U.S. Statement of Demonstrated Ability Aeromedical Waivers

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INTRODUCTION: The Statement of Demonstrated Ability (SODA) is a type of U.S. aeromedical waiver used for disqualifying conditions that are not expected to change. About 21,000 (2%) U.S. pilots possess a SODA waiver.

METHODS: We matched all pilot medical exams from the FAA's medical certification database from 2002 through 2011 to their respective accidents in the National Transportation Safety Board accident database. The association of SODA waivers and SODA conditions with the odds of an accident were explored using logistic regression techniques.

RESULTS: For 3rd class flight exams, the presence of a SODA waiver was not associated with the odds of an accident. For the 1st and 2nd class exams, the accident odds ratio (OR = 1.45) was statistically significant. Crop dusting operations accounted for 17 of the 40 accidents where SODAs were present and returned a significant accident OR = 1.68. SODAs were not associated with the odds of accidents during other commercial operations. Six SODA conditions (amputation, internal eye, external eye, visual fields, bone and joint, and miscellaneous) were also found to have elevated ORs but were based on very small accident counts. NTSB investigators and the authors reviewed all accidents and none thought the SODA condition to be contributory.

DISCUSSION: SODA waivers were not associated with increased accident odds except for crop dusting operations. Six specific SODA conditions also had elevated odds of an accident, but there was no evidence they contributed to the accidents. Overall, U.S. pilots with SODA waivers appear to have a satisfactory safety record.

KEYWORDS: certification, safety, aviation accidents.

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Aeromedical waivers are important tools for certification authorities. Waivers allow flexibility to approve pilots who have disqualifying medical conditions by regulations, but are individually found to be fit to fly. The use of aeromedical waivers is recognized internationally in Standard 1.2.4.9 of the International Civil Aviation Organization (ICAO) which is a unit of the United Nations intended to harmonize international flight operations.[6] This standard explicitly permits the issuance of medical waivers where "accredited medical conclusion indicates that in special circumstances the applicant's failure to meet any requirement, whether numerical or otherwise, is such that exercise of the privileges of the license applied for is not likely to jeopardize flight safety." So, this standard provides substantial latitude for certification authorities to issue waivers when considered consistent with flight safety.

The U.S. Federal Aviation Administration (FAA) issues two types of aeromedical waivers. For conditions that may progress, such as cardiac disease or cancer, the "Special Issuance" (SI) waiver is available. This involves a time-limited certificate with requirement for periodic medical reevaluations to confirm continued fitness to fly, and was the subject of a previous research study.[8] The other type of waiver, which is the subject of this study, is the "Statement of Demonstrated Ability" (SODA.) This is a waiver that is not time-limited and is used for conditions that are not expected to progress. The issuance of a SODA is frequently based on a one-time medical flight test (MFT) to demonstrate that the disqualifying condition does not interfere with safe flight. These MFTs are carried out by FAA Aviation Safety Inspectors (ASIs) who follow the requirements of FAA

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Order 8900.1.[4] ASI pilots are nonmedical FAA employees who administer, investigate, and enforce FAA safety regulations and standards. Order 8900.1 gives general guidance along with specific criteria for color vision deficiencies, visual defect, hearing defect, speech defect, and deformity or absence of an extremity. However, for most of the criteria, the ASI has considerable leeway in judging acceptable performance. This is especially true for defects that don't fit well into any of these categories such as weakness or paralysis of a muscle, or limited range-of-motion of a joint. SODA waivers are specific to class of medical certificate, may be limited to specific aircraft, may require specific aids such as hand controls for the rudder pedals, and may be withdrawn upon evidence that the condition has progressed.

The U.S. Federal Air Surgeon has granted waivers for some airmen who don't meet the medical certification standards since 1926 when issuance of medical certificates was adopted. Specific authority for the SODA waiver was added to Section 67.401 of the Federal Aviation Regulations (FARs) Part 67 when it was revised in 1996.[5]

During the time frame of this study, from 2002 through 2011, our data show that the FAA processed 4,149,726 applications of which 83,452 (2%) were for pilots holding a SODA waiver. About 10,000 (0.24%) of these applications required a new SODA waiver. Note that a large number of SODAs prior to 1996 were issued because uncorrected distant vision did not meet the 20/100 standard. Although this standard was eliminated in 1996 and these SODAs were no longer needed, many pilots continue to report them.[5] If these SODAs are not counted, then the total number of exams with a SODA is 59,954 (1.4%) representing 15,102 unique pilots. The FAA's Aerospace Medical Certification Division (AMCD), which is located at the Civil Aerospace Medical Institute (CAMI) in Oklahoma City, manages most U.S. medical certifications and waivers. The nine Regional Flight Surgeon's offices and the Federal Air Surgeon's office evaluate cases not managed by the AMCD.

A literature search by the authors did not identify any previous analytic studies regarding the impact of FAA SODA waivers on safety. Our online PubMed search using the key words "Aerospace Medicine, or Aeromedical, or Aviation Medicine," and "Waiver" with no date limit returned 78 articles. Only three of these articles were analytic studies of the relationship of waivers to aviation accident risk. Our recent study of Special Issuance FAA waivers found that these waivers were associated with lower odds of an accident than nonwaivered pilots for 3rd class certificate holders and no difference for holders of 1st and 2nd class certificates.[8] Another study explored special issuance waivers granted to insulin-treated diabetic pilots and found no increase in the odds of an accident for these closely monitored pilots.[9]

An analytic study, published in 2002, explored the association of waiver status in U.S. naval aviators with mishaps during 1992 to 1999.[14] It appears that over half of the waivered conditions for these pilots would be analogous to the FAA SODA waivers for civilian pilots. This study included 234 pilots in the accident group. The author found no association between waivers and serious mishaps. There is also a purely descriptive 1972 report of waivered Air Force pilots who were involved in accidents from 1962 through 1970.[11] This study found that of 447 pilots with medical waivers who were involved in an accident, the waivered condition may have been contributory to the accident in 33 cases. Most of these conditions would have required special issuance waivers for the FAA. Of the 81 that would have been considered for FAA SODA waivers only one color vision waiver was thought to be related to the accident. Note that most conditions receiving FAA SODA waivers would not be considered for waiver by the U.S. Air Force or the U.S. Navy.[12,13] The aim of our current study was to contribute to reducing the gap in knowledge regarding the safety of U.S. SODA waivers.

METHODS

Subjects

This study was approved in advance by the FAA Institutional Review Board. (IRB Protocol #16,001.) This exploration of SODAs is an extension of our recent study of Special Issuance waivers and uses similar techniques and source of subjects.[8] Aeromedical certification and waiver information for U.S. pilots is contained in the FAA's Document Imaging Workflow System (DIWS) and includes over 22 million examinations for over 3.6 million applicants. For each examination, this database includes demographic data, medical history and physical exam data, pathology codes (path codes) for medical conditions known to the FAA, and detailed certification actions. Note that the DIWS has no restrictions on values entered for flight hours, dates, height, weight, and SODA serial numbers, so data entry errors may occasionally be found in these fields as mentioned in the discussion section. We queried all 4,149,726 exams, representing 1,093,443 pilots, contained in the DIWS from January 1, 2002 to December 31, 2011, for presence or absence of a SODA. This data file was available from our previous study of special issuance waivers. Since SODA waivers do not expire, we trimmed the SODA issuance date to no earlier than 1970. The only major change in ASI instructions that we are aware of was color vision, which was made much more rigorous in 2008. The current instructions for the ASIs which specifically cover hearing impairment/loss, deformity/absence of an extremity, visual defect, and speech defect consist of brief guidelines that leave much of the pass/fail determination to the ASI's discretion.[4]

A large number of SODAs prior to 1996 were issued because uncorrected distant vision did not meet the 20/100 standard. This standard was eliminated in 1996 and these SODAs were no longer needed, but many pilots continued to report them. A separate logistic regression analysis demonstrated that these distant vision SODAs were not associated with accidents. Therefore, exams having these pre-1996 distant vision SODAs were included in the comparison group of all exams not having a SODA waiver.

We collected applicant ID number and exam ID number, exam date, gender, age at exam, height, weight, self-reported six-month and total flight hours, SODA serial number if present, exam expiration date, path codes, and class issued code in

an encrypted data file. Exam duration was calculated (in years) from the difference between exam date and exam expiration date. Longer duration represented more exposure to the chance of having an accident.

Procedure

The National Transportation Safety Board (NTSB) maintains a database of U.S. aviation accidents.[10] Each of the 4,149,726 exams was matched to the NTSB database to identify any accidents that occurred while that exam was valid for pilot duties. We matched these exams to 15,683 accidents. We collected accident date, type of operation (Part 91 - General Aviation, 121 - Air Carrier, 135 – Air Taxi, etc.), highest injury, and NTSB number for each accident.

The group of 3rd class medical certificate holders differ from those holding 1st and 2nd class certificates due to the relationship between the type of their flight hours and the nature of their accidents. We examined these two groups separately. The 3rd class pilots' accidents and flight hours both involve mainly Part 91 general aviation operations. However, while 1st and 2nd class pilots obtain the vast majority of their flight hours flying commercially, 72% of their accidents occurred during noncommercial flight operations (6073 of 8445 accidents). We were unable to determine the Part 91 noncommercial flight hours for commercial pilots, so we were limited to analyzing commercial accidents for pilots with 1st and 2nd medical certificates. We assume that for the commercial pilot group, personal flying represents a small proportion of their total flight times. The exams in our SODA group included 1.5% (18,731/1,236,084) of 3rd class and 1.4% (38,375/2,836,571) of the 1st and 2nd class exams.

The serial number issued to pilots who are approved for a SODA includes a code for the condition requiring the SODA. There are 26 SODA conditions. Examples include amputations, color vision deficiency, and hearing deficiency. Eleven of these conditions are inactive and have not been in regular use for 20 yr. These active and inactive conditions are included in **Table I** with frequencies for the active reasons.

For analyzing the association of SODA waivers with aviation accidents, the most useful study units were determined to be the individual exams. Use of exams captured all of the available data and allowed for the most straightforward models for associations of SODA waivers with the odds of an accident. The alternative approach using individual pilots as the data points is problematic due to changes over the 10-yr study period in consistency of annual flying hours, class of exam, and type of flight operations as well as lapses in exams, and some pilots' requirement for SODA waivers for only part of the study period. We will provide the number of pilots represented by a group of exams where this is helpful.

Statistical Analysis

We employed logistic regression models to determine odds ratios (ORs) for the association of a SODA waiver with aircraft accidents. This technique has been successfully used previously to explore the association of other conditions with risk of aircraft accidents using similar data sources.[7] The outcome variable was occurrence of an aircraft accident. The predictor variables included age, total and past 6-mo flight experience, gender, body mass index (BMI) calculated from the height and weight, and certificate duration (a measure of exposure) in addition to the presence of a SODA waiver. We calculated odds ratios with 95% confidence intervals. Since a unit size of one for the quantitative predictor variables would result in miniscule ORs, a unit size of 10 yrs. was used for age, 25 h for recent flight time, 1000 h for total flight time, and 10 units for BMI in order to scale the ORs to be more understandable.

Logistic regression models similar to the one above were also performed using the SODA conditions as predictors to explore which specific conditions may be associated with the odds of an accident. Note that the SODA serial number is provided for each new exam by the pilot, so that omissions and typos were a significant challenge for this analysis.

Descriptive statistics, logistic regression, and Chi-squared testing were performed using SPSS version 21 (IBM, Armonk, NY), using a statistical significance level of $\alpha = 0.05$.

Table I. SODA Conditions with Total Numbers and Number of Accidents.

	3rd CLASS		1st/2nd CLASS	
SODA CONDITION	NUMBER	ACCIDENTS	NUMBER	ACCIDENTS
Color Vision	10,727	58	25,409	25
Distant Vision	2948	17	4893	3
Hearing	835	8	2039	2
Amputation	817	10*	1273	2
Visual Field	768	11*	886	2
Internal Eye	764	6	1368	3*
Miscellaneous	480	8*	470	1
External Eye	369	6*	1079	0
Muscles	226	0	239	0
Bone and Joint	167	3*	216	0
Neurological	159	2	211	1
Near Vision	121	1	156	1
Throat	29	1	25	0
Glaucoma	20	0	22	0
Mute	3	0	6	0
Total	18,433	131	38,292	40

Additional SODA conditions not used since the 1990s include Ear, Nose, Respiratory, Heart Disease – General, Heart Disease – Valvular, Heart Disease – Vascular, Heart Disease – Arrhythmia, Electrocardiogram Abnormalities, Abdominal, Mental/Nervous, and Malignancy.

* Statistically significant association with accidents but low confidence due to very small counts.

RESULTS

Our study included the 10-yr period from January 1, 2002 to December 31, 2011, during which 1,093,443 different individuals submitted 4,149,726 medical exam applications to the FAA. During the study period, the FAA issued 4,072,660 valid medical certificates to 1,051,388 pilots. Of these certificates, 83,452 (2.0%) were issued with a SODA waiver. This included 21,163 unique pilots (2.0% of issued individuals) who were approved for one or more SODA waivers. Removing all SODAs issued prior to 1970 and those SODAs issued for distant vision prior to 1997 left 57,106 (1.4%) issued certificates

and 13,791 (1.3%) unique pilots with a SODA waiver for analysis in this study.

For this study, we restricted age-at-exam to 16 yr to 100 yr, last 6-mo flight time to 600 h, and total flight time to 40,000 h, because of a small number of probable reporting errors that would significantly distort the results. These restrictions removed 3003 (0.2%) exams and 2448 (0.4%) pilots from the 3rd class group leaving 1,233,083 exams and 582,214 pilots, as well as 18,077 (0.6%) of the exams and 2367 (0.5%) of the pilots from the 1st and 2nd class group. This left 12,667 pilots in the SODA groups. **Table II** compares demographics between exams with and without a SODA waiver by class.

Logistic regression models for the 3rd class group reveal that the overall crude accident OR for pilots with a SODA was significant with OR = 1.34 (95% CI: 1.13–1.59, $P = 0.001$). However, this association between presence of a SODA and accidents is due to confounding. For example, the pilots with SODA exams were significantly older, which is a risk factor for accidents.[1,2] We adjusted for the effect of age, gender, Body Mass Index (BMI), total flight hours, flight hours over the previous 6-mo, and duration of the medical certificate using a logistic regression model. The results are shown in **Table III**.

These findings, as adjusted to account for confounding factors, show that the presence of a SODA is not associated with accidents with an OR point estimate of only 1.12 ($P = 0.199$). They also show that increasing age is an accident risk with 31.5% greater accident odds ratio for each 10 yr, and that female pilots have a 15.6% lower odds of an accident. Both of these findings agree with previous studies.[1,9] Exam duration is a measure of exposure to accidents and, as expected, longer duration was associated with a 36.1% increased odds of an accident per year. Reported flight time in the last 6 mo is also associated with odds of an accident with a 15.9% increased odds for every 25 h. The 6-mo flight time measures both exposure to risk and recent experience. The OR point estimate for increasing total flying time showed a minimal protective effect of an 0.8% decrease per 1000 flight hours, but was not statistically significant ($P = 0.059$). This would be a measure of overall flying experience. BMI had no significant association with accidents. If only the significant covariates are retained in the above model, the results are very similar.

Table II. Comparison of Pilot Demographics Between 3rd Class Applicants and 1st and 2nd Class Applicants with a SODA Waiver.

	3rd CLASS ALL	3rd CLASS SODA	1st & 2nd CLASS ALL	1st & 2nd SODA
Age (yr, Mean)	48.8	57.9	44.7	49.4
Gender (% female)	6.3	1.4	4.3	0.9
SI percent	9.1	17.8	4.7	10.5
BMI (Mean)	27.6	28.2	27.1	27.7
Total Flight Time (h, median)	270.0	800	6480.0	7750
Past 6-mo flight time (h, median)	10.0	15.0	200.0	180.0
Exam Duration (yr, median)	2.01	2.00	0.8	0.93
Total Accidents	6360	131	8483	179
Commercial Accidents	0	0	2104	40
Number of Exams	1214,369	18,712	2818,495	38,780
Number of Pilots	564,153	7426	455,500	5241

Age between 16 to 100 yr; previous 6-mo flight time maximum 600 h and total flight time maximum 40,000 h. SODAs excluded those issued prior to 1970. Exams with SODAs for distant vision issued prior to 1997 were not included in the SODA group.

Table III. Results of Logistic Regression Model for 3rd Class Accidents.

PREDICTOR VARIABLE IN MODEL	ODDS RATIO	95% CI	P
SODA	1.122	0.941–1.336	0.199
Age (per 10 yr)	1.315	1.288–1.343	< 0.001
Gender (compared to male)	0.844	0.748–0.951	0.006
BMI (per 10 units)	1.039	0.982–1.101	0.185
Total Flight Hrs. (per 1000 h)	0.992	0.984–1.000	0.059
Six-Month Flight Time (per 25 h)	1.159	1.148–1.170	< 0.001
Exam Duration (per yr)	1.361	1.320–1.404	< 0.001

The result for each predictor variable was adjusted for the effect of other predictor variables.
Units for continuous covariates were chosen to improve clarity.

Logistic regression models for the 1st and 2nd class group show that the overall crude accident OR for pilots holding 1st and 2nd class medical certificates with a SODA was significant (OR = 1.47; 95% CI: 1.27–1.71; $P < 0.001$). A logistic regression model was used to remove confounding from the same parameters as in the model for pilots holding a 3rd class certificate. The results of this model are shown in **Table IV**. This logistic regression model for commercial accidents in the overall 1st and 2nd class group, adjusted for the confounding variables, included 2,780,388 (98%) of the exams with 2104 non-SODA accidents and only 40 SODA accidents after removal of accidents with missing covariate values.

In 1st and 2nd class accidents, the presence of a SODA has a significant association with an odds ratio of OR = 1.452, 95% CI: 1.06–1.99, $P = 0.020$. Age has a smaller effect in 1st and 2nd class pilots than in 3rd class pilots, with 6.7% greater accident odds ratio for each 10 yr, female pilots have a 30.2% lower odds of an accident, and reported flight time in the last 6 mo is associated with a 7.4% increase in odds for every 25 h in this group. BMI was statistically significant in this model with a weak effect of 5% greater accident odds ratio for each additional 10 units increment.

Of the 40 commercial accidents, 17 were the result of agricultural flying (Part 137). Air Taxi (Part 135) was responsible for another 16 accidents. Since crop dusting is known to be a demanding activity with little room for error, we looked at this group separately. For Part 137 flying, the odds of an accident

Table IV. Results of Logistic Regression Model for 1st and 2nd Class Accidents.

PREDICTOR VARIABLE	ODDS RATIO	95% CI	P
SODA	1.452	1.061–1.987	0.020
Age (per 10 yr)	1.067	1.017–1.120	0.008
Gender (compared to male)	0.698	0.534–0.891	0.004
BMI (per 10 units)	1.045	1.026–1.065	< 0.001
Total Flight Hrs. (per 1000 h)	0.993	0.984–1.002	0.118
Flight Time 6 Month (per 25 h)	1.074	1.066–1.083	< 0.001
Exam Duration (per yr)	1.423	1.352–1.498	< 0.001

The result for each predictor variable was adjusted for the effect of other predictor variables.
Units for continuous covariates were chosen to improve clarity.

were significantly associated with the presence of a SODA (OR = 1.68, 95% CI: 1.04–2.72, $P = 0.035$). None of the SODA conditions were significantly associated with accident odds for this group. The numbers of accidents for the individual conditions are small. For the remainder of the commercial flight operations (mostly Part 135) the presence of a SODA was not significantly associated with odds of an accident (OR = 1.31, 95% CI: 0.86–1.97, $P = 0.205$).

The association of individual conditions requiring a SODA for 3rd class and 1st and 2nd class pilots was also explored. The list of SODA conditions with the overall number and number of accidents for each condition is displayed in Table I. Logistic regression models were used to assess the association of the different SODA conditions with odds of an accident. Age, gender, flight hours, BMI, and medical certificate length were again included as covariates to reduce confounding.

For the 3rd class group, the results for the covariates are almost identical to the 3rd class model above except that total flight time is now statistically significant ($P = 0.047$) with the same OR showing a tiny effect of reducing accident odds by 0.8% for each 1000 h of increased total flight time. Of the 15 active conditions requiring a SODA, 5 were associated with statistical significance as shown below.

- Amputation (OR = 2.0, CI: 1.08–3.42, $P = 0.034$) with 8 accidents
- External Eye (OR = 2.5, CI: 1.046–5.27, $P = 0.027$) with 6 accidents
- Visual Field (OR = 2.1, CI: 1.09–3.80, $P = 0.024$) with 11 accidents
- Bone and Joint (OR = 3.2, CI: 1.03–9.16, $P = 0.046$) with 3 accidents
- Miscellaneous (OR = 2.9, CI: 1.22–4.96, $P = 0.003$) with 8 accidents

The number of accidents for these significant SODA conditions is very small, ranging from 3 to 11, which doesn't give us a high level of confidence in the results, although the logistic regression models did converge. To examine this further, each accident for these SODA conditions was subjectively evaluated for a possible relation of the SODA to the circumstances of the accident. Note that the NTSB did not implicate the SODA condition as contributory to any of these accidents.

- For pilots holding a SODA for amputations there were eight accidents. Four of these appeared completely unrelated. Two were landing accidents with loss of control after touchdown in pilots with below the knee leg amputations. Both wore prosthesis and did not use hand controls. Another similar accident occurred to a pilot with a hemipelvectomy who took three tries to pass his MFT. The other accident involved a pilot with left hand amputation who veered off the runway during landing. Historically about 20% of accidents in these aircraft types are runway excursions.[3] A Chi-squared for goodness of fit shows this is a statistically significant difference from the 50% (4 of 8) in this group ($P = 0.034$)
- For 3rd class "bone and joint" SODAs there were 3 accidents. Two did not show any relation to the SODA. One accident involved loss of directional control of a pilot with "atrophy muscle left leg" and appeared similar to the leg amputation accidents above.
- For 3rd class visual field SODAs there were 11 accidents. Nine of these accidents were not related to vision. Two accidents were due to failure of visual detection, including a midair collision. Historically, just over 1% of accidents in these aircraft types are midairs, but this isn't significantly different than that seen in this group.[3]
- For SODAs of pilots with 3rd class medical certificates for "external eye" defects there were 6 accidents. None of these accidents involved visual deficiency.
- Pilots holding a SODA for "miscellaneous" conditions were involved in eight accidents. Most of these conditions could have been classified under more specific SODA conditions. Six accidents were not related to the SODA condition. A pilot with radial nerve damage of his arm lost control, affecting aileron action during the landing roll, and a paraplegic pilot who used hand rudder controls lost control while maneuvering during instrument meteorological conditions.

The SODA condition affected an in-flight function that was involved in the accidents mentioned above in 9 of 36 cases, but the NTSB had no evidence that this was contributory to the accident. All but two of these accidents were nonfatal; therefore, although the accident investigator had the great benefit of interviewing the pilot, they did not cite the SODA condition as contributory in any of them.

"Internal Eye" was also found to be significant in the 1st and 2nd class group in the logistic regression model with 3 accidents (OR = 3.2; CI: 1.86–5.05; $P < 0.001$). Although this model did converge, we have very little confidence in the significance due to the small number of accidents. On review of the circumstances, two accidents were unrelated to vision and the pilot in the other accident failed to secure a panel that was difficult to inspect due to the color scheme. All of these pilots were available for interview by the investigator and the NTSB did not identify the SODA condition as a contributing factor for either of these accidents.

Since the risk of a SODA in the 1st and 2nd class group is concentrated in agricultural flight operations, all 17 of these accidents were individually reviewed. The SODA condition was not cited by the investigators for any of these accidents. One accident involved a wire strike with a pilot having no useful vision in his right eye, but of these 17 accidents there were 3 other wire strikes in pilots with no visual defects. The SODA condition seemed completely unrelated to the other 16 accidents. Conditions that required a SODA in these Part 137 accidents included 12 for defective color vision, 3 for defective distant vision, 1 hearing impairment, and 1 below knee amputation.

DISCUSSION

This study explored the U.S. safety experience with SODA waivers in a very large pilot population consisting of 1,051,388 U.S.

pilots who submitted 4,072,660 applications for medical certificates from January 1, 2002 to December 31, 2011. SODA waivers were associated with 83,452 (2.0%) issued exams and 21,163 unique pilots (2.0% of issued individuals.)

The pilots with SODA waivers were significantly older, with a much smaller proportion of women, more total flight time, and slightly higher BMI than pilots not requiring a SODA waiver. The proportion of special issuance waivers was also about twice that of non-SODA pilots which, along with the higher total flight time, is probably related to the older age of the SODA pilots. Annual flight time for the SODA pilots was slightly greater for pilots with 3rd class certificates and was somewhat smaller for 1st and 2nd class holders.

The association of SODA waivers with accident odds was evaluated using logistic regression models that were adjusted to remove the confounding effects of age, gender, total flight time, flight time in previous 6–mo, BMI, and exam duration.

For the 3rd class group, logistic regression modeling found that presence of a SODA waiver was not significantly associated with accident odds. As found in previous studies and for the 1st, 2nd, and 3rd class groups in this study, increasing age was associated with higher accident odds, women had lower accident odds than men, and higher recent flight time (exposure) was associated with increased accident odds.

For the 1st and 2nd class group, logistic regression modeling found that presence of a SODA waiver was significantly but weakly associated with higher odds of an accident (OR = 1.45, 95% CI: 1.06 – 1.99, $P = 0.020$). The largest proportion of the commercial accidents were from crop dusting (Part 137) operations and this was entirely responsible for the elevated risk with OR = 1.68 (95% CI: 1.04 - 2.72, $P = 0.035$). SODA waivers were not significantly associated with increased odds for other commercial accidents which were mostly air taxi (Part 135) (OR = 1.31, 95% CI: 0.86 - 1.97, $P = 0.205$). All 17 of the crop dusting accidents were reviewed individually but only 1 involved an inflight function related to the SODA waiver and it was not cited by the NTSB as contributory.

Logistic regression models were carried out on the 15 active SODA conditions for each group to detect associations that may be obscured in the overall models. The models flagged five SODA conditions in the 3rd class group and one condition in the commercial group as possible risks, but the number of accidents for each condition was very small. Each of these accidents was reviewed by the authors to determine whether the SODA condition could have been related to the circumstances of the accident. For 10 of 38 cases the accident involved an inflight function related to the SODA. However, the NTSB investigators, having had the advantage of interviewing the pilot in all but two accidents, did not cite the SODA conditions in any of these cases. We feel that our evidence is too weak to postulate that any of these conditions is an accident risk. The only finding from our accident review that we feel may benefit from further consideration concerns leg amputation/dysfunction, which showed a statistically significant increase in runway excursion accidents.

A significant limitation of this study was the very small number of commercial accidents by holders of SODA waivers. The number was sufficient to reach statistical significance in our logistic regression model but doesn't instill confidence in the results for the 1st and 2nd class group. There was a larger number of general aviation accidents in the 1st and 2nd class group that couldn't be included in the analysis due to the lack of congruence between the accidents and flight hours for the 1st and 2nd class group. That is, the accidents were mostly the result of general aviation operations, but the number of flight hours were large and mostly resulted from commercial flying. Unfortunately, there was no way to capture and adjust for the general aviation flight hours alone. Another limitation is the number of incorrect or missing SODA numbers. These are provided by the pilot or the AME during each medical exam and errors are not captured by the medical certification process. We were unable to quantitate the number of such mistakes, but we discovered and rejected thousands of impossible SODA serial numbers during the data cleaning plus a number of more subtle typos during manual review of the accident cases and the DIWS medical records associated with these cases.

In conclusion, the proportion of pilots who require a SODA waiver to pursue their flying activity is small. The number of accidents involving a SODA waiver is very small and we did not find FAA SODA waivers for 3rd class applicants to be a safety risk overall. This finding suggests that SODA waivers are effective in permitting pilots holding 3rd class medical certificates to fly safely.

The number of commercial accidents in the 1st and 2nd class SODA group totals only 40 over the 10-yr period of the study, which included 455,500 commercial pilots. Despite this small number of accidents, logistic regression modeling did show a statistically significant association between SODA and accident odds in the commercial group. This was entirely due to the significant relationship of SODA waivers to accident odds ratio for Part 137 (crop dusting) operations. The NTSB accident investigators did not cite the SODA condition for any of these accidents, and the accident odds ratio was not significant for the other commercial operations. It is conceivable that the SODA conditions identified by our models can result in a subtle reduction in function that was not identified by the accident investigators. It is also possible that other confounding variables, not available for our model, may be responsible for the association we observed. It is possible that the MFT procedures for some conditions may ensure safe operations under normal conditions but may be insufficient for more demanding conditions such as regaining control after a difficult landing or during crop dusting operations. These SODA conditions may benefit from further research.

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