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ATCS Age and En Route Operational Errors: A Re-Investigation

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Public Law 92-297 requires that air traffic control specialists (ATCSs), hired on or after May 16, 1972, retire at age 56. This law is based on testimony given in 1971 that as controllers aged, the cumulative effects of stress, fatigue (from shift work), and age-related cognitive changes created a safety risk (U.S. House of Representatives, 1971). The hypothesis has been considered in two studies of en route operational errors (OEs) with contradictory results (Center for Naval Analyses Corporation (CNAC), 1995; Broach, 1999). The purpose of this re-investigation was to test the hypothesis that controller age, controlling for experience, was related to the occurrence of OEs using a statistical method appropriate for rare events. A total of 3,054 usable en route OE records were extracted from the FAA OE database for the period FY1997 through FY2003 and matched with air route traffic control center (ARTCC) non-supervisory controller staffing records, resulting in a database of 51,898 records. Poisson regression was used to model OE count as a function of the explanatory variables age and experience using the SPSS® version 11.5 General Loglinear (GENLOG) procedure. The Poisson regression model fit the data poorly (Likelihood Ratio $\chi 2 = 283.81$, $p < .001$). The odds of OE involvement, estimated with the Generalized Log Odds Ratio, for older controllers (GE age 56) were 1.02 times greater than the odds for younger (LE age 55) controllers, with a 95% confidence interval of 0.42 to 1.64. The range of odds indicated that neither age group was less or more likely to be involved in an OE, controlling for experience. This analysis does *not* support the hypothesis that older en route controllers are at greater risk of involvement in an OE. This finding suggests that the original rationale for the mandatory retirement of ATCSs may need to be re-evaluated. Additional research is recommended.

Public Law 92-297 requires that Air Traffic Control Specialists (ATCSs), hired on or after May 16, 1972 by the FAA, retire at age 56[1]. Controllers with "exceptional skills and abilities" may be given a waiver and continue working until reaching the 61st birthday. The primary evidence offered in support of the mandatory retirement of ATCSs at age 56 in 1971 consisted of anecdotal reports of stress from controllers, studies of self-reported "stress-related" symptoms, physiological correlates of stress, and medical disability retirements of controllers. Despite strong assertions made by various parties, no testimony or data were presented in 1971 to demonstrate that older controllers were more likely than younger controllers to make errors that might compromise the safety of flight.

Several studies of ATCS age and performance have been conducted since passage of P.L. 92-297 (see Broach & Schroeder, in press, for a review). A variety of measures of job performance have been examined in research, ranging from over-the-shoulder subjective evaluations to computer-based measures. Three studies focused specifically on operational errors (OEs). An OE results when an ATCS fails to maintain appropriate separation between aircraft, terrain, and other obstacles to safe flight. OEs are rare compared to the number of operations handled in the U.S. air traffic system. For example, there were 1,145 OEs in fiscal year (FY) 2000 compared to 166,669,557 operations, or 6.8 OEs per million operations (Pounds & Ferrante, 2003; DOT Inspector General, 2003a). Despite their rarity, OEs may pose safety risks, depending on the degree to which separation is lost, and are critical safety indicators for the operation of the air traffic control system (Department of Transportation Inspector General, 2003a,b). OEs occur when through a controller's actions (or inaction), less than standard separation is maintained.

Spahn (1977) investigated the relationship of age to System Errors (now called Operational Errors) and concluded that "no age group has neither more nor less than its proportional share of system errors" (p. 3-35). The Center for Naval Analyses Corporation (CNAC) found in 1995 that the likelihood of an OE in the period January 1991 to July 1995 declined dramatically in the first few years at an air route traffic control center (ARTCC) and then appeared to approach a constant value. However, CNAC did not examine controller age nor control for age effects. Broach (1999) re-analyzed the CNAC data set from the perspective of controller age and found that the likelihood of an OE might increase with age. The regression analysis also found that experience might mitigate the risk of an OE associated with increasing age. Additional research on the relationship of chronological age, experience, and OEs was recommended. The present study builds on that recommendation. This study was designed to test the hypothesis that older controllers were more likely than younger controllers to commit errors that reduced the safety of flight.

Method

Source Data

A total of 3,054 usable en route OE records were extracted from the FAA Operational Error/Deviation System (OEDS) for the period FY1997 through FY2003. Records for controllers employed at ARTCCs were extracted from the FAA Consolidated Personnel Management Information System (CPMIS) for each fiscal year. There was one CPMIS record in a year for each controller. The OE and CPMIS records were matched by controller identifier and year, producing a database with 51,898 matched records. The number of ATCS with and without OEs is presented by fiscal year in Table 1. For example, of the 7,178 non-supervisory ATCS stationed at ARTCCs in FY1997, 6,864 (95.6%) had no operational errors, while 303 controllers (4.2%) had one OE, and 11 had 2 errors (0.2%). No ATCS had 3 errors in that fiscal year.

Methodological Considerations

Both CNAC (1995) and Broach (1999) calculated the dependent variable of interest as the ratio of controllers with errors in an experience or age range to the total number of controllers in that experience or age range. CNAC labeled this ratio as the "likelihood" of involvement in an error. In fact, both CNAC and Broach calculated the proportion of controllers in a given category that were involved in an error at a given point in time, that is, the prevalence rate. The result is a person-based estimate of risk. However, a person-based estimate of risk does not take into account the varying degrees of exposure between controllers. For example, a controller working a busy, low-altitude transitional sector with multiple merging airways that feed a major hub during an afternoon rush will have a greater opportunity to commit an OE than another controller working a high-altitude sector with sparse cross-continental traffic in steady, predictable east/west flows. Time on position may vary as well. For example, a controller working longer on a given position will have greater opportunity to commit an OE than another controller working less time on a position. As noted by Della Rocco, Cruz, and Clemens (1999), a measure of exposure is required to analyze the risk of being involved in an OE appropriately. However, such measures were unavailable for the present study, leaving the count of errors and prevalence as the variables of interest.

Analysis of counts, such as the number of OEs committed by a controller during a specified period of time, poses analytic challenges. Events such as OEs are rare, compared to the number of operations in the air traffic control system, the number of hours worked by controllers, or even the number of controllers working. While rare events such as OEs are important because of their signal value and potential costs, they are also difficult to study (Hulin & Rousseau, 1980). Techniques borrowed from epidemiology such as count-oriented regression have proven useful in the analysis of rare events. Poisson regression, a count-oriented regression technique, was used in the present study to investigate the degree to which the number of errors is related to controller age.

Poisson Regression

Poisson regression is a statistical technique used to model the expected count of some event as a function of one or more explanatory variables. Examples of events that follow a Poisson distribution are doctor visits, absenteeism in the workplace, mortgage pre-payments and loan defaults, bank failures, insurance claims, and airplane accidents (Cameron & Trivedi, p. 11). In statistics, the "law of rare events" states that the total number of events of interest will take, approximately, the Poisson distribution if (a) the event may occur in any of a large number of trials, but (b) the probability of occurrence in any given trial is small (Cameron & Trivedi, 1998). This statistical "law of rare events" might apply to air traffic control operations as well: there are a large number of aircraft under the control of a relatively large number of controllers at any given moment, but the likelihood of an OE for any given aircraft by any single controller is very small. In this application, the analytic goal was to model the number of OEs incurred by a controller as a function of age and experience (e.g., tenure in the FAA).

Procedure

The data for this analysis consisted of the 51,899 records for non-supervisory center controllers with and without OEs for the period FY1997 through FY2003 (see Table 1). Tenure was recoded into discrete categories to simplify the analysis. The first category for tenure was based on the average of about three years required to complete on-the-job training for center controllers (Manning, 1998). The next interval was 6-years wide (4 through 9), followed five-year increments (Table 2). Age was recoded into two groups: age 55 and younger; and age 56 and older. This split was used to specifically assess the risk that might be associated with controllers older than the mandatory separation age.

Table 1: *N non-supervisory en route ATCS on-board with 0, 1, 2, or 3 operational errors by fiscal year*

	N ATCS with Operational Errors (OEs)				
Fiscal Year	0	1	2	3	AOB Total
1997	6,864	303	11	0	7,178
1998	6,932	389	16	0	7,337
1999	6,869	422	21	0	7,312
2000	6,833	487	31	0	7,351
2001	6,827	549	45	1	7,422
2002	7,110	416	32	0	7,558
2003	7,410	313	17	1	7,741

Table 2: *Tenure by age cross-classification table for Poisson regression analysis*

	Number of OEs (n_{ij})		ATCS Population (N_{ij})	
Tenure Group	LE Age 55	GE Age 56	LE Age 55	GE Age 56
LE 3 Years	44	4	3,587	110
4 – 9 Years	488	10	7,574	191
10 – 14 Years	1,112	20	15,758	280
15 – 19 Years	1,007	2	14,816	128
20 – 24 Years	343	2	5,615	67
GE 25 Years	142	57	2,587	1,186

The data were aggregated by fiscal year, age group, and tenure group to create a cross-classification table suitable for Poisson regression, as shown in Table 2. The columns labeled "Number of OEs (n_{ij})" contain the counts of OEs reported for each age and tenure group combination. For example, there were 44 OEs in the period FY1997 to FY2003 for controllers age 55 or less and with 3 years or less tenure, and 4 OEs for controllers age 56 or older and with 3 years or less tenure. The columns labels "ATCS Population (N_{ij})" contain data representing the number of controllers "exposed" to the risk of incurring an OE during the observation period for each age-tenure combination. For example, there were 3,587 records for en route controllers age 55 or less with 3 years or less tenure who were "at risk" of incurring an OE during the observation period. The goal of the regression analysis is to assess the relative effects of age and tenure on the ratios of errors to "at risk" population. The SPSS® version 11.5 General Loglinear (GENLOG; SPSS, 1999) method was used to conduct the Poisson regression analysis

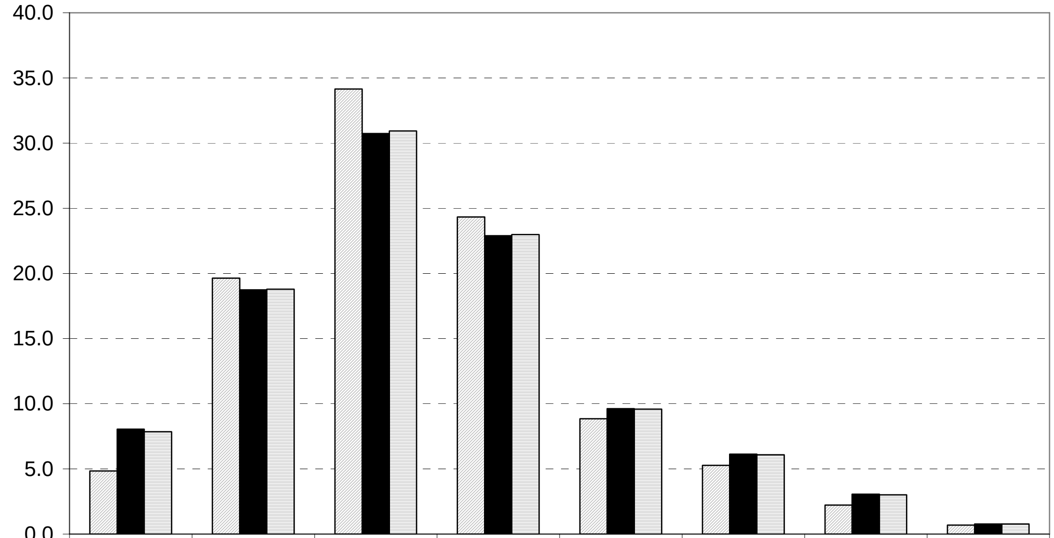
Results

Descriptive Statistics

The initial analyses consisted of simple descriptive statistics. First, the number of OEs per age group for the observation period (FY1997 through 2003) was examined, as shown in Table 2. In this analysis, each controller could have as many as seven records, one for each fiscal year. The records were pooled and then broken out by the number of OEs reported for that age group across the 7 years of observation. As shown in Tables 2, most controllers were not involved in an operational error during the 7-year period. Moreover, the error distribution appears to be similar to the distribution of age, that is, more errors are observed for the more populous age groups. The distribution of controllers with no and one or more OEs by age group is illustrated in Figure 1, relative to the age distribution for all non-supervisory enroute controllers. As found by Spahn in 1977, the distribution of errors by age was very similar to the distribution of age across controllers. No particular age group appeared to experience OEs at a rate disproportionate to their representation in the workforce.

Poisson Regression

Overall, the Poisson regression model fit the data poorly (Likelihood Ratio $\chi 2 = 283.81$, $p < .001$). The parameter estimate for the main effect of age (3.50) was significantly different from 0 (with a 95% confidence interval of 3.29 – 3.70), as were the parameter estimates for tenure. To consider the effect of age across tenure, the two age groups were contrasted. The Generalized Log-Odds Ratio was



	LE 30	31-35	36-40	41-45	46-50	51-55	56-60	GE 61
OE>=1	4.8	19.6	34.2	24.3	8.8	5.3	2.2	0.7
OE=0	8.0	18.7	30.7	22.9	9.6	6.1	3.1	0.8
Total ATCS	7.9	18.8	30.9	23.0	9.6	6.1	3.0	0.8

Figure 1: *OE Involvement by age group compared to distribution of age for all ARTCC controllers, FY1997-2003*

used to estimate the odds ratio for age, that is, the odds of OE involvement for older (GE age 56) controllers (see SPSS, 1999, p. 202 – 203). The odds of OE involvement for older controllers (GE age 56) were 1.02 times greater than the odds for younger (LE age 55) controllers, with a 95% confidence interval of 0.42 to 1.64. A confidence interval for the odds ratio that includes 1.0 indicates that the odds of involvement for the two groups are equal: neither age group was less or more likely to be involved in an OE.

Discussion

The Poisson regression analysis did not support the hypothesis that the likelihood of involvement in an en route OE increased with age. This finding undermines the explicit assertion that early retirement of controllers was "primarily a safety measure" (Testimony of Donald Francke, U.S. House of Representatives, 1971). As noted by Li, Baker, Grabowski, Qiang, McCarthy and Rebok (2003), age in and of itself may have little bearing on safety-related outcomes if factors such as individual job experience, workload, traffic complexity, and time-on-position are taken into consideration (p. 878). For example, supervisors may assign older controllers to less difficult sectors or provide assign an assistant controller during periods of heavy traffic. All other things being equal, age may influence performance through two conflicting pathways. On the one hand, the inevitable changes in cognitive function, particularly speed of processing, may result in slower and less efficient performance. On the other hand, experience is gained with age, and compensatory strategies and meta-strategies may result in safer and more efficient performance by controllers. Additional research on OEs, age, and ATCS performance is recommended to extend and confirm the findings of the present study.

References

Broach, D. (1999, May). *An examination of the relationship between air traffic controller age and en route operational errors.* Paper presented at the 10th International Symposium on Aviation Psychology, Columbus, OH.

Broach, D. & Schroeder, D. (In press). *ATCS Age 56 Report 1: Review of the Scientific Basis for the Mandatory Separation of an Air Traffic Control Specialist (ATCS) at Age 56.* Washington, DC: Federal Aviation Administration Office of Aerospace Medicine.

Cameron, A. C. & Trivedi, P. K. (1998). *Regression analysis of count data.* New York: Cambridge University Press.

Center for Naval Analyses Corporation. (1995, November). *Analysis of operational errors for air route traffic control centers. Volume I: Final report.* (IPR 95-5108). Alexandria, VA: The Center for Naval Analyses Corporation Institute for Public Research.

Della Rocco, P. S., Cruz, C. E., & Clemens, J. A. (1999). Operational errors/deviations and shift work in air traffic control. In Della Rocco, P.S., (Ed.). *The role of shift work and fatigue in air traffic control operational errors and incidents* (pp. 11–21). (DOT/FAA/AM-99/2). Washington, DC: Federal Aviation Administration Office of Aerospace Medicine.

Department of Transportation Inspector General. (2003a). *Operational errors and runway incursions: Progress made, but the number of incidents is still high and presents serious safety risks.* (DOT OIG AV-2003-040). Washington, DC: Department of Transportation Office of the Inspector General.

Department of Transportation Inspector General. (2003b). *DOT's Top management challenges.* (DOT OIG PT-2004-006). Washington, DC: Department of Transportation Office of the Inspector General.

Hulin, C. L. & Rousseau, D. M. (1980). Analyzing infrequent events: Once you find them, your troubles begin. In K. Roberts & L. Burstein (Eds.), *New directions for methodology of social and behavioral science 6: Issues in aggregation* (pp. 65–75). San Francisco, CA: Jossey-Bass.

Li, G., Baker, S. P., Grabowski, J. G., Qiang, Y., McCarthy, M. L., & Rebok, G. W. (2003). Age, flight experience, and risk of crash involvement in a cohort of professional pilots. *American Journal of Epidemiology*, *157*, 874 – 880.

Manning, C. A. (1998). Air traffic control specialist field training programs, 1981-1992. In D. Broach (Ed.). *Recovery of the FAA Air traffic control specialist workforce, 1981-1992* (pp. 23–32). Washington, DC: Federal Aviation Administration Office of Aviation Medicine.

Pounds, J. & Ferrante, A. S. (2003). *FAA Strategies for reducing operational error causal factors.* (DOT/FAA/AM-03/19). Washington, DC: Federal Aviation Administration Office of Aerospace Medicine.

Spahn, M. J. (1977). *The human element in air traffic control: Observations and analyses of the performance of controllers and supervisors in providing ATC separation services. Supplement 2: Analysis of the System Effectiveness Information System (SEIS) data base.* (MITRE Report MTR-7655 Supplement 2). McLean, VA: The MITRE Corporation.

SPSS, Inc. (1999). *SPSS Advanced models 10.0.* Chicago, IL: Author.

Tsang, P. S. (2003). Assessing cognitive aging in piloting. In P. S. Tsang & M. A. Vidulich (Eds.), *Principles and practice of aviation psychology* (pp. 507–546). Mahway, NJ: Erlbaum.

U.S. House of Representatives. (June 8 & 9, 1971). *Career program for air traffic controllers: Hearings before the Committee on Post Office and Civil Service on H.R. 8083 and Similar Bills.* (House of Representatives, Ninety-Second Congress, First Session. Serial No. 92-10). Washington, DC: Government Printing Office.

End notes:

[1]Mandatory separation is not required for controllers hired before May 16, 1972. The number of controllers age 56 and older increased from 155 in FY1997 to 488 in FY2003.