprechenden nachweisbaren negativen gesundheitlichen Folgen (rot).

4.7 Ergebnisse im Überblick

Wie bereits einleitend ausgeführt, erheben diese Ergebnisse keinen Anspruch auf Vollständigkeit. Es wurden exemplarisch jene Gesundheitsfolgen ausführlicher dargestellt, die entweder häufig auftreten oder besonders schwerwiegend sind. Zu letzter Gruppe zählen zweifellos **Krebserkrankungen**, wobei Studien zeigen, dass das Risiko an irgendeiner Form von Krebs zu erkranken bei Flugbegleitern im Vergleich zur Allgemeinbevölkerung um ca. 10% erhöht ist. Besonders das Risiko für **Brustkrebs** der Frau sowie **Hautkrebs** ist erhöht, nämlich um etwa 40 bis 100%. Die genauen Ursachen der Risikoerhöhung sind in ihrer Gewichtung noch strittig, da es sich um ein Bündel an Ursachen handeln könnte. Es umfasst unter anderem Auswirkungen des gestörten Tagesrhythmus auf Hormonspiegel, insbesondere bezüglich Melatonin, ionisierende Strahlung und berufsassoziierte Verhaltensweisen wie etwa Sonnenexposition.

Die **Störung des Tagesrhythmus** muss nicht nur in Zusammenhang mit dem Krebsrisiko thematisiert werden, sondern spielt wahrscheinlich auch eine Rolle bei einem deutlich erhöhten Risiko für **Fehlgeburten**. Sie bewirkt auch **Schlafstörungen**, die sich ihrerseits negativ auf Leistungsfähigkeit und Wohlbefinden und auswirken und den **Stress** verstärken, der sich bereits aus dem sozial anspruchsvollen Aufgabenbereich ergibt. Chronischer Stress stellt für sich ein Gesundheitsrisiko dar.

Zusätzlich wurde auch im Hinblick auf den aktuellen Anlass das **Infektionsrisiko** ausführlicher dargestellt. Auch hier zeigen Studien ein erhöhtes Risiko für FlugbegleiterInnen, die etwa durch den direkten Kontakt mit zahlreichen Personen gefährdet sind.

5 SCHLUSSFOLGERUNGEN UND EMPFEHLUNGEN AUS ARBEITSMEDIZINISCHER SICHT

Im Rahmen des vorliegenden Literaturreviews konnten Hauptfaktoren basierend auf rezenter Literatur genauer bearbeitet und erneut bestätigt werden. Diese Belastungsfaktoren stehen in enger Wechselbeziehung und bestimmen wesentlich den Berufsalltag bzw. die tägliche Belastung und damit auch die damit verbundenen gesundheitlichen Auswirkungen auf das Flugpersonal: Stress, Erschöpfung sowie Störung des zirkadianen Rhythmus. Weiters zu berücksichtigen ist die erhöhte Strahlenbelastung im Vergleich zur Allgemeinbevölkerung.

Wie in Abbildung 2 ersichtlich, wirken multiple, unterschiedliche Einflussfaktoren auf physiologische und psychologische Weise auf FlugbegleiterInnen in ihrem Arbeitsumfeld ein. Zum Teil handelt es sich um sehr spezielle Belastungsfaktoren, die praktisch kaum in einem anderen Beruf eine Entsprechung finden.

Bei einem Großteil dieser Faktoren kann die Belastung durch gezielte Intervention im jeweiligen Bereich reduziert/minimiert werden und so der Einfluss auf das Flugpersonal, im Sinne einer Risikoprävention, deutlich gesenkt werden. Als Beispiele können hier verlängerte/häufigere Ruhe- bzw. Stehzeiten, Personalaufstockung und Bereitstellung entsprechender Ruheräume genannt werden.

Die Höhenstrahlung – Belastung durch kosmische Hintergrundstrahlung – lässt sich durch technische Maßnahmen im oder am Flugzeug nicht ausreichend abschirmen. Das Ausmaß der zusätzlichen Strahlenbelastung beim Fliegen hängt vor allem von der Flugdauer, der Route, Flughöhe und der Sonnenaktivität ab. Folglich sind – im Sinne einer Risikominimierung – organisatorische Maßnahmen zur Dosisreduktion insbesondere betreffend Flugdauer und -frequenz, aber auch Flughöhe und -route, umzusetzen.

Speziell wenn häufig Langstrecken auf den nördlichen Polrouten geflogen werden, erhalten diese Berufsgruppe Strahlendosen, die vergleichbar sind mit Dosiswerten in Berufsgruppen, die ionisierende Strahlung einsetzen oder mit radioaktiven Quellen umgehen. Die Strahlenbelastung von PilotInnen und FlugbegleiterInnen wird zwar überwacht und beschränkt, darf aber als Belastungsfaktor insgesamt nicht vernachlässigt werden.

Ähnliches gilt für die chronobiologischen Folgen aufgrund der Desynchronisation zwischen verschiedenen rhythmischen physiologischen Funktionen und dem Aktivitätsrhythmus. Auch in diesem Fall werden gewisse Störungen unvermeidbar sein. Daher sind auch dahingehend weitere Anstrengungen notwendig, um Störungen zu minimieren als auch diese stärker als Belastungsfaktoren zu berücksichtigen.

Erfahrungsgemäß ist ein Großteil aller FlugbegleiterInnen weiblich. Von den vorhin genannten und bearbeiteten Endpunkten betreffen zwei vor allem (Brustkrebs) bzw. ausnahmslos (Fehlgeburten) Frauen. Daher kann die Berufsgruppe „Fliegendes Personal“ als Risikopopulation definiert werden.

Speziell die fordernde bzw. emotional schwierige Interaktion mit Passagieren kombiniert mit einem hohen Maß an erforderlicher Selbstkontrolle führt zu Stress und kann auf Dauer zu Erschöpfungszuständen bzw. zu entsprechenden gesundheitlichen Folgen beitragen. Diese immer stärker belastende Facette des Arbeitsalltages ist bisher kaum in entsprechendem Ausmaß arbeitsmedizinisch gewürdigt und letztlich auch – wenn überhaupt – nur in Ansätzen öffentlich dargestellt worden.

Daher ist eine gezielte Öffentlichkeitsarbeit wesentlich z.B. durch entsprechende Kampagnen, die wertschätzenden, respektvollen Umgang der Passagiere mit dem Flugpersonal sowie Verständnis für die anspruchsvollen Arbeitsbedingungen und ihren essenziellen Beitrag zur Flugsicherheit fördert. Dies muss selbstverständlich seitens der Arbeitgeber dezidiert mitgetragen werden.

Weiters kann regelmäßige Inanspruchnahme von Supervisions-Angeboten für das Personal ein wichtiger Faktor zur Bewältigung herausfordernder Arbeitssituationen und Arbeitsbedingungen sein; das Angebot diesbezüglich sollte daher entsprechend des Bedarfs ausgebaut werden.

Weitere Maßnahmen zum Arbeitnehmerschutz von FlugbegleiterInnen und zur Risikominimierung der dargestellten Beeinträchtigungen und Erkrankungen sind aus arbeitsmedizinischer Sicht dringend erforderlich.

Aufgrund der Vielfalt an Belastungsfaktoren ist es auch aus arbeitshygienisch/arbeitsmedizinischer Sicht dringend zu überlegen, ob nicht etwa auch eine Einstufung als Schwerarbeit gerechtfertigt wäre.

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Zevitas, C. D. *et al.* Assessment of noise in the airplane cabin environment. *J Expo Sci Environ Epidemiol* **28**, 568–578 (2018).

ANHANG

1 – KREBSERKRANKUNGEN

Anderson JL, Waters MA, Hein MJ, Schubauer-Berigan MK, Pinkerton LE. Assessment of occupational cosmic radiation exposure of flight attendants using questionnaire data. *Aviat Space Environ Med*. 2011;82(11):1049-1054.

Introduction: Female flight attendants may have a higher risk of breast and other cancers than the general population because of routine exposure to cosmic radiation. As part of a forthcoming study of breast and other cancer incidence, occupational cosmic radiation exposure of a cohort of female flight attendants was estimated.

Methods: Questionnaire data were collected from living female cohort members who were formerly employed as flight attendants with Pan American World Airways. These data included airline at which the flight attendant was employed, assigned domicile, start and end dates for employment at domicile, and number of block hours and commuter segments flown per month. Questionnaire respondents were assigned daily absorbed and effective doses using a time-weighted dose rate specific to the domicile and/or work history era combined with self-reported work history information.

Results: Completed work history questionnaires were received from 5898 living cohort members. Mean employment time as a flight attendant was 7.4 yr at Pan Am and 12 yr in total. Estimated mean annual effective dose from all sources of occupational cosmic radiation exposure was 2.5 +/- 1.0 mSv, with a mean career dose of 30 mSv.

Discussion: Annual effective doses were similar to doses assessed for other flight attendant cohorts; however, questionnaire-based cumulative doses assessed in this study were on average higher than those assessed for other flight attendant cohorts using company-based records. The difference is attributed to the inclusion of dose from work at other airlines and commuter flights, which was made possible by using questionnaire data.

Anisimov VN. The role of pineal gland in breast cancer development. *Crit Rev Oncol Hematol*. 2003;46(3):221-234.

The role of the modulation of the pineal gland function in development of breast cancer is discussed in this review. An inhibition of the pineal function with pinealectomy or with the exposure to the constant light regimen stimulates mammary carcinogenesis, whereas the light deprivation inhibits the carcinogenesis. Epidemiological observations on increased risk of breast cancer in night shift workers, flight attendants, radio and telegraph operators and on decreased risk in blind women are in accordance with the results of experiments in rodents. Treatment with pineal indole hormone melatonin inhibits mammary carcinogenesis in pinealectomized rats, in animals kept at the standard light/dark regimen (LD) or at the constant illumination (LL) regimen. Pineal peptide preparation Epithalamin and synthetic tetrapeptide Epitalon (Ala-Glu-Asp-Gly) are potent inhibitors of mammary carcinogenesis in rodents and might be useful in the prevention of breast cancer in women at risk.

Bagshaw M. Cosmic radiation in commercial aviation. Travel Med Infect Dis. 2008 May;6(3):125-7.

This paper reviews the current knowledge of cosmic radiation and its applicability to commercial aviation. Galactic cosmic radiation emanates from outside the solar system, while occasionally a disturbance in the suns' atmosphere leads to a surge in radiation particles. Protection is provided by the suns' magnetic field, the earths' magnetic field, and the earths' atmosphere. Dose rates are dependent on the altitude, the geomagnetic latitude and the solar cycle. For occupational exposure to ionising radiation, which includes aircrew, the International Commission on Radiological Protection recommends maximum mean body effective dose limits of 20mSv/yr (averaged over 5 years, with a maximum in any 1 year of 50mSv). Radiation doses can be measured during flight or may be calculated using a computer-modelling program such as CARI, EPCARD, SIEVERT or PCAIRE. Mean ambient equivalent dose rates are consistently reported in the region of 4-5microSv/h for long-haul pilots and 1-3microSv/h for short-haul, giving an annual mean effective exposure of the order 2-3mSv for long-haul and 1-2mSv for short-haul pilots. Epidemiological studies of flight crew have not shown conclusive evidence for any increase in cancer mortality or cancer incidence directly attributable to ionising radiation exposure. Whilst there is no level of radiation exposure below which effects do not occur, current evidence indicates that the probability of airline crew or passengers suffering adverse health effects as a result of exposure to cosmic radiation is very low.

Ballard T, Lagorio S, De Angelis G, Verdecchia A. Cancer incidence and mortality among flight personnel: a meta-analysis [published correction appears in Aviat Space Environ Med 2000;71(12):1262]. *Aviat Space Environ Med*. 2000;71(3):216-224.

Background: Increased cancer risk among flight personnel have previously been noted, including breast cancer among flight attendants and acute myeloid leukemia among pilots.

Hypothesis: Exposure to cosmic radiation and other physical or chemical agents may pose health risks for flight personnel.

Methods: We performed an exhaustive search for published and unpublished cohort studies of flight personnel from 1986-98. We combined relative risks (RR) for selected causes from four mortality and/or incidence studies of pilots and two incidence studies of flight attendants, using standard meta-analytic methods. Heterogeneity among the combined studies was explored and adjustments were made for possible confounding by socioeconomic status (SES), where indicated, using correction factors from published studies.

Results: SES-adjusted combined RRs were elevated (>1.2) among male pilots for mortality from melanoma 11.97 (95%, CI: 1.02-3.82)] and brain cancer [1.49 (0.89-2.20)], and for cancer incidence of the prostate [1.65 (1.19-2.29)] and the brain [1.74 (0.87-3.30)]. Among female flight attendants, increases were seen for incidence of all cancers [1.29 (0.98-1.70)], melanoma [11.54 (0.83-2.87)], and breast cancer [1.35 (1.00-1.83)].

Conclusions: Flight personnel appear to be at increased risk for several types of cancer. Both occupational exposures and well-established non-occupational risk factors may contribute to this increased risk. To better control for confounding factors and to identify exposures potentially amenable to preventive measures, future studies should compare risks within cohorts by flight routes, work history, and exposure to cosmic and UV radiation, electromagnetic fields, and chemical substances.

Band PR, Le ND, Fang R, et al. Cohort study of Air Canada pilots: mortality, cancer incidence, and leukemia risk. *Am J Epidemiol*. 1996;143(2):137-143.

Despite the special working environment and exposures of airline pilots, data on risk of death and cancer incidence in this occupational group are limited. The authors investigated a cohort of 2,740 Air Canada pilots who contributed 62,449 person-years of observation. All male pilots employed for at least 1 year on and since January 1, 1950, were studied. The cutoff date for outcome information was December 31, 1992. Standardized mortality ratio (SMR) and standardized incidence ratio (SIR) were used to compare mortality rates and cancer incidence rates of the cohort with the respective Canadian population rates. Ninety percent confidence intervals of the SMR and SIR were calculated. Statistically significant decreased mortality was observed for all causes (SMR = 0.63, 90% confidence interval (CI) 0.56-0.70), for all cancers (SMR = 0.61, 90% CI 0.48-0.76), and for all noncancer diseases (SMR = 0.53, 90% CI 0.45-0.62). Mortality from aircraft accidents was significantly raised (SMR = 26.57, 90% CI 19.3-35.9). Significantly decreased cancer incidence was observed for all cancers (SIR = 0.71, 90% CI 0.61-0.82), rectal cancer (SIR = 0.42, 90% CI 0.14-0.96), lung cancer (SIR = 0.28, 90% CI 0.16-0.46), and bladder cancer (SIR = 0.36, 90% CI 0.12-0.82). Prostate cancer (SIR = 1.87, 90% CI 1.38-2.49) and acute myeloid leukemia (SIR = 4.72, 90% CI 2.05-9.31) were significantly increased. The preferred relative risk model for radiation-induced nonchronic lymphoid leukemia (Beir V report) was applied to the cohort by using published estimates of in-flight radiation exposures. The estimated relative risk ranged from 1.001 to 1.06 and did not differ significantly from the observed SIR (SIR = 1.88, 90% CI 0.80-3.53). However, the incidence rate of acute myeloid leukemia was significantly increased. Monitoring of in-flight radiation exposure and long-term follow-up of civil aviation crew members is needed to further assess cancer incidence and leukemia risk in this special occupational group.

Blettner M et al. Mortality from cancer and other causes among male airline cockpit crew in Europe. Int J Cancer. 2003 10;106(6):946-52.

Airline pilots and flight engineers are exposed to ionizing radiation of cosmic origin and other occupational and life-style factors that may influence their health status and mortality. In a cohort study in 9 European countries we studied the mortality of this occupational group. Cockpit crew cohorts were identified and followed-up in Denmark, Finland, Germany, Great Britain, Greece, Iceland, Italy, Norway and Sweden, including a total of 28,000 persons. Observed and expected deaths for the period 1960-97 were compared based on national mortality rates. The influence of period and duration of employment was analyzed in stratified and Poisson regression analyses. The study comprised 547,564 person-years at risk, and 2,244 deaths were recorded in male cockpit crew (standardized mortality ratio [SMR] = 0.64, 95% confidence interval [CI] = 0.61-0.67). Overall cancer mortality was decreased (SMR = 0.68; 95% CI = 0.63-0.74). We found an increased mortality from malignant melanoma (SMR = 1.78, 95% CI = 1.15-2.67) and a reduced mortality from lung cancer (SMR = 0.53, 95% CI = 0.44-0.62). No consistent association between employment period or duration and cancer mortality was observed. A low cardiovascular mortality and an increased mortality caused by aviation accidents were noted. Our study shows that cockpit crew have a low overall mortality. The results are consistent with previous reports of an increased risk of malignant melanoma in airline pilots. Occupational risk factors apart from aircraft accidents seem to be of limited influence with regard to the mortality of cockpit crew in Europe.

Blettner M, Zeeb H, Langner I, Hammer GP, Schafft T. Mortality from cancer and other causes among airline cabin attendants in Germany, 1960-1997 [published correction appears in Am J Epidemiol. 2009 15;170(4):534-5. *Am J Epidemiol*. 2002;156(6):556-565.

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.

Boice JD Jr, Blettner M, Auvinen A. Epidemiologic studies of pilots and aircrew. *Health Phys.* 2000;79(5):576-84.

During flight, pilots and cabin crew are exposed to increased levels of cosmic radiation which consists primarily of neutrons and gamma rays. Neutron dosimetry is not straightforward, but typical annual effective doses are estimated to range between two and five mSv. Higher dose rates are experienced at the highest altitudes and in the polar regions. Mean doses have been increasing over time as longer flights at higher altitudes have become more frequent. Because there are so few populations exposed to neutrons, studies of airline personnel are of particular interest. However, because the cumulative radiation exposure is so low, statistical power is a major concern. Further, finding an appropriate comparison group is problematic due to selection into these occupations and a number of biases are possible. For example, increased rates of breast cancer among flight attendants have been attributed to reproductive factors such as nulliparity and increased rates of melanoma among pilots have been attributed to excessive sun exposure during leisure time activities. Epidemiologic studies conducted over the last 20 y provide little consistent evidence linking cancer with radiation exposures from air travel.

Buja A, Lange JH, Perissinotto E, et al. Cancer incidence among male military and civil pilots and flight attendants: an analysis on published data. *Toxicol Ind Health*. 2005;21(10):273-282.

Flight personnel are exposed to cosmic ionizing radiation, chemicals (fuel, jet engine exhausts, cabin air pollutants), electromagnetic fields from cockpit instruments, and disrupted sleep patterns. Only recently has cancer risk among these workers been investigated. With the aim of increasing the precision of risk estimates of cancer incidence, follow-up studies reporting a standardized incidence ratio for cancer among male flight attendants, civil and military pilots were obtained from online databases and analysed. A meta-analysis was performed by applying a random effect model, obtaining a meta-standardized incidence ratio (SIR), and 95% confidence interval (CI). In male cabin attendants, and civil and military pilots, meta-SIRs were 3.42 (CI = 1.94-6.06), 2.18 (1.69-2.80), 1.43 (1.09-1.87) for melanoma; and 7.46 (3.52-15.89), 1.88 (1.23-2.88), 1.80 (1.25-2.58) for other skin cancer, respectively. These tumors share as risk factors, ionizing radiation, recreational sun exposure and socioeconomic status. The meta-SIRs are not adjusted for confounding; the magnitude of risk for melanoma decreased when we corrected for socioeconomic status. In civil pilots, meta-SIR was 1.47 (1.06-2.05) for prostate cancer. Age (civil pilots are older than military pilots and cabin attendants) and disrupted sleep pattern (entailing hyposecretion of melatonin, which has been reported to suppress proliferative effects of androgen on prostate cancer cells) might be involved. In male cabin attendants, meta-SIR was 21.5 (2.25-205.8) for Kaposi's sarcoma and 2.49 (1.03-6.03) for non-Hodgkin's lymphoma. AIDS, which was the most frequent single cause of death in this occupational category, likely explains the excess of the latter two tumors.

Buja A et al. Cancer incidence among female flight attendants: a meta-analysis of published data. *J Womens Health.* 2006;15(1):98-105.

Background: Flight attendants are exposed to cosmic ionizing radiation and other potential cancer risk factors, but only recently have epidemiological studies been performed to assess the risk of cancer among these workers. The aim of the present work was to evaluate the incidence of various types of cancer among female cabin attendants by combining cancer incidence estimates reported in published studies.

Methods: All follow-up studies reporting standardized incidence ratio (SIR) for cancer among female flight attendants were obtained from online databases and analyzed. A metaanalysis was performed by applying Bayesian hierarchical models, which take into account studies that reported SIR = 0 and natural heterogeneity of study-specific SIRs.

Results: A total of seven published studies reporting SIR for several cancer types were extracted. Meta-analysis showed a significant excess of melanoma (meta-SIR 2.15, 95% posterior interval [PI] 1.56-2.88) and breast carcinoma (meta-SIR 1.40; PI 1.19-1.65) and a slight but not significant excess of cancer incidence across types (meta-SIR 1.11, PI 0.98-1.25).

Conclusions: Although further studies are necessary to clarify the exact role of occupational exposure, all airlines should, as some companies do, estimate radiation dose, organize the schedules of crew members in order to reduce further exposure in highly exposed flight attendants, inform crew members about health risks, and give special protection to pregnant women.

Cadilhac P et al. In-Flight Ultraviolet Radiation on Commercial Airplanes. *Aerosp Med Hum Perform*. 2017;88(10):947-951.

Introduction: Epidemiological studies suggest that pilots and cabin crew have higher incidences and mortality rates of cutaneous malignant melanoma than those of the general population. Exposure to UV radiation is one of the main risk factors for this type of cancer. The aim of this study was to evaluate the level of UV radiation in an airliner in flight.

Methods: Measurements were taken with a three sensor-integrated electronics UV radiometer (A, B, and C) during 14 flights from July to October 2016. They were performed during daylight hours once the airliner had reached cruising altitude.

Results: We failed to find UVC radiation. The measurements detected neither UV A nor B in any parts of the cabins of the planes tested, nor in the Airbus cockpits. UVA radiation was however found in the cockpit of Boeing 777s. But UVA levels remained well below the values found at ground level and they were also strongly reduced (more than 10 times) by cockpit sun visors.

Discussion: Few studies have assessed the level of UV radiation in an airplane. They suggested that the cockpit windshields reduced this type of radiation to some degree (according mainly to the wavelength of the radiation and the nature of the windshield). Our study strongly confirms these results and suggests that increased incidence of melanoma and mortality by this type of illness found among pilots and airline cabin crews may not be related to in-flight UV radiation exposure.Cadilhac P, Bouton M-C, Cantegril M, Cardines C, Gisquet A, Kaufman N, Klerlein M. In-flight ultraviolet radiation on commercial airplanes. Aerosp Med Hum Perform 2017; 88(10):947-951.

Cavallo D et al. Chromosomal aberrations in long-haul air crew members. Mutat Res. 2002;513(1-2):11-5.

The increasing use of air travel suggests the need for risk assessment and cytogenetic analysis of flight personnel, to check for the risk of developing cancer. Taking into consideration occupational risk and possible confounding factors, we used traditional cytogenetics, the micronucleus test and fluorescent in situ hybridization (FISH) analysis to study 48 male crew members working on long-haul flights and a control group of 48 ground staff. Compared to controls, we detected a significant increase in the relative risk of gaps and breaks (adjusted odds ratio (OR(adj))--7.8; 95% confidence interval (CI) - 2.4-24.9) and of translocations (OR(adj)--5.1; 95% CI 1.5-17.3) in crew members, with a non-significant difference in the other chromosomal aberrations. The possibility of a correlation between translocations and cancer risk highlights the need for preventive measures for aircraft personnel.

Cavallo D et al. Evaluation of DNA damage in flight personnel by Comet assay. Mutat Res. 2002;516(1-2):148-52.

There have been some suggestions that air-crew are at a higher-than-normal risk of developing cancer, since they are exposed to potential genotoxic factors. These include cosmic radiations, airborne pollutants such as the combustion products of jet propulsion, ozone, and electromagnetic fields. We used the Comet assay to investigate DNA damage in flight personnel with the aim of assessing potential health hazards in this occupational category. We studied 40 civil air-crew members who had been flying long-haul routes for at least 5 years, and compared them with a homogeneous control group of 40 healthy male ground staff. The Comet assay, or single-cell gel electrophoresis (SCGE), detects DNA single- and double-strand breaks (DSBs) and alkali-labile lesions in individual cells, and is a powerful and sensitive technique for detecting genetic damage induced by different genotoxic agents. Taking into consideration occupational risk and possible confounding factors, this assay showed a small increase, that did not reach statistical significance, of DNA damage in long-haul crew members compared to controls, indicating a lack of evident

genotoxic effects. An association, although again not statistically significant, was found between reduced DNA damage and use of protective drugs (antioxidants).

De Angelis G, Caldora M, Santaquilani M, Scipione R, Verdecchia A. Radiation-induced biological effects on crew members: a combined analysis on atmospheric flight personnel. Phys Med. 2001;17 Suppl 1:173-4.

There are few Human data on low dose rate radiation exposure and its effects are not readily available. A huge amount of such data may be obtained through flight personnel cohorts, in the form of epidemiological studies on delayed health effects induced by the cosmic-ray generated atmospheric ionizing radiation, to which flight personnel are exposed all throughout their work activity. All the available results from different studies on flight personnel exposure have been combined in various ways to evaluate the association between atmospheric ionizing radiation environment and health risks and to assess directions for future investigations.

De Stavola BL et al. Cause-specific mortality in professional flight crew and air traffic control officers: findings from two UK population-based cohorts of over 20,000 subjects. I. Int Arch Occup Environ Health. 2012;85(3):283-93.

Objective: Flight crew are exposed to several potential occupational hazards. This study compares mortality rates in UK flight crew to those in air traffic control officers (ATCOs) and the general population.

Methods: A total of 19,489 flight crew and ATCOs were identified from the UK Civil Aviation Authority medical records and followed to the end of 2006. Consented access to medical records and questionnaire data provided information on demographic, behavioral, clinical, and occupational variables. Standardized mortality ratios (SMR) were estimated for these two occupational groups using the UK general population. Adjusted mortality hazard ratios (HR) for flight crew versus ATCOs were estimated via Cox regression models.

Results: A total of 577 deaths occurred during follow-up. Relative to the general population, both flight crew (SMR 0.32; 95% CI 0.30, 0.35) and ATCOs (0.39; 0.32, 0.47) had lower all-cause mortality, mainly due to marked reductions in mortality from neoplasms and cardiovascular diseases, although flight crew had higher mortality from aircraft accidents (SMR 42.8; 27.9, 65.6). There were no differences in all-cause mortality (HR 0.99; 95% CI 0.79, 1.25), or in mortality from any major cause, between the two occupational groups after adjustment for health-related variables, again except for those from aircraft accidents. The latter ratios, however, declined with increasing number of hours.

Conclusions: The low all-cause mortality observed in both occupational groups relative to the general population is consistent with a strong "healthy worker effect" and their low prevalence of smoking and other risk factors. Mortality among flight crew did not appear to be influenced by occupational exposures, except for a rise in mortality from aircraft accidents.

Di Trolio R, Di Lorenzo G, Fumo B, Ascierto PA. Cosmic radiation and cancer: is there a link? *Future Oncol*. 2015;11(7):1123-1135.

Cosmic radiation can cause genetic and cytogenetic damage. Certain occupations including airline pilots and cabin crew are acknowledged to have a greater exposure to cosmic radiation. In a systematic search of MEDLINE, performed from 1990 to 2014, we analyzed clinical studies using the keywords: cosmic radiation, cancer, chromosome aberration, pilots and astronauts. Increased incidence of skin cancers among airline cabin crew has been reported in a number of studies and appears to be the most consistent finding. However, as with other cancers, it is unclear whether increased exposure to cosmic radiation is a factor in the increased incidence or whether this can be explained by lifestyle factors. Further research is needed to clarify the risk of cancer in relation to cosmic radiation.

Diffey BL, Roscoe AH. Exposure to solar ultraviolet radiation in flight. *Aviat Space Environ Med.* 1990;61(11):1032-5.

The ultraviolet radiation (UVR) exposure of airline pilots during flight was measured with ultraviolet-sensitive film badges. The badges were worn by flight crew on the epaulette nearest to the window of either a Boeing 737 or 767 during 18 different flights in 1989. The results showed in every case that the UVR exposure was negligible; a flight lasting several hours resulted in an exposure equivalent to no more than a minute or two outdoors. There is anecdotal evidence that pilots may be at increased risk of developing skin cancer compared with many other occupational groups. The suggestion that this is due to significant exposure to UVR, the main aetiological factor in skin cancer, on the flight deck cannot be sustained.

Dos Santos Silva I, De Stavola B, Pizzi C, Evans AD, Evans SA. Cancer incidence in professional flight crew and air traffic control officers: disentangling the effect of occupational versus lifestyle exposures. Int J Cancer. 2013;132(2):374-84.

Flight crew are occupationally exposed to several potentially carcinogenic hazards; however, previous investigations have been hampered by lack of information on lifestyle exposures. The authors identified, through the United Kingdom Civil Aviation Authority medical records, a cohort of 16,329 flight crew and 3,165 air traffic control officers (ATCOs) and assembled data on their occupational and lifestyle exposures. Standardised incidence ratios (SIRs) were estimated to compare cancer incidence in each occupation to that of the general population; internal analyses were conducted by fitting Cox regression models. All-cancer incidence was 20-29% lower in each occupation than in the general population, mainly due to a lower incidence of smoking-related cancers [SIR (95% CI) = 0.33 (0.27-0.38) and 0.42 (0.28-0.60) for flight crew and ATCOs, respectively], consistent with their much lower prevalence of smoking. Skin melanoma rates were increased in both flight crew (SIR = 1.87; 95% CI = 1.45-2.38) and ATCOs (2.66; 1.55-4.25), with rates among the former increasing with increasing number of flight hours (p-trend = 0.02). However, internal analyses revealed no differences in skin melanoma rates between flight crew and ATCOs (hazard ratio: 0.78, 95% CI = 0.37-1.66) and identified skin that burns easily when exposed to sunlight (p = 0.001) and sunbathing to get a tan (p = 0.07) as the strongest risk predictors of skin melanoma in both occupations. The similar site-specific cancer risks between the two occupational groups argue against risks among flight crew being driven by occupation-specific exposures. The skin melanoma excess reflects sun-related behaviour rather than cosmic radiation exposure.

Dreger S, Wollschläger D, Schafft T, Hammer GP, Blettner M, Zeeb H. Cohort study of occupational cosmic radiation dose and cancer mortality in German aircrew, 1960-2014. *Occup Environ Med*. 2020;77(5):285-291.

Objectives: To determine cancer mortality compared with the general population and to examine dose-response relationships between cumulative occupational radiation dose and specific cancer outcomes in the German aircrew cohort.

Methods: For a cohort of 26 846 aircrew personnel, standardised mortality ratios (SMR) were calculated. Dose-response analyses were carried out using Poisson regression to assess dose-related cancer risks for the period 1960-2014. Exposure assessment

comprises recently available dose register data for all cohort members and newly estimated retrospective cabin crew doses for 1960-2003.

Results: SMR for all-cause, specific cancer groups and most individual cancers were reduced in all aircrew groups. The only increases were seen for brain cancer in pilots (n=23, SMR 2.01, 95% CI 1.15 to 3.28) and for malignant melanoma (n=10, SMR 1.88, 95% CI 0.78 to 3.85). Breast cancer mortality among female cabin crew was similar to the general population (n=71, SMR 1.06, 95% CI 0.77 to 1.44). Overall median cumulative effective dose was 34.2 mSv (max: 116 mSv) for 1960-2014. No dose-response associations were seen in any of the models. For brain cancer, relative risks were elevated across dose categories. An indicative negative trend with increasing dose category was seen for large intestine cancer in female cabin crew (n=23).

Conclusions: There was no evidence for significant dose-response patterns for the considered cancer types. Interpretation of results remains difficult as cumulative dose is closely related to age. Future work should focus on investigating radiation jointly with other risk factors that may contribute to risks for specific cancers among aircrew.

Filipski E, Lévi F. Circadian disruption in experimental cancer processes. *Integr Cancer Ther*. 2009;8(4):298-302.

The circadian timing system (CTS) coordinated by the suprachiasmatic nuclei (SCN) of the hypothalamus regulates daily rhythms of behavior, physiology, as well as cellular metabolism and proliferation. Altered circadian rhythms predict for poor survival in cancer patients. An increased incidence of several cancers has been reported in flight attendants and in shift workers. To explore the contribution of the CTS to tumor growth, we developed experimental models of disrupted or enhanced circadian coordination through stereotaxic destruction of the SCN, modifications of photoperiodic or feeding synchronizers and/or the administration of pharmacologic agents. SCN ablation or exposure to experimental chronic jetlag (CJL, consisting of an 8-hour advance of the light-dark cycle every 2 days) caused alterations in circadian physiology and significantly accelerated tumor growth. CJL suppressed or altered the rhythms of clock gene and cell cycle gene expression in mouse liver. It increased p53 and decreased c-Myc expression, a result in line with the promotion of diethylnitrosamine -initiated hepatocarcinogenesis in jet-lagged mice. The accelerating effect of CJL on tumor growth was counterbalanced by the regular timing of food access over the 24-h. Meal timing prevented the circadian disruption produced by CJL and slowed down tumor growth. In synchronized mice, meal timing reinforced host circadian coordination, phase-shifted the transcriptional rhythms of clock genes in the liver of tumor-bearing mice and slowed down cancer progression. These results support the role of the CTS in cancer progression and call for the development of therapeutic strategies aimed at preventing or treating circadian clock dysfunctions.

Gassmann AS, Gonzalez M, Mathelin C. Les hôtesses de l'air sont-elles à risque accru de cancer du sein ? [Have female flight attendants an over-risk of breast cancer?]. Gynecol Obstet Fertil. 2015 Jan;43(1):41-8.

Objective: The aim of this revue was to estimate the level of breast cancer risk among female flight attendants.

Material and methods: The selected articles were taken from the PUBMED database, between January 1st 1995 and December 31st 2013 by the means of the following keywords: "breast cancer", "flight attendants", "airline cabin crew" and "flight personnel". Seventeen articles were finally selected.

Results: The incidence of breast cancer is significantly higher among female flights attendants [standardized incidence ratio (SIR) 1.04-5.24, 95% CI 1.00-17.38]. However, no studies have demonstrated a significant increase of mortality by breast cancer [standardized mortality ratio (SMR) 1.0-1.28, 95% CI 0.54-3.7]. The circadian rhythm disruption through night work and time zones leading to disorder of melatonin secretion just as exposure to cosmic radiation could account for this increase of risk.

Discussion and conclusion: A medical supervision concerning breast cancer for flight attendants is recommended. Additional studies seem to be necessary in order to estimate the additional role of other risk factors, in particular hormonal factor.

Grajewski B et al. Airline pilot cosmic radiation and circadian disruption exposure assessment from logbooks and company records. RT 2nd. *Ann Occup Hyg.* 2011;55(5):465-75.

Objectives: US commercial airline pilots, like all flight crew, are at increased risk for specific cancers, but the relation of these outcomes to specific air cabin exposures is unclear. Flight time or block (airborne plus taxi) time often substitutes for assessment of exposure to cosmic radiation. Our objectives were to develop methods to estimate exposures to cosmic radiation and circadian disruption for a study of chromosome aberrations in pilots and to describe workplace exposures for these pilots.

Methods: Exposures were estimated for cosmic ionizing radiation and circadian disruption between August 1963 and March 2003 for 83 male pilots from a major US airline. Estimates were based on 523 387 individual flight segments in company records and pilot logbooks as well as summary records of hours flown from other sources. Exposure was estimated by calculation or imputation for all but 0.02% of the individual flight segments' block time. Exposures were estimated from questionnaire data for a comparison group of 51 male university faculty.

Results: Pilots flew a median of 7126 flight segments and 14 959 block hours for 27.8 years. In the final study year, a hypothetical pilot incurred an estimated median effective dose of 1.92 mSv (absorbed dose, 0.85 mGy) from cosmic radiation and crossed 362 time zones. This study pilot was possibly exposed to a moderate or large solar particle event a median of 6 times or once every 3.7 years of work. Work at the study airline and military flying were the two highest sources of pilot exposure for all metrics. An index of work during the standard sleep interval (SSI travel) also suggested potential chronic sleep disturbance in some pilots. For study airline flights, median segment radiation doses, time zones crossed, and SSI travel increased markedly from the 1990s to 2003 (P(trend) < 0.0001). Dose metrics were moderately correlated with records-based duration metrics (Spearman's r = 0.61-0.69).

Conclusions: The methods developed provided an exposure profile of this group of US airline pilots, many of whom have been exposed to increasing cosmic radiation and circadian disruption from the 1990s through 2003. This assessment is likely to decrease exposure misclassification in health studies.

Grajewski B, Pinkerton LE. Exposure assessment at 30 000 feet: challenges and future directions. *Ann Occup Hyg*. 2013;57(6):692-694.

Few studies of cancer mortality and incidence among flight crew have included a detailed assessment of both occupational exposures and lifestyle factors that may influence the risk of cancer. In this issue, Kojo et al. (Risk factors for skin cancer among Finnish airline cabin crew. Ann Occup. Hyg 2013; 57: 695-704) evaluated the relative contributions of ultraviolet and cosmic

radiation to the incidence of skin cancer in Finnish flight attendants. This is a useful contribution, yet the reason flight crew members have an increased risk of skin cancer compared with the general population remains unclear. Good policy decisions for flight crew will depend on continued and emerging effective collaborations to increase study power and improve exposure assessment in future flight crew health studies. Improving the assessment of occupational exposures and non-occupational factors will cost additional time and effort, which are well spent if the role of exposures can be clarified in larger studies.

Griffiths RF, Powell DM. The occupational health and safety of flight attendants. *Aviat Space Environ Med*. 2012;83(5):514-521.

In order to perform safety-critical roles in emergency situations, flight attendants should meet minimum health standards and not be impaired by factors such as fatigue. In addition, the unique occupational and environmental characteristics of flight attendant employment may have consequential occupational health and safety implications, including radiation exposure, cancer, mental ill-health, musculoskeletal injury, reproductive disorders, and symptoms from cabin air contamination. The respective roles of governments and employers in managing these are controversial. A structured literature review was undertaken to identify key themes for promoting a future agenda for flight attendant health and safety. Recommendations include breast cancer health promotion, implementation of Fatigue Risk Management Systems, standardization of data collection on radiation exposure and health outcomes, and more coordinated approaches to occupational health and safety risk management. Research is ongoing into cabin air contamination incidents, cancer, and fatigue as health and safety concerns. Concerns are raised that statutory medical certification for flight attendants will not benefit either flight safety or occupational health.

Gundestrup M, Storm HH. Radiation-induced acute myeloid leukaemia and other cancers in commercial jet cockpit crew: a population-based cohort study. Lancet. 1999 11;354(9195):2029-31.

Background: Cockpit crews receive cosmic radiation during flight operations. The increasing total accumulated dose over the years might be expected to cause increased frequency of radiation-induced cancer. The rate should increase with number of flight hours per year, number of years of flying, and higher flight altitude. If the cumulative radiation exposure during flights is of concern, we would expect an increased cancer risk to be present among those crew members flying jets.

Methods: Cockpit-crew medical records (pilots and flight engineers) from 1946 onwards, holding information on the individual, flight hours, aircraft type, and date of commercial certification and decertification, were linked to the population-based Danish Cancer Registry, the central population registry, and the National Death Index.

Findings: Altogether 3877 cockpit crew members could be traced for follow-up, accruing 61095 person-years at risk in 3790 men and 661 in 87 women. The total number of cancers observed was 169 whereas 153.1 were expected (standardised incidence ratio 1.1 [95% CI 0.94-1.28]). Significantly increased risks of acute myeloid leukaemia (5.1 [1.03-14.91]), skin cancer, excluding melanoma (3.0 [2.12-4.23]), and total cancer (1.2 [1.00-1.53]) were observed among Danish male jet cockpit crew members flying more than 5000 h. Increased risk of malignant melanoma irrespective of aircraft type was also found among those flying more than 5000 h.

Interpretation: Both malignant melanoma and skin cancer were found in excess in cockpit crew members with a long flying history, probably attributable to sun exposure during leisure time at holiday destinations. We cannot confirm previously reported increased risk of brain and rectal cancers in pilots. The study shows that male cockpit crew members in jets flying more than 5000 h have significantly increased frequency of acute myeloid leukaemia.

Gurwitz D. **Flight attendants, breast cancer, and melatonin**. *Lancet*. 1998;352(9137):1389-1390.

Kein Abstract verfügbar

Hammer GP, Auvinen A, De Stavola BL, et al. Mortality from cancer and other causes in commercial airline crews: a joint analysis of cohorts from 10 countries. *Occup Environ Med*. 2014;71(5):313-322.

Background: Commercial airline crew is one of the occupational groups with the highest exposures to ionising radiation. Crew members are also exposed to other physical risk factors and subject to potential disruption of circadian rhythms.

Methods: This study analyses mortality in a pooled cohort of 93 771 crew members from 10 countries. The cohort was followed for a mean of 21.7 years (2.0 million person-years), during which 5508 deaths occurred.

Results: The overall mortality was strongly reduced in male cockpit (SMR 0.56) and female cabin crews (SMR 0.73). The mortality from radiation-related cancers was also reduced in male cockpit crew (SMR 0.73), but not in female or male cabin crews (SMR 1.01 and 1.00, respectively). The mortality from female breast cancer (SMR 1.06), leukaemia and brain cancer was similar to that of the general population. The mortality from malignant melanoma was elevated, and significantly so in male cockpit crew (SMR 1.57). The mortality from cardiovascular diseases was strongly reduced (SMR 0.46). On the other hand, the mortality from aircraft accidents was exceedingly high (SMR 33.9), as was that from AIDS in male cabin crew (SMR 14.0).

Conclusions: This large study with highly complete follow-up shows a reduced overall mortality in male cockpit and female cabin crews, an increased mortality of aircraft accidents and an increased mortality in malignant skin melanoma in cockpit crew. Further analysis after longer follow-up is recommended.

He C, Anand ST, Ebell MH, Vena JE, Robb SW. Circadian disrupting exposures and breast cancer risk: a meta-analysis. *Int Arch Occup Environ Health*. 2015;88(5):533-547.

Purpose: Shift work, short sleep duration, employment as a flight attendant, and exposure to light at night, all potential causes of circadian disruption, have been inconsistently associated with breast cancer (BrCA) risk. The aim of this meta-analysis is to quantitatively evaluate the combined and independent effects of exposure to different sources of circadian disruption on BrCA risk in women.

Methods: Relevant studies published through January 2014 were identified by searching the PubMed database. The pooled relative risks (RRs) and corresponding 95 % confidence intervals (CIs) were estimated using fixed- or random effects models as indicated by heterogeneity tests. Generalized least squares trend test was used to assess dose-response relationships.

Results: A total of 28 studies, 15 on shift work, 7 on short sleep duration, 3 on flight attendants, and 6 on light at night were included in the analysis. The combined analysis suggested a significantly positive association between circadian disruption and BrCA risk (RR = 1.14; 95 % CI 1.08-1.21). Separate analyses showed that the RR for BrCA was 1.19 (95 % CI 1.08-1.32) for shift work, 1.120 (95 % CI 1.119-1.121) for exposure to light at night, 1.56 (95 % CI 1.10-2.21) for employment as a flight attendant, and 0.96 (95 % CI 0.86-1.06) for short sleep duration. A dose-response analysis showed that each 10-year increment of shift work was associated with 16 % higher risk of BrCA (95 % CI 1.06-1.27) based on selected case-control studies. No significant dose-response effects of exposure to light at night and sleep deficiency were found on BrCA risk.

Conclusions: Our meta-analysis demonstrates that circadian disruption is associated with an increased BrCA risk in women. This association varied by specific sources of circadian disrupting exposures, and a dose-response relationship remains uncertain. Therefore, future rigorous prospective studies are needed to confirm these relationships.

Kamdar BB, Tergas AI, Mateen FJ, Bhayani NH, Oh J. Night-shift work and risk of breast cancer: a systematic review and meta-analysis. *Breast Cancer Res Treat*. 2013;138(1):291-301.

A 2007 report by the International Agency for Research on Cancer classified night-shift work as possibly carcinogenic to humans, emphasizing, in particular, its association with breast cancer. Since this report and the publication of the last systematic review on this topic, several new studies have examined this association. Hence, to provide a comprehensive update on this topic, we performed a systematic review and meta-analysis. We searched Medline, Embase, CINAHL, Web of Science (Conference Proceedings), and ProQuest dissertations for studies published before March 1, 2012, along with a manual search of articles that cited or referenced the included studies. Included were observational case-control or cohort studies examining the association between night-shift work and breast carcinogenesis in women, which all ascertained and quantified night-shift work exposure. The search yielded 15 eligible studies for inclusion in the systematic review and meta-analysis. Using random-effects models, the pooled relative risk (RR) and 95 % confidence intervals (CIs) of breast cancer for individuals with ever night-shift work exposure was 1.21 (95 % CI, 1.00-1.47, p = 0.056, I (2) = 76 %), for short-term night-shift workers (<8 years) was 1.13 (95 % CI, 0.97-1.32, p = 0.11, I (2) = 79 %), and for long-term night-shift workers (≥8 years) was 1.04 (95 % CI, 0.92-1.18, p = 0.51, I (2) = 55 %), with substantial between-study heterogeneity observed in all analyses. Subgroup analyses suggested that flight attendants with international or overnight work exposure and nurses working night-shifts long-term were at increased risk of breast cancer, however, these findings were limited by unmeasured confounding. Overall, given substantial heterogeneity observed between studies in this meta-analysis, we conclude there is weak evidence to support previous reports that night-shift work is associated with increased breast cancer risk.

Kim JN, Lee BM. Risk factors, health risks, and risk management for aircraft personnel and frequent flyers. J Toxicol Environ Health B Crit Rev. 2007;10(3):223-34.

Health risks associated with long periods of time in flight are of concern to astronauts, crew members, and passengers. Many epidemiological studies showed that occupational and frequent flyers may be susceptible to ocular, cardiovascular, neurological, pulmonary, gastrointestinal, sensory, immunological, physiological, and even developmental disorders. In addition, the incidences of cancer and food poisoning are expected to be higher in such individuals. This article reviews health risks and risk factors associated with air travel, and discusses risk management strategies. To reduce adverse health risks, risk factors such as radiation, infection, stress, temperature, pressure, and circadian rhythm need to be avoided or reduced to levels that are as low as technologically achievable to protect flight personnel and passengers.

Kojo K, Pukkala E, Auvinen A. Breast cancer risk among Finnish cabin attendants: a nested case-control study. Occup Environ Med. 2005;62(7):488-93.

Background: Earlier studies have found increased breast cancer risk among female cabin crew. This has been suggested to reflect lifestyle factors (for example, age at first birth), other confounding factors (for example, age at menarche), or occupational factors such as exposure to cosmic radiation and circadian rhythm alterations due to repeated jet lag.

Aims: To assess the contribution of occupational versus lifestyle and other factors to breast cancer risk among cabin attendants in Finland.

Methods: A standardised self-administered questionnaire on demographic, occupational, and lifestyle factors was given to 1041 cabin attendants. A total of 27 breast cancer cases and 517 non-cases completed the questionnaire. Breast cancer diagnoses were confirmed through the Finnish Cancer Registry. Exposure to cosmic radiation was estimated based on self-reported flight history and timetables. A conditional logistic regression model was used for analysis.

Results: In the univariate analysis, family history of breast cancer (OR = 2.67, 95% CI: 1.00 to 7.08) was the strongest determinant of breast cancer. Of occupational exposures, sleep rhythm disruptions (OR = 1.72, 95% CI: 0.70 to 4.27) were positively related and disruption of menstrual cycles (OR = 0.71, 95% CI: 0.26 to 1.96) negatively related to breast cancer. However, both associations were statistically non-significant. Cumulative radiation dose (OR = 0.99, 95% CI: 0.83 to 1.19) showed no effect on breast cancer.

Conclusions: Results suggest that breast cancer risk among Finnish cabin attendants is related to well established risk factors of breast cancer, such as family history of breast cancer. There was no clear evidence that the three occupational factors studied affected breast cancer risk among Finnish flight attendants.

Kojo K, Helminen M, Pukkala E, Auvinen A. Risk factors for skin cancer among Finnish airline cabin crew. *Ann Occup Hyg*. 2013;57(6):695-704.

Increased incidence of skin cancers among airline cabin crew has been reported in several studies. We evaluated whether the difference in risk factor prevalence between Finnish airline cabin crew and the general population could explain the increased incidence of skin cancers among cabin crew, and the possible contribution of estimated occupational cosmic radiation exposure. A self-administered questionnaire survey on occupational, host, and ultraviolet radiation exposure factors was conducted among female cabin crew members and females presenting the general population. The impact of occupational cosmic radiation dose was estimated in a separate nested case-control analysis among the participating cabin crew (with 9 melanoma and 35 basal cell carcinoma cases). No considerable difference in the prevalence of risk factors of skin cancer was found between the cabin crew (N = 702) and the general population subjects (N = 1007) participating the study. The mean risk score based on all the conventional skin cancer risk factors was 1.43 for cabin crew and 1.44 for general population (P = 0.24). Among the cabin crew, the estimated

cumulative cosmic radiation dose was not related to the increased skin cancer risk [adjusted odds ratio (OR) = 0.75, 95% confidence interval (CI): 0.57-1.00]. The highest plausible risk of skin cancer for estimated cosmic radiation dose was estimated as 9% per 10 mSv. The skin cancer cases had higher host characteristics scores than the non-cases among cabin crew (adjusted OR = 1.43, 95% CI: 1.01-2.04). Our results indicate no difference between the female cabin crew and the general female population in the prevalence of factors generally associated with incidence of skin cancer. Exposure to cosmic radiation did not explain the excess of skin cancer among the studied cabin crew in this study.

Kraus JF. Epidemiological studies of health effects in commercial pilots and flight attendants: a review. *J UOEH*. 1985;7 Suppl:32-44.

Kein Abstract verfügbar

Lerchl A. Flight attendants, breast cancer, and melatonin. *Lancet*. 1998;352(9137):1388-1389.

Kein Abstract verfügbar

Lim MK. Exposure of airline pilots and cabin crew to cosmic radiation during flight--what's the fuss? Ann Acad Med Singapore. 2001 Sep;30(5):494-8.

The International Commission on Radiological Protection (ICRP) had in 1990 recommended that civilian aircrew be classified as being occupationally exposed to low-dose ionizing radiation, in view of their increased exposure to cosmic rays at altitude. In 2000, the European Union had gone ahead with legislation which requires all European airlines to monitor cosmic radiation levels during flight and to inform aircrew of the possible health risks. However, the evidence for a causal link between cosmic radiation exposure and health risks remains elusive despite recent findings of increased cancer incidence among airline pilots and cabin crew. The inconclusiveness of the evidence notwithstanding, there are compelling reasons for adopting a prudent and precautionary stance.

Lim MK. Cosmic rays: are air crew at risk?.Occup Environ Med. 2002;59(7):428-32

This article reviews the current knowledge about cosmic rays and their possible effects on health of air crew, discusses research directions necessary for establishing and measuring the risks, and highlights the need for physicians and air crew to be informed, despite the inconclusiveness of the evidence. A literature review of computerised medical and scientific databases was carried out. Recent reports highlighting increased incidence of cancer among airline pilots and cabin crew have renewed concerns about possible exposure to harmful levels of cosmic radiation at altitude. Such low energy ionising radiation has been shown to cause double stranded DNA deletions and induce genomic instability in human chromosomes. In the field of microelectronics, cosmic rays have been shown to cause "hard" and "soft" errors in computer microchips, in a dose-response fashion with increasing altitude. Pregnant cabin crew members are of special concern. Although the epidemiological evidence is still inconclusive, we know enough to warrant a cautionary stance. The European Union (EU) leads the way in legislation.

Linnersjö A, Hammar N, Dammström BG, Johansson M, Eliasch H. Cancer incidence in airline cabin crew: experience from Sweden [published correction appears in Occup Environ Med. 2004 Jan;61(1):94]. *Occup Environ Med*. 2003;60(11):810-814.

Aims: To determine the cancer incidence in Swedish cabin crew.

Methods: Cancer incidence of cabin crew at the Swedish Scandinavian Airline System (SAS) (2324 women and 632 men) employed from 1957 to 1994 was determined during 1961-96 from the Swedish National Cancer Register. The cancer incidence in cabin crew was compared with that of the general Swedish population by comparing observed and expected number of cases through standardised incidence ratios (SIR). A nested case-control study was performed, including cancer cases diagnosed after 1979 and four controls per case matched by gender, age, and calendar year.

Results: The SIR for cancer overall was 1.01 (95% CI 0.78 to 1.24) for women and 1.16 (95% CI 0.76 to 1.55) for men. Both men and women had an increased incidence of malignant melanoma of the skin (SIR 2.18 and 3.66 respectively) and men of non-melanoma skin cancer (SIR 4.42). Female cabin attendants had a non-significant increase of breast cancer (SIR 1.30; 95% CI 0.85 to 1.74). No clear associations were found between length of employment or cumulative block hours and cancer incidence.

Conclusions: Swedish cabin crew had an overall cancer incidence similar to that of the general population. An increased incidence of malignant melanoma and non-melanoma skin cancer may be associated with exposure to UV radiation, either at work or outside work. An increased risk of breast cancer in female cabin crew is consistent with our results and may in part be due to differences in reproductive history.

Liu T, Zhang C, Wang S, Zhang J. Meta-analysis of incidence of brain cancer among aircrew. International Journal of Travel Medicine and Global Health 2017: *5*(1), 14-19.

Introduction: Previous studies on Brain and other Nervous System Cancers (BNSC) and aircrew have shown inconsistent results, possibly due to their relatively small sample sizes; therefore, the current study aimed to increase the precision of risk estimates.
Methods: Systematic searches of PubMed and Embase for pertinent studies up to August 2016 were performed and supplemented by manual reviews of bibliographies. The pooled standard incidence ratio (SIR) and corresponding 95% CIs were estimated with random effects models.
Results: Among the 903 studies retrieved, 7 studies (5 cohort studies and 2 pooled analyses) were included in the current meta-analysis. The pooled SIR (95% CI) of BNSC incidence in aircrew was 1.01 (0.77, 1.31) with no significant heterogeneity (I2 = 36.1%, P = .199). The null association persisted when the analysis was stratified by geographic area (Europe or America), publication year (before or after 2001), air population (pilots or cabin crew), cancer site (brain, nervous system, or brain/nervous system), and gender (male or female).
Conclusion: The current evidence is not sufficient to support a significant positive association between aircrew employment and BNSC risk. However, the interpretation and extrapolation of this meta-analysis are restricted by the possible impact exerted by health worker effect and potential clinical heterogeneity. More studies based on other populations, including Asian aircrews, are warranted.

Liu T, Zhang C, Liu C. The incidence of breast cancer among female flight attendants: an updated meta-analysis. *J Travel Med*. 2016;23(6):taw055.

Background: Several studies have indicated an increased risk of breast cancer (BC) among female flight attendants (FFAs); however, the results from epidemiological studies were not consistent. We thus conducted an updated meta-analysis to re-assess the risk of BC among FFAs, according to the MOOSE guideline.

Methods: A systematical search of PubMed and Embase for relevant observational studies up to March 2016 was performed, supplemented by manual reviews of bibliographies in relevant studies. A random effect model was conducted to calculate the combined standard incidence ratio (SIR) and 95% confidence interval (95% CI) in BC risk.

Results: Of the 719 citations retrieved, 10 were included, with more than 31 679 participants and 821 new cases. The combined SIR (95% CI) for BC in FFAs was 1.40 (95%CI 1.30-1.50), with no significant heterogeneity (P = 0.744; I(2)=( )0.0%) or publication bias (Begg's test: z = 0.72, P = 0.474; Egger's test: t = 0.25, P = 0.805) among the included studies. The results were not significantly modified by publication year, geographic area, study quality or whether the fertility variables were adjusted.

Conclusions: Our meta-analysis suggests that FFAs have a higher risk of BC compared with the general population. More vigorous studies with larger sample sizes based on other populations, including the Chinese, are needed.

Liu GS, Cook A, Richardson M, Vail D, Holsinger FC, Oakley-Girvan I. Thyroid cancer risk in airline cockpit and cabin crew: a meta-analysis. Cancers Head Neck. 2018 Aug 17;3:7.

Background: Airline crew are exposed to ionizing radiation as part of their occupation and have a documented increased risk of melanoma and cataracts. However, whether their occupation predisposes them to an increased risk of thyroid cancer is not established. The purpose of this systematic review and meta-analysis was to assess the risk of thyroid cancer in airline cockpit and cabin crew compared with the general population.

Methods: The MEDLINE database accessed via PubMed and Cochrane Database were searched. We included cohort studies reporting the standardized incidence ratio (SIR) or standardized mortality ratio (SMR) of thyroid cancers in any flight-based occupation.

Results: Of the 1777 citations retrieved in PubMed, eight studies with a total of 243,088 aircrew members and over 3,334,114 person-years of follow-up were included in this meta-analysis. No relevant studies were identified on Cochrane Database. The overall summary SIR of participants in any flight-based occupation was 1.11 (95% CI, 0.79-1.57; p = 0.613; 6 records). The summary SIR for cockpit crew was 1.21 (95% CI, 0.75-1.95; p = 0.383; 4 records) and the summary SIR for cabin crew was 1.00 (95% CI, 0.60-1.66; p = 0.646; 2 records). The overall summary standardized mortality ratio for airline crew was 1.19 (95% CI, 0.59-2.39; p = 0.773; 2 records).

Conclusion: Airline crew were not found to have a significantly elevated risk of thyroid cancer incidence or mortality relative to the general population. Future research should capitalize on the growing occupational cohort dataset and employ innovative methods to quantify lifetime radiation exposure to further assess thyroid cancer risk in airline crew.

Mawson AR. Breast cancer in female flight attendants. *Lancet*. 1998;352(9128):626.

Kein Abstract verfügbar

McNeely E, Mordukhovich I, Tideman S, Gale S, Coull B. Estimating the health consequences of flight attendant work: comparing flight attendant health to the general population in a cross-sectional study. BMC Public Health. 2018 Mar 23;18(1):346.

Background: Flight attendants are an understudied occupational group, despite undergoing a wide and unique range of adverse job-related exposures. In our study, we aimed to characterize the health profile of cabin crew relative to the U.S. general population.

Methods: In 2014-2015, we surveyed participants of the Harvard Flight Attendant Health Study. We compared the prevalence of their health conditions to a contemporaneous cohort in the National Health and Nutrition Examination Survey (NHANES 2013-2014) using age-weighted standardized prevalence ratios (SPRs). We also analyzed associations between job tenure and selected health outcomes, using logistic regression and adjusting for potential confounders.

Results: Compared to the NHANES population (n = 2729), flight attendants (n = 5366) had a higher prevalence of female reproductive cancers (SPR = 1.66, 95% CI: 1.18-2.33), cancers at all sites (SPR = 2.15, 95% CI: 1.73-2.67 among females), as well as sleep disorders, fatigue, and depression, with SPRs ranging between 1.98 and 5.57 depending on gender and the specific condition examined. In contrast, we observed a decreased prevalence of cardiac and respiratory outcomes among flight crew relative to NHANES. Health conditions that increased with longer job tenure were sleep disorders, anxiety/depression, alcohol abuse, any cancer, peripheral artery disease, sinusitis, foot surgery, infertility, and several perinatal outcomes.

Conclusions: We observed higher rates of specific adverse health outcomes in U.S. flight attendants compared to the general population, as well as associations between longer tenure and health conditions, which should be interpreted in light of recall bias and a cross-sectional design. Future longitudinal studies should evaluate specific exposure-disease associations among flight crew.

McNeely E, Mordukhovich I, Staffa S, Tideman S, Gale S, Coull B. Cancer prevalence among flight attendants compared to the general population. Environ Health. 2018 Jun 26;17(1):49.

Background: Flight attendants are an understudied occupational group, despite undergoing a wide range of adverse job-related exposures, including to known carcinogens. In our study, we aimed to characterize the prevalence of cancer diagnoses among U.S. cabin crew relative to the general population.

Methods: In 2014-2015, we surveyed participants of the Harvard Flight Attendant Health Study. We compared the prevalence of their self-reported cancer diagnoses to a contemporaneous cohort in the National Health and Nutrition Examination Survey (NHANES 2013-2014) using age-weighted standardized prevalence ratios (SPRs). We also analyzed associations between job tenure and the prevalence of selected cancers, using logistic regression and adjusting for potential confounders.

Results: Compared to NHANES participants with a similar socioeconomic status (n = 2729), flight attendants (n = 5366) had a higher prevalence of every cancer we examined, especially breast cancer, melanoma, and non-melanoma skin cancer among females. SPR for these conditions were 1.51 (95% CI: 1.02, 2.24), 2.27 (95% CI: 1.27, 4.06), and 4.09 (95% CI: 2.70, 6.20), respectively. Job tenure was positively related to non-melanoma skin cancer among females, with borderline associations for melanoma and non-melanoma skin cancers among males. Consistent with previous studies, we observed associations between job tenure and breast cancer among women who had three or more children.

Conclusions: We observed higher rates of specific cancers in flight attendants compared the general population, some of which were related to job tenure. Our results should be interpreted in light of self-reported health information and a cross-sectional study design. Future longitudinal studies should evaluate associations between specific exposures and cancers among cabin crew.

Megdal SP, Kroenke CH, Laden F, Pukkala E, Schernhammer ES. Night work and breast cancer risk: a systematic review and meta-analysis. Eur J Cancer. 2005 Sep;41(13):2023-32.

The association between occupations that involve night shift work (a surrogate for exposure to light at night with subsequent melatonin suppression) and breast cancer risk is uncertain. We therefore conducted a systematic review and meta-analysis of observational studies to assess the effects of night work on breast cancer risk. Data sources were MEDLINE from January 1960 to January 2005, experts in the field, bibliographies, and abstracts. Search terms included night work terms, flight personnel terms, cancer terms, and risk terms. Independent data extraction by two authors using standardised forms was performed. The method of DerSimonian and Laird was used to derive combined estimates and Egger's; and Begg and Mazumdar's tests for publication bias were conducted. Based on 13 studies, including seven studies of airline cabin crew and six studies of other night shift workers, the aggregate estimate for all studies combined was 1.48 (95% CI, 1.36-1.61), with a similar significant elevation of breast cancer risk among female airline cabin crew (standardised incidence ratio (SIR), 1.44; 95% CI, 1.26-1.65), and female night workers (relative risk (RR), 1.51; 95% CI, 1.36-1.68) separately. We found some evidence suggesting confounding due to incomplete adjustment for breast cancer risk factors, with smaller effects in the studies that more completely adjusted for reproductive history and other confounding factors. Egger's and Begg and Mazumdar's tests for publication bias showed no significant asymmetry (P>0.05). Studies on night shift work and breast cancer risk collectively show an increased breast cancer risk among women. Publication bias is unlikely to have influenced the results.

Miura K, Olsen CM, Rea S, Marsden J, Green AC. Do airline pilots and cabin crew have raised risks of melanoma and other skin cancers? Systematic review and meta-analysis. *Br J Dermatol*. 2019;181(1):55-64.

Background: Airline pilots and cabin crew are potentially exposed to hazardous ultraviolet and cosmic radiation, which may increase their risk of melanoma and other skin cancers.

Objectives: To establish precise risks of melanoma and keratinocyte cancer (KC) for airline pilots and for cabin crew based on all studies published to date.

Methods: We searched MEDLINE, ISI Science Citation Index, Embase, SCOPUS and CINAHL to June 2018. All studies of melanoma and KC risk and mortality in airline pilots and cabin crew compared with the general population were eligible. Standardized incidence ratios (SIRs) and standardized mortality ratios (SMRs) were pooled using random effects models.

Results: From 5866 papers retrieved, we reviewed 44 full-text articles, of which 12 studies with data collected mostly between the 1970s and 1990s were eligible for inclusion. The pooled SIR (pSIR) for melanoma in pilots was 2.03 [95% confidence interval (CI) 1.71–2.40] and in cabin crew it was 2.12 (95% CI 1.71–2.62). For pilots, the pooled SMR for melanoma was 1.99 (95% CI 1.17–3.40) and for cabin crew it was 1.18 (95% CI 0.73–1.89). For KC, the pSIR was 1.86 (95% CI 1.54–2.25) in pilots and 1.97 (95% CI 1.25–2.96) in cabin crew. There was no evidence of study heterogeneity.

Conclusions: The available evidence shows that airline pilots and cabin crew have about twice the risk of melanoma and other skin cancers than the general population, with pilots more likely to die from melanoma. However, most of the evidence was collected several decades ago and their relevance to contemporary levels of risk is uncertain.

Paridou A, Velonakis E, Langner I, Zeeb H, Blettner M, Tzonou A. Mortality among pilots and cabin crew in Greece, 1960-1997. *Int J Epidemiol*. 2003;32(2):244-247.

Background: Specific health hazards, among them radiation of cosmic origin, have caused some concern among aircrew in civil aviation in recent years. Several cohort studies in Northern countries have investigated mortality and cancer incidence among aircrew. Our goal was to study the pattern of mortality among Greek commercial airline cockpit and cabin crew.

Methods: We performed a retrospective cohort study including 843 Olympic Airways cockpit crew and 1835 cabin attendants. Standardized mortality ratios (SMR) were calculated based on death rates of the Greek population. Duration of employment as a proxy for occupational exposure was used to stratify the cohort.

Results: For cockpit crew, the overall SMR was 0.7 (n = 65, 95% CI: 0.5-0.9). The SMR for all cancers was also significantly decreased (n = 17; SMR = 0.6; 95% CI: 0.3-0.9). Most of this reduction was due to a large deficit in lung cancer deaths (SMR = 0.1; 95% CI: 0.0-0.5). Slight but non-significant increases were noted for brain and liver cancer. The SMR for cardiovascular death was close to unity. Among female cabin attendants the SMR for all causes was 0.8 (95% CI: 0.4-1.3). The SMR for all cancers was 0.8 (95% CI: 0.3-1.7). Mortality from breast cancer was not increased. Among male cabin crew, SMR for all causes was 0.5 (95% CI: 0.3-0.9). Analyses according to duration of employment showed no pattern.

Conclusions: In this first-ever occupational cohort study in Greece, Greek aircrew had a low overall and cancer mortality. Due to the small number of events, the strength of our study is limited. The Greek data will be included in a pooled analysis of European studies.

Pinkerton LE, Waters MA, Hein MJ, Zivkovich Z, Schubauer-Berigan MK, Grajewski B. Cause-specific mortality among a cohort of U.S. flight attendants. *Am J Ind Med*. 2012;55(1):25-36.

Background: We evaluated mortality among 11,311 former U.S. flight attendants. The primary a priori outcomes of interest were breast cancer and melanoma.

Methods: Vital status was ascertained through 2007, and life table analyses was conducted. Cumulative exposure to cosmic radiation and circadian rhythm disruption were estimated from work history data and historical published flight schedules.

Results: All-cause mortality was less than expected among women but was elevated among men, primarily due to elevated HIV-related disease mortality. Mortality from breast cancer among women and melanoma was neither significantly elevated nor related to metrics of exposure. Mortality was elevated for non-Hodgkin's lymphoma among men; for alcoholism, drowning, and intentional self-harm among women; and for railway, water, and air transportation accidents.

Conclusions: We found no evidence of increased breast cancer or melanoma mortality. Limitations include reliance on mortality data and limited power resulting from few melanoma deaths and relatively short employment durations.

Pinkerton LE, Hein MJ, Anderson JL, Little MP, Sigurdson AJ, Schubauer-Berigan MK. Breast cancer incidence among female flight attendants: exposure-response analyses. *Scand J Work Environ Health*. 2016;42(6):538-546.

Objective: The aim of this study was to examine the association of breast cancer incidence with cosmic radiation dose and circadian rhythm disruption in a cohort of 6093 US female flight attendants.

Methods: The association of breast cancer risk with cumulative cosmic radiation dose, time spent working during the standard sleep interval, and time zones crossed (all lagged by ten years), adjusted for non-occupational breast cancer risk factors, was evaluated using Cox regression. Individual exposure estimates were derived from work history data and domicile- and era-specific exposure estimates. Breast cancers were identified from telephone interviews and state cancer registries, and covariate data were obtained from telephone interviews.

Results: Breast cancer incidence in the overall cohort was not associated with exposure. Positive associations in breast cancer incidence were observed with all three exposures only among the 884 women with parity of ≥3. Adjusted excess relative risks for women with parity of ≥3 were 1.6 [95% confidence interval (95% CI) 0.14-6.6], 0.99 (95% CI -0.04-4.3), and 1.5 (95% CI 0.14-6.2) per 10 mGy, per 2000 hours spent working in the standard sleep interval, and per 4600 time zones crossed (the approximate means of the fourth exposure quintiles among breast cancer cases), respectively.

Conclusions: Positive exposure-response relations, although observed only in a small subset of the cohort, were robust. Future studies of breast cancer incidence among other workers with circadian rhythm disruption should assess interaction with parity to see if our findings are confirmed.

Pinkerton LE, Hein MJ, Anderson JL, et al. Melanoma, thyroid cancer, and gynecologic cancers in a cohort of female flight attendants. *Am J Ind Med*. 2018;61(7):572-581.

Background: Flight attendants may have an increased risk of some cancers from occupational exposure to cosmic radiation and circadian disruption.

Methods: The incidence of thyroid, ovarian, and uterine cancer among ~6000 female flight attendants compared to the US population was evaluated via life table analyses. Associations of these cancers, melanoma, and cervical cancer with cumulative cosmic radiation dose and metrics of circadian disruption were evaluated using Cox regression.

Results: Incidence of thyroid, ovarian, and uterine cancer was not elevated. No significant, positive exposure-response relations were observed. Weak, non-significant, positive relations were observed for thyroid cancer with cosmic radiation and time zones crossed and for melanoma with another metric of circadian disruption.

Conclusions: We found little evidence of increased risk of these cancers from occupational cosmic radiation or circadian disruption in female flight attendants. Limitations include few observed cases of some cancers, limited data on risk factors, and misclassification of exposures.

Pukkala E et al. Cancer incidence among Nordic airline cabin crew. Int J Cancer. 2012 15;131(12):2886-97.

Airline cabin crew are occupationally exposed to cosmic radiation and jet lag with potential disruption of circadian rhythms. This study assesses the influence of work-related factors in cancer incidence of cabin crew members. A cohort of 8,507 female and 1,559 male airline cabin attendants from Finland, Iceland, Norway and Sweden was followed for cancer incidence for a mean follow-up time of 23.6 years through the national cancer registries. Standardized incidence ratios (SIRs) were defined as ratios of observed and expected numbers of cases. A case-control study nested in the cohort (excluding Norway) was conducted to assess the relation between the estimated cumulative cosmic radiation dose and cumulative number of flights crossing six time zones (indicator of circadian disruption) and cancer risk. Analysis of breast cancer was adjusted for parity and age at first live birth. Among female cabin crew, a significantly increased incidence was observed for breast cancer [SIR 1.50, 95% confidence interval (95% CI) 1.32-1.69], leukemia (1.89, 95% CI 1.03-3.17) and skin melanoma (1.85, 95% CI 1.41-2.38). Among men, significant excesses in skin melanoma (3.00, 95% CI 1.78-4.74), nonmelanoma skin cancer (2.47, 95% CI 1.18-4.53), Kaposi sarcoma (86.0, 95% CI 41.2-158) and alcohol-related cancers (combined SIR 3.12, 95% CI 1.95-4.72) were found. This large study with complete follow-up and comprehensive cancer incidence data shows an increased incidence of several cancers, but according to the case-control analysis, excesses appear not to be related to the cosmic radiation or circadian disruptions from crossing multiple time zones.

Rafnsson V, Tulinius H, Jónasson JG, Hrafnkelsson J. Risk of breast cancer in female flight attendants: a population-based study (Iceland). Cancer Causes Control. 2001;12(2):95-101.

Objectives: To study whether increased cancer risk, particularly of cancer types previously related to radiation, was found among cabin attendants, using employment time as a surrogate of exposure to cosmic radiation.

Methods: A cohort of 1690 cabin attendants, 158 men and 1532 women from the Icelandic Cabin Crew Association and two airline companies in Iceland, was established. Cancer sites were ascertained between 1955 and 1997 by follow-up in a cancer registry. The personal identification number of each subject was used in record linkage to population-based registers containing vital and emigration status, reproductive factors and histologically verified cancer diagnosis. Standardized incidence rates (SIR) of different cancer sites in relation to employment time and year of hiring were calculated, as well as predictive values of breast cancer risk for evaluating possible confounding due to reproductive factors.

Results: The total number of person-years was 27,148. Among the women, 64 cancers were observed whereas 51.63 were expected (SIR 1.2, 95% CI 1.0-1.6), and significantly increased risk for malignant melanoma (SIR 3.0, 95% CI 1.2-6.2) was found. Significantly increased risks of overall cancers (SIR 1.3, 95% CI 1.0-1.8) and breast cancer (SIR 1.6, 95% CI 1.0-2.4) were observed among the female cabin attendants when 15 years lag time was applied. Those hired in 1971 or later had the heaviest exposure to cosmic radiation at a young age and had significantly increased risk of overall cancer (SIR 2.8, 95% CI 1.4-4.9) and breast cancer (SIR 4.1, 95% CI 1.7-8.5). Predictive values calculated on the basis of reproductive factors among the cabin attendants and the population, and risk of breast cancer were 1.0 for parous vs. nulliparous, 1.0 for number of children, and 1.1 for age at birth of first child.

Conclusion: The increased risk of breast cancer and malignant melanoma among cabin attendants seems to be occupationally related. The part played by occupational exposures, i.e. cosmic radiation, disturbance of the circadian rhythm, and electromagnetic fields or combination of these factors in the etiology of breast cancer among the cabin crew, is still a puzzle as confounding due to parity appears to be ruled out. The relationship between the sunbathing habits of the cabin crew and the increased risk of malignant melanoma needs to be clarified. There is also an urgent need to elucidate the importance of these findings for today's aviation.

Reynolds P, Cone J, Layefsky M, Goldberg DE, Hurley S. Cancer incidence in California flight attendants (United States). *Cancer Causes Control*. 2002;13(4):317-324.

Objective: To examine unusual exposure opportunities to flight crews from chemicals, cosmic radiation, and electric and magnetic fields.

Methods: This project evaluated the incidence of cancers of the breast and other sites among Association of Flight Attendants (AFA) members residing in California. AFA membership files were matched to California's statewide cancer registry to identify a total of 129 newly diagnosed invasive cancers among AFA members with California residential histories between 1988 and 1995.

Results: Compared to the general population, female breast cancer incidence was over 30% higher than expected, and malignant melanoma incidence was roughly twice that expected. Both of these are cancers that are associated with higher socioeconomic status and have been suggestively associated with various sources of radiation.

Conclusions: Consistent with the results from Nordic studies of cabin crews and a recent meta-analysis of prior studies, these data suggest that follow-up investigations should focus on the potential relative contribution of workplace exposures and lifestyle characteristics to the higher rates of disease for these two cancers.

Salhab M, Mokbel K. Breast cancer risk in flight attendants: an update. *Int J Fertil Womens Med*. 2006;51(5):205-207.

Although further research is required, epidemiological evidence indicates that breast cancer risk is increased by 40% among flight attendants. Female flight attendants and women who fly frequently should be informed of this potential increase in risk and be encouraged to participate in appropriate breast cancer screening programs.

Sanlorenzo M et al. The risk of melanoma in airline pilots and cabin crew: a meta-analysis. JAMA Dermatol. 2015;151(1):51-8.

Importance: Airline pilots and cabin crew are occupationally exposed to higher levels of cosmic and UV radiation than the general population, but their risk of developing melanoma is not yet established.

Objective: To assess the risk of melanoma in pilots and airline crew.

Data sources: PubMed (1966 to October 30, 2013), Web of Science (1898 to January 27, 2014), and Scopus (1823 to January 27, 2014).

Study selection: All studies were included that reported a standardized incidence ratio (SIR), standardized mortality ratio (SMR), or data on expected and observed cases of melanoma or death caused by melanoma that could be used to calculate an SIR or SMR in any flight-based occupation.

Data extraction and synthesis: Primary random-effect meta-analyses were used to summarize SIR and SMR for melanoma in any flight-based occupation. Heterogeneity was assessed using the $\chi 2$ test and I2 statistic. To assess the potential bias of small studies, we used funnel plots, the Begg rank correlation test, and the Egger weighted linear regression test.

Main outcomes and measures: Summary SIR and SMR of melanoma in pilots and cabin crew.

Results: Of the 3527 citations retrieved, 19 studies were included, with more than 266 431 participants. The overall summary SIR of participants in any flight-based occupation was 2.21 (95% CI, 1.76-2.77; P < .001; 14 records). The summary SIR for pilots was 2.22 (95% CI, 1.67-2.93; P = .001; 12 records). The summary SIR for cabin crew was 2.09 (95% CI, 1.67-2.62; P = .45; 2 records). The overall summary SMR of participants in any flight-based occupation was 1.42 (95% CI, 0.89-2.26; P = .002; 6 records). The summary SMR for pilots was 1.83 (95% CI, 1.27-2.63, P = .33; 4 records). The summary SMR for cabin crew was 0.90 (95% CI, 0.80-1.01; P = .97; 2 records).

Conclusions and relevance: Pilots and cabin crew have approximately twice the incidence of melanoma compared with the general population. Further research on mechanisms and optimal occupational protection is needed.

Schubauer-Berigan MK, Anderson JL, Hein MJ, Little MP, Sigurdson AJ, Pinkerton LE. Breast cancer incidence in a cohort of U.S. flight attendants. Am J Ind Med. 2015;58(3):252-66.

Background: Flight attendants may have elevated breast cancer incidence (BCI). We evaluated BCI's association with cosmic radiation dose and circadian rhythm disruption among 6,093 female former U.S. flight attendants.

Methods: We collected questionnaire data on BCI and risk factors for breast cancer from 2002-2005. We conducted analyses to evaluate (i) BCI in the cohort compared to the U.S. population; and (ii) exposure-response relations. We applied an indirect adjustment to estimate whether parity and age at first birth (AFB) differences between the cohort and U.S. population could explain BCI that differed from expectation.

Results: BCI was elevated but may be explained by lower parity and older AFB in the cohort than among U.S. women. BCI was not associated with exposure metrics in the cohort overall. Significant positive associations with both were observed only among women with parity of three or more.

Conclusions: Future cohort analyses may be informative on the role of these occupational exposures and non-occupational risk factors.

Sigurdson AJ, Ron E. Cosmic radiation exposure and cancer risk among flight crew. Cancer Invest. 2004;22(5):743-61.

Nearly 20 epidemiologic or related studies of cancer incidence and mortality have been published during or since 2000, with several reporting increased risks of female breast cancer among flight attendants and melanoma among both pilots and cabin crew. Occasionally, excesses of other cancers have been observed, but not consistently. Although the real causes of these excess cancer risks are not known, there is concern that they may be related to occupational exposures to ionizing radiation of cosmic origin. It is possible that confounding risk factors may partially or totally explain the observed relationships, but several investigations are beginning to address lack of past adjustment for reproductive factors and sun exposure with improved study designs. With progress in aviation technology, planes will fly longer and at higher altitudes, and presumably the number of flights and passengers will increase. To respond responsibly to the real and perceived risks associated with flying, more extensive data are needed, but special efforts should be considered to ensure new projects can genuinely add to our current knowledge.

Stewart T, Stewart N. Breast cancer in female flight attendants. *Lancet*. 1995;346(8987):1379.

Kein abstract verfügbar

Tokumaru O, Haruki K, Bacal K, Katagiri T, Yamamoto T, Sakurai Y. Incidence of cancer among female flight attendants: a meta-analysis. *J Travel Med*. 2006;13(3):127-132.

Background: Airline flight personnel work in a unique environment with exposure to known or suspected carcinogens and mutagens including ionizing cosmic radiation. A meta-analysis was conducted to study whether the occupational exposure of female flight attendants (FA) increased their relative risk of cancer incidence.

Methods: A bibliographical computer search from 1966 to 2005 of cancer incidence cohort studies of female FA was performed. Combined relative risks (RRc) in cancer incidence were calculated by means of meta-analysis.

Results: RRc and 95% confidence interval (CI) for malignant melanoma and breast cancer in female FA were 2.13 (95% CI: 1.58-2.88) and 1.41 (1.22-1.62) ($p < 0.0001$). Excess risk was not significant for all-site cancer with RRc of 1.10 (0.99-1.21).

Conclusions: The meta-analysis confirmed the significantly increased risks for malignant melanoma and breast cancer in female FA. Increased exposure to cosmic radiation during flight has been suggested as a potential occupational risk factor. Ultraviolet radiation exposure on board seems an unlikely occupational risk, but nonoccupational leisure time sun exposure is a possible risk factor. The etiology of the observed increase in incidence of some cancers remains controversial because assessment of possible confounders, especially nonoccupational exposure factors, has thus far been limited.

Van Dycke KC, Rodenburg W, van Oostrom CT, et al. Chronically Alternating Light Cycles Increase Breast Cancer Risk in Mice. *Curr Biol*. 2015;25(14):1932-1937.

Although epidemiological studies in shift workers and flight attendants have associated chronic circadian rhythm disturbance (CRD) with increased breast cancer risk, causal evidence for this association is lacking. Several scenarios have been proposed to contribute to the shift work-cancer connection: (1) internal desynchronization, (2) light at night (resulting in melatonin suppression), (3) sleep disruption, (4) lifestyle disturbances, and (5) decreased vitamin D levels due to lack of sunlight. The confounders inherent in human field studies are less problematic in animal studies, which are therefore a good approach to assess the causal relation between circadian disturbance and cancer. However, the experimental conditions of many of these animal studies were far from the reality of human shift workers. For example, some involved xenografts (addressing tumor growth rather than cancer initiation and/or progression), chemically induced tumor models, or continuous bright light exposure, which can lead to suppression of circadian rhythmicity. Here, we have exposed breast cancer-prone p53(R270H/+)WAPCre conditional mutant mice (in a FVB genetic background) to chronic CRD by subjecting them to a weekly alternating light-dark (LD) cycle throughout their life. Animals exposed to the weekly LD inversions showed a decrease in tumor suppression. In addition, these animals showed an increase in body weight. Importantly, this study provides the first experimental proof that CRD increases breast cancer development. Finally, our data suggest internal desynchronization and sleep disturbance as mechanisms linking shift work with cancer development and obesity.

Weiderpass E, Meo M, Vainio H. Risk factors for breast cancer, including occupational exposures. *Saf Health Work*. 2011;2(1):1-8.

The knowledge on the etiology of breast cancer has advanced substantially in recent years, and several etiological factors are now firmly established. However, very few new discoveries have been made in relation to occupational risk factors. The International Agency for Research on Cancer has evaluated over 900 different exposures or agents to-date to determine whether they are carcinogenic to humans. These evaluations are published as a series of Monographs (www.iarc.fr). For breast cancer the following substances have been classified as "carcinogenic to humans" (Group 1): alcoholic beverages, exposure to diethylstilbestrol, estrogen-progestogen contraceptives, estrogen-progestogen hormone replacement therapy and exposure to X-radiation and gamma-radiation (in special populations such as atomic bomb survivors, medical patients, and in-utero exposure). Ethylene oxide is also classified as a Group 1 carcinogen, although the evidence for carcinogenicity in epidemiologic studies, and specifically for the human breast, is limited. The classification "probably carcinogenic to humans" (Group 2A) includes estrogen hormone replacement therapy, tobacco smoking, and shift work involving circadian disruption, including work as a flight attendant. If the association between shift work and breast cancer, the most common female cancer, is confirmed, shift work could become the leading cause of occupational cancer in women.

Whelan EA. Cancer incidence in airline cabin crew. *Occup Environ Med*. 2003;60(11):805-806.

Kein Abstract verfügbar

Winter M, Blettner M, Zeeb H. Prevalence of risk factors for breast cancer in German airline cabin crew: a cross-sectional study. J Occup Med Toxicol. 2014;9:27.

Background: Many epidemiological studies point to an increased risk of breast cancer among female airline cabin crew. Possible causes include occupational factors (e.g. cosmic radiation exposure, chronodisruption), as well as lifestyle and reproductive factors.

Aims: To investigate the frequency of various risk factors in German flight attendants which are recognised to be associated with breast cancer.

Methods: 2708 current and former female cabin crew were randomly selected by a flight attendants' union and mailed a questionnaire; 1311 responded (48% response). Descriptive statistics were used to compare the distribution of breast cancer risk factors with general German population data.

Results: On average, cabin crew were 3.0 cm (95% CI 2.7-3.3) taller than the comparison group, while their body mass index was 2.5 kg/m(2) (95% CI 2.4-2.6) lower. We found less use of hormone replacement therapy, but longer average use of oral contraceptives. Nulliparity among respondents aged 45+ was 57% (95% CI 54%-60%) compared to 16%. Average age at first birth was 32.1 years (95% CI 31.7-32.4) vs. 25.5 years. The birth rate was 0.62 (95% CI 0.58-0.67), less than half the population average of 1.34. Alcohol consumption was considerably higher, whereas cabin crew tended to smoke less and performed more physical exercise.

Conclusion: We found important differences in terms of anthropometric, gynaecological, reproductive and lifestyle factors. Some of these differences (e.g. higher nulliparity, alcohol consumption, taller size) could contribute to a higher breast cancer risk, whereas others could lead to a reduction (e.g. increased physical exercise, lower BMI, less HRT use).

Yong LC, Sigurdson AJ, Ward EM, et al. Increased frequency of chromosome translocations in airline pilots with long-term flying experience. *Occup Environ Med*. 2009;66(1):56-62.

Background: Chromosome translocations are an established biomarker of cumulative exposure to external ionising radiation. Airline pilots are exposed to cosmic ionising radiation, but few flight crew studies have examined translocations in relation to flight experience.

Methods: We determined the frequency of translocations in the peripheral blood lymphocytes of 83 airline pilots and 50 comparison subjects (mean age 47 and 46 years, respectively). Translocations were scored in an average of 1039 cell equivalents (CE) per subject using fluorescence in situ hybridisation (FISH) whole chromosome painting and expressed per 100 CE. Negative binomial regression models were used to assess the relationship between translocation frequency and exposure status and flight years, adjusting for age, diagnostic x ray procedures, and military flying.

Results: There was no significant difference in the adjusted mean translocation frequency of pilots and comparison subjects (0.37 (SE 0.04) vs 0.38 (SE 0.06) translocations/100 CE, respectively). However, among pilots, the adjusted translocation frequency was significantly associated with flight years (p = 0.01) with rate ratios of 1.06 (95% CI 1.01 to 1.11) and 1.81 (95% CI 1.16 to 2.82) for a 1- and 10-year incremental increase in flight years, respectively. The adjusted rate ratio for pilots in the highest compared to the lowest quartile of flight years was 2.59 (95% CI 1.26 to 5.33).

Conclusions: Our data suggests that pilots with long-term flying experience may be exposed to biologically significant doses of ionising radiation. Epidemiological studies with longer follow-up of larger cohorts of pilots with a wide range of radiation exposure levels are needed to clarify the relationship between cosmic radiation exposure and cancer risk.

Zeeb H, Hammer GP, Langner I, Schafft T, Bennack S, Blettner M. Cancer mortality among German aircrew: second follow-up. *Radiat Environ Biophys*. 2010;49(2):187-194.

Aircrew members are exposed to cosmic radiation and other specific occupational factors. In a previous analysis of a large cohort of German aircrew, no increase in cancer mortality or dose-related effects was observed. In the present study, the follow-up of this cohort of 6,017 cockpit and 20,757 cabin crew members was extended by 6 years to 2003. Among male cockpit crew, the resulting all-cancer standardized mortality ratio (SMR) (n = 127) is 0.6 (95% CI 0.5-0.8), while for brain tumors it is 2.1 (95% CI 1.0-3.9). The cancer risk is significantly raised (RR = 2.2, 95% CI 1.2-4.1) among cockpit crew members employed 30 years or more compared to those employed less than 10 years. Among both female and male cabin crew, the all-cancer SMR and that for most individual cancers are close to 1. The SMR for breast cancer among female crew is 1.2 (95% CI 0.8-1.8). Non-Hodgkin's Lymphoma among male cabin crew is increased (SMR 4.2; 95% CI 1.3-10.8). However, cancers associated with radiation exposure are not raised in the cohort. It is concluded that among cockpit crew cancer mortality is low, particularly for lung cancer. The positive trend of all cancer with duration of employment persists. The increased brain cancer SMR among cockpit crew requires replication in other cohorts. For cabin crew, cancer mortality is generally close to population rates. Cosmic radiation dose estimates will allow more detailed assessments, as will a pooling of updated aircrew studies currently in planning.

Zeeb H, Hammer GP, Blettner M. Epidemiological investigations of aircrew: an occupational group with low-level cosmic radiation exposure. *J Radiol Prot*. 2012;32(1):N15-N19.

Aircrew and passengers are exposed to low-level cosmic ionising radiation. Annual effective doses for flight crew have been estimated to be in the order of 2-5 mSv and can attain 75 mSv at career end. Epidemiological studies in this occupational group have been conducted over the last 15-20 years, usually with a focus on radiation-associated cancer. These studies are summarised in this note. Overall cancer risk was not elevated in most studies and subpopulations analysed, while malignant melanoma, other skin cancers and breast cancer in female aircrew have shown elevated incidence, with lesser risk elevations in terms of mortality. In some studies, including the large German cohort, brain cancer risk appears elevated. Cardiovascular mortality risks were generally very low. Dose information for pilots was usually derived from calculation procedures based on routine licence information, types of aircraft and routes/hours flown, but not on direct measurements. However, dose estimates have shown high validity when compared with measured values. No clear-cut dose-response patterns pointing to a higher risk for those with higher cumulative doses were found. Studies on other health outcomes have shown mixed results. Overall, aircrew are a highly selected group with many specific characteristics and exposures that might also influence cancers or other health outcomes. Radiation-associated health effects have not been clearly established in the studies available so far.

2 – ZIRKADIANE RHYTHMIK

Bassett JR, Spillane R. Urinary cortisol excretion and mood ratings in aircraft cabin crew during a tour of duty involving a disruption in circadian rhythm. *Pharmacol Biochem Behav*. 1987;27(3):413-420.

A psychophysiological study was carried out on 28 cabin crew, comprising two teams, who were to travel from Sydney to Los Angeles and return, with stopovers in Los Angeles of 58 and 82 hr respectively. Every urine sample for a period of nine days, commencing 2 days before the flight, was collected. The volume and time the sample was passed were recorded so that urinary cortisol secretion rates could be calculated. Mood was also rated on a scale scored 0-9 at the same time the urine sample was collected. A control group matched for age, sex ratio, and degree of manual labour involved in their occupation, but not involved with the flights, was included in the study for comparison. On the basis of urinary cortisol excretion rates, the crews in Sydney before the flight and in Los Angeles were more highly stressed than the control group. The urinary cortisol excretion rates were significantly greater than those of the control group in Sydney before the flight, in Los Angeles, and during the return flight, but not on the flight out. The high excretion rates before the flight were attributed to an apprehension factor, whereas the elevated values in Los Angeles and during the flight back were attributed to a disruption in circadian rhythm. A factor analysis of mood ratings showed three major factors assessing vitality, distress, and relaxation. Analysis of variance of the mood ratings showed significant changes over the tour of duty for 13 of the 14 moods.

Cho K, Ennaceur A, Cole JC, Suh CK. Chronic jet lag produces cognitive deficits. *J Neurosci*. 2000;20(6):RC66.

Traveling across time zones causes disruption to the normal circadian rhythms and social schedules because of travelers' shift in time. As the endogenous circadian timing system adapts slowly to new time cues, the phase relationship between biological rhythms and external time cues are out of synchronization for a period of time. This disturbance of circadian rhythms has been shown to impair physical and psychological health (Winget et al., 1984). To test the effects of repeated jet lag on mental abilities, airline cabin crew were compared with ground crew. Salivary cortisol was used as a physiological marker for circadian disruption. The cabin crew group, who had a history of repeated jet lag, had significantly higher salivary cortisol levels in an average working day. In addition, this elevated level of cortisol was only seen in the same subjects when the cabin crew were on transmeridian flights but not domestic flights. Cabin crew also exhibited cognitive deficits, possibly in working memory, that became apparent after several years of chronic disruption of circadian rhythms.

Eriksen CA, Akerstedt T. Aircrew fatigue in trans-Atlantic morning and evening flights. *Chronobiol Int*. 2006;23(4):843-858.

The aim of the investigation was to compare sleepiness and sleep on westward morning and evening flights. Seven morning-crew pilots and seven evening-crew pilots participated. Data were collected before, during, and after outward-bound (westward) and homeward-bound (eastward) flights across six time zones. A sleep/wake diary (with repeated sleepiness and performance ratings) and wrist actigraphy were used for data collection. Maximum sleep was obtained after return and minimum sleep before the outward-bound flights. Actigraphy measures and sleep efficiency over the course of the study showed no significant differences between the morning and evening crews. There was a trend for a significant effect of morning vs. evening flight for time with heavy eyelids, with the homeward-bound flight showing more time with heavy eyelids. There were no significant differences between morning and evening crews with regard to napping during the flight. The duration of wakefulness was longer for the evening flight crew. There were significant interactions for Karolinska sleepiness scale (KSS) self-ratings on both the outward-bound and homeward-bound flights, and KSS was elevated during a considerable portion of the evening flights. Rated performance showed a significant time effect, but there was no difference in self-ratings between morning and evening crews. Evening flights involve higher levels of sleepiness than morning flights, presumably because of the close proximity in time to the circadian trough of alertness.

Gander PH, Gregory KB, Miller DL, Graeber RC, Connell LJ, Rosekind MR. Flight crew fatigue V: long-haul air transport operations. *Aviat Space Environ Med*. 1998;69(9 Suppl):B37-B48.

We monitored 32 flight crewmembers before, during, and after 4-9 d commercial long-haul trips crossing up to 8 time zones per 24 h. The average duty day lasted 9.8 h, and the average layover 24.8 h. Layover sleep episodes averaged 105 min shorter than pretrip sleep episodes. However, in two-thirds of layovers, crewmembers slept twice so that their total sleep per 24 h on trips averaged 49 min less than pretrip. Greater sleep loss was associated with nighttime flights than with daytime flights. The organization of layover sleep depended on prior flight direction, local time, and the circadian cycle. The circadian temperature rhythm did not synchronize to the erratic environmental time cues. Consequently, the circadian low point in alertness and performance sometimes occurred in flight. On trip days, by comparison with pretrip, crewmembers reported higher fatigue and lower activation; drank more caffeine; ate more snacks and fewer meals; and there were marked increases in reports of headaches, congested nose, and back pain. Scheduling strategies and countermeasures to improve layover sleep, cockpit alertness, and performance, are discussed.

Gander P, Mulrine HM, van den Berg MJ, et al. Does the circadian clock drift when pilots fly multiple transpacific flights with 1- to 2-day layovers? *Chronobiol Int*. 2016;33(8):982-994.

On trips with multiple transmeridian flights, pilots experience successive non-24 h day/night cycles with circadian and sleep disruption. One study across a 9-day sequence of transpacific flights (no in-flight sleep, 1-day layovers between flights) reported an average period in the core body temperature rhythm of 24.6 h (circadian drift). Consequently, pilots were sometimes flying through the circadian performance nadir and had to readapt to home base time at the end of the trip. The present study examined circadian drift in trip patterns with longer flights and in-flight sleep. Thirty-nine B747-400 pilots (19 captains, 20 first officers, mean age = 55.5 years) were monitored on 9- to 13-day trips with multiple return flights between East Coast USA and Japan (in 4-pilot crews) and between Japan and Hawaii (in 3-pilot crews), with 1-day layovers between each flight. Measures included total in-flight sleep (actigraphy, log books) and top of descent (TOD) measures of sleepiness (Karolinska Sleepiness Scale), fatigue (Samn-Perelli Crew Status Check) and psychomotor vigilance task (PVT) performance. Circadian rhythms of individual pilots were not monitored. To detect circadian drift, mixed-model analysis of variance examined whether for a given flight, total in-flight sleep and TOD measures varied according to when the flight occurred in the trip sequence. In addition, sleep propensity curves for pre-trip and post-trip days were examined (Chi-square periodogram analyses). Limited data suggest that total in-flight sleep of relief crew at landing may have decreased across successive East Coast USA-Japan (flights 1, 3, 5 or 7; median arrival 03:45 Eastern Daylight Time (EDT)). However, PVT response speed at TOD was faster on East Coast USA-Japan flights later in the trip. On

these flights, circadian drift would result in flights later in the trip landing closer to the evening wake maintenance zone, when sleep is difficult and PVT response speeds are fastest. On Japan-East Coast USA flights (flights 2, 4, 6 or 8; median arrival time 14:52 EDT), PVT response speeds were slower on flight 8 than on flight 2. Circadian drift would move these arrivals progressively earlier in the SCN pacemaker cycle, where PVT response speeds are slower. Across the five post-trip days, 12 pilots (Group A) immediately resumed their pre-trip sleep pattern of a single nocturnal sleep episode; 9 pilots (Group B) had a daytime nap on most days that moved progressively earlier until it merged with nocturnal sleep and 17 pilots (Group C) had nocturnal sleep and intermittent naps. Chi-square periodogram analyses of the sleep propensity curves for each group across baseline and post-trip days suggest full adaptation to EDT from post-trip day 1 (dominant period = 24 h). However, in Groups B and C, the patterns of split sleep post-trip compared to pre-trip suggest that this may be misleading. We conclude that the trends in total in-flight sleep and significant changes in PVT performance speed at TOD provide preliminary evidence for circadian drift, as do persistent patterns of split sleep post-trip. However, new measures to track circadian rhythms in individual pilots are needed to confirm these findings.

Grajewski B, Waters MA, Whelan EA, Bloom TF. Radiation dose estimation for epidemiologic studies of flight attendants. *Am J Ind Med*. 2002;41(1):27-37.

Background: NIOSH is conducting health studies of female flight attendants. Exposures of interest include cosmic radiation and circadian rhythm disruption, however, the data needed to estimate cumulative radiation dose are not found in work histories.

Methods: We developed an algorithm to generate from work histories the required input data for Federal Aviation Administration radiation estimation software and evaluated whether effects of cumulative radiation dose could be distinguished analytically from effects of circadian rhythm disruption.

Results: The algorithm has relatively low bias (< 6%) for longer flights, which contribute most to cumulative radiation dose. In one NIOSH study, 44 crew incurred an estimated average annual occupational dose of 1.5-1.7 mSv. Selection of a study population flying predominantly North-South flights can provide the necessary distinction between radiation and time zone crossing exposures.

Conclusions: Methods developed will be useful for exposure assessment in cabin crew studies with relatively short study periods, (e.g., reproductive health studies) for which limited flight history details are generally available.

Grajewski B, Nguyen MM, Whelan EA, Cole RJ, Hein MJ. Measuring and identifying large-study metrics for circadian rhythm disruption in female flight attendants. Scand J Work Environ Health. 2003;29(5):337-346.

Objectives: Flight attendants can experience circadian rhythm disruption due to travel through multiple time zones. The objectives of this study were to determine whether flight attendants are more likely than teachers (comparison group) to experience circadian disruption, as measured by melatonin production, and to identify metrics of circadian disruption for epidemiologic studies of reproductive health in which biomonitoring is infeasible.

Methods: Each day, for one menstrual cycle, 45 flight attendants and 26 teachers kept a daily diary, collected and measured their overnight urine, and wore an activity monitor to assess sleep displacement. The relation between melatonin production and flight attendant and teacher status was analyzed with linear and multiple logistic regression. The relation between sleep displacement, melatonin, and flight-history-derived variables (including time zones crossed) were examined with exploratory factor analyses.

Results: Flight attendants experience increased circadian disruption, as measured by a higher adjusted melatonin rate variance, than teachers [2.8 x 10(5) versus 1.0 x 10(5) (ng/hour)2, respectively: P=0.04] and are more likely to be in the highest quartile of melatonin variance (odds ratio 2.3; 95% confidence interval 0.6-9.1). In the factor analysis, the number of time zones crossed was related to both melatonin desynchronization and sleep displacement.

Conclusions: Flight attendants experience increased circadian disruption, as measured by more variable melatonin rates, than a minimally flying comparison group. For epidemiologic studies of flight crews in which melatonin measurement is infeasible, the number of time zones crossed is a useful indicator of both sleep displacement and melatonin desynchronization.

Grajewski B, Whelan EA, Nguyen MM, Kwan L, Cole RJ. Sleep Disturbance in Female Flight Attendants and Teachers. Aerosp Med Hum Perform. 2016;87(7):638-645.

Background: Flight attendants (FAs) may experience circadian disruption due to travel during normal sleep hours and through multiple time zones. This study investigated whether FAs are at higher risk for sleep disturbance compared to teachers, as assessed by questionnaire, diary, and activity monitors.

Methods: Sleep/wake cycles of 45 FAs and 25 teachers were studied. For one menstrual cycle, participants wore an activity monitor and kept a daily diary. Sleep metrics included total sleep in the main sleep period (MSP), sleep efficiency (proportion of MSP spent sleeping), and nocturnal sleep fraction (proportion of sleep between 10 p.m. to 8 a.m. home time). Relationships between sleep metrics and occupation were analyzed with mixed and generalized linear models.

Results: Both actigraph and diary data suggest that FAs sleep longer than teachers. However, several actigraph indices of sleep disturbance indicated that FAs incurred significant impairment of sleep compared to teachers. FAs were more likely than teachers to have poor sleep efficiency [adjusted odds ratio (OR) for lowest quartile of sleep efficiency = 1.9, 95% Confidence Interval (CI) 1.2 - 3.0] and to have a smaller proportion of their sleep between 10 p.m. and 8 a.m. home time (adjusted OR for lowest quartile of nocturnal sleep fraction = 3.1, CI 1.1 -9.0).

Discussion: Study FAs experienced increased sleep disturbance compared to teachers, which may indicate circadian disruption.

Härmä M, Laitinen J, Partinen M, Suvanto S. The effect of four-day round trip flights over 10 time zones on the circadian variation of salivary melatonin and cortisol in airline flight attendants. *Ergonomics*. 1994;37(9):1479-1489.

To study the effect of a four-day-round trip flight on the sleep-wakefulness of airline flight attendants, subjective sleep-wakefulness and autonomic sleep phases were measured. Forty flight attendants (mean age 33 years, range 21-50) kept daily logs on sleepiness, the time when going to bed, and sleep quality. In addition, the autonomic sleep phases of 21 subjects were studied by the static charge sensitive bed (SCSB) method. After the westward flight, the subjects went to bed approximately 1-3 h local time earlier during the first few days and were very sleepy compared to the week before the flight. There was a significant increase

in the number of awakenings and in the feeling of 'not being at all rested' in the mornings. After the return flight eastwards, the subjects were very sleepy on the first evening but slept rather well for about 11 h. During the three following days, sleep restlessness, difficulties in falling asleep, and the feelings of sleepiness in the mornings increased compared to the week before the flights. Four days after the return flight, sleep length and the quality of sleep were, on average, the same as before the flights. According to the SCSB method, there were only small changes in the autonomic sleep phases due to the flights. After the westward flight, quiet sleep increased and intermediate sleep decreased compared to the sleep before the flight. The results indicate that most flight attendants have significant disturbances in sleep quality after transmedian flights. Sleep disturbances increase after both westward and eastward transmedian flights, but differ from each other in specific features.

He C, Anand ST, Ebell MH, Vena JE, Robb SW. Circadian disrupting exposures and breast cancer risk: a meta-analysis. *Int Arch Occup Environ Health*. 2015;88(5):533-547.

Purpose: Shift work, short sleep duration, employment as a flight attendant, and exposure to light at night, all potential causes of circadian disruption, have been inconsistently associated with breast cancer (BrCA) risk. The aim of this meta-analysis is to quantitatively evaluate the combined and independent effects of exposure to different sources of circadian disruption on BrCA risk in women.

Methods: Relevant studies published through January 2014 were identified by searching the PubMed database. The pooled relative risks (RRs) and corresponding 95 % confidence intervals (CIs) were estimated using fixed- or random effects models as indicated by heterogeneity tests. Generalized least squares trend test was used to assess dose-response relationships.

Results: A total of 28 studies, 15 on shift work, 7 on short sleep duration, 3 on flight attendants, and 6 on light at night were included in the analysis. The combined analysis suggested a significantly positive association between circadian disruption and BrCA risk (RR = 1.14; 95 % CI 1.08-1.21). Separate analyses showed that the RR for BrCA was 1.19 (95 % CI 1.08-1.32) for shift work, 1.120 (95 % CI 1.119-1.121) for exposure to light at night, 1.56 (95 % CI 1.10-2.21) for employment as a flight attendant, and 0.96 (95 % CI 0.86-1.06) for short sleep duration. A dose-response analysis showed that each 10-year increment of shift work was associated with 16 % higher risk of BrCA (95 % CI 1.06-1.27) based on selected case-control studies. No significant dose-response effects of exposure to light at night and sleep deficiency were found on BrCA risk.

Conclusions: Our meta-analysis demonstrates that circadian disruption is associated with an increased BrCA risk in women. This association varied by specific sources of circadian disrupting exposures, and a dose-response relationship remains uncertain. Therefore, future rigorous prospective studies are needed to confirm these relationships.

Heidecker B, Spencer RM, Hayes V, et al. High Prevalence and Clinical/Sociodemographic Correlates of Miscarriages Among Flight Attendants. Am J Med. 2017;130(12):1397-1401.

Background: There are many occupational health hazards associated with long hours of air travel, including cosmic radiation exposure, circadian rhythm disruptions, prior and secondhand smoke exposure, for flight attendants who flew before smoking bans were initiated in the 1990s. Previous studies in flight attendants have found increased incidence of breast cancer and melanoma. However, there is little information on the relationship of airline travel and reproductive health in flight attendants. Secondhand smoke exposure has numerous negative health effects, such as increased cardiac events and respiratory infections, but its effect on reproductive health is not known. This study seeks to examine the role of secondhand smoke exposure on the miscarriage rate in flight attendants who flew before the smoking ban.

Methods: Flight attendants who flew before the smoking ban and participating in a study of health effects of secondhand smoke were asked to complete a reproductive health survey. We compared miscarriage rates of flight attendants to the general population using 2010 data from the Centers for Disease Control and Prevention.

Results: In our cohort of 145 female flight attendants exposed to secondhand smoke, there were 45 miscarriages (26%), compared with a 17.1% rate in the Centers for Disease Control and Prevention report (P = .002). There was no difference in secondhand smoke exposure between the flight attendants with miscarriage and the group without miscarriage (P = .93).

Conclusions: This study found an increased incidence of miscarriage in flight attendants, which was unrelated to secondhand smoke exposure. Other factors, such as circadian rhythm disruption and radiation, may be related to these reproductive health findings and require further investigation.

Lahti T, Terttunen J, Leppämäki S, Lönnqvist J, Partonen T. Field trial of timed bright light exposure for jet lag among airline cabin crew. Int J Circumpolar Health. 2007;66(4):365-369.

Objectives: Commercial airlines' flight crew members on transmeridian long-haul flights are constantly exposed to rapid changes in external time. Following rapid changes in circadian rhythm may lead to several symptoms known as jet lag. Our aim was to alleviate jet-lag symptoms by timed exposure to bright light (natural sunlight if present, otherwise artificial bright light).

Study design: Observational field trial with bright light against jet lag.

Methods: Information on the effects of bright lights on health was delivered through corporate level wellness programs. Volunteer study subjects were cabin crew members on long-haul flights. Subjects filled in a 16-Item Columbia Jet Lag Scale (maximum score 64) before the flight (expected symptoms based on previous flights), on the third day at the destination and again on the third day after returning home. Changes in scores were compared relative to the timed exposure to bright light, and to flights eastwards or westwards, and in summer or winter.

Results: Out of 75 subjects, 15 returned the questionnaires for a total of 28 flights. The mean estimated effect of bright light was a decrease of 5.3 points on the symptom scale. The difference was not significant (SE = 3.4, df = 11, t = -1.6, p = 0.15). The flight had no influence on the estimate.

Conclusions: The results do not give support to the hypothesis that timed exposure to bright light would alleviate jet lag symptoms, although the small sample size was a problem. More field studies are needed to establish the feasibility of bright light for reducing jet lag.

Petrie K, Dawson AG, Thompson L, Brook R. A double-blind trial of melatonin as a treatment for jet lag in international cabin crew. Biol Psychiatry. 1993;33(7):526-530.

This study investigated the efficacy of oral melatonin in alleviating jet lag in flight crew after a series of international flights. The optimal time for taking melatonin in this group was also investigated. In a double-blind placebo-controlled trial, 52 international cabin crew were randomly assigned to three groups; early melatonin (5 mg started 3 days prior to arrival until 5 days after return home); late melatonin (placebo for 3 days then 5 mg melatonin for 5 days); and placebo. Daily ratings showed a trend in jet lag, mood, and sleepiness measures toward an improved recovery in the late melatonin group and a worse recovery in the early melatonin group as compared to placebo. Retrospective ratings made 6 days after arrival showed the late melatonin group reported significantly less jet lag and sleep disturbance following the flight compared to placebo. The late melatonin group also showed a significantly faster recovery of energy and alertness than the early melatonin group, which reported a worse overall recovery than placebo. These findings show melatonin may have potential benefits for international aircrew.

Preston FS, Ruffell Smith HP, Sutton-Mattocks VM. Sleep loss in air cabin crew. Aerosp Med. 1973;44(8):931-935.

Kein Abstract verfügbar

Preston FS. Physiological problems in air cabin crew. Proc R Soc Med. 1974;67(9):825-829.

Kein Abstract verfügbar

Schaffler K, Renemann HH. Schlafstörungen des Kabinenpersonals nach transmeridianen Langstreckenflügen [Sleep disorders of cabin crew following transmeridian long-distance flights]. Med Klin. 1976;71(46):1985-1995.

Kein Abstract verfügbar

Signal TL, Gander PH, van den Berg MJ, Graeber RC. In-flight sleep of flight crew during a 7-hour rest break: implications for research and flight safety. Sleep. 2013;36(1):109-115.

Study objectives: To assess the amount and quality of sleep that flight crew are able to obtain during flight, and identify factors that influence the sleep obtained.

Design: Flight crew operating flights between Everett, WA, USA and Asia had their sleep recorded polysomnographically for 1 night in a layover hotel and during a 7-h in-flight rest opportunity on flights averaging 15.7 h.

Setting: Layover hotel and in-flight crew rest facilities onboard the Boeing 777-200ER aircraft.

Participants: Twenty-one male flight crew (11 Captains, mean age 48 yr and 10 First Officers, mean age 35 yr).

Measurements and results: Sleep was recorded using actigraphy during the entire tour of duty, and polysomnographically in a layover hotel and during the flight. Mixed model analysis of covariance was used to determine the factors affecting in-flight sleep. In-flight sleep was less efficient (70% vs. 88%), with more nonrapid eye movement Stage 1/Stage 2 and more frequent awakenings per h (7.7/h vs. 4.6/h) than sleep in the layover hotel. In-flight sleep included very little slow wave sleep (median 0.5%). Less time was spent trying to sleep and less sleep was obtained when sleep opportunities occurred during the first half of the flight. Multivariate analyses suggest age is the most consistent factor affecting in-flight sleep duration and quality.

Conclusions: This study confirms that even during long sleep opportunities, in-flight sleep is of poorer quality than sleep on the ground. With longer flight times, the quality and recuperative value of in-flight sleep is increasingly important for flight safety. Because the age limit for flight crew is being challenged, the consequences of age adversely affecting sleep quantity and quality need to be evaluated.

Suvanto S, Härmä M, Ilmarinen J, Partinen M. Effects of 10 h time zone changes on female flight attendants' circadian rhythms of body temperature, alertness, and visual search. Ergonomics. 1993;36(6):613-625.

The aim of the study was to analyse the effects of rapid time zone changes on the circadian rhythms of flight attendants. The mean age of the 40 female subjects was 30.0 (SD = 6.9) years. Measurements of oral temperature, alertness, and visual search were performed at two hour intervals two days before the flight from Helsinki to Los Angeles, during the second and the fourth day in the USA and during the second and fourth day after the return flight to Finland. The body temperature desynchronized and the phases of the alertness and visual search rhythms shifted rapidly in the USA. After the return flight, the acrophases of the circadian rhythms delayed during the second and fourth day in Finland. During the fourth day the acrophase of alertness was 35 min and the acrophases of body temperature and visual search were 2 h 2 min and 3 h 8 min delayed, respectively. The mathematical model based on the C-, S- and W-process theory of alertness explained 25-96% of the variation of observed mean alertness of the subjects in different conditions. It is concluded that the duration of the de- and resynchronization process of the flight attendants' circadian rhythms is on the average longer than 9 days during and after round flights over ten time zones. The mean alertness of the subject can be predicted with considerable accuracy using the mathematical model.

Touitou Y. Light at night pollution of the internal clock, a public health issue. Bull Acad Natl Med. 2015;199(7):1081-1098.

Light is the major synchronizer of the internal clock located in the suprachiasmatic nuclei of the anterior hypothalamus. Retinal ganglion cells contain melanopsin, a photoreceptor with a peak sensitivity to blue wavelength (460-480 nm). Light signal is transmitted from the eye to the clock, then to the pineal gland which produces melatonin, considered as the hand of the clock. Even a weak intensity of light (LEDs, tablets, mobile phones, computers...) is able to block the secretion of melatonin, the hormone of darkness. Light is also able to phase advance or phase delay the circadian system according to the timing of exposure. This Phase Response Curve (PRC) is used to resynchronize the clock in various situations of circadian desynchronization. Exposure to Light at Night (LAN) results in a disruption of the circadian system which is deleterious to health. In industrialized countries, including France, 75 % of the total workforce is estimated to be involved in atypical hours, far from the classical diurnal hours of work. Of interest, shift work and night work involve 15.4 % of the French workforce. A number of epidemiologic studies, peiformed mainly on nurses, showed an association between sustained night work (3 to 20 years) and an increased risk of breast cancer Health problems faced by flight attendants have also been reported, though other causes like exposure to radiations cannot be ruled out. Other deleterious effects are reported in this paper. The potential mechanisms of the deleterious effects of LAN on health are suppression of melatonin andsleep deprivation. The International Agencyfor Cancer Research (IARC) classified shift work that involves circadian disruption as (probably carcinogenic to humans". Countermeasures (e.g melatonin, bright light, use of psychotropic drugs) have been proposed as a means to improve adaptation to shift work and night work and to fight " clock pollution " and circadian desynchronization by LAN.

Waters MA, Grajewski B, Pinkerton LE, Hein MJ, Zivkovich Z. Development of historical exposure estimates of cosmic radiation and circadian rhythm disruption for cohort studies of Pan Am flight attendants. Am J Ind Med. 2009;52(10):751-761.

Background: The National Institute for Occupational Safety and Health is conducting cohort studies of flight crew employed by the former Pan American World Airways company (Pan Am) as part of an effort to examine flight crew workplace exposures and health effects. Flight crew are exposed to elevated levels of cosmic radiation and to disruption of circadian rhythm when flying across multiple time zones. Methods exist to calculate cosmic radiation effective doses on individual flights; however, only work histories which provided an employee's domicile (home base) history rather than a record of every flight flown were available.

Methods/results: We developed a method for estimating individual cumulative domicile-based cosmic radiation effective doses and two metrics for circadian rhythm disruption for each flight attendant: cumulative times zones crossed and cumulative travel time during the standard sleep interval.

Conclusions: The domicile-exposure matrix developed was used to calculate exposure estimates for a cohort mortality study of former Pan Am flight attendants.

INFEKTIONEN

Alpert JS. Airline hygiene. *Am J Med*. 2015;128(8):799.

Kein Abstract verfügbar

Boel NM, Klokker M. Upper Respiratory Infections and Barotrauma Among Commercial Pilots. Aerosp Med Hum Perform. 2017 Jan 1;88(1):17-22.

Background: Health incapacitation is a serious threat to flight safety. Therefore, a study conducted 10 yr ago examined the incidents of ear-nose-throat (ENT) barotrauma and upper respiratory infection (URI) among commercial pilots and found that a large number continued to carry out their duties despite the risk of incapacitation. Now, 10 yr later, this new study examines if the attention to URIs has improved.

Method: This study was conducted at the Danish Aeromedical Centre over the course of 1 yr with 463 valid respondents to a questionnaire on URIs and ENT barotrauma. These respondents were compared to 940 respondents answering the same questionnaire 10 yr prior in the same setting.

Results: This study shows a significant increase in the number of pilots flying despite signs of an URI from 42.8 to 50.1% and in the number of pilots using decongestant medicine from 43.3 to 59.5%. The proportion of pilots experiencing one or more ENT barotraumas has also increased from 37.4 to 55.5% for barotitis media and from 19.5 to 27.9% for barosinusitis.

Conclusion: Half of all pilots in this study fly despite signs of an URI. This is a significant increase and shows that after 10 yr an URI is still not considered a valid reason for reporting in sick despite international aeromedical recommendation. Based on these findings, the study recommends that awareness of the risk of flying with an URI be increased.Boel NM, Klokker M. Upper respiratory infections and barotrauma among commercial pilots.

Blanc L, Raviglione M. Prevention and control of tuberculosis during air travel. *Travel Med Infect Dis*. 2010;8(2):79-80.

Kein Abstract verfügbar

Byrne N. Low prevalence of TB on long-haul aircraft. *Travel Med Infect Dis*. 2007;5(1):18-23.

Background: Proximity to an infectious TB case is a potential risk in any close contact setting. However, the rapid growth in airline transportation is in stark contrast to the lack of evidence about the prevalence of TB among airline passengers and crew. The rate of ventilation in the aircraft cabin is far superior to other forms of transportation and reduces the risk of airborne transmission.

Methods: This study calculated TB disease rates among passengers and cabin crew during the 5-year study period. The principal study outcome was the number of notifications of confirmed TB disease cases and potential under-reporting was estimated. The airline rates were compared with the WHO definition of low incidence--"a TB notification rate below 10 per 100,000 population and declining".

Findings: The TB case notification rate was 0.05 per 100,000 long-haul passengers. The risk increased seven-fold on flights from TB-endemic areas in Africa or India. The aircraft cabin remains classified as a low TB incidence environment on all routes within a wide margin of error. Low occupational prevalence was observed in the cabin crew workforce.

Interpretation: Airline passengers are considered to be a select group with low TB rates. This study provides important evidence that confirms the aircraft as a low-risk setting for transmission of TB and emphasizes the presence of environmental-control measures that reduce the risk as far as possible.

Cimerman S, Barata LC, Pignatari AC, et al. Malaria Transmission Associated with Airplane Travel. Braz J Infect Dis. 1997;1(3):135-137.

Plasmodium falciparum malaria was diagnosed in 3 patients in Sã o Paulo during a 5 day period between August 31, and September 4, 1996, at a time and place where malaria transmission does not occur. After investigation of the 3 cases it was determined that the infections were acquired as a result of an international airplane flight from Lebanon to São Paulo on August 16, which included a 30 minute stop-over in Abidjan, Ivory Coast, Africa. During the epidemiological evaluation, it was found that each of the 3 patients had been seated in the first class cabin. Entomological investigation at the airport revealed the presence of 4 specimens of Anopheles gambiae in airplanes (3 in the first class cabin and 1 in the luggage compartment) used on this route. The species of mosquito identified is predominant in Africa. Two of the patients were seriously ill, but all recovered after treatment with either mefloquine (1 patient) or artesunate (2 patients). A survey of other passengers on the same flight or on similar Aights did not reveal any other eases of malaria. Malaria was not considered during initial evaluation by the attending physicians at the three different hospitals where the patients were admitted. These cases reveal the existence of vector borne disease transmission

during airplane travel, and emphasize the importance of obtaining a travel history during the evaluation of an ill patient. In addition, the cases reinforce the need for vigilance in the control of vectors of disease around seaports, airports and hospitals.

Dowdall NP, Evans AD, Thibeault C. Air Travel and TB: an airline perspective. *Travel Med Infect Dis*. 2010;8(2):96-103.

The commercial airline industry in the 21st century is a global business, able to transport large numbers of people to almost any part of the world within a few hours. There has long been concern in public health circles about the potential for transmission of communicable diseases, such as TB, on board aircraft. The recent threats from novel and emerging infectious diseases including SARS and pandemic flu has facilitated unprecedented levels of cooperation between international industry representatives, regulators and public health authorities in addressing the issues of air travel and communicable disease. This paper reviews the regulatory environment, ways in which the risks are mitigated through aspects of aircraft design, opportunities for prevention by identifying individuals who may be suffering from a communicable disease prior to flight and the approach used in managing suspected cases of communicable disease on board aircraft.

Edelson PJ. Patterns of measles transmission among airplane travelers. *Travel Med Infect Dis*. 2012;10(5-6):230-235.

With advanced air handling systems on modern aircraft and the high level of measles immunity in many countries, measles infection in air travelers may be considered a low-risk event. However, introduction of measles into countries where transmission has been controlled or eliminated can have substantial consequences both for the use of public health resources and for those still susceptible. In an effort to balance the relatively low likelihood of disease transmission among largely immune travelers and the risk to the public health of the occurrence of secondary cases resulting from importations, criteria in the United States for contact investigations for measles exposures consider contacts to be those passengers who are seated within 2 rows of the index case. However, recent work has shown that cabin air flow may not be as reliable a barrier to the spread of measles virus as previously believed. Along with these new studies, several reports have described measles developing after travel in passengers seated some distance from the index case. To understand better the potential for measles virus to spread on an airplane, reports of apparent secondary cases occurring in co-travelers of passengers with infectious cases of measles were reviewed. Medline™ was searched for articles in all languages from 1946 to week 1 of March 2012, using the search terms "measles [human] or rubeola" and ("aircraft" or "airplane" or "aeroplane" or "aviation" or "travel" or "traveler" or "traveller"); 45 citations were returned. Embase™ was searched from 1988 to week 11 2012, using the same search strategy; 95 citations were returned. Papers were included in this review if they reported secondary cases of measles occurring in persons traveling on an airplane on which a person or persons with measles also flew, and which included the seating location of both the index case(s) and the secondary case(s) on the plane. Nine reports, including 13 index cases and 23 apparent secondary cases on 10 flights, were identified in which transmission on board the aircraft appeared likely and which included seating information for both the index (primary) and secondary cases. Separation between index and secondary cases ranged from adjacent seats to 17 rows, with a median of 6 rows. Three flights had more than one index case aboard. Based on previously published data, it is not possible to say how unusual cases of measles transmission among air travelers beyond the usual zone of contact investigation (the row the index case sat in and 2 rows ahead of or behind that row) may be. The fact that several flights had more than one infectious case aboard and that all but two index cases were in the prodromal phase may be of importance in understanding the wider spread described in several of the reviewed reports. Although the pattern of cabin air flow typical of modern commercial aircraft has been considered highly effective in limiting the airborne spread of microorganisms, concerns have been raised about relying on the operation of these systems to determine exposure risk, as turbulence in the cabin air stream is generated when passengers and crew are aboard, allowing the transmission of infectious agents over many rows. Additionally, the characteristics of some index cases may reflect a greater likelihood of disease transmission. Investigators should continue to examine carefully both aircraft and index-case factors that may influence disease transmission and could serve as indicators on a case-by-case basis to include a broader group of travelers in a contact investigation.

Grout A, Howard N, Coker R, Speakman EM. Guidelines, law, and governance: disconnects in the global control of airline-associated infectious diseases. *Lancet Infect Dis*. 2017;17(4):e118-e122.

International air travel is increasingly affecting the epidemiology of infectious diseases. A particular public health, economic, and political concern is the role of air travel in bringing infectious passengers or vectors to previously non-endemic areas. Yet, little research has been done to investigate either the infection risks associated with air travel or the empirical evidence for the effectiveness of infection control measures on aircraft and at borders. We briefly review the interface between international and national legislation, policy, and guidelines in the context of existing infection risks and possible scenarios. We have found that public health guidance and legislation, which airlines are required to follow, are often contradictory and confusing. Infection control measures for air travel need to be underpinned by coherent and enforceable national and international legislation that is based on solid epidemiological evidence. We recommend further research investment into more effective on-board vector control, health screening, and risk communications strategies, and the development of enforceable and harmonised international legislation.

Gupta JK, Lin CH, Chen Q. Risk assessment of airborne infectious diseases in aircraft cabins. *Indoor Air*. 2012;22(5):388-395.

Passengers in an aircraft cabin can have different risks of infection from airborne infectious diseases such as influenza, severe acute respiratory syndrome (SARS), and tuberculosis (TB) because of the non-uniform airflow in an aircraft cabin. The current investigation presents a comprehensive approach to assessing the spatial and temporal distributions of airborne infection risk in an aircraft cabin. A case of influenza outbreak was evaluated in a 4-h flight in a twin-aisle, fully occupied aircraft cabin with the index passenger seated at the center of the cabin. The approach considered the characteristics of the exhalation of the droplets carrying infectious agents from the index passenger, the dispersion of these droplets, and the inhalation of the droplets by susceptible passengers. Deterministic and probabilistic approaches were used to quantify the risks based on the amount of inhaled influenza virus RNA particles and quanta, respectively. The probabilistic approach indicated that the number of secondary infection cases can be reduced from 3 to 0 and 20 to 11, for influenza cases if N95 respirator masks are used by the passengers. The approach and methods developed can easily be implemented in other enclosed spaces such as buildings, trains, and buses to assess the infection risk.

Practical implications: Airborne infectious disease transmission could take place in enclosed environments such as buildings and transport vehicles. The infection risk is difficult to estimate, and very few mitigation methods are available. This study used a 4-h flight as an example in analyzing the infection risk from influenza and in mitigating the risk with an N95 mask. The results will be

useful to the airline industry in providing necessary protection to passengers and crew, and the results can also be used for other enclosed spaces.

Gutersohn T, Steffen R, Van Damme P, Holdener F, Beutels P. Hepatitis A infection in aircrews: risk of infection and cost-benefit analysis of hepatitis A vaccination. *Aviat Space Environ Med*. 1996;67(2):153-156.

Background: Since a hepatitis A vaccine (HAV) with long-lasting efficacy has become available, its indication in airline crews needs to be determined.

Hypothesis: Destinations in developing countries are a risk factor for hepatitis A infection in airline crews, and vaccination is cost-beneficial.

Methods: Retrospective analysis was performed for all Swissair medical files for the period 1987-91. Denominator and cost data were obtained by the personnel department, and a cross-sectional seroepidemiological survey was performed in 734 Sabena staff.

Results: Among 3,322 Swissair crewmembers who spent an average of 45 nights in developing countries, 22 hepatitis A infections occurred. For the non-immune crewmembers, the overall annual incidence rate was 1.53 per 1000, whereas the incidence rate while staying in a high risk country was 12.2 per 1000. Cockpit crews with destinations limited to Europe had a rate of zero. Male flight attendants had a threefold higher rate as compared to female flight attendants or pilots. In Sabena, anti-HAV seroprevalence was 33.3%. Increased rates were observed in male as compared to female flying crews and in employees stationed abroad, whereas flying personnel had no higher rate than ground personnel. Simplified comparison of cost of infection and cost of vaccination indicates that vaccination may be cost-saving to the airline company for both male flight-attendants and pilots.

Conclusions: Hepatitis A vaccination may be recommended to staff stationed in high risk countries and to flying crews with such destinations.

Han Z, To GN, Fu SC, Chao CY, Weng W, Huang Q. Effect of human movement on airborne disease transmission in an airplane cabin: study using numerical modeling and quantitative risk analysis. *BMC Infect Dis*. 2014;14:434. Published 2014 Aug 6.

Background: Airborne transmission of respiratory infectious disease in indoor environment (e.g. airplane cabin, conference room, hospital, isolated room and inpatient ward) may cause outbreaks of infectious diseases, which may lead to many infection cases and significantly influences on the public health. This issue has received more and more attentions from academics. This work investigates the influence of human movement on the airborne transmission of respiratory infectious diseases in an airplane cabin by using an accurate human model in numerical simulation and comparing the influences of different human movement behaviors on disease transmission.

Methods: The Eulerian-Lagrangian approach is adopted to simulate the dispersion and deposition of the expiratory aerosols. The dose-response model is used to assess the infection risks of the occupants. The likelihood analysis is performed as a hypothesis test on the input parameters and different human movement pattern assumptions. An in-flight SARS outbreak case is used for investigation. A moving person with different moving speeds is simulated to represent the movement behaviors. A digital human model was used to represent the detailed profile of the occupants, which was obtained by scanning a real thermal manikin using the 3D laser scanning system.

Results: The analysis results indicate that human movement can strengthen the downward transport of the aerosols, significantly reduce the overall deposition and removal rate of the suspended aerosols and increase the average infection risk in the cabin. The likelihood estimation result shows that the risk assessment results better fit the outcome of the outbreak case when the movements of the seated passengers are considered. The intake fraction of the moving person is significantly higher than most of the seated passengers.

Conclusions: The infection risk distribution in the airplane cabin highly depends on the movement behaviors of the passengers and the index patient. The walking activities of the crew members and the seated passengers can significantly increase their personal infection risks. Taking the influence of the movement of the seated passengers and the index patient into consideration is necessary and important. For future studies, investigations on the behaviors characteristics of the passengers during flight will be useful and helpful for infection control.

Haditsch M. Flugtauglichkeit bei Infektionskrankheiten [Flying fitness of patients with infections]. *Wien Med Wochenschr*. 2002;152(17-18):469-472.

To certify fitness for (international) air flights one must differentiate between target groups, i.e. pilots, cabin crew and passengers and the stage of infection, i.e. acute and chronic phase of disease and (organ) deficiency after infection, respectively. Publications mostly show indefinite terms which makes principles of quality assessment and international harmonization difficult, in some instances even impossible. Whereas certification of fitness in pilots in respect of infectious diseases should ensure a safe travel problems of infectious diseases in cabin crew and passengers are mainly focused on the risk of avoidable sequelae concerning the person itself and of the transmission to other passengers, respectively.

Hertzberg VS, Weiss H, Elon L, Si W, Norris SL; FlyHealthy Research Team. Behaviors, movements, and transmission of droplet-mediated respiratory diseases during transcontinental airline flights. *Proc Natl Acad Sci U S A*. 2018;115(14):3623-3627.

With over 3 billion airline passengers annually, the inflight transmission of infectious diseases is an important global health concern. Over a dozen cases of inflight transmission of serious infections have been documented, and air travel can serve as a conduit for the rapid spread of newly emerging infections and pandemics. Despite sensational media stories and anecdotes, the risks of transmission of respiratory viruses in an airplane cabin are unknown. Movements of passengers and crew may facilitate disease transmission. On 10 transcontinental US flights, we chronicled behaviors and movements of individuals in the economy cabin on single-aisle aircraft. We simulated transmission during flight based on these data. Our results indicate there is low probability of direct transmission to passengers not seated in close proximity to an infectious passenger. This data-driven, dynamic network transmission model of droplet-mediated respiratory disease is unique. To measure the true pathogen burden, our team

collected 229 environmental samples during the flights. Although eight flights were during Influenza season, all qPCR assays for 18 common respiratory viruses were negative.

Hertzberg VS, Weiss H. On the 2-Row Rule for Infectious Disease Transmission on Aircraft. *Ann Glob Health*. 2016;82(5):819-823.

Background: With over two billion airline passengers annually, in-flight transmission of infectious diseases is an important global health concern. Many instances of in-flight transmission have been documented, but the relative influence of the many factors (see below) affecting in-flight transmission has not been quantified. Long-standing guidance by public health agencies is that the primary transmission risk associated with air travel for most respiratory infectious diseases is associated with sitting within two rows of an infectious passenger. The effect of proximity may be one of these factors.

Objective: The aim of this study was to determine the risk of infection within and beyond the 2-row rule given by public health guidance.

Methods: We searched the literature for reports of in-flight transmission of infection which included seat maps indicating where the infectious and infected passengers were seated.

Findings: There is a ~ 6% risk to passengers seated within the 2-rows of infected individual(s) and there is ~ 2% risk to passengers seated beyond 2-rows from the infectious individual.

Discussion: Contact tracing limited to passengers within 2-rows of the infectious individual(s) could fail to detect other cases of infections. This has important consequences for assessing the spread of infectious diseases.

Conclusions: Infection at a distance from the index case indicates other factors, such as airflow, movement of passenger/crew members, fomites and contacts between passengers in the departure gate before boarding, or after deplaning, are involved.

Hoad VC, O'Connor BA, Langley AJ, Dowse GK. Risk of measles transmission on aeroplanes: Australian experience 2007-2011. *Med J Aust*. 2013;198(6):320-323.

Objective: To quantify the risk of transmission of measles associated with infectious people who travelled on aeroplane flights to or within Australia.

Design, setting and subjects: Data were obtained from state and territory health authorities on all measles notifications from January 2007 to June 2011 for people who were likely to have been infectious or infected while travelling on aeroplanes in Australia.

Results: Forty-five infectious people travelled on aeroplanes. Twenty secondary infections occurred in people on seven of 49 flights (14%; 95% CI, 6%-29%), comprising 19% (95% CI, 8%-40%) of the 36 international flights and none of 13 (95% CI, 0-28%) domestic flights that carried infectious people. Secondary infections occurred in nine people who were seated within two rows of the index case and in 11 people who were seated outside of two rows. Secondary transmission was more likely to occur with younger index cases (P = 0.025) and when there were multiple infectious people travelling (P = 0.018). About a third(15/49) of flight manifests were available to health authorities within 5 days oftravel.

Conclusion: Despite secondary measles transmission occurring on 19% of international flights carrying infectious people, risk was not clearly related to seating proximity, and contact tracing was ineffective, especially given delays in diagnosis, notification and accessing flight manifests. We recommend that direct contact tracing to identify susceptible people exposed to people infected with measles on aeroplane flights should not be undertaken routinely, and other strategies should be considered.

Holdener F, Grob PJ, Joller-Jemelka HI. Hepatitis virus infection in flying airline personnel. *Aviat Space Environ Med*. 1982;53(6):587-590.

Sera of 1126 flying personnel of an airline were tested for signs of ongoing or past infections with hepatitis B virus (HBV) or with hepatitis A virus (HAV). The prevalence of anti-HA antibodies was similar in all professional categories of flying personnel and the same or slightly lower than in Swiss blood donors. The frequency of immune markers identifying HBV immunity was similar in pilots, flight-engineers, and female flight attendants compared to Swiss blood donors. However, HBV immunity was clearly more prevalent in male flight attendants. Within 1 year, 13 of 2624 flying personnel had acute hepatitis. This higher-than-average incidence of hepatitis amongst flying personnel compared to the Swiss population was mainly due to a high incidence of hepatitis B amongst male flight attendants. Their special life-styles might be responsible for the high prevalence of HBV immunity and for the high incidence of hepatitis B.

Holmes JD, Simmons GC. Gastrointestinal illness associated with a long-haul flight. *Epidemiol Infect*. 2009;137(3):441-447.

An in-flight incident of vomiting in the cabin and toilet on a trans-Pacific aircraft flight resulted in an outbreak of gastrointestinal (GI) illness among passengers, some of whom subsequently joined a 14-day cruise in New Zealand and Australia. A retrospective cohort analysis of illness occurring in aircraft passengers was undertaken using routine GI illness surveillance data collected by medical staff on a cruise vessel. This was supplemented with data collected from some other passengers and crew on the aircraft. Information was gathered on 224 of the 413 (54.2%) people on the flight (222 passengers and 2 crew members). GI illness within 60 h of arrival in Auckland was reported by 41 of the 122 (33.6%, Fisher's 95% confidence interval 25.3-42.7) passengers seated in the two zones adjacent to the vomiting incident. The pattern of illness suggests a viral infection and highlights the potential of aerosol transmission as well as surface contamination in a closed environment. The spread of infection may have been enhanced by cross-contamination in the toilet cubicle. The significance of the vomiting event was not recognized by the aircraft cabin crew and no pre-arrival information about on-board illness was given to airport health authorities. Isolation of vomiting passengers, where possible, and promotion of appropriate hand hygiene on aircraft has the potential to reduce the spread of infection in passengers on long-haul flights.

Kenyon TA, Valway SE, Ihle WW, Onorato IM, Castro KG. Transmission of multidrug-resistant Mycobacterium tuberculosis during a long airplane flight. *N Engl J Med*. 1996;334(15):933-938.

Background: In April 1994, a passenger with infectious multi-drug resistant tuberculosis traveled on commercial-airline flights from Honolulu to Chicago and from Chicago to Baltimore and returned one month later. We sought to determine whether she had infected any of her contacts on this extensive trip.

Methods: Passengers and crew were identified from airline records and were notified of their exposure, asked to complete a questionnaire, and screened by tuberculin skin tests.

Results: Of the 925 people on the airplanes, 802 (86.7 percent) responded. All 11 contacts with positive tuberculin skin tests who were on the April flights and 2 of 3 contacts with positive tests who were on the Baltimore-to-Chicago flight in May had other risk factors for tuberculosis. More contacts on the final, 8.75-hour flight from Chicago to Honolulu had positive skin tests than those on the other three flights (6 percent, as compared with 2.3, 3.8, and 2.8 percent). Of 15 contacts with positive tests on the May flight from Chicago to Honolulu, 6 (4 with skin-test conversion) had no other risk factors; all 6 had sat in the same section of the plane as the index patient (P=0.001). Passengers seated within two rows of the index patient were more likely to have positive tuberculin skin tests than those in the rest of the section (4 of 13, or 30.8 percent, vs. 2 of 55, or 3.6 percent; rate ratio, 8.5; 95 percent confidence interval, 1.7 to 41.3; P=0.01).

Conclusions: The transmission of Mycobacterium tuberculosis that we describe aboard a commercial aircraft involved a highly infectious passenger, a long flight, and close proximity of contacts to the index patient.

Kirking HL, Cortes J, Burrer S, et al. Likely transmission of norovirus on an airplane, October 2008. *Clin Infect Dis*. 2010;50(9):1216-1221.

Background: On 8 October 2008, members of a tour group experienced diarrhea and vomiting throughout an airplane flight from Boston, Massachusetts, to Los Angeles, California, resulting in an emergency diversion 3 h after takeoff. An investigation was conducted to determine the cause of the outbreak, assess whether transmission occurred on the airplane, and describe risk factors for transmission.

Methods: Passengers and crew were contacted to obtain information about demographics, symptoms, locations on the airplane, and possible risk factors for transmission. Case patients were defined as passengers with vomiting or diarrhea (> or =3 loose stools in 24 h) and were asked to submit stool samples for norovirus testing by real-time reverse-transcription polymerase chain reaction.

Results: Thirty-six (88%) of 41 tour group members were interviewed, and 15 (41%) met the case definition (peak date of illness onset, 8 October 2008). Of 106 passengers who were not tour group members, 85 (80%) were interviewed, and 7 (8%) met the case definition after the flight (peak date of illness onset, 10 October 2008). Multivariate logistic regression analysis showed that sitting in an aisle seat (adjusted relative risk, 11.0; 95% confidence interval, 1.4-84.9) and sitting near any tour group member (adjusted relative risk, 7.5; 95% confidence interval, 1.7-33.6) were associated with the development of illness. Norovirus genotype II was detected by reverse-transcription polymerase chain reaction in stool samples from case patients in both groups.

Conclusions: Despite the short duration, transmission of norovirus likely occurred during the flight.

Kornylo, K, Kim D, Widdowson MA, et l. Risk of norovirus transmission during air travel. J Travel Med. 2009; 16(5):349-51.

Background: During October 2006, an outbreak of norovirus gastroenteritis sickened 200 (59%) of the 379 passengers and 26 (18%) of the 144 crew members on a riverboat. In November 2006, CDC was notified that a group of ill passengers had boarded a commercial flight from St Louis, Missouri, to Atlanta, Georgia. A recent study demonstrated probable norovirus transmission from eight symptomatic flight attendants to passengers on board an aircraft during an international flight; however, there are no published reports of transmission of norovirus on flights of short duration.

Methods: We investigated the risk of norovirus transmission on a short flight as part of an outbreak response. Using a standardized questionnaire, we conducted interviews of passengers and flight attendants who were on the flight. We collected information on traveler demographics and illness before, during, and after the flight. We also collected information about potential onboard risk factors for norovirus transmission, such as proximity and contact with ill appearing persons during the flight, as well as use of onboard lavatories and hand hygiene.

Results: We were able to complete questionnaires for 50 (56%) of the 89 passengers on the flight and 2 (67%) of the 3 flight attendants. Two (5%) of 42 possible secondary cases were identified. These two passengers neither sat in proximity to an index-case passenger during the flight nor reported use of an onboard lavatory.

Conclusions: Although onboard transmission cannot be excluded, likelihood of norovirus transmission on a short flight when ill travelers do not have episodes of vomiting or diarrhea appears minimal.

Kotila SM, Payne Hallström L, Jansen N, Helbling P, Abubakar I. Systematic review on tuberculosis transmission on aircraft and update of the European Centre for Disease Prevention and Control risk assessment guidelines for tuberculosis transmitted on aircraft (RAGIDA-TB). *Euro Surveill*. 2016;21(4):10.2807/1560-7917.ES.2016.21.4.30114.

As a setting for potential tuberculosis (TB) transmission and contact tracing, aircraft pose specific challenges. Evidence-based guidelines are needed to support the related-risk assessment and contact-tracing efforts. In this study evidence of TB transmission on aircraft was identified to update the Risk Assessment Guidelines for TB Transmitted on Aircraft (RAGIDA-TB) of the European Centre for Disease Prevention and Control (ECDC). Electronic searches were undertaken from Medline (Pubmed), Embase and Cochrane Library until 19 July 2013. Eligible records were identified by a two-stage screening process and data on flight and index case characteristics as well as contact tracing strategies extracted. The systematic literature review retrieved 21 records. Ten of these records were available only after the previous version of the RAGIDA guidelines (2009) and World Health Organization guidelines on TB and air travel (2008) were published. Seven of the 21 records presented some evidence of possible in-flight transmission, but only one record provided substantial evidence of TB transmission on an aircraft. The data indicate that overall risk of TB transmission on aircraft is very low. The updated ECDC guidelines for TB transmission on aircraft have global implications due to inevitable need for international collaboration in contract tracing and risk assessment.

Leder K, Newman D. Respiratory infections during air travel. *Intern Med J*. 2005;35(1):50-55.

An increasing number of individuals undertake air travel annually. Issues regarding cabin air quality and the potential risks of transmission of respiratory infections during flight have been investigated and debated previously, but, with the advent of severe acute respiratory syndrome and influenza outbreaks, these issues have recently taken on heightened importance. Anecdotally, many people complain of respiratory symptoms following air travel. However, studies of ventilation systems and patient outcomes indicate the spread of pathogens during flight occurs rarely. In the present review, aspects of the aircraft cabin environment that affect the likelihood of transmission of respiratory pathogens on airplanes are outlined briefly and evidence for the occurrence of outbreaks of respiratory illness among airline passengers are reviewed.

Lei H, Li Y, Xiao S, et al. Routes of transmission of influenza A H1N1, SARS CoV, and norovirus in air cabin: Comparative analyses. *Indoor Air*. 2018;28(3):394-403.

Identifying the exact transmission route(s) of infectious diseases in indoor environments is a crucial step in developing effective intervention strategies. In this study, we proposed a comparative analysis approach and built a model to simulate outbreaks of 3 different in-flight infections in a similar cabin environment, that is, influenza A H1N1, severe acute respiratory syndrome (SARS) coronavirus (CoV), and norovirus. The simulation results seemed to suggest that the close contact route was probably the most significant route (contributes 70%, 95% confidence interval [CI]: 67%-72%) in the in-flight transmission of influenza A H1N1 transmission; as a result, passengers within 2 rows of the index case had a significantly higher infection risk than others in the outbreak (relative risk [RR]: 13.4, 95% CI: 1.5-121.2, P = .019). For SARS CoV, the airborne, close contact, and fomite routes contributed 21% (95% CI: 19%-23%), 29% (95% CI: 27%-31%), and 50% (95% CI: 48%-53%), respectively. For norovirus, the simulation results suggested that the fomite route played the dominant role (contributes 85%, 95% CI: 83%-87%) in most cases; as a result, passengers in aisle seats had a significantly higher infection risk than others (RR: 9.5, 95% CI: 1.2-77.4, P = .022). This work highlighted a method for using observed outbreak data to analyze the roles of different infection transmission routes.

Leitmeyer K, Adlhoch C. Review Article: Influenza Transmission on Aircraft: A Systematic Literature Review. *Epidemiology*. 2016;27(5):743-751.

Background: Air travel is associated with the spread of influenza through infected passengers and potentially through in-flight transmission. Contact tracing after exposure to influenza is not performed systematically. We performed a systematic literature review to evaluate the evidence for influenza transmission aboard aircraft.

Methods: Using PubMed and EMBASE databases, we identified and critically appraised identified records to assess the evidence of such transmission to passengers seated in close proximity to the index cases. We also developed a bias assessment tool to evaluate the quality of evidence provided in the retrieved studies.

Results: We identified 14 peer-reviewed publications describing contact tracing of passengers after possible exposure to influenza virus aboard an aircraft. Contact tracing during the initial phase of the influenza A(H1N1)pdm09 pandemic was described in 11 publications. The studies describe the follow-up of 2,165 (51%) of 4,252 traceable passengers. Altogether, 163 secondary cases were identified resulting in an overall secondary attack rate among traced passengers of 7.5%. Of these secondary cases, 68 (42%) were seated within two rows of the index case.

Conclusion: We found an overall moderate quality of evidence for transmission of influenza virus aboard an aircraft. The major limiting factor was the comparability of the studies. A majority of secondary cases was identified at a greater distance than two rows from the index case. A standardized approach for initiating, conducting, and reporting contact tracing could help to increase the evidence base for better assessing influenza transmission aboard aircraft.

Leitmeyer K. European risk assessment guidance for infectious diseases transmitted on aircraft--the RAGIDA project. *Euro Surveill*. 2011;16(16):19845. Published 2011 Apr 21.

In order to assist national public health authorities in the European Union to assess the risks associated with the transmission of infectious agents on board aircrafts, the European Centre for Disease Prevention and Control initiated in 2007 the RAGIDA project (Risk Assessment Guidance for Infectious Diseases transmitted on Aircraft). RAGIDA consists of two parts: the production of a systematic review and a series of disease-specific guidance documents. The systematic review covered over 3,700 peer-reviewed articles and grey literature for the following diseases: tuberculosis, influenza, severe acute respiratory syndrome (SARS), invasive meningococcal disease, measles, rubella, diphtheria, Ebola and Marburg haemorrhagic fevers, Lassa fever, smallpox and anthrax. In addition, general guidelines on risk assessment and management from international aviation boards and national and international public health agencies were systematically searched. Experts were interviewed on case-based events by standardised questionnaires. Disease-specific guidance documents on tuberculosis, SARS, meningococcal infections, measles, rubella, Ebola and Marburg haemorrhagic fevers, Lassa fever, smallpox and anthrax were the result of consultations of disease-specific expert panels. Factors that influence the risk assessment of infectious disease transmission on board aircrafts and decision making for contact tracing are outlined.

Lopman B. Air sickness: vomiting and environmental transmission of norovirus on aircraft. *Clin Infect Dis*. 2011;53(6):521-522.

Kein Abstract verfügbar

Mazumdar S, Chen Q. A one-dimensional analytical model for airborne contaminant transport in airliner cabins. *Indoor Air*. 2009;19(1):3-13.

Quick information on airborne infectious disease transmission in airliner cabins is essential to reduce the risk of infection of passengers and crew members. This investigation proposed a one-dimensional analytical model that can predict the longitudinal transmission of airborne contaminants or disease viruses inside an airliner cabin. The model considered both diffusive and convective transport of contaminants in the longitudinal direction of the cabin but assumed complete mixing of contaminants in the cabin cross-section. The effect of recirculation of the cabin air and efficiency of the high-efficiency particulate air (HEPA) filters is also considered in the model. The analytical solution for the one-dimensional contaminant transport model is obtained by using the principle of superposition and the method of separation of variables. The analytical solutions agree well with the computational fluid dynamics (CFD) results. The coupling of a CFD model with the one-dimensional analytical model could capture the impact

of local airflow on contaminant transport. This analytical model has been used for analyzing contaminant transport in a 30-row all-economy-class airliner cabin with minimal computing effort.

Practical implications: The paper presents a new one-dimensional analytical model that can provide quick information on global airborne contaminant transmissions in airliner cabins for effective response plans. The model can be used to study the effects of air exchange rates, recirculation, efficiency of the high-efficiency particulate air (HEPA) filters and longitudinal airflow on airborne contaminant transport in airliner cabins with minimal computing effort.

Miller MA, Valway S, Onorato IM. Tuberculosis risk after exposure on airplanes. *Tuber Lung Dis*. 1996;77(5):414-419.

Setting: Domestic and international air-flights.

Objective: To estimate the risk of tuberculosis (TB) transmission aboard aircraft.

Design: A contact investigation of passengers and crew from two flights was conducted following identification of a fellow passenger with pulmonary TB. Immediate post-exposure and follow-up tuberculin skin tests (TSTs) were obtained.

Results: Of 120 contacts, 86 (72%) had a negative TST (< 5 mm); 29 (24%) a positive TST (> or = 5 mm), and 5 (4%) a TST conversion. Of the 29 persons with a positive TST, 27 had other identified risk factors for TB. Risk factors for positive TST included non-US birth (Relative Risk (RR) 9.7 P < 0.01) or history of Bacille Calmette-Guérin (BCG) vaccination (RR undefined; P < 0.01). Risk was not associated with specific aircraft or seat relative to the index case for US-born contacts. All five TST converters were born in countries where BCG vaccine is routinely given.

Conclusion: The positive TST reactions and conversions suggest boosting from BCG vaccination or prior exposure in TB-endemic countries. Since two positive contacts had no other identified risk factor, TB transmission on board the aircraft could not be excluded. Contact investigation of exposed aircraft passengers should be considered on a case-by-case basis, with consideration of the infectiousness of the ill passenger and the flight circumstances.

Mixéu MA, Vespa GN, Forleo-Neto E, Toniolo-Neto J, Alves PM. Impact of influenza vaccination on civilian aircrew illness and absenteeism. Aviat Space Environ Med. 2002 Sep;73(9):876-80.

Background: Approximately 10% of the general population worldwide acquires influenza infection every year. Airline crews run a particularly high risk of contracting influenza and influenza-like viruses because they come in contact with hundreds of potentially infected individuals every day. Respiratory diseases are the most frequent cause of absenteeism among flight crews in airline companies. Several studies have shown the efficacy of influenza vaccination in the workplace of healthy, working adults leading to increased productivity and lower absenteeism. We conducted a double blind, randomized, placebo-controlled study on flight crews of an airline company in order to determine the safety and efficacy of a trivalent inactivated influenza vaccine in reducing illness and absences from work.

Methods: The 813 healthy members of a Brazilian airline company were randomly assigned to receive injections of either an influenza vaccine or a placebo, with a follow-up period of 7 mo after vaccination. Primary outcomes included influenza-like illness episodes and absenteeism from work due to such episodes.

Results: Demographic characteristics were similar in the two groups. No significant side-effects occurred in either group. Compared to the placebo group, individuals receiving the vaccine showed 39.5% fewer episodes of flu-like illness (p < 0.001) and 26% fewer days of work lost (p = 0.03). The vaccinated group developed 33% fewer episodes of any severe flu-like illness (p < 0.01).

Conclusion: The data indicates that influenza vaccination is safe in airline flight crews and may produce health-related benefits including reduced absenteeism.

Norbäck D, Lindgren T, Wieslander G. Changes in ocular and nasal signs and symptoms among air crew in relation to air humidification on intercontinental flights. *Scand J Work Environ Health*. 2006;32(2):138-144.

Objective: This study evaluates the influence of air humidification in aircraft on symptoms, tear-film stability, nasal patency, and peak expiratory flow.

Methods: Commercial air crew (N=71) were given a medical examination during eight flights from Stockholm to Chicago and eight flights in the opposite direction. Examinations were done onboard one Boeing 767 aircraft equipped with an evaporation humidifier in the forward part of the cabin. The investigators followed the air crew, staying one night in Chicago and returning with the same crew. Four of the flights had the air humidification device active in-flight to Chicago and deactivated when returning to Stockholm. The other four flights had the inverse humidification sequence. The humidification sequence was randomized and double blind. Hygienic measurements were performed.

Results: The humidification increased the relative air humidity by 10% in the 1st row in business class, by 3% in the last row (39th row) in tourist class, and by 3% in the cockpit. Air humidification increased tear-film stability and nasal patency and decreased ocular, nasal, and dermal symptoms and headache. The mean concentration of viable bacteria [77-108 colony-forming units (cfu)/m(3)], viable molds (74-84 cfu/m(3)), and particulate matter (1-8 microg/m(3)) was low, both during the humidified and non-humidified flights.

Conclusions: Relative air humidity is low (10-12%) during intercontinental flights and can be increased by the use of a ceramic evaporation humidifier, without any measurable increase of microorganisms in cabin air. Air humidification could increase passenger and crew comfort by increasing tear-film stability and nasal patency and reducing various symptoms.

Olsen SJ, Chang HL, Cheung TY, et al. Transmission of the severe acute respiratory syndrome on aircraft. *N Engl J Med*. 2003;349(25):2416-2422.

Background: The severe acute respiratory syndrome (SARS) spread rapidly around the world, largely because persons infected with the SARS-associated coronavirus (SARS-CoV) traveled on aircraft to distant cities. Although many infected persons traveled on commercial aircraft, the risk, if any, of in-flight transmission is unknown.

Methods: We attempted to interview passengers and crew members at least 10 days after they had taken one of three flights that transported a patient or patients with SARS. All index patients met the criteria of the World Health Organization for a probable case of SARS, and index or secondary cases were confirmed to be positive for SARS-CoV on reverse-transcriptase polymerase chain reaction or serologic testing.

Results: After one flight carrying a symptomatic person and 119 other persons, laboratory-confirmed SARS developed in 16 persons, 2 others were given diagnoses of probable SARS, and 4 were reported to have SARS but could not be interviewed. Among the 22 persons with illness, the mean time from the flight to the onset of symptoms was four days (range, two to eight), and there were no recognized exposures to patients with SARS before or after the flight. Illness in passengers was related to the physical proximity to the index patient, with illness reported in 8 of the 23 persons who were seated in the three rows in front of the index patient, as compared with 10 of the 88 persons who were seated elsewhere (relative risk, 3.1; 95 percent confidence interval, 1.4 to 6.9). In contrast, another flight carrying four symptomatic persons resulted in transmission to at most one other person, and no illness was documented in passengers on the flight that carried a person who had presymptomatic SARS.

Conclusions: Transmission of SARS may occur on an aircraft when infected persons fly during the symptomatic phase of illness. Measures to reduce the risk of transmission are warranted.

Rachael T, Schubert K, Hellenbrand W, Krause G, Stuart JM. Risk of transmitting meningococcal infection by transient contact on aircraft and other transport. *Epidemiol Infect*. 2009;137(8):1057-1061.

Contact tracing of persons with meningococcal disease who have travelled on aeroplane or other multi-passenger transport is not consistent between countries. We searched the literature for clusters of meningococcal disease linked by transient contact on the same plane, train, bus or boat. We found reports of two clusters in children on the same school bus and one in passengers on the same plane. Cases within each of these three clusters were due to strains that were genetically indistinguishable. In the aeroplane cluster the only link between the two cases was through a single travel episode. The onset of illness (2 and 5 days after the flight) is consistent with infection from an unidentified carrier around the time of air travel. In contrast to the established risk of transmission from a case of tuberculosis, it is likely that the risk from a case of meningococcal disease to someone who is not identified as a close contact is exceedingly low. This should be considered in making international recommendations for passenger contact tracing after a case of meningococcal disease on a plane or other multi-passenger transport.

Rosenkvist L, Klokker M, Katholm M. Upper respiratory infections and barotraumas in commercial pilots: a retrospective survey. Aviat Space Environ Med. 2008 Oct;79(10):960-3.

Introduction: One of the most common causes of acute incapacitation among aircrew is barotrauma induced by pressure changes during descent in aviation. However, the incidence of ENT barotrauma during flight among commercial pilots with or without upper respiratory infections (URI) has not been described in detail.

Method: There were 948 commercial pilots--equivalent to one-third of all commercial pilots in Denmark--visiting the Danish Aero Medical Centre during a 6-mo period who answered a questionnaire regarding signs and symptoms of URI and barotrauma incidence in relation to flying with a common cold.

Results: On average, every commercial pilot experienced one to two URI per year. About two-thirds of the pilots (57.2%) reported themselves unfit, while 42.8% continued with their flying duties despite signs and symptoms of a URI. Of the latter group the 78.0% reported taking decongestant medication. More than one-third of all pilots (37.6%) reported having experienced one or more episodes of ear barotrauma, mainly during descent (90%), whereas 19.5% reported one or more sinus barotrauma incidents during their flying career. Less than 2% of these had felt incapacitated prior to the flight.

Conclusion: The results suggest that not all pilots and airline companies consider URI a valid reason for unfitness to fly despite the risk for acute incapacitation. Urgent attention to this fact and to the risk factors caused by URI are strongly recommended.

Schwartz MD, Macias-Moriarity LZ, Schelling J. Professional aircrews' attitudes toward infectious diseases and aviation medical issues. Aviat Space Environ Med. 2012 Dec;83(12):1167-70.

Introduction: Air carrier and professional corporate aircrews provide a unique and highly distinct population in which to examine potential transport and transmission of infectious diseases (ID). This study sought to assess frequency of flying while acutely ill, identify clinical triggers in self-grounding, determine employer support for self-grounding, examine rates of influenza vaccination, and identify unmet needs for current information on ID issues related to extensive travel required of professional aircrews.

Methods: Anonymous questionnaires were completed by select European mainline, U.S. regional airline, and professional corporate aircrews on ID topics such as flying while ill, flying with ill crewmembers, receipt of influenza vaccination, disinfection, and other aviation medical issues. Data were analyzed and reported as composite and stratified by airline vs. corporate aviation respondents.

Results: Aircrews often flew while ill (or with ill crewmembers); 52% flew until fever reached 38 degrees C (100.4 degrees F) and an additional 37% flew up to 38.89 degrees C (102 degrees F). Rate of annual influenza vaccination was quite low for all groups, but especially so for airline crews (21-27%), even given potential occupational exposure risk. Crews also had strongly differing perceptions of employer views on self-grounding, depending upon employment setting.

Conclusions: There were sizable disparities between aircrew flying for U.S. regional, European mainline, and large corporate aviation departments with respect to self-grounding when ill and routinely receiving a seasonal influenza vaccination. All study groups reported a pressing need for enhanced anonymous access to current ID and medical information.

Thibeault C, Tanguay F, Lacroix C, Menzies R, Rivest P. A case of active tuberculosis in a cabin crew: the results of contact tracing. *Aviat Space Environ Med*. 2012;83(1):61-63.

Introduction: Transmission of communicable diseases on board aircraft is of considerable concern for passengers and aircrew. Previously published estimates of risk of tuberculosis (TB) transmission have been highly variable. Furthermore, very few studies have been published for active TB in aircrew.

Methods: The public health authorities advised the Medical Advisor of an airline that a cabin crewmember had been diagnosed with active TB. Contact tracing was done for the cabin crew who worked with the index case for more than 8 h. Cabin crewmembers

were divided in two groups according to their exposure and had one tuberculin skin test (TST) more than 8 wk after the last exposure. Those with a TST > or = 5 mm have been recommended to have a QuantiFERON-TB Gold In-Tube (QFT) assay.

Results: Among the 56 identified contacts, 32 agreed to be evaluated, of whom 6 (19%) had a TST > or = 5 mm. Of those six, four underwent a QFT with one positive result. None had active TB. The percentages of positives in the two exposure groups were similar. All the positive contacts were born in Canada in the period when the childhood Bacille Calmette-Guérin (BCG) vaccination program was in effect.

Discussion: The same percentage of positives in the two exposure groups, the proportion of positive contacts below the expected rate in Canadians, and the high proportion of QFT negative among the TST positive contacts suggest that transmission of TB to the cabin crew is unlikely.

Thornley CN, Emslie NA, Sprott TW, Greening GE, Rapana JP. Recurring norovirus transmission on an airplane. *Clin Infect Dis*. 2011;53(6):515-520.

Background: Previously reported outbreaks of norovirus gastroenteritis associated with aircraft have been limited to transmission during a single flight sector. During October 2009, an outbreak of diarrhea and vomiting occurred among different groups of flight attendants who had worked on separate flight sectors on the same airplane. We investigated the cause of the outbreak and whether the illnesses were attributable to work on the airplane.

Methods: Information was obtained from flight attendants on demographic characteristics, symptoms, and possible transmission risk factors. Case patients were defined as flight attendants with diarrhea or vomiting <51 hours after the end of their first flight sector on the airplane during 13-18 October 2009. Stool samples were tested for norovirus RNA.

Results: A passenger had vomited on the Boeing 777-200 airplane on the 13 October flight sector. Sixty-three (82%) of 77 flight attendants who worked on the airplane during 13-18 October provided information, and 27 (43%) met the case definition. The attack rate among flight attendants decreased significantly over successive flight sectors from 13 October onward (P < .001). Working as a supervisor was independently associated with development of illness (adjusted odds ratio, 5.8; 95% confidence interval, 1.3-25.6). Norovirus genotype GI.6 was detected in stool samples from 2 case patients who worked on different flight sectors.

Conclusions: Sustained transmission of norovirus is likely to have occurred because of exposures on this airplane during successive flight sectors. Airlines should make provision for adequate disinfection of airplanes with use of products effective against norovirus and other common infectious agents after vomiting has occurred.

Tracy MJ. Transmission of tuberculosis during a long airplane flight. *N Engl J Med*. 1996;335(9):675-676.

PMID: 8692253

Kein Abstract verfügbar

Vogt TM, Guerra MA, Flagg EW, Ksiazek TG, Lowther SA, Arguin PM. Risk of severe acute respiratory syndrome-associated coronavirus transmission aboard commercial aircraft. *J Travel Med*. 2006;13(5):268-272.

Background: Severe acute respiratory syndrome-associated coronavirus (SARS-CoV) was introduced to the United States through air travel. Although the risk of SARS-CoV transmission within aircraft cabins has been addressed by several studies, the magnitude of the risk remains unclear.

Methods: We attempted to contact all persons with working US telephone numbers aboard seven US-bound flights carrying SARS patients. Consenting participants responded to a questionnaire, and a serum sample was collected at least 38 days after the flight and tested for SARS-CoV-associated antibodies. Participants reporting an illness compatible with SARS, with onset during the 2- to 10-day incubation period, were considered suspect cases; positive serology was required for confirmed cases.

Results: Among 1,766 passengers and crew, 339 (19%) persons were contacted. Of these, 312 (92%) completed questionnaires, and blood was collected from 127 (37%). Serology was negative for all 127 participants, including three of four who met the clinical case criteria for SARS, and the fourth had a mild illness that lasted only 5 days.

Conclusions: Transmission of SARS-associated CoV was not observed, suggesting that the risk of transmission is not amplified aboard aircraft.

Weiss H, Hertzberg VS, Dupont C, et al. The Airplane Cabin Microbiome. *Microb Ecol*. 2019;77(1):87-95.

Serving over three billion passengers annually, air travel serves as a conduit for infectious disease spread, including emerging infections and pandemics. Over two dozen cases of in-flight transmissions have been documented. To understand these risks, a characterization of the airplane cabin microbiome is necessary. Our study team collected 229 environmental samples on ten transcontinental US flights with subsequent 16S rRNA sequencing. We found that bacterial communities were largely derived from human skin and oral commensals, as well as environmental generalist bacteria. We identified clear signatures for air versus touch surface microbiome, but not for individual types of touch surfaces. We also found large flight-to-flight beta diversity variations with no distinguishing signatures of individual flights, rather a high between-flight diversity for all touch surfaces and particularly for air samples. There was no systematic pattern of microbial community change from pre- to post-flight. Our findings are similar to those of other recent studies of the microbiome of built environments. In summary, the airplane cabin microbiome has immense airplane to airplane variability. The vast majority of airplane-associated microbes are human commensals or non-pathogenic, and the results provide a baseline for non-crisis-level airplane microbiome conditions.

Whitlock G, Calder L, Perry H. A case of infectious tuberculosis on two long-haul aircraft flights: contact investigation. *N Z Med J*. 2001;114(1137):353-355.

Aim: During a five-week period in 1996, a passenger with highly infectious tuberculosis travelled on five long-haul aircraft flights. We investigated passengers and crew on two of these flights to identify whether transmission of Mycobacterium tuberculosis had occurred.

Methods: Crew and passengers were identified from airline and immigration records. Contacts were notified of their exposure and invited to attend their local public health clinic. At the clinic, a questionnaire was administered by a public health worker, and a Mantoux skin test was performed. When indicated, a second test was carried out twelve weeks later. Test positivity and conversion were defined according to the 1996 New Zealand tuberculosis control guidelines.

Results: Data were obtained on 206 (87%) of the 238 contacts. Twenty four contacts had a positive Mantoux test result, four of which were conversions. All of these contacts had at least one other major risk factor for a positive result, such as a previous BCG vaccination (n=17) or having lived in a country in which tuberculosis is endemic (n=15). To our knowledge, no contacts have subsequently developed tuberculosis disease.

Conclusions: The investigation produced inconclusive evidence about the hypothesis that Mycobacterium tuberculosis was transmitted on one or both of these flights.

Wilson ME. What goes on board aircraft? Passengers include Aedes, Anopheles, 2019-nCoV, dengue, Salmonella, Zika, et al. *Travel Med Infect Dis*. 2020; 33:101572.

Kein Abstract verfügbar

STRESS

Barayan OS. Cabin crew stress factors examined. ICAO J. 1991 May;46(5):9-11.

NASA: The impact of reduced cockpit crew on the cabin crew in commercial airlines is examined. One hundred cabin crew members participated in a study to determine what stressors are present in contemporary transport aircraft, the extent of differences in rating context-related and task-related stressors, and the effect of peak versus normal periods of duty time on stress factors. Results indicate that under peak period conditions, context-related factors are more stressful than task-related factors. Recommendations to alleviate cabin crew stress factors include training to maximize crew knowledge and abilities, elevate cabin crew to the same status as cockpit crew, improve the cabin crew certification program, and expose cabin crew to cockpit crew procedures to foster better communication and enhance safety.

Bowles S, Ursin H, Picano J. Aircrew perceived stress: examining crew performance, crew position and captains personality. Aviat Space Environ Med. 2000 Nov;71(11):1093-7.

This study was conducted at NASA Ames Research Center as a part of a larger research project assessing the impact of captain's personality on crew performance and perceived stress in 24 air transport crews (5). Three different personality types for captains were classified based on a previous cluster analysis (3). Crews were comprised of three crewmembers: captain, first officer, and second officer/flight engineer. A total of 72 pilots completed a 1.5-d full-mission simulation of airline operations including emergency situations in the Ames Manned Vehicle System Research Facility B-727 simulator. Crewmembers were tested for perceived stress on four dimensions of the NASA Task Load Index after each of five flight legs. Crews were divided into three groups based on rankings from combined error and rating scores. High performance crews (who committed the least errors in flight) reported experiencing less stress in simulated flight than either low or medium crews. When comparing crew positions for perceived stress over all the simulated flights no significant differences were found. However, the crews led by the "Right Stuff" (e.g., active, warm, confident, competitive, and preferring excellence and challenges) personality type captains typically reported less stress than crewmembers led by other personality types.

DeHart RL. Health issues of air travel. Annu Rev Public Health. 2003;24:133-51.

Every day in the United States the airline industry boards over 1.7 million passengers for a total of 600 million passengers per year. As these passengers enter the cabin of their aircraft few are aware of the artificial environment that will protect them from the hazards of flight. Passengers are exposed to reduced atmospheric pressure, reduced available oxygen, noise, vibration, and are subject to below zero temperatures that are only a quarter inch away-the thickness of the aircraft's skin. Over the past decade there have been both technical and lay articles written on the perception of poor cabin air quality. Studies have, in part, supported some of those concerns, but, in general, the air quality exceeds that found in most enclosed spaces on terra firma. Since the events of September 11th, passengers have not only been exposed to the physical stress of flight, but also to social and emotional stress preceding departure. There has been a significant increase in air rage on board aircraft, which poses a threat to flight safety and a fear of harm to passengers and crew. The phrase "economy class syndrome" has received popular press attention and refers to the possibility of deep vein thrombosis (DVT) in the tight confines of an aircraft cabin. Studies have been conducted that demonstrate DVT can occur in flight just as it occurs in other modes of transportation or with prolonged sitting. In part, because of the stress related to commercial flight it is not a mode of transportation for everyone. Certain cardiovascular, pulmonary, and neuropsychiatric conditions are best left on the ground. Although medical problems and death are rare in flight, they do occur, and one major airline reported 1.52 medical diversions per billion revenue passenger miles flown. To provide medical support at 36,000 ft (11,000 m) most airlines now carry on-board medical kits as well as automatic external defibrillators. A recent survey conducted by a major airline revealed that there was at least one physician on 85% of all its flights. Both passenger and cargo aircraft have proven to be vectors of disease in that they transport humans, mosquitoes, and other insects and animals who, in turn, transmit disease. Transmission to other passengers has occurred with tuberculosis and influenza. Vectors for yellow fever, malaria, and dengue have been identified on aircraft. Although there are numerous health issues associated with air travel they pale in comparison to the enormous benefits to the traveler, to commerce, to international affairs, and to the public's health.

MacDonald LA, Deddens JA, Grajewski BA, Whelan EA, Hurrell JJ. Job stress among female flight attendants. J Occup Environ Med. 2003 Jul;45(7):703-14.

We evaluated the presence of chronic job stressors among flight attendants (FAs) to examine the relationships between these job stressors and psychological distress and job dissatisfaction. Seventy-three female FAs (90% participation) employed at two commercial airlines completed a detailed questionnaire. Standard questions and scale measures were used to assess job stressors, psychological distress, and job dissatisfaction. The association between job stressors and these outcomes was evaluated using multiple regression analysis. Except for fatigue, distress and job dissatisfaction were moderate to low. Job stressors were found to have a substantive effect on these outcomes, following adjustment for individual factors. Despite

moderate-to-low levels of distress and dissatisfaction, targeted efforts to reduce selected job stressors and to enhance social support may be important steps toward improving the well-being and satisfaction of FAs.

Omholt ML, Tveito TH, Ihlebæk C. Subjective health complaints, work-related stress and self-efficacy in Norwegian aircrew. Occup Med (Lond). 2017 Mar 1;67(2):135-142.

Background: The European civilian aviation industry has undergone major changes in the last decade. Despite this, there is little knowledge about work-related stress and subjective health complaints (SHCs) affecting Norwegian aircrew.

Aims: To investigate the relationships between work-related stress, self-efficacy and SHCs in commercial aircrew in Norway and to explore differences between cockpit and cabin crew.

Methods: Aircrew members from the three major airlines operating from Norway completed an electronically distributed questionnaire. Linear regression analyses were used to investigate the association between work-related stress, self-efficacy and SHCs.

Results: There was a 21% response rate. Among the 843 study subjects, tiredness, sleep problems, bloating, low back pain, headaches and neck pain were the most prevalent SHCs. Cabin crew reported significantly higher numbers, prevalences and mean values for all SHCs compared with cockpit crew ($P < 0.05$). In total, 20% reported high stress levels. High levels of work-related stress were significantly associated with all SHC factors in both groups. Self-efficacy partly moderated the relationship between stress and psychological complaints in both cockpit and cabin crew, and for musculoskeletal complaints in cockpit crew. The model explained 23 and 32% of the variance in psychological complaints for cockpit and cabin crew, respectively.

Conclusions: Commercial aircrew in Norway reported high numbers of SHCs, and high levels of work-related stress were associated with high numbers of SHC. More knowledge is needed on the physical, organizational and psychosocial stressors affecting cockpit and cabin crew in order to create a healthier work environment for these groups.

Zevitas CD, Spengler JD, Jones B, McNeely E, Coull B, Cao X, Loo SM, Hard AK, Allen JG. Assessment of noise in the airplane cabin environment. J Expo Sci Environ Epidemiol. 2018 Nov;28(6):568-578.

Objective: To measure sound levels in the aircraft cabin during different phases of flight.

Methods: Sound level was measured on 200 flights, representing six aircraft groups using continuous monitors. A linear mixed-effects model with random intercept was used to test for significant differences in mean sound level by aircraft model and across each flight phase as well as by flight phase, airplane type, measurement location and proximity to engine noise.

Results: Mean sound levels across all flight phases and aircraft groups ranged from 37.6 to >110 dB(A) with a median of 83.5 dB(A). Significant differences in noise levels were also observed based on proximity to the engines and between aircraft with fuselage- and wing mounted engines. Nine flights (4.5%) exceeded the recommended 8-h TWA exposure limit of 85 dB(A) by the NIOSH and ACGIH approach, three flights (1.5%) exceeded the 8-h TWA action level of 85 dB(A) by the OSHA approach, and none of the flights exceeded the 8-h TWA action level of 90 dB(A) by the OSHA PEL approach.

Conclusions: Additional characterization studies, including personal noise dosimetry, are necessary to document accurate occupational exposures in the aircraft cabin environment and identify appropriate response actions. FAA should consider applying the more health-protective NIOSH/ACGIH occupational noise recommendations to the aircraft cabin environment.

ERSCHÖPFUNG

Castro M, Carvalhais J, Teles J. Irregular working hours and fatigue of cabin crew. Work. 2015;51(3):505-11.

Background: Beyond workload and specific environmental factors, flight attendants can be exposed to irregular working hours, conflicting with their circadian rhythms and having a negative impact in sleep, fatigue, health, social and family life, and performance which is critical to both safety and security in flight operations.

Objective: This study focuses on the irregular schedules of cabin crew as a trigger of fatigue symptoms in a wet lease Portuguese airline. The aim was to analyze: what are the requirements of the cabin crew work; whether the schedules being observed and effective resting timeouts are triggering factors of fatigue; and the existence of fatigue symptoms in the cabin crew.

Methods: A questionnaire has been adapted and applied to a sample of 73 cabin crew-members (representing 61.9% of the population), 39 females and 34 males, with an average age of 27.68 ± 4.27 years.

Results: Our data indicate the presence of fatigue and corresponding health symptoms among the airline cabin crew, despite of the sample favorable characteristics. Senior workers and women are more affected.

Conclusions: Countermeasures are required. Recommendations can be made regarding the fatigue risk management, including work organization, education and awareness training programmes and specific countermeasures.

Houston S, Dawson K, Butler S. Fatigue reporting among aircrew: incidence rate and primary causes. Aviat Space Environ Med. 2012 Aug;83(8):800-4.

Introduction: In this study we describe our experience of voluntary fatigue reporting among pilots and cabin crew.

Method: This was a prospective study to determine the crude incidence rate and primary cause of fatigue report form submission among cabin crew and pilots within one airline. All crew duties had already undergone scrutiny at the 'roster build' stage to ensure compliance with fatigue control measures. Reports were investigated by the airline's medical officer to determine the primary cause of fatigue and then allocated to one of five categories. The frequency and proportion of reports within each category was determined.

Results: The crude incidence rate of fatigue report submission was 103 and 68 cases per 1000 persons per year for pilots and cabin crew, respectively. The primary cause for 27% of reports was attributed to the rostered duty pattern. Of the reports, 24% were primarily caused by roster disruption, 17% by problems with layover accommodation or transport, 23% by a domestic issue,

and 9% had no obvious cause or were deemed invalid. A subanalysis of the 'domestic' category revealed that half had a primary cause attributable to commuting to or from the workplace.

Conclusion: The number and trend of reports received per month can be used to detect otherwise unknown fatigue hazards and identify where improvements can be made. Fatigue reports allow individual crewmembers to give vital feedback on 'whole-of-life' fatigue risks, both inside and outside the workplace.

Van den Berg MJ, Signal TL, Mulrine HM, Smith AA, Gander PH, Serfontein W. Monitoring and Managing Cabin Crew Sleep and Fatigue During an Ultra-Long Range Trip. Aerosp Med Hum Perform. 2015 Aug;86(8):705-13.

Background: The aims of this study were to monitor cabin crew fatigue, sleep, and performance on an ultra-long range (ULR) trip and to evaluate the appropriateness of applying data collection methods developed for flight crew to cabin crew operations under a fatigue risk management system (FRMS).

Methods: Prior to, throughout, and following the ULR trip (outbound flight ULR; mean layover duration=52.6 h; inbound flight long range), 55 cabin crew (29 women; mean age 36.5 yr; 25 men; mean age 36.6 yr; one missing data) completed a sleep/duty diary and wore an actigraph. Across each flight, crewmembers rated their fatigue (Samn-Perelli Crew Status Check) and sleepiness (Karolinska Sleepiness Scale) and completed a 5-min Psychomotor Vigilance Task (PVT) at key times.

Results: Of crewmembers approached, 73% (N=134) agreed to participate and 41% (N=55) provided data of suitable quality for analysis. In the 24 h before departure, sleep averaged 7.0 h and 40% took a preflight nap. All crewmembers slept in flight (mean total sleep time=3.6 h outbound, 2.9 h inbound). Sleepiness and fatigue were lower, and performance better, on the longer outbound flight than on the inbound flight. Post-trip, crewmembers slept more on day 1 (mean=7.9 h) compared to baseline days, but there was no difference from day 2 onwards.

Discussion: The present study demonstrates that cabin crew fatigue can be managed effectively on a ULR flight and that FRMS data collection is feasible for cabin crew, but operational differences between cabin crew and flight crew need to be considered.

Van den Berg MJ, Signal TL, Gander PH. Fatigue risk management for cabin crew: the importance of company support and sufficient rest for work-life balance-a qualitative study. Ind Health. 2020 Feb 4;58(1):2-14.

Knowledge about cabin crew fatigue associated with ultra-long range (ULR) flights is still limited. Current ULR scheduling for cabin crew is therefore predominantly based on flight crew data. Cabin crews' views on fatigue, and their strategies for mitigating it, have seldom been sought. To better understand the causes and consequences of cabin crew fatigue, semi-structured focus group discussions were held. Thematic analysis was undertaken with data from 25 cabin crew. Participants indicated that the consequences of fatigue are twofold, affecting 1) cabin crew health and wellbeing and 2) safety (cabin, passenger and personal) and cabin service. While the primary causes of fatigue were sleep loss and circadian disruption, participants also identified other key factors including: insufficient rest, high workload, the work environment, a lack of company support, and insufficient fatigue management training. They highlighted the importance of sufficient rest, not only for obtaining adequate recovery sleep but also for achieving a work-life balance. They also highlighted the need for company support, effective communication, and management's engagement with cabin crew in general. We recommend that priority is given to fatigue management training for cabin crew, which may also enhance perceived company support and assist with achieving a better work-life balance.

FEHLGEBURT

Aspholm R, Lindbohm ML, Paakkulainen H, Taskinen H, Nurminen T, Tiitinen A. Spontaneous abortions among Finnish flight attendants. J Occup Environ Med. 1999 Jun;41(6):486-91.

We conducted a retrospective cohort study to investigate whether work as a cabin attendant is related to an increased risk for spontaneous abortion. Data on female cabin crew members were linked to medical records on pregnancies. There were 1751 eligible pregnancies for the final analysis. Flight attendants who worked during early pregnancy had a slightly elevated risk of spontaneous abortion, as compared with attendants who were pregnant outside a time span of active flying (odds ratio [OR] = 1.3; 95% confidence interval [CI], 0.9 to 1.8). During the earliest years of the study period (1973 through 1977), the risk seemed to be decreased (OR = 0.4; 95% CI, 0.2 to 1.1), whereas during the later years (1978 through 1994) the risk was increased (OR = 1.6; 95% CI, 1.1 to 2.4). The results are in agreement with earlier studies, showing suggestive evidence of a slightly increased risk of spontaneous abortion among female cabin crew members.

Beeton S. Pregnancy and travel. Community Nurse. 1996 Nov-Dec;2(10):45-7.

Poor quality medical care in some countries is an important concern, because of a lack of sterile equipment and lack of screening of blood products The safest time for travel is 18-24 weeks--after the risk of miscarriage and unpleasant nausea, but before problems such as premature labour Women with a previous history of miscarriage or ectopic pregnancy should be advised against travelling to countries where medical care is poor After 28 weeks a doctor's letter may be required before an airline will allow a pregnant woman to fly On board an aircraft, pregnant women should walk around the cabin at least once an hour to minimise the risk of deep vein thrombosis Malaria in pregnancy can be severe for both mother and fetus: chloroquine and proguanil have a long safety record Mefloquine is contraindicated in the first trimester and doxycycline should be avoided during pregnancy.

Cameron RG. Effect of flying on the menstrual function of air hostesses. Aerosp Med. 1969 Sep;40(9):1020-3.

Kein Abstract verfügbar

Dos Santos Silva I, Pizzi C, Evans A, Evans S, De Stavola B. Reproductive history and adverse pregnancy outcomes in commercial flight crew and air traffic control officers in the United kingdom. J Occup Environ Med. 2009 Nov;51(11):1298-305.

Methods: Ten thousand two hundred five flight crew members and a control group of 2118 air traffic control officers completed a questionnaire in 2001 to 2004, United Kingdom.

Results: Similar proportions of flight crew and air traffic control officers reported having ever had difficulties in conceiving a baby. Risks of miscarriages and congenital malformations among pregnancies fathered by men who did not differ by occupation, but

stillbirth risk was higher among flight crew (odds ratio = 2.85; 95% CI = 1.30-6.23). Among pregnancies reported by women, risks of miscarriage and stillbirth did not differ by occupation but risk of congenital malformations was higher among flight crew (odds ratio = 2.37; 95% CI = 0.43-13.06).

Conclusions: Flight crew-related exposures were not associated with adverse reproductive outcomes except for possible links, based on small numbers, between paternal exposure and stillbirths and maternal exposure and congenital malformations.

Grajewski B, Whelan EA, Lawson CC, Hein MJ, Waters MA, Anderson JL, MacDonald LA, Mertens CJ, Tseng CY, Cassinelli RT 2nd, Luo L. Miscarriage among flight attendants. Epidemiology. 2015 Mar;26(2):192-203.

Background: Cosmic radiation and circadian disruption are potential reproductive hazards for flight attendants.

Methods: Flight attendants from 3 US airlines in 3 cities were interviewed for pregnancy histories and lifestyle, medical, and occupational covariates. We assessed cosmic radiation and circadian disruption from company records of 2 million individual flights. Using Cox regression models, we compared respondents (1) by levels of flight exposures and (2) to teachers from the same cities, to evaluate whether these exposures were associated with miscarriage.

Results: Of 2654 women interviewed (2273 flight attendants and 381 teachers), 958 pregnancies among 764 women met study criteria. A hypothetical pregnant flight attendant with median first-trimester exposures flew 130 hours in 53 flight segments, crossed 34 time zones, and flew 15 hours during her home-base sleep hours (10 pm-8 am), incurring 0.13 mGy absorbed dose (0.36 mSv effective dose) of cosmic radiation. About 2% of flight attendant pregnancies were likely exposed to a solar particle event, but doses varied widely. Analyses suggested that cosmic radiation exposure of 0.1 mGy or more may be associated with increased risk of miscarriage in weeks 9-13 (odds ratio = 1.7 [95% confidence interval = 0.95-3.2]). Risk of a first-trimester miscarriage with 15 hours or more of flying during home-base sleep hours was increased (1.5 [1.1-2.2]), as was risk with high physical job demands (2.5 [1.5-4.2]). Miscarriage risk was not increased among flight attendants compared with teachers.

Conclusions: Miscarriage was associated with flight attendant work during sleep hours and high physical job demands and may be associated with cosmic radiation exposure.

Magann EF, Chauhan SP, Dahlke JD, McKelvey SS, Watson EM, Morrison JC. Air travel and pregnancy outcomes: a review of pregnancy regulations and outcomes for passengers, flight attendants, and aviators. Obstet Gynecol Surv. 2010 Jun;65(6):396-402.

To review flight regulations and gestational complications associated with air travel in pregnant passengers, flight attendants, and aviators. A literature search was undertaken on the relationship of air travel and spontaneous pregnancy losses, intrauterine fetal demise (IUFD), birth weight<10th percentile, preterm delivery, and neonatal intensive care unit admissions. The literature search identified 128 abstracts, of which 9 evaluated air travel and pregnancy outcomes. The risk of a pregnancy loss (spontaneous abortion or IUFD) was greater in flight attendants than controls (odds ratio [OR]: 1.62, 95% confidence interval [CI]: 1.29, 2.04). The risk of preterm birth<37 weeks was greater in passengers than controls (OR: 1.44, 95% CI: 1.07, 1.93). However, the risk of preeclampsia (OR: 0.86, 95% CI: 0.58, 1.27), neonatal intensive care unit admissions (OR: 1.19, 95% CI: 0.78, 1.82), or birth weight<10th percentile (OR: 1.25, 95% CI: 0.62, 2.48) was not increased. Flight attendants did not have an increased risk of preterm birth compared to controls (OR: 1.37, 95% CI: 0.85, 2.22) or delivering infants with birth weight<10th percentile (OR: 1.57, 95% CI: 0.68, 3.74). The risks of spontaneous abortions and other adverse pregnancy outcomes have been poorly studied in a limited number of investigations. An analysis of the available information suggests a greater risk of spontaneous abortions or IUFD in flight attendants, and a greater risk of preterm birth<37 weeks in air passengers. However, the literature on which these findings are based is generally not of high methodologic quality.

Scholten P. Pregnant stewardess--should she fly? Aviat Space Environ Med. 1976 Jan;47(1):77-81.

There is much pressure on the airlines to allow stewardesses to fly while pregnant. Some of them want to fly in quite advanced stages of pregnancy. This paper offers a survey of the problem, the hazards that may occur and some guidelines for the physician. The author outlines the normal changes to be expected with advancing pregnancy and those factors that could have an adverse effect on a pregnant stewardess and her fetus, such as hypoxia, trauma, abortion, the hazards of travel, and flying itself. Certain legal problems of unemployment and medical disability also are discussed. Travel alone offers no real danger to the pregnant stewardess in the first trimester of pregnancy; however, because of the changing mechanics of her size, posture, and increasing unsteadiness, it would be wisest to require a pregnant stewardess to cease flying at 13 weeks, with an absolute prohibition of flying after the 20th week.

Yang Y, Zhang W, Chan A, Li C, He X, Cui L, Lv Y, Liu J, Guo X. An epidemiological study of reproductive health in female civil aviation employees. Aviat Space Environ Med. 2013 Jun;84(6):625-9.

Objective: To investigate the correlations between occupational risk factors and reproductive health and to provide targeted healthcare services to female civil aviation employees based on surveys about menstrual and reproductive health status.

Methods: Subjects were selected from flight attendants working for China Southern Airlines, Air China, and other airlines; employees of China Aviation Oil Limited, China TravelSky, and China Aviation Supplies Holding Company; and airport ground service crews. Data were collected using anonymous questionnaires. A total of 1175 valid questionnaires were recovered. The subjects were categorized into a flight attendant group and a ground service group, which contained 563 and 612 women, respectively.

Results: The prevalence of irregular menstruation, including abnormal cycles, severe dysmenorrhea, and hypomenorrhea or menorrhagia, was significantly higher in the flight attendant group (30.55%) than in the ground service group (13.40%); in concordance, the fertility rate was significantly lower in the flight attendant group (36.59%) than in the ground service group (43.95%). The spontaneous abortion rate in the flight attendant group (6.80%) was significantly higher than in the ground service group (2.97%). The rate of life-threatening abortions, preterm births, and low birth weight was significantly lower in the flight attendant group than in the ground service group.

Conclusion: The impact of occupational risk factors on the reproductive health of female aviation workers should be evaluated and examined more thoroughly. Additional healthcare services such as routine menstruation healthcare and policies for workers

planning to have a pregnancy are beneficial in monitoring reproductive health, reducing harmful exposures during early pregnancy, and preventing incapacitating gynecologic events.

COVID 19

Chen J, He H, Cheng W, et al. Potential transmission of SARS-CoV-2 on a flight from Singapore to Hanghzou, China: An epidemiological investigation *Travel Med Infect Dis*. 2020;36:101816.

Background: Between January 24, 2020 and February 15, 2020, an outbreak of COVID-19 occurred among 335 passengers on a flight from Singapore to Hangzhou in China. This study aimed to investigate the source of the outbreak and assess the risk of transmission of COVID-19 during the flight.

Method: Using a standardized questionnaire, we collected information on the travelers' demographic characteristics and illness before, during, and after the flight. We also collected data on factors potentially associated with COVID-19 transmission during the flight.

Results: A total of 16 COVID-19 patients were diagnosed among all passengers; the overall attack rate was 4.8%. The attack rate among passengers who had departed from Wuhan was significantly higher than that among those who had departed from other places. One passenger without an epidemiological history of exposure before boarding developed COVID-19. During the flight, he was seated near four infected passengers from Wuhan for approximately an hour and did not wear his facemask correctly during the flight.

Conclusions: COVID-19 transmission may have occurred during the flight. However, the majority of the cases in the flight-associated outbreak could not be attributed to transmission on the flight but were associated with exposure to the virus in Wuhan or to infected members in a single tour group.

Eldin C, Lagier JC, Mailhe M, Gautret P. Probable aircraft transmission of Covid-19 in-flight from the Central African Republic to France. Travel Med Infect Dis. 2020 May-Jun;35:101643.

Kein Abstract verfügbar

Hoehl S, Karaca O, Kohmer N, Westhaus S, Graf J, Goetsch U, Ciesek S. Assessment of SARS-CoV-2 Transmission on an International Flight and Among a Tourist Group. JAMA Netw Open. 2020 Aug 3;3(8):e2018044.

This case series describes severe acute respiratory syndrome coronavirus (SARS-CoV-2) transmission on a international commercial airline flight.

Nir-Paz R, Grotto I, Strolov I, Salmon A, Mandelboim M, Mendelson E, Regev-Yochay G. Absence of in-flight transmission of SARS-CoV-2 likely due to use of face masks on board. J Travel Med. 2020 Jul 14:taaa117.

Using flights was severely affected during the COVID19 pandemic. We describe a 14 hours flight of 11 passengers and 4 crew members in which 2 positive SARS-COV-2 were on board. No new viral acquisitions found in this flight, probably due to the use of masks.

Schwartz KL, Murti M, Finkelstein M, et al. Lack of COVID-19 transmission on an international flight. *CMAJ*. 2020;192(15):E410. doi:10.1503/cmaj.75015

Kein Abstract verfügbar

Yang N, Shen Y, Shi C, Ma AHY, Zhang X, Jian X, Wang L, Shi J, Wu C, Li G, Fu Y, Wang K, Lu M, Qian G. In-flight transmission cluster of COVID-19: a retrospective case series. Infect Dis (Lond). 2020 Jul 31:1-11.

Background: No data is available about in-flight transmission of SARS-CoV-2. Here, we report an in-flight transmission cluster of COVID-19 and describe the clinical characteristics of these patients.

Methods: After a flight, laboratory-confirmed COVID-19 was reported in 12 patients. Ten patients were admitted to the designated hospital. Data was collected from 25th January to 28th February 2020. Clinical information was retrospectively collected.

Results: All patients were passengers, and none were flight attendants. The median age was 33 years, and 70% were females. None was admitted to intensive care unit, and no patients died up to 28th February. The median incubation period was 3.0 days and time from onset of illness to hospital admission was 2 days. The most common symptom was fever. Two patients were asymptomatic and had normal chest CT scan during hospital stay. On admission, initial RT-PCR was positive in 9 patients, and initial chest CT was positive in half of the patients. The median lung 'total severity score' of chest CT was 6. 'Crazy-paving' pattern, pleural effusion, and ground-glass nodules were seen.

Conclusion: There is potential for COVID-19 transmission in aeroplanes, but the symptoms were mild in our patients. Passengers and attendants must be protected during flights.

WEITERE BELASTUNGSFAKTOREN

de Boer J, Antelo A, van der Veen I, Brandsma S, Lammertse N. Tricresyl phosphate and the aerotoxic syndrome of flight crew members--current gaps in knowledge. Chemosphere. 2015 Jan;119 Suppl:S58-61.

Tricresyl phosphate (TCP), and in particular its tri-ortho substituted isomer (o,o,o-TCP), has been frequently used in aircraft engine oil. Bleed air, provided to the flight deck and cabin can contain traces of TCP. TCP can cause neurotoxic effects in humans. Regularly, airline pilots complain about loss of memory, headaches, dizziness, tunnel vision and other neurotoxic effects. The concentrations of TCP reported in flight deck air (max. ca. 50-100 ng m(-3) total TCP) do not exceed provisional toxicity thresholds. These thresholds, however, contain a very high uncertainty and need further underpinning. The many non-detects and relatively low TCP concentrations reported suggest that TCP on its own is not likely to be responsible for the reported health problems of

pilots. Specific conditions in air planes and other toxic compounds present in bleed air, whether or not in combination with TCP, may be responsible for the reported neurotoxic syndromes. Sensitivity of individuals seems to be an important factor as well. The clinical signs observed with a selected group of pilots are serious enough to call for further elucidation of this issue.

Lee H, Wilbur J, Conrad KM, Mokadam D. Work-related musculoskeletal symptoms reported by female flight attendants on long-haul flights. Aviat Space Environ Med. 2006 Dec;77(12):1283-7.

Introduction: Flight attendants working on long-haul international commercial airline operations exposed to ergonomic stressors are likely to experience work-related musculoskeletal symptoms (WMS). To date, however, no studies investigating the extent of WMS experienced by this specific population have been published. The purpose of this study was to identify the prevalence and severity (frequency, duration, and intensity) of WMS experienced by female flight attendants working on long-haul international flights for one major airline.

Methods: A cross-sectional, mailed survey was conducted with female flight attendants randomly selected from a union membership list. Inclusion criteria were female flight attendants who had worked at least one long-haul international flight in the prior 3 mo and had worked at least 75 flight hours in the prior month. A total of 185 eligible flight attendants returned completed questionnaires (63% response rate). WMS in nine body regions were measured by the Nordic Musculoskeletal Questionnaire and the National Institute for Occupational Safety and Health Symptom Survey.

Results: The prevalence of WMS by body region ranged from 50% to 86%. Almost all (97%) of the flight attendants in this study experienced some level of WMS during the past year. The WMS tended to involve more than one body region, and the lower back was the most commonly affected body region.

Discussion: Female flight attendants working on long-haul international flights at one major airline showed a high prevalence of WMS, suggesting the need for replication studies with other airlines and the need for investigation into the risk factors associated with this substantial problem.

Mulay RV, Gangwal A, Shyam AK, Sancheti PK. Prevalence and risk factors for work related musculoskeletal disorders in flight attendants. International Journal of Community Medicine and Public Health (2019): *6*(6), 2456.

Kein Abstract verfügbar.

Posch M, Schranz A, Lener M, Senn W, Äng BO, Burtscher M, Ruedl G. Prevalence and potential risk factors of flight-related neck, shoulder and low back pain among helicopter pilots and crewmembers: a questionnaire-based study. BMC Musculoskelet Disord. 2019 Jan 29;20(1):44.

Background: Flight-related neck, shoulder and low back pain are the most common musculoskeletal disorders among helicopter pilots and their crewmembers, thus becoming a growing concern. Information on the combined prevalence of these types of pain and related risks are scarce. The aim of this study was therefore to estimate pain prevalence and to evaluate potential risk factors for neck pain among helicopter pilots and crewmembers within the armed forces, the airborne police and airborne rescue organizations in Austria.

Methods: Among a cohort of 104 helicopter pilots and 117 crewmembers (69.8% compliance), demographics, flying experience, use of Night Vision Goggles (NVG), helicopter type flown, prevalence and intensity of musculoskeletal symptoms (pain was defined as any reported pain experience, ache or discomfort) were collected by an online-based questionnaire.

Results: For helicopter pilots the 12-month prevalence of neck pain was 67.3%, followed by low back (48.1%) and shoulder pain (43.3%). Among crewmembers, the 12-month pain prevalence were 45.3, 36.8 and 30.8% among the neck, lower back and shoulder, respectively. During this period, 41.8% of these helicopter pilots had experienced 8-30 pain days in the areas of neck (45.7%), shoulder (37.8%) and lower back (42.0%) whereas 47.8% of crewmembers self-reported 1-7 days of neck (54.7%), low back (44.2%) and shoulder (44.4%) pain in the previous year. The 3-month prevalence of neck pain was 64.4% followed by low back (42.3%) and shoulder pain (38.5%) for helicopter pilots. Among crewmembers, 41.9% suffered from neck, 29.9% from low back and 29.1% from shoulder pain the previous 3 months. Multivariate regression analysis revealed NVG use (OR 1.9, 95% CI, 1.06-3.50, $p = 0.032$), shoulder pain (OR 4.9, 95% CI, 2.48-9.55, $p < 0.001$) and low back pain (OR 2.3, 95% CI, 1.21-4.31, $p = 0.011$) to be significantly associated with neck pain.

Conclusions: The 12- and 3-month prevalence of neck, shoulder and low back is considerably high among both, helicopter pilots and crewmembers confirming the existence of this growing concern. The use of NVG devices, shoulder and low back pain in the previous 12 months represent independent risk factors for neck pain. These findings highlight the need for longitudinal studies.

Rau PP, Tsao L, Dong L, Liu X, Ma L, Wang J. General and passenger-relevant factors of work-related musculoskeletal disorders (WMSDs) among Chinese female flight attendants. Work. 2020;66(4):861-869.

Background: A high prevalence of work-related musculoskeletal disorders (WMSDs) has been reported among flight attendants. Identifying the root causes of these disorders may improve the health conditions of flight attendants and further improve flight safety and service quality.

Objective: In this study, we aimed to identify WMSD risk factors for a specific population, namely Chinese female flight attendants.

Methods: A two-stage survey including an online questionnaire (46 flight attendants) and a semi-structured interview (16 flight attendants) was used to assess the WMSDs of Chinese female flight attendants. Text analysis tools in NVivo 11 were used to identify the main concerns and risk factors for WMSDs of Chinese flight attendants.

Results: In the online questionnaire, more than 86% of the participants reported discomfort in at least one body part. Biomechanical factors, work organizational factors, and psychosocial factors were reported by participants in this study. Chinese passengers were found to have an effect on WMSD development in Chinese flight attendants.

Conclusions: The results of this study suggested that WMSDs are severe problems among Chinese flight attendants. General factors as well as the passenger-relevant factor were identified as the most influential causes of WMSDs.

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