Medical Symptoms Among Pilots Associated with Work and Home Environments: A 3-Year Cohort Study

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OBJECTIVE: To study associations between the cockpit environment, psychosocial work environment, home environment, and medical symptoms in a cohort of commercial pilots followed over 3 yr.

METHODS: A standardized questionnaire was mailed in February-March 1997 to all Stockholm-based pilots on duty in a Scandinavian flight company ($N = 622$); 577 (93%) participated. During this time smoking was allowed on long haul flights, but not on shorter flights. Smoking was prohibited on all flights after September 1997. The same questionnaire was sent to the cohort of 577 pilots in February-March 2000; 436 participated (76%). The questionnaire contained questions on symptoms, the psychosocial work environment, and the home environment. Associations were investigated using multiple logistic and ordinal regression.

RESULTS: Symptoms were common, especially eye symptoms (38.5%), nose symptoms (39.9%), and tiredness (29.9%). Pilots exposed to environmental tobacco smoke (ETS) on long haul flights had more eye symptoms (odds ratio = 1.91) and tiredness (odds ratio = 2.73). These symptoms were reduced when no longer exposed to ETS. Those who started working on long haul flights developed more nose symptoms. Pilots reporting increased work demands developed more nose and dermal symptoms and tiredness and those with decreased work control developed more eye symptoms. Pilots living in new houses, multifamily houses, and in recently painted homes reported more symptoms.

CONCLUSION: Eliminating ETS exposure on board reduced medical symptoms. Further work to reduce ETS exposure globally is needed. Psychosocial aspects of the work environment for commercial pilots should be considered, as well as the home environment.

KEYWORDS: aircraft environment, commercial pilots, environmental tobacco smoke, psychosocial work environment.

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Commercial aircraft pilots have unique working conditions that can be associated with different types of illnesses. Epidemiological studies in commercial pilots have investigated a broad spectrum of diseases (e.g., cancer, cardiovascular diseases, psychiatric illness, and respiratory illness).[6–8] Moreover, there has been concern about the indoor environmental exposure in commercial aircraft. There is little information on discomfort and indoor-related medical symptoms among commercial pilots in relation to the indoor environment in the cabin and the flight deck. One previous study found that pilots often reported air dryness and dustiness in the cockpit.[8] Dry eye symptoms were reported commonly in Australian pilots and were associated with type of airplane and flying time.[12] Moreover, one previous study found higher prevalence of eye, nose, throat, and facial skin symptoms in airline crew as compared with office workers in the same company, but this study did not analyze pilots and cabin attendants separately.[7]

When occurring in certain buildings, indoor-related symptoms (eye, nose, throat, and skin symptoms, tiredness, and headache) are sometimes called sick building syndrome (SBS).[13] SBS is more common in buildings with poor ventilation, environmental tobacco smoke (ETS), low relative air humidity, and elevated levels of volatile organic compounds and microbial exposure (molds and bacteria), as well as in

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buildings with dampness in the construction. In addition, SBS can be affected by personal factors such as female gender and allergies.[13] Moreover, SBS can also be affected by psychosocial work conditions, which can be measured by the demand-control-support model, including psychosocial demand at work, work control, and social support at work.[18]

The indoor environment in aircraft is characterized by low relative air humidity and low cabin pressure. Other environmental exposure in the cabin environment includes mold, bacteria, volatile organic compounds, and ozone.[4,9,24] Moreover, furry pet allergens were found in relatively high levels in the cabin and the cockpit, and elevated levels of certain microbial volatile organic compounds, such as pentanols.[4] Most environmental measurements in commercial aircraft have been performed in the cabin and few measurements of the cockpit environment are available. The cockpit has a separate ventilation system, usually without any air recirculation. One study demonstrated that the relative air humidity in the cockpit was lower than 5% during most of the time during cruise on intercontinental flights.[9] The ozone level in the cockpit is usually lower than the occupational limit level (100-200 $\mu g \cdot m^{-3}$) due to well-functioning ozone converters.[9]

Before the smoking ban on commercial flights, the cabin environment had high levels of respirable particles from ETS[9] and cabin attendants had elevated levels of cotinine (biological marker of nicotine exposure) levels in their urine after flights with ETS exposure.[10] A few weeks after the smoking ban in 1997, eye symptoms, headache, and tiredness were reported less commonly among the airline crew. This longitudinal study was relatively small and included both pilots and cabin attendants. However, the number of pilots was not large enough to do a separate analysis of the health effects among pilots of the ETS elimination on board.[24]

Previous investigations of medical symptoms or perception of the aircraft environment among airline crew are mostly cross-sectional studies. Moreover, to our knowledge, epidemiological health studies among pilots have not included information on the work environment and the indoor home environment. The main aim of this 3-yr follow-up study among commercial pilots was to study associations between risk factors in the work environment, including psychosocial work environment, and the indoor environment in the aircraft and the dwelling in relation to prevalence and change of medical symptoms. The second aim was to study how changes of risk factors (personal, psychosocial, occupational, and domestic factors) are associated with changes of environmental perceptions and medical symptoms. Since the follow-up period included the time when smoking on board was prohibited by the airline company, our study is also a longitudinal follow-up of long-term health effects of eliminating ETS on board.

METHODS

Subjects

A self-administered questionnaire was answered by the pilots at baseline (1997) and at follow-up after 3 yr (2000). The first questionnaire was mailed to all pilots on duty at the airline in February to March 1997 ($N = 622$); 577 pilots participated (93%). In February to March 2000, 3 yr later, the same questionnaire was sent to all pilots who participated in 1997; 436 participated (76%). The cohort of 436 pilots participating twice was the study population.

Procedure

This follow-up study was a part of a larger project studying medical symptoms and the perception of cabin and cockpit air quality, including the psychosocial work environment and personal factors, among airline crew at Scandinavian Airlines System. The protocol of the study was approved by the Ethical Committee of the Medical Faculty at Uppsala University and the participants gave informed consent.

All pilots had a rotating work schedule, changing aircrafts from day to day, but they operated the same type of aircraft for a longer period as they were contracted with the company. During Scandinavian and European flights, the following aircraft were used: Fokker F-28, McDonnell Douglas DC-9-21/41/81, and McDonnell Douglas MD-80/90 series. All intercontinental flights were operated using the Boeing 767 series. Short haul flights were defined as flights within Europe with duration of less than 7 h. Long haul flights were defined as intercontinental flights between Scandinavia and America or Asia with flight duration of 7-12 h.

When the baseline questionnaire study was performed in 1997, smoking was allowed on all intercontinental flights and on flights to destinations south of the Alps (3–5 h), and to Greenland (5 h), but not on shorter European flights (1–3 h) or Scandinavian domestic flights (0.6–1.5 h). After 1st September 1997, smoking was banned on all flights, but sporadic occupational ETS exposure could occur in other workplace indoor environments (e.g., in meeting rooms in countries where smoking was allowed).

Questionnaire

The questionnaire consisted of six sets of questions. The six sets were personal factors, symptoms during the last week (7 d), symptoms during the last 3 mo, air quality perceptions at work during the last 3 mo, specific work environment factors for airline crew, current home environment, and information on personal factors, including age, gender, smoking habits, and pollen or furry pet allergies. A current smoker was defined as a subject who reported current smoking (>1 cigarette/day) in the questionnaire, or who had stopped smoking <6 mo ago. The questions on air quality perceptions and medical symptoms the last 3 mo, as well as psychosocial work conditions, were obtained from a standardized indoor questionnaire (MM 040 NA) developed by the Department of Occupational and Environmental Medicine in Örebro University Hospital.[1] The questions about medical symptoms the last week (7 d) were obtained from another questionnaire[24] and questions on specific work environment factors relevant for airline crews was obtained from another questionnaire.[8] These questions were developed by the Clinic for Occupational and Environmental Medicine, Department of Medical Sciences, Uppsala University. The questions about the home environment were obtained from an additional home environment questionnaire developed for the European Community Respiratory Health Survey adapted for North European home environment conditions.[14]

Questions about symptoms in the last week included eye symptoms (7 questions), nose symptoms (4 questions), skin symptoms (5 questions), headache (1 question), and tiredness (1 question).[23,25] There were two options for answers in this section (yes/no). At least one "yes" in each group of questions (eye, nose, and dermal symptoms) was required to be counted for the relevant symptom in the last week. The questions about symptoms in the last 3 mo included eye symptoms (1 question), nose symptoms (1 question), skin symptoms (3 questions), headache (1 question), and tiredness (1 question). There were three alternatives to each question: no never, yes sometimes, and yes often (every week).The questions for skin symptoms were combined as any skin symptom if there was one "yes" for any of the three questions. Eye symptoms were defined as reporting either history of itching, burning, or irritation of the eyes. Nose symptoms were defined as irritated, stuffy, or runny nose.[24] Skin symptoms were defined as reporting either history of dry flushed facial skin, scaling/itching scalp or ears, and hands with dry, itching, red skin.[7]

Three questions on perceived work environment were analyzed in this study: perception of stuffy air, perception of dry air, and passive smoking at work, all with a recall time of 3 mo. Work environment for the pilots mainly referred to the flight deck environment, but they also spent some time in the cabin and shorter times in meeting rooms in the airports. Each question had three alternatives: never, sometimes, and often (every week).

Questions on work environment factors included long/short haul flight and psychosocial work conditions. There were four questions covering different aspects of the psychosocial work conditions, a simplified Swedish version of the demand-control-social support model.[5,21] The question "interesting/stimulation at work" measured work satisfaction. The question "opportunity to influence working conditions" measured the degree of influence on working conditions, and the question "Do you get help from your colleagues when you have a problem at work" measured the degree of social support. Finally there was a question on "too much work to do," which covered stress due to an excess of work. The questions on psychosocial conditions had four possible answers: "yes, often," "yes, sometimes," "no, seldom," and "no, never."

Information on the current home environment included type of home (single-family house, apartment, other), construction year of the building, furry pet keeping, and ETS. Moreover, there were yes/no questions about the indoor painting and redecoration in the last 12 mo, window pane condensation in winter, and four yes/no questions on water damage, visible molds, signs of floor dampness (bubbles on vinyl floor or blackened parquet), and mold odor at home the last 12 mo. The four questions on dampness were combined (any dampness yes/no).

Statistical Analysis

For all yes/no questions, 'no' was coded "0" and 'yes' was coded "1." For questions about medical symptoms or environmental perceptions in the last 3 mo, 'no' was coded "0," 'yes, sometimes' was coded "1," and 'yes, often' was coded "2." For the psychosocial questions, 'no, never' was coded "0," 'no, seldom' was coded "1," 'yes, sometimes' was coded "2," and 'yes, often' was coded "3." For the question about "too much work to do," the values were assigned the reverse way. The values were then divided by 3 in order to obtain four psychosocial variables, each ranging from 0–1, where 0 is the most unfavorable condition and 1 is the most favorable condition. Changes of variables during the follow-up period were calculated by subtracting the value at baseline from the value at follow-up. The scores for change of symptoms and environmental perceptions ranged from -2 to 2 and each psychosocial variable ranged from -1 to 1.

McNemar's test was used to compare changes of prevalence from 1997 to 2000 for dichotomous variables. Wilcoxon matched pairs signed rank test, a nonparametric test, was used to compare changes of variables with ordinal scales. Initially, a cross-sectional analysis of baseline data was performed by stepwise multiple logistic regression (Wald, backward elimination, $P >$ 0.1 as exclusion criteria) to analyze associations between personal and environmental risk factors at home and at work and symptoms in the last week. Symptoms in the last week were chosen to be used in the cross-sectional analysis at baseline since there were detailed information on type of flight that the pilots had been on the last week. The workplace ETS variable was used a categorical variable, coded as flight with no ETS, any European flight with ETS, and any long haul flight (all with ETS) in the last week. The category of no ETS flight in the last week was used as a reference category.

As a next step, multiple ordinal regression was used to study changes of symptoms and environmental perceptions from 1997 to 2000 in relation to baseline exposure in 1997. In this analysis, changes of symptoms and environmental perceptions reported for the last 3 mo were dependent variables. This model included personal factors, work factors, and home factors at the baseline level in 1997. Finally, a second set of multiple ordinal regression models studied changes of symptoms and environmental perceptions in the last 3 mo in relation to changes of personal factors and environmental factors at home or at work. Two different models were used, one with and one without the home environment factors. Information on type of flight during the last 3 mo was used. The flight duration variable in the longitudinal analysis was coded as a categorical variable by combining information on flight duration type in 1997 and 2000. Working on a short haul flight both at baseline and at follow-up was used as reference category.

All statistical calculations were done with SPSS version 21 and a P-value < 0.05 was considered statistically significant. Odds ratios (OR) with a 95% confidence interval (CI) were calculated for the multiple logistic regression analysis and coefficients with 95% CI intervals were calculated for the ordinal regression models. Associations for age in the logistic and ordinal regression were expressed as changes per 10 yr.

RESULTS

The prevalence of eye symptoms in the last week ($P = 0.03$) and in the last 3 mo ($P = 0.001$) had increased during the follow-up. In contrast, dermal symptoms in the last 3 mo had decreased ($P < 0.001$). Moreover, exposure to ETS at work had decreased drastically ($P < 0.001$). For other symptoms or environmental perceptions, the prevalence had not changed significantly (**Table I**). The perceived psychosocial work environment had improved during the follow-up, with less reports on low stimulation ($P = 0.008$), low control ($P < 0.001$), and low support ($P = 0.02$). Concerning changes in the home environment, pilots tended to move from multifamily to single family buildings ($P < 0.001$), furry pet keeping had increased ($P = 0.001$), and ETS exposure at home had decreased ($P = 0.001$) (**Table II**). The prevalence of pollen allergies was 16.9% at baseline (1997) and 19.4% at follow up (2000).

Table III shows the results from the stepwise logistic regression model for baseline data. Older pilots reported less nose symptoms (adjusted OR 0.55, 95%CI 0.42–0.72; $P < 0.001$) and headache (adjusted OR 0.55, 95%CI 0.38–0.82; $P = 0.003$). Female pilots had more skin symptoms (adjusted OR 3.68, 95%CI 1.41–9.59; $P = 0.008$) and headaches (adjusted OR 3.11, 95%CI 1.19–8.12; $P = 0.02$) than men. Pilots who had been on a long haul flight with ETS exposure in the last week had more eye symptoms (adjusted OR 1.91, 95%CI 1.10–3.33; $P = 0.02$) and more tiredness (adjusted OR 2.73, 95%CI 1.57–4.75; $P < 0.001$). Those living in multifamily houses had more eye symptoms (adjusted OR 1.90, 95% CI 1.14–3.17; $P = 0.01$) and those keeping furry pets had less eye symptoms (adjusted OR 0.53, 95% CI 0.31–0.95; $P = 0.03$). Pilots living in homes with signs of dampness and mold growth in the last 12 mo reported more tiredness (adjusted OR 2.25, 95%CI 1.01–5.03; $P = 0.049$), and those who had their home painted indoors in the last 12 mo had more headaches (adjusted OR 1.84, 95%CI 1.03–3.28; $P = 0.04$). Finally, those reporting window pane condensation in winter, an indicator of poor ventilation and high relative air humidity, reported less skin symptoms (adjusted OR 0.34, 95% CI 0.13–0.86; $P = 0.02$). Among the psychosocial variables, high demands was associated with more eye symptoms (adjusted OR 3.59, 95% CI 1.26–10.25; $P = 0.02$). No significant associations were found for the other psychosocial scales.

Table I. Prevalence of Symptoms During the Last Week and the Last 3 mo.

	SYMPTOM PREVALENCE (%)		
	1997	2000	*P*-VALUE*
7-d symptoms			
Eye	38.5	44.6	0.03
Nose	39.9	39.6	0.87
Skin	19.8	17.1	0.19
Headache	17.2	16.9	1.00
Tiredness	29.9	30.9	0.86
3-mo symptoms			
Eye			
Sometimes	27.0	31.1	0.001
Often	2.8	5.3	
Nose			
Sometimes	45.3	43.7	0.67
Often	7.7	9.1	
Skin			
Sometimes	42.0	23.2	<0.001
Often	14.0	9.3	
Headache			
Sometimes	26.3	27.4	0.85
Often	1.2	0.9	
Tiredness			
Sometimes	69.1	64.8	0.54
Often	13.7	15.0	
Stuffy air			
Sometimes	39.5	40.1	0.18
Often	7.5	9.6	
Dry air			
Sometimes	30.6	33.1	0.28
Often	55.1	51.2	
ETS at work			
Sometimes	48.7	1.9	<0.001
Often	3.5	0.2	

* 7-d symptoms were calculated by McNemar's test, and 3-mo symptoms were calculated by Wilcoxon signed rank test.

Table II. Prevalence of Work Factors and Home Factors.

	PREVALENCE (%)		
ENVIRONMENTAL FACTORS	1997	2000	*P*-VALUE*
Work factors			
Low stimulation			
Never (0)	83.1	87.4	0.008
Seldom (1)	13.9	11.9	
Sometimes (2)	2.8	0.7	
Often (3)	0.2	0	
High demand			
Never (0)	5.3	5.1	0.56
Seldom (1)	53.8	52.9	
Sometimes (2)	38.3	38.8	
Often (3)	2.5	3.2	
Low control			
Never (0)	8.6	11.1	<0.001
Seldom (1)	31.1	38.0	
Sometimes (2)	46.6	41.7	
Often (3)	13.7	9.3	
Low support			
Never (0)	50.5	52.5	0.02
Seldom (1)	32.6	35.8	
Sometimes (2)	11.9	8.4	
Often (3)	5.0	3.3	
Long haul flight	25.9	25.2	0.46
Current home factors			
Construction year			
before 1960	31.3	34.3	0.52
1961-1975	23.8	20.9	
after 1975	44.9	44.8	
Multifamily/house	21.9	15.8	<0.001
Furry pet keeping	21.3	26.5	0.001
ETS at home	8.3	4.6	0.001
Indoor painting last 12 mo	26.3	26.7	1.00
Dampness/ mold last 12 mo	7.6	6.0	0.39
Window condensation in winter	13.7	11.8	0.21

* Work factors and construction year were calculated by Wilcoxon signed rank test; other home factors were calculated by McNemar's test.

Table III. Associations Between Symptoms (Last Week) at Baseline and in the Work and Home Environments from Stepwise Logistic Regression.

	ADJ OR (95% CI)	*P*-VALUE
Any eye symptom		
High demand	3.59 (1.26-10.25)	0.02
Low control	2.05 (0.93-4.53)	0.07
No ETS at work (ref)	1	
European flight with ETS	1.55 (0.89-2.69)	0.12
Long haul flight ETS	1.91 (1.10-3.33)	0.02
Furry pet keeping	0.53 (0.31-0.95)	0.03
Window pane condensation in winter	1.82 (0.99-3.37)	0.06
Multifamily house	1.90 (1.14-3.17)	0.01
Any nose symptom		
Age per 10 yr	0.55 (0.42-0.72)	<0.001
Pollen/pet allergy	1.71 (1.02-2.86)	0.04
Any skin symptom		
Woman	3.68 (1.41-9.59)	0.008
Low control	2.32 (0.86-6.20)	0.10
Construction year of dwelling	0.76 (0.56-1.03)	0.08
Dampness/mold at home last 12 mo	2.29 (0.94-5.60)	0.07
Window condensation in winter	0.34 (0.13-0.86)	0.02
Headache		
Age per 10 yr	0.55 (0.38-0.82)	0.003
Woman	3.11 (1.19-8.12)	0.02
Indoor painting last 12 mo	1.84 (1.03-3.28)	0.04
Tiredness		
Age per 10 yr	0.53 (0.40-0.72)	<0.001
No ETS at work (ref)	1	
European flight with ETS	1.53 (0.85-2.74)	0.16
Long haul flight ETS	2.73 (1.57-4.75)	<0.001
Dampness/mold at home last 12 mo	2.25 (1.01-5.03)	0.049

When analyzing associations between personal factors and exposures at baseline and changes of symptoms and environmental perceptions over the 3-yr period, women got less headaches as compared to men in the follow-up (score change −1.14; 95% CI −2.17–−0.11; $P = 0.03$). Older pilots reported less stuffy air (score change −0.30; 95% CI −0.56–−0.05; $P = 0.02$) during the follow-up. Pilots being on long haul flights with ETS exposure at baseline reported less tiredness (Score change −1.12; 95% CI −1.70–−0.55; $P < 0.001$) at follow-up as compared to those who were on smoke-free flights at baseline. There were no associations between psychosocial work conditions at baseline and changes of medical symptoms or environmental perceptions during follow-up. Finally, pilots living in new houses developed more tiredness during the follow-up (score change 0.30; 95% CI 0.04–0.56; $P = 0.023$), but there were no other associations between home environmental factors at baseline and changes of medical symptoms or environmental perceptions.

Finally, associations between changes of symptoms, changes of own smoking status and changes of environmental factors at home and at work were analyzed (**Table IV**). Female pilots developed less nose symptoms ($P = 0.048$) and less headache ($P = 0.04$) at follow-up and reported less stuffy air ($P = 0.03$) than men. Those who had started smoking reported more problems with stuffy air at work ($P = 0.04$). Pilots who changed from short haul flight to long haul flight reported more nose problems ($P < 0.001$) as compared to those working on short haul flights all the time (reference category). Moreover, changes of psychosocial variables were associated with changes of symptoms and environmental perceptions. Those who reported less work stimulation during follow-up reported more stuffy air ($P = 0.009$). Pilots reporting increased demand at work got more nose symptoms ($P = 0.035$), skin symptoms ($P = 0.017$), and tiredness ($P = 0.001$), and more often reported stuffy air ($P = 0.01$) and dry air at work ($P = 0.029$). Those reporting less work control got more eye symptoms ($P = 0.002$). Changes of home environmental factors were not significantly associated with any changes of symptoms or environmental perceptions at work.

DISCUSSION

Medical symptoms were common among the pilots, especially eye and nose symptoms and tiredness. In addition many perceived air dryness at work. Psychosocial work environment and exposure to ETS on long haul flights were associated with prevalence of symptoms at baseline. Moreover, changes of the psychosocial work environment, especially increase of demand and lower work control, were associated with an increase of mucosal and dermal symptoms, tiredness, and perception of stuffy air and dry air at work. Female pilots reported more skin symptoms and headache at baseline, but developed less nose symptoms and headache during follow-up as compared to male pilots. The elimination of ETS exposure on long haul flights, which occurred in the beginning of the follow-up period, decreased eye symptoms, tiredness, and perception of stuffy air at work. Moreover, those who started working on long haul flights during the follow-up period reported more nasal symptoms. In addition, there were associations between symptoms and certain factors in the home environment, including recent indoor painting, dampness and indoor mold growth, living in a multifamily house, and living in a new house.

This study represents historical data from pilots in one airline company performed around 15 yr ago. However, to our knowledge, it is the only long-term cohort study on associations between medical symptoms and the work and home environments for pilots. Epidemiological studies can be influenced by selection bias and information bias (recall bias). The cohort included all pilots belonging to the crew base in Stockholm and was followed over a 3-yr period. The response rate was reasonably high: 93% participated at baseline and 76% of those participating at baseline participated in the follow-up. Information on present symptoms, the psychosocial work environment, and perceptions of air quality was gathered with the same questionnaire. This could have resulted in recall bias in the cross-sectional analysis at baseline. However, in the longitudinal analysis, changes of risk factors predicted changes of symptoms over a 3-yr period. In longitudinal analyses where changes of health status are investigated, recall bias is less likely. Exposure assessment for ETS at work was based on type of flight, long haul or short haul, and since the pilots have a contract to work on certain types of airplanes for a number of years, recall bias for this

Table IV. Ordinal Regression for Symptom and Air Quality Perception Changes vs. Work Factor and Home Factor Changes.

SYMPTOM CHANGE/ FACTOR CHANGE	EYE† RRR (95% CI)	NOSE† RRR (95% CI)	SKIN† RRR (95% CI)	HEADACHE† RRR (95% CI)	TIREDNESS† RRR (95% CI)	STUFFY AIR†† RRR (95% CI)	DRY AIR†† RRR (95% CI)
Age per 10 yr	0.06 (−0.15,0.27)	0.23 (0.03,0.43)*	0.06 (−0.14,0.25)	0.10 (−0.12,0.32)	−0.12 (−0.33,0.09)	−0.14 (−0.32,0.05)	0.01 (−0.18,0.20)
Woman	−0.12 (−0.42,0.18)	−0.29 (−0.58,-0.00)*	−0.06 (−0.34,0.22)	−0.35 (−0.67,-0.02)*	0.02 (−0.28,0.33)	−0.30 (−0.58, −0.02)*	0.13 (−0.16,0.42)
Pollen/pet allergies	0.28 (−0.09,0.64)	0.06 (−0.29,0.40)	0.06 (−0.28,0.40)	−0.23 (−0.62,0.15)	−0.26 (−0.62,0.11)	−0.06 (−0.39,0.27)	−0.11 (−0.45,0.23)
Smoker	−0.38 (−0.91,0.15)	−0.40 (−0.90,0.11)	−0.44 (0.93,0.05)	0.31 (−0.25,0.87)	0.15 (−0.38,0.67)	0.52 (0.03,1.00)*	0.33 (−0.17,0.82)
Low stimulation	0.23 (−0.62,1.08)	0.07 (−0.73,0.86)	−0.31 (−1.08,0.47)	0.52 (−0.38,1.42)	0.40 (−0.45,1.24)	1.04 (0.26,1.81)**	0.29 (−0.50,1.09)
High demand	0.46 (−0.17,1.09)	0.64 (0.05,1.24)*	0.72 (0.13,1.31)*	0.16 (−0.51,0.84)	1.11 (0.48,1.75)**	0.77 (0.18,1.36)*	0.67 (0.07,1.27)*
Low control	0.83 (0.297,1.367)**	0.48 (−0.02,0.98)	0.35 (−0.15,0.84)	0.57 (−0.01,1.15)	0.32 (−0.21,0.85)	−0.13 (0.0.63,0.37)	0.03 (−0.48,0.54)
Low support	−0.11 (−0.60,0.38)	−0.03 (−0.49,0.43)	0.01 (−0.45,0.46)	−0.48 (−1.00,0.04)	0.14 (−0.36,0.63)	−0.28 (−0.74,0.18)	−0.02 (−0.49,0.46)
short97short00‡	1	1	1	1	1	1	1
short97long00‡	0.439 (0.04,0.84)	0.71 (0.34,1.09)***	−0.03 (−0.39,0.34)	0.17 (−0.25,0.59)	0.13 (−0.27,0.53)	−0.34 (−0.70,0.02)	0.09 (−0.27,0.46)
long97short00‡	−0.54 (−1.01, −0.07)*	0.27 (−0.17,0.71)	0.20 (−0.23,0.63)	−0.18 (−0.67,0.32)	−0.86 (−1.32, −0.39)***	−0.63 (−1.07, −0.19)**	−0.16 (−0.61,0.29)
long97long00‡	−0.22 (−0.62,0.19)	0.29 (−0.09,0.67)	0.30 (−0.08,0.67)	0.04 (−0.40,0.47)	−0.11 (−0.52,0.30)	−0.02 (−0.38,0.35)	−0.15 (−0.53,0.23)

†Keeping personal factors age, sex, pollen/pet allergies, work factors, and current home environment factors.
††Only included personal factors age, sex, and pollen/pet allergies and work factors.
‡Flight haul categories were named by the combination of flight duration type and year in both 1997 and 2000. short97short00 means a pilot worked at short haul flight in 1997, and also short haul flight in 2000; short97long00 means a pilot worked at short haul flight in 1997, but in long haul flight in 2000.
*$0.01 \leq P < 0.05$.
**$0.001 \leq P < 0.01$.
***$P < 0.001$.

variable is less likely. Thus it is less likely that observed associations are due to selection bias or recall bias.

Medical symptoms were common among the pilots, especially eye symptoms and tiredness. Prevalence of symptoms in the last week was high at baseline, but the prevalence of symptom occurring at least once a week during the last 3-mo period were less common. The prevalence of eye symptoms increased and dermal symptoms decreased during the follow-up. There are few other studies on these types of medical symptoms among pilots. Dry eye symptoms have been reported from Australian pilots and were associated with flying time.[12] Female pilots reported more dermal symptoms, but developed less nose symptoms and less headache during follow-up as compared to male pilots. We found no other information on gender differences for these types of symptoms among commercial pilots. However, among office workers, several studies have demonstrated that women report more symptoms than men.[2,22] The reasons remain unclear, but different work tasks, higher psychosocial work load and different life situations, general excess of psychosocial conditions among women, and different social roles have been suggested as causes. However, pilots are selected to be healthy and women and men are doing exactly the same type of work. This can explain why we did not find any major gender difference in symptom prevalence at baseline, except for skin symptoms. Changes in this type of symptom have been studied in two longitudinal population studies in the general adult population in Sweden, following adult population cohorts over 10 yr. None of these studies found any gender differences in incidence or remission of mucosal, dermal, or general symptoms (headache or tiredness).[19,20] We have no explanation for why female pilots developed less symptoms over time, but since more and more pilots are women, this is a beneficial aspect.

Older pilots reported less nose symptoms and less tiredness at baseline, but developed more nose symptoms during follow-up. An increased incidence of mucosal symptoms, including nasal symptoms, in relation to age has previously been reported from one of the Swedish population cohorts.[20] Older pilots generally have more experience and can be more adapted to the work, with more skills, and this could explain why they report less tiredness.

Association between age and flight type (long/short haul) was checked and there was no association at baseline between the pilots' ages and the type of flight they worked with, but younger pilots (4 yr younger of mean age) tended to change type of flight during the follow-up. However, the association between work environment and symptoms were always adjusted by age in order to adjust for possible confounding by age.

Pollen allergies were associated with a higher prevalence of nose symptoms at baseline, but were not associated with any change of symptoms over time. Thus hay fever did not seem to be a major determinant of symptom development in this cohort. The prevalence of pollen allergies was 16.9% at baseline (1997) and 19.4% at follow-up (2000). Our prevalence among pilots was somewhat higher than the prevalence of pollen allergies (hay fever) reported from two Swedish population studies, 14% in 1997[19] and 16% in 2001.[20]

An overall improvement of the psychosocial work environment was observed during the follow-up, with better stimulation, better work control, and better social support. We have no explanation for this improvement, since no other major organizational changes beside the smoking ban on board aircraft took place during the follow-up period (1997-2000). The study was performed before the period when organizational changes took place in many airlines due to the increased competition from low-fare airlines. Impaired self-reported psychosocial work environment, especially increased demands and less work control, was associated with increased symptom scores for eye, nose, and skin symptoms and more tiredness. Moreover, increased work demands increased reports of stuffy air and dry air during the follow-up. Associations were more pronounced in the longitudinal analysis when changes of the psychosocial work environment were used as independent variables. The questionnaire used in this study is based on the demand control social support model, but it contains only four questions so it is not directly comparable with the more extensive questionnaires used in previous cross-sectional studies on the psychosocial work environment.[16–18] We found few studies analyzing the health aspects of psychosocial work conditions for commercial pilots. One prevalence study found associations between low social support and high demands and sleep problems among commercial pilots.[17] Another analysis of the same study population found associations between high work demands and low social support and musculoskeletal symptoms.[16] We found no previous longitudinal study on psychosocial work environment among commercial pilots analyzing the same type of symptoms as in this study. However, in one cross-sectional study in a random sample of the adult Swedish population, associations were found between eye symptoms and low social support combined with strained work situations. In addition, tiredness was more common with low social support combined with strained job situations.[18] Finally, in a previous analysis of cross-sectional data from the same airline company, combining data from pilots and cabin attendants, associations between psychosocial excess work, poor work control, low social support, and tiredness were found. Moreover, there was an association between stress due to excess work and skin symptoms.[7] This study used the same simplified psychosocial questionnaire with four questions as in our study.

Before the elimination of smoking on commercial airlines, pilots and cabin attendants were exposed to high levels of particles[9] and the concentration of cotinine, a metabolite of nicotine, was increased afterwards among airline crew due to ETS exposure on board during intercontinental flights.[10] Pilots spend the most time on the flight deck, which has a separate ventilation system, usually without any air recirculation, so their ETS exposure should be considerably less than for cabin attendants. However, since this study was done before the September 11th terrorist attacks, pilots could spend shorter periods in the forward galley when they had a break, and then they were exposed to ETS in the cabin environment. Our cross-sectional analysis found that pilots on long haul flights with ETS exposure of 7-12 h duration had more eye symptom and tiredness, and for shorter European flights with ETS exposure there was a nonsignificant tendency to an increase of these symptoms. Moreover, after the ban on smoking on board, tiredness decreased and reports of stuffy air at work were less common. One previous study, including both pilots and cabin attendants, investigated symptom improvements and changes of clinical signs from the ocular and nasal mucosa a few weeks after the ban on smoking in 1997. The smoking ban caused a drastic decrease in respirable particles onboard, from 66 to 3 $\mu g \cdot m^{-3}$, and the prevalence of ocular symptoms and headache was reduced. Moreover, tear film stability was increased.[24] We found no other longitudinal studies investigating health improvement after the ban on smoking on commercial airlines, but previous studies evaluating the effect of the ban on smoking in restaurants have shown similar health improvements.[11,15] To our knowledge, our study is the first epidemiological study among commercial pilots including both the work and home environments in the same study.

In the cross-sectional analysis, eye symptoms were more common among pilots living in multifamily houses (apartment) and less common among furry pet keepers. The negative association for furry pet keeping could be selection effects, where allergic subjects avoid keeping a pet. Skin symptoms were less common in homes with window pane condensation in winter, an indicator of high relative air humidity due to low air exchange rate. Headache was more common in homes with recent indoor painting and tiredness was more common in homes with dampness and indoor mold. Finally, pilots living in newer houses at baseline developed more tiredness during follow-up. For indoor painting and building dampness, similar associations have been reported in population studies from the adult Swedish population. Indoor painting was associated with less remission (more persistence) of general symptoms (including headache and tiredness) in a longitudinal population study. Moreover, dampness and indoor mold was associated with a higher incidence and a lower remission of general symptoms.[20] Building age and type of home (apartment or single-family house) reflects different types of building construction and newer buildings have been demonstrated to have a higher prevalence of symptoms included in the sick building syndrome.[3]

In conclusion, mucosal, dermal, and general symptoms were common among the pilots, especially eye and nose symptoms and tiredness. Psychosocial work environment was an important work factor, especially for the development of symptoms and perceived air quality on board, and the most important aspects were high demand and low control. An overall improvement of the perceived psychosocial work environment was observed during the follow-up. It is important to consider psychosocial aspects of organizational changes in commercial airlines in order to create psychosocial work conditions that favor health. Our study confirmed data from a previous smaller short-term study showing a reduction of eye irritation and tiredness after the ban on smoking on board aircraft. The experience from commercial airlines should encourage further work to reduce exposure to ETS on a global level. Even if

ETS exposure on board is history nowadays, there is still a need to improve the cabin environment, especially on long haul flights. Finally, when investigating health aspects of the work environment for airline crew, risk factors in the home environment, where we spend most of our time, should not be forgotten.

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