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# Aerospace Medicine and Human Performance

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# Aerospace Medicine and Human Performance

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**This journal, representing the members of the Aerospace Medical Association, is published for those interested in aerospace medicine and human performance. It is devoted to serving and supporting all who explore, travel, work, or live in hazardous environments ranging from beneath the sea to the outermost reaches of space.**

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# Aerospace Medicine and Human Performance

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The paper used in this publication meets the minimum requirements of American National Standard for Information Sciences—Permanence of Paper for Printed Library Materials. ANSI Z39.48-1984.

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**www.courses-uhms.org/live-courses/medical-examiner-of-divers-2022.html?idU=2**

# 93rd AsMA Annual Scientific Meeting: “Aerospace and the Next Generation“

## Sheraton New Orleans Hotel, New Orleans, LA, USA
## May 21 – 25, 2023

# Call for Abstracts

## Deadline: November 1, 2022
## *No Exceptions!*

The Aerospace Medical Association’s 2023 Annual Scientific Meeting will be held in New Orleans, LA, USA. The theme for this year’s Annual Scientific Meeting is **“Aerospace and the Next Generation.”** With emerging technology and new entrants into the aviation and space environment, it is now more important than ever to encourage the next generation of young people to consider entering career fields like aerospace medicine, engineers, operators, pilots, mechanics, and air traffic controllers to name a few. To quote a staff member, “if a young person can’t see it, they can’t be it.” Many of our youth have no awareness of the career opportunities in aerospace medicine. We need to be out in our schools and youth organizations telling our story. In addition, AsMA members will need to maintain a full awareness and in many cases a working knowledge of the innovations so we can better respond to needs of the aviation and space community. The future will require us to think differently as the airspace system changes.

The Annual Scientific Meeting is the premier international forum to learn and discuss evolving trends and multidisciplinary best practices in research, clinical applications, human performance, and flight safety. The 93rd Annual Scientific Meeting welcomes abstracts in the many areas related to Aerospace Medicine. For a complete list see the box on p. 2 of this form.

### ASMA ABSTRACT SUBMISSION PROCESS

**LIMIT: 350 words/2500 characters including spaces; NO Tables or Figures or References should be included in the abstract.**

**All abstracts must be submitted via the electronic submission system linked to the association's web site: *https://www.asma.org*.**

**ATTENTION:** You **MUST** use personal email addresses when entering your abstracts and those of your co-authors.

### ABSTRACT TYPES AND CATEGORIES

The Annual Scientific Meeting highlights several types of presentation formats. Posters are on display for two full conference days, each in its assigned space. Authors will be asked to present their poster for a single designated 120-min period on one of these days. PowerPoint presentations will be organized by topic area and presented during 90-minute blocks of time, 6 periods of 15 minutes each. **Individual PowerPoint presentations are limited to 15 minutes,** including 3 to 5 minutes for questions and discussion. Panels also have 90 minutes.: ideally 5 presentations of 15 minutes each, followed by a 15-minute discussion period.

There are four **TYPES** of submissions:

**1. Poster:** Standalone Digital Poster presentation that will be integrated into a session, grouped by topic. The presntation must be submitted as a PowerPoint with up to 10 slides. Video and audio clips can be embedded. They will be displayed digially.

**2. PowerPoint:** Standalone 15-minute slide presentation with questions/discussion that will be integrated into a session, grouped by topic.

**3. Individual Invited Panel:** Invited Presentation that will link to support a Panel Overview containing five (non-case study) or six (case study) abstracts presented as a cohesive whole.

**4. Individual Invited Workshop:** Invited Presentation that will link to and support a Workshop Overview.

### CATEGORIES

There are two categories based on the topic to be presented. Templates and examples (examples available on the submission site) are provided for each type and will be available at the abstract submission website. Authors will be required to enter abstract text under the headings as described below.

**1. Original Research:** Material that is original in nature and has not been previously presented. Original analysis of a hypothesis involving data collection and analysis. Headings include Introduction, Methods, Results and Discussion.

**2. Education:** Typically, a discussion of information that is already available.

***a. Program / Process Review:*** Description of a program or process that is used to solve a problem or accomplish a task. Headings include Background, Description, and Discussion.

***b. Tutorial /Review:*** An educational session intended as a review of established material. Headings include Introduction, Topic, and Application.

***c. Case Study:*** A single clinical or human performance event. Headings include Introduction, Case Description, and Discussion.

### PANEL GUIDANCE

**Panels** must be composed of a coordinated sequence of 4-5 abstracts that flow logically from one to another supporting the central theme. Panels must contain abstracts that allow 15 minutes of structured discussion at the end of the session.

**Case Study Panels:** Case Study Panels can have 6 abstracts, and are intended to highlight a particular institution, community or aeromedical issue, usually presented from the same institution or aeromedical community.

***It is the responsibility of the Panel Chairs to ensure that the abstract authors describe in each abstract how it relates to the Panel theme.*** If the Panel theme is not clearly identified and/or the abstracts do not support a central theme, the Scientific Program-ming Committee may unbundle individual abstracts and evaluate them as separate slide or poster abstracts. Unrelated abstracts from a laboratory or organization do not constitute a Panel (unless they are Case Studies). Panel Chairs are also responsible for preparing questions and discussion points to facilitate a moderated discussion with the audience during the sixth period. Each Panel speaker should cite or link directly to the Panel theme, and at the end of their talk should provide a logical segue to the next abstract.

### WORKSHOPS

Rules for workshops and the review process are similar to those for Panels (above). Overview abstracts should reflect the material to be presented in this long format for up to 8 hours of CME credit. Individual abstracts must be entered for each invited presenter and all necessary information must be entered in the same manner as all other abstracts, including conflict of interest statements. Course materials should be made available for registrants.

A separate fee is charged for Workshops registration. For additional information contact Jeff Sventek, Executive Director, at jsventek@asma.org.

## AsMA ABSTRACT SUBMISSION PROCESS

All abstracts must be submitted via the electronic submission system linked to the association's web site: https://www.asma.org. Click on the link to the abstract submission site--available on the AsMA home page and Meetings page on or about September 1, 2022. Authors with questions regarding the abstract submission process should contact AsMA directly at (703) 739-2240, x101 (Ms. Pam Day); or e-mail pday@asma.org.

The following information is required during the submission process: Abstract title, presenting author information (including complete mailing and e-mail addresses and telephone numbers), topic area (from list provided on back of form), contributing authors and their e-mails and institutions, abstract **(LIMIT: 350 words/2500 characters including spaces)**, **at least 2 Learning Objectives** (the Accreditation Council for Continuing Medical Education-ACCME-requires brief statements on the speaker's learning objectives for the audience). Read instructions online for further details. Poster presenters are required to upload a pdf of their poster in advance of the meeting.

**PLEASE NOTE:** Presenters (including panelists) are required to register for the meeting. There is a discounted fee for nonmember presenters. *Registration limited to the day of presentation will be available onsite*.

### Financial Disclosure/Conflict of Interest/Ethics

Abstracts will not be accepted without a financial disclosure/conflict of interest form. The form is included in the website submission process. The presenting author must agree to comply. Scientific presentations at AsMA-sponsored events will adhere to the highest standards of scientific ethics, including appropriate acknowledgment or reference to scientific and/or financial sources. Presenters must avoid the endorsement of commercial products in their abstracts and during their presentations. There must be no advertisements on Posters, AV, or handout materials.

### Presentation Retention Policy

AsMA will use live capture to make presentations from the Meeting available to members / attendees after the meeting. Authors are required to provide permission for live capture and a nonexclusive license to repurpose the content. An electronic copy of the presentation suitable for release at the time of the presentation must be provided. PDF copies of Poster presentaions must be uploaded to the submission site.

### Permissions and Clearances

It is the author's responsibility to obtain all necessary permissions and clearances prior to submission of the abstract. AsMA assumes no liability or responsibility for the publication of any submitted material.

### Acceptance Process

Abstracts will be reviewed by a minimum of three members of the AsMA Scientific Program Committee. Acceptance will be based on the abstract's originality, relevance, scientific quality, and adherence to the guidelines provided. Criteria for non-acceptance include, but are not limited to: insufficient, inconsistent, or ambiguous data; commercialism; or reviews of previously published literature. **Abstracts must be 100% complete upon submission, including all final data and results.** How well authors abide by submission and format guidelines will also be one of the criteria used to determine acceptance of abstracts.

Presenters are limited to **one** senior-authored presentation, unless given specific prior permission by the Scientific Program Committee Chair, Dr. Ian Mollan, at: sciprog@asma.org. Following review by the Scientific Program Committee in November, all contributors will receive a notification of acceptance or non-acceptance by e-mail. Accepted abstracts will be published in *Aerospace Medicine and Human Performance*.

While the Scientific Program Committee strives to honor the presenter's desired presentation format, for reasons such as space limitations or dissimilar content, an abstract may be changed to an alternative presentation format. Assignment of an abstract to either a poster or a slide presentation will be recommended by the Scientific Program Committee, but the final decision will be made by the Program Chair.

### Abstract Withdrawal

Withdrawing abstracts is strongly discouraged. However, if necessary, a request to withdraw an abstract should be sent to Dr. Ian Mollan, the Scientific Program Chair, at sciprog@asma.org; and Pam Day at pday@asma.org. The request for withdrawal must include the abstract title, authors, ID number, and reason for withdrawal. Due to publishing deadlines, withdrawal notification should be received by January 15, 2022. As abstracts are published in *Aerospace Medicine and Human Performance* prior to the scientific meeting, a list of abstracts withdrawn or not presented will be printed in the journal following the annual meeting.

## MENTORSHIP

### Optional review / feedback for student and resident presenters at AsMA 2023

AsMA is continuing its mentorship initiative for student and resident authors for the 2023 Scientific Meeting. You have the option to submit a draft of your abstract to a group of senior AsMA members for review and feedback. If you have questions about this opportunity, please e-mail sciprog@asma.org. E-mail your abstract to sciprog@asma.org no later than 1 October 2022. The Program Mentor Group will review provide feedback via e-mail by 20 October 2022. The abstract will still need to be finalized in the submission system.

**TOPIC AREAS:** (These will be listed on a drop-down menu on the submission site. They are used to organize the abstracts into sessions.)

**1: Human Performance**
1.1 Personnel Selection
1.2 Training
1.3 Hypobaric & Hyperbaric Physiology
1.4 Thermal Physiology
1.5 Acceleration / Vibration/ Impact
1.6 Fatigue
1.7 Neurophysiology & Sensory (inc. Vision, Auditory, Vestibular, Spatial Disorientation)
1.8 Aerospace Human Factors & Psychology
1.9 Aerospace Human Systems Integration
**2: Clinical Medicine**
2.1 Aviation Medicine
2.2 Health Promotion and Wellness Programs
2.3 Medical Standards / Aircrew Health
2.4 Occupational / Environmental Medicine
2.5 Operational Medicine
2.6 Hyperbaric Medicine
**3: Travel and Transport Medicine**
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3.4 Commercial
3.5 Pandemic Preparedness
**4: Space Medicine**
4.1 Space Medicine
4.2 Space Operations
**5: Safety and Survivability**
5.1. Escape / Survival
5.2. Flight Safety/Accident Investigation
**6: Other**
6.1 History of Aerospace Medicine
6.2 Ethics

Follow the link to the abstract submission site on our home page: ***https://www.asma.org***
**Deadline is November 1, 2022 (NO EXCEPTIONS!!!!!!!)**

# Pace of Innovation

Susan Northrup, M.D., M.P.H., FAsMA

General Aviation is Back! By the time this is printed, I will have attended the Experimental Aircraft Association's AirVenture for the second year in a row. For years, I had heard how large the event was and it really is! There is always something to do or see.

One significant thing I've seen this week dovetails very well with my goal of supporting STEM education for all students – EAA and their sponsors have significantly reduced the price of admission to students up to 18 years of age! As in, FREE! Further, there are lots of exhibits with STEM events for every age group from KidVenture to the exhibits scattered about the grounds. This week one of their summer camp events was aimed at girls in high school called GirlVenture. I was fortunate enough to stumble across a group of these young women last year over in Warbirds and chatted with them for several minutes (they had to listen to my pep talk on staying in school, doing well, and setting goals). Watching the wonder and awe on young people's faces as they learn about aviation and then watch the airshow is positively heartwarming. EAA had set up simulators for interested young people to experience controlling an aircraft and it was one of the busiest tents. And, it had air conditioning. I got lots of ideas for future STEM efforts while there. I personally encourage each of you to get involved with your local schools, youth groups, and flight schools. We have to replace ourselves someday and we need these young people to get enthused.

I was also fortunate to attend an AbleFlight event and watched four people be awarded wings. AbleFlight sponsors individuals with physical challenges in pursuing flight training. Working with flight programs and modified flight decks, people who would not otherwise have the opportunity have slipped the surly bounds of Earth. How can we as aerospace medicine professionals expand this to get more people in our field? Do we need to switch from rules-based decision making to performance-based? What will it take to be more inclusive? I think we need to be open to opportunities at every turn.

On a personal note, last year I was fortunate to actually fly into Oshkosh in our Harvard Mk4 (think T-6 or SNJ but built in Canada). We had hoped to make the trip in our newly restored Stearman so I could personally land here. Maybe next year. For those of you who are pilots, it was an amazing experience and well worth the trip.

I hope to see many of you in Paris for ICAM. Fly safe!

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# Cognitive Style and Flight Experience Influence on Confirmation Bias in Lost Procedures

Quan Xu; Mengyun Wang; Hongwei Wang; Bo Liu; Xuqun You; Ming Ji

**BACKGROUND:** Accident analysis and empirical research have shown that the decision-making process of pilots after becoming lost is adversely affected by confirmation bias; this constitutes a serious threat to aviation safety. However, the underlying mechanism of confirmation bias in the context of lost procedures are still unclear.

**METHODS:** This study used scenario-based map-reading tasks to conduct two experiments to explore the mechanism of confirmation bias in the lost procedures. In Experiment 1, 34 undergraduate students and 28 flying cadets were enrolled in a formal experiment to examine the effects of verbal-imagery cognitive style, experience level, and their interaction on confirmation bias. In Experiment 2, we further explored the influence of strategy as a core component of experience on confirmation bias with 26 flying cadets.

**RESULTS:** The study found that individuals were subject to confirmation bias in lost procedures. Visualizers (M = 0.78, SD = 0.75) were almost twice as likely to select the disconfirmatory features than verbalizers (M = 0.37, SD = 0.49). Visualizers exhibited a lower degree of confirmation bias than verbalizers, and experience helps verbalizers to reduce their degree of confirmation bias. The protective effect of experience mainly lies in individuals' choice of strategy.

**DISCUSSION:** Future aviation safety campaigns could be aimed at adopting a candidate selection process that focuses more on psychological attributes by testing for cognitive style, and enriching individual experience through adequate training. Such measures would reduce confirmation bias.

**KEYWORDS:** confirmation bias, aviation safety, individual differences, cognitive style, experience.

**Xu Q, Wang M, Wang H, Liu B, You X, Ji M. *Cognitive style and flight experience influence on confirmation bias in lost procedures*. Aerosp Med Hum Perform. 2022; 93(8):618–626.**

Poor decision-making by the pilot is considered to be an important cause of aviation accidents or incidents.[17,19] Accident investigation has revealed that 56.5% of accidents are related to pilot errors in decision-making.[1] Confirmation bias—a tendency to seek out and interpret information in ways that conform to preexisting beliefs, expectations, or a hypothesis[22]—has been found to adversely affect the pilot's decision-making process.[16,20,32] This is particularly the case in the decision-making process after becoming lost, when the pilot incorrectly judges the current location of the aircraft due to the influence of confirmation bias; this constitutes a serious threat to aviation safety.[6] Although research to date has creatively applied confirmation bias to the aviation field and has proven the adverse effect of confirmation bias on the pilot's decision-making, there is a lack of in-depth research on the psychological mechanism influencing pilot confirmation bias. Considering the serious consequences that may be caused by confirmation bias, further exploration of the underlying mechanism behind confirmation bias in the aviation context is conducive to targeted prevention and intervention that could reduce pilots' decision-making errors.

Confirmation bias is a reflection of the limitations of human cognitive processing,[9] which has been proven to be widespread in all fields of real life, including politics,[36] medicine,[25] and sports.[18] Researchers have explored the cognitive mechanism of

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confirmation bias in depth and suggested that confirmation bias is mainly derived from the heuristics that people use when processing tasks.[9,31] Specifically, when individuals face complex problems in the decision-making process, in order to ease cognitive load, they will not carefully consider or comprehensively search for all available information, but will instead rely on cognitive shortcuts or heuristics to make decisions faster.[5] However, the use of heuristics may lead to confirmation bias and affect the accuracy of decision-making.[31,32] In everyday situations, the consequences of decision errors caused by confirmation bias may be relatively minimal. However, in a high-stakes industry, especially the aviation industry, the cost of making wrong decisions may be serious casualties and property losses.[32] The decision-making process of pilots after becoming lost is a typical example.

When pilots get lost, flight safety can be threatened in a number of ways, including air collisions, intrusion into restricted airspace, and controlled flight into terrain (CFIT). In order to avoid the risk of being lost, pilots are taught to use a fixed lost procedure to help them judge current location.[6] First, change the current course, fly in a circle, and maintain a safe altitude. Second, according to the initial flight plan, time, speed, and the last known location, guess the current approximate location and mark a circle at the corresponding location on the map, which is called the "circle of uncertainty". Finally, search for ground features from the cockpit and compare them with the "circle of uncertainty" marked on the map to check whether the plane is currently in this theorized location. Actually, the "circle of uncertainty" marked on the map is the hypothesis, and the ground features observed from the cockpit are the evidence used to test it. The pilot needs to use the evidence to constantly check whether the hypothesis is correct. Thus, this is a hypothesis testing process that is susceptible to confirmation bias.[35] Gilbey and Hill first explored confirmation bias in the lost procedures through three scenario-based map-reading tasks.[6] In each scenario task, subjects must choose one of three ground features that they consider the most useful to determine whether the "circle of uncertainty" marked on the map is correct, as pilots would do when lost. It was discovered that the subjects more frequently chose evidence that was consistent with their hypothesis than evidence that indicated that their hypothesis might be wrong, which indicated that they are susceptible to the effect of confirmation bias.

Cognitive style refers to individual habits of information processing, which are specifically manifested in the preference in perceiving, organizing, and remembering information.[3,26] The cognitive style integration model groups various cognitive styles into wholist-analytic and verbalizer-imager dimensions.[26,27] The model describes verbal-imagery cognitive style as a preference for processing information by either verbal (the verbal cognitive style) or imagery (the imagery cognitive style) processes when performing cognitive tasks.[12] Many studies have shown that the verbal-imagery cognitive style has an important influence on map or picture information processing, spatial navigation, and information searching behavior. A study examined the impact of cognitive styles on learning with texts and pictures, and showed that visualizers spend more time inspecting pictures than verbalizers, and the performance of visualizers was better than that of verbalizers when learning materials that combine texts and pictures.[11] Pazzaglia and Moè investigated the effects of different cognitive styles on learning performance with two types of maps,[24] and found that cognitive style significantly predicts learning performance on maps; visualizers have better learning performance on maps with rich visual features. Moreover, researchers have also found that verbal-imagery cognitive style affects individuals' performance at spatial navigation[3] and information searching behavior.[7] Visualizers tended to search in a general area and then narrow down the search, while verbalizers tended to search in a narrow area and then broaden the search. Also, visualizers spent less time than verbalizers on completing these tasks.

Actually, in the decision-making process after becoming lost, pilots need to continuously represent or process map information and spatial ground feature information.[6] Thus, this decision-making process has specific attributes involving the processing of map or picture information and spatial information. Therefore, intuitively, verbal-imagery cognitive style may play an important role in this decision-making process. Specifically, due to the difference in information processing preference, visualizers prefer to process map or picture information and spatial information more than verbalizers,[11,12] which may better match the characteristics of the decision-making task in lost procedures. The cognitive style integration model suggests that when the cognitive style matches the characteristics of the decision-making task, the subjective difficulty of the task for the individual will be reduced, thus reducing the cognitive load in the process of task execution.[26,27] Therefore, visualizers may perceive lower task difficulty and cognitive load than verbalizers when performing the decision-making task in lost procedures. According to the cognitive mechanism of confirmation bias, the reduction of cognitive load is beneficial to reduce the individual's reliance on cognitive shortcuts or heuristics in the decision-making process, thereby reducing the degree of confirmation bias. Based on these arguments, it was expected that visualizers would exhibit a lower degree of confirmation bias than verbalizers in lost procedures.

Furthermore, some studies have explored the influence of individual experience on confirmation bias, but no consensus has been reached. On the one hand, studies have pointed out that the superior knowledge possessed by experienced individuals enables them to quickly and effectively evaluate hypotheses and make correct decisions, while inexperienced individuals tend to grant too much weight to current hypotheses.[2,4] For example, compared with experienced criminal investigators, college students who lack experience in handling cases are more likely to accept the hypothesis provided by the examiner to make judgments, showing stronger confirmation bias.[2] Thus, the more experienced an individual is, the less likely they are to be affected by confirmation bias. On the other hand, some studies have found that individual experience cannot reduce the degree of confirmation bias, especially when faced with tasks with different attributes. Some research on confirmation bias in complex tasks has shown that experience not only cannot help individuals avoid confirmation bias, but even leads to a higher degree of confirmation bias.[10,25] In a study on attitude change, a strong sophistication effect was found: the more experienced an individual was, the easier it was for them to defend their own attitude or opinion, showing a strong confirmation bias.[29]

It can be seen that the effect of experience on confirmation bias may be moderated by other factors, such as task difficulty or individual differences. Therefore, it is necessary to further explore the internal mechanism of the influence of experience on confirmation bias and analyze the potential moderating factors that may exist in it. For example, does the effect of experience on confirmation bias vary according to the different cognitive styles of individuals? In addition, a large number of studies have found that the differences between pilots with different experience are mainly manifested in their choice of strategy; in other words, strategy can be regarded as one of the main components of experience.[15,28] Strategy usually refers to a plan or approach of doing something to achieve a specific goal.[21] Many studies have shown that different strategies adopted by individuals to complete tasks affect the decision-making process and decision-making performance.[23,28] For example, based on experiments in a simulator, Schriver et al. found that different strategies affect the decision accuracy of pilots in fault diagnosis.[28] Similarly, when pilots get lost, the strategies they use to reason about their location may affect the decision-making process and decision accuracy, and appropriate strategies may help pilots reduce confirmation bias in the decision-making process.

To sum up, there is little research that deeply explores the underlying mechanism of confirmation bias in the aviation context. The aim of this study was to examine the impact of cognitive style, experience, and strategy on confirmation bias in lost procedures. Based on the theoretical perspective of the cognitive style integration model and the cognitive mechanism of confirmation bias, we made the following hypotheses. Visualizers may exhibit a lower degree of confirmation bias than verbalizers in lost procedures (Hypothesis 1). Experience may negatively affect confirmation bias in lost procedures, and this effect may be moderated by cognitive style (Hypothesis 2). Different strategies in the decision-making process may affect confirmation bias in lost procedures (Hypothesis 3).

## EXPERIMENT 1

### Methods

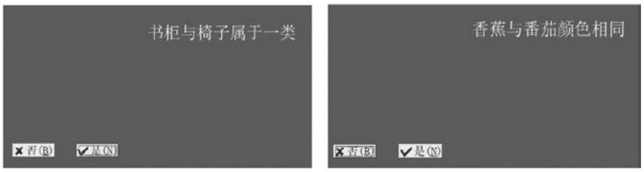
***Subjects.*** A total of 62 subjects took part in the experiment, including 34 undergraduate students ($M_{age}$ = 20.32, $SD_{age}$ = 2.50) from Shaanxi Normal University, and 28 flying cadets ($M_{age}$ = 20.68, $SD_{age}$ = 0.67) from the Air Force Aviation University of China. All subjects were men, right-handed, and reported normal or corrected-to-normal visual acuity. The experiment was conducted between late February and early March 2019. Undergraduate students were randomly recruited on campus by distributing experimental recruitment information, and flight cadets were contacted and recruited with the help of a flight instructor. Additionally, the collection of flying cadet data was jointly completed by a flight instructor and a graduate student majoring in aviation psychology. To protect confidentially, only the age information of the flying cadets was collected. According to the flight instructor, all flying cadets participating in this experiment had at least 50 h of flying experience. Based on the effect size reported in the previous study ($d$ = 0.69),[6] the power analysis using G*Power 3.1 showed that a sample size of 19 individuals was sufficient to achieve the power of 0.8, with alpha set at 0.05, two-tailed.

Furthermore, the subjects were preselected from a larger sample which consisted of 124 subjects (74 undergraduate students and 50 flying cadets) who had completed the Chinese version of the verbal-imagery subset of the Cognitive Style Analysis test (CSA-VI). According to the standard of the Chinese version of the CSA-VI,[13] subjects with a verbal-imagery ratio higher than or equal to 1.00 (imagery profile) and less than or equal to 0.86 (verbal profile) were invited to participate in the formal experiment. Finally, a total of 30 verbal subjects (17 undergraduate students and 13 flying cadets) and 32 imagery subjects (17 undergraduate students and 15 flying cadets) were screened out. The verbal subjects had an average verbal-imagery ratio of 0.75 (SD = 0.08), and the imagery subjects had an average verbal-imagery ratio of 1.10 (SD = 0.09). The study protocol was approved by the ethics committee of Shaanxi Normal University.

### Materials

***Cognitive style analysis.*** The Chinese version of the Cognitive Style Analysis test was revised by Li and Che on the basis of the original CSA test.[13,26] The verbal-imagery subset (CSA-VI) is composed of 6 practices and 48 formal trials; each trial is a statement, half of which are concept classification items, such as "bookcases and chairs belong to one category", while the other half are imagery classification items, such as "bananas are the same color as tomatoes". Each type of statement contains half correct and half incorrect items. As shown in **Fig. 1**, after each statement was presented on the task interface, subjects were required to judge whether the statement was correct or not by pressing one of two designated keys on the keyboard (if the answer is "No", press "B"; otherwise, press "N"), and subjects' response times (RTs) on each item were recorded.

CSA-VI takes the ratio of the RTs of concept classification items to the RTs of imagery classification items as an index for classification into verbal or imagery cognitive style. It was



书柜与椅子属于一类

香蕉与番茄颜色相同

Concept classification item

Imagery classification item

**Fig. 1.** Task interface and sample stimuli of CSA-VI.

assumed that visualizers respond more quickly to imagery classification items because they are more likely to form color representations of objects (e.g., the color of bananas and tomatoes), whereas verbalizers respond more quickly to concept classification items that require verbal association between word meanings (e.g., bookcases and chairs).[26,27] Therefore, the low verbal-imagery ratio belongs to the verbal cognitive style, while the high ratio belongs to the imagery cognitive style. In the Chinese version of the CSA-VI,[13] a ratio lower than or equal to 0.86 indicates a verbal profile, whereas a ratio higher than or equal to 1.00 indicates an imagery profile, and a ratio between 0.86 and 1.00 indicates a mixed profile.

***Scenario-based map-reading tasks.*** The investigation of confirmation bias in lost procedures in this experiment is based on the experimental paradigm of Gilbey and Hill,[6] in which scenario-based map-reading tasks were used as experimental material. The original English version of this material was provided by Professor Gilbey, and then we translated the English description of each scenario into Chinese and made a small amount of revision to make it more suitable for Chinese subjects. The experimental task consists of three scenarios: motorcycle, yacht, and light aircraft. The three scenarios were similar in nature, but the superficial descriptions between the scenarios were different. To complete the task in each scenario, subjects were asked to imagine that they had lost their way and had an urgent need to reorient themselves (similar to the situation in which pilots get lost in flight). In each scenario task, subjects were provided with a text description of the scenario and a map describing the area of the scenario, with a compass rose on each map. The textual description of the scenario provided sufficient information to simulate people in a lost situation and to guide subjects to form a hypothesis about the possible location. For example, subjects imagined themselves as a passenger on a lost yacht whose captain had fallen overboard (yacht scenario), or imagined themselves on a cross-country flight in a light aircraft whose pilot was unsure of his location (light aircraft scenario).

As a necessary condition of the experimental design, the hypothetical location (the circle marked location) in each scenario map in this study was drawn in advance by the researcher. Each circle location was a false hypothesis: the circle marked location was not the actual location. In addition, subjects were told that they could see three ground features from their actual location (e.g., "the main road and rail run directly side-by-side below you", listed after each scenario), and that they needed to choose the one most useful feature to determine whether they were really in the circle marked location on the map. In other words, the ground features were used to test the authenticity of the hypothetical map location.

Of the three ground features given in each scenario, two features appeared both in the hypothetical location on the map and also in the actual location. These two features can be used as evidence to support the hypothetical location is correct, and choosing either of these features indicates that individuals are overly dependent on evidence consistent with their assumptions about where they believe they are (positive tests of the hypothetical location). Therefore, these two features were regarded as confirmatory choices (e.g., "you can see small aircraft landing and taking off close behind the town" and "you can see a wide river mouth" in the yacht scenario). Meanwhile, the third feature did not appear in the hypothetical location on the map and only appeared in the actual location. This feature can be used as evidence to support the hypothetical location is wrong and the selection of this feature indicates that the individual carried out a negative test on the hypothetical location. Thus, this feature was regarded as a disconfirming choice (e.g., "there appears to be a high bush-clad peak behind the town, directly to your north" in the yacht scenario). Furthermore, selecting the disconfirming choice could determine that the hypothetical location was wrong and so it was the most useful feature for subjects to use in deciding whether they were in the circled area. According to the experimental paradigm of Gilbey and Hill,[6] if the rate of selecting the disconfirming choice is significantly lower than would be expected by chance, it indicates that individuals are subject to confirmation bias.

***Apparatus.*** All tests and experimental tasks were performed on a computer, specifically a Dell Inspiron 5559 laptop (Intel Core i7-6500U) with a 15.6-inch screen and 1366 × 768 resolution. In addition, the presentation of scenario-based map-reading task materials, program running, and data collection in the formal experiment of this study were all completed in iMotions 6.2 software, which is a comprehensive desktop-based synchronization research platform for psychology and human factors.

***Procedures.*** In order to screen out verbalizers and visualizers, all subjects first completed the CSA-VI on the computer and the verbal-imagery ratio of each subject was recorded. After each subject completed the CSA-VI, the experimenter immediately checked the test results to determine whether the subject met the criteria for participating in the formal experiment. According to the standard of the Chinese version of the CSA-VI,[13] the experimenter invited subjects with a ratio higher than or equal to 1.00 (imagery profile) and less than or equal to 0.86 (verbal profile) to participate in the formal experiment.

In the formal experiment, the subjects were first asked to spend 5 min learning the map symbols on the paper with detailed instructions and became familiar with the meanings of the different symbols. Next, the experimenter introduced the whole experimental process and precautions to the subjects. Once the subjects understood the experimental process and felt familiar with the map symbols, they clicked "Next" at the bottom of the task interface to complete the experimental tasks for each scenario in turn. Each scenario task was presented in two interfaces. The first interface presented the text description of the scenario and the second interface presented the map and three features. When solving the task of each scenario, the subjects used the mouse to click the corresponding feature on the second interface of the scenario to complete the selection. According to the experimental paradigm of Gilbey and Hill,[6] subjects were given no time limit to solve each scenario task. Overall, all subjects were able to complete the task in about 15 min.

***Statistical analysis.*** SPSS 22.0 was used to analyze all data in this study. The total number of disconfirming choices chosen by the subject across the three scenarios was used as the dependent variable index. A single sample *t*-test (two-tailed, test value = 1) was conducted to examine whether individuals were subject to confirmation bias in lost procedures. Furthermore, a 2 cognitive style (verbal and imagery) × 2 experience (inexperienced and experienced) analysis of variance (ANOVA) was performed to examine the effects of verbal-imagery cognitive style and experience level and their interaction on confirmation bias in lost procedures. Also, simple effect analysis was performed to inspect the nature of the interaction between cognitive style and experience.

### Results

The analysis of the performance of all subjects in three scenario-based map-reading tasks showed that subjects made 0 ($N = 31$), 1 ($N = 27$), 2 ($N = 3$), or 3 ($N = 1$) disconfirming choices. In other words, the disconfirmatory feature was chosen only 19.35% of the time and half of subjects made no disconfirming choice. The mean number of disconfirmatory features chosen by the subjects was 0.58 and the standard deviation was 0.67. Visualizers (M = 0.78, SD = 0.75) were almost twice as likely to select the disconfirmatory features than verbalizers (M = 0.37, SD = 0.49). For the sake of comparison, if they had answered randomly, the average number of disconfirming choices would be 1. Based on this, a single sample *t*-test was conducted (two-tailed, test value = 1) on the total number of disconfirming choices. The result was significant [$t(61) = -4.954$, $P < 0.001$, $d = 0.54$, 95% confidence interval (CI) = −0.59, −0.25], indicating that the actual performance of subjects was worse than the performance expected from random answers. Thus, subjects were more likely to use confirmatory evidence than disconfirmatory evidence to test their location.

ANOVA conducted on the total number of disconfirming choices showed that the main effect of cognitive style was significant [$F(1, 58) = 5.646$, $P < 0.05$, $\eta^2_p = 0.089$]. The number of disconfirming choices of subjects with an imagery profile was significantly higher than that of subjects with a verbal profile. The main effect of experience was not significant [$F(1, 58) = 2.375$, $P > 0.05$, $\eta^2_p = 0.039$]. The two-way interaction between cognitive style and experience was also significant [$F(1, 58) = 4.474$, $P < 0.05$, $\eta^2_p = 0.072$].

As shown in **Fig. 2**, further simple effect analyses showed that, for the verbal cognitive style, there were significant differences in the number of disconfirming choices of subjects with different experiences [$F(1, 58) = 6.432$, $P < 0.05$, $\eta^2_p= 0.1$] and the number of disconfirming choices of the flying cadets (M = 0.69, SD = 0.48) was significantly higher than that of the undergraduate students (M = 0.12, SD = 0.33). For the imagery cognitive style, there was no significant difference in the number of disconfirming choices of subjects with different experiences [$F(1, 58) = 0.171$, $P = 0.68$, $\eta^2_p = 0.003$].

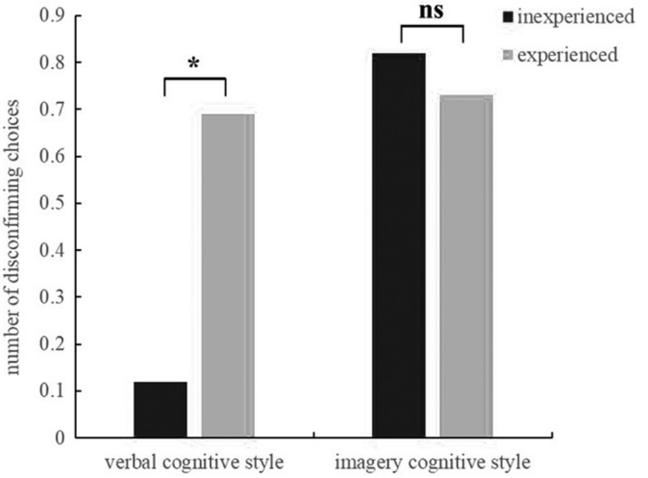


**Fig. 2.** The total number of disconfirming choices as a function of cognitive style and experience (ns indicates $P > 0.05$, * indicates $P < 0.05$).

### Discussion

The results of Experiment 1 indicated that the subjects were influenced by confirmation bias in lost procedures, which is consistent with the work of Gilbey and Hill.[6] We also found that individuals with an imagery profile had a lower degree of confirmation bias than individuals with a verbal profile. This finding echoes the related findings related to verbal-imagery cognitive style.[3,11,24] Furthermore, the effect of experience on confirmation bias was significant in the verbal cognitive style group, but not in the imagery cognitive style group. These results suggest that the effect of experience on confirmation bias is moderated by cognitive style, and experience has a protective effect against confirmation bias in individuals with a verbal cognitive style.

Studies have shown that the differences between pilots with different levels of experience are mainly manifested in strategy.[15,28] Therefore, in order to further explore what components of experience have an effect on confirmation bias, we examined the influence of strategy on confirmation bias in the following experiment.

## EXPERIMENT 2

### Methods

***Subjects.*** In this study, 26 male flying cadets from the Air Force Aviation University of China participated ($M_{age} = 20.89$, $SD_{age} = 0.65$). The experiment was conducted in mid-March 2019, and the subjects in this experiment did not participate in Experiment 1. All subjects had at least 50 h of flying experience, were right-handed, and reported normal or corrected-to-normal visual acuity. They were all contacted and recruited with the help of a flight instructor.

***Procedure.*** A mixed method approach combining an experimental method and a survey method was used to explore the influence of strategies on confirmation bias. In this experiment, subjects first completed three scenario-based map-reading tasks in turn. The procedure for completing these tasks was the same as Experiment 1. After subjects completed all experimental tasks, they were asked about their decision-making strategies in completing the tasks. The same question was employed in all cases: "Why do you think the feature you selected was the most useful? Please briefly describe the reason or basis for your choice, which can be specifically explained in conjunction with one of the scenarios." The question was conducted in the form of a paper-and-pencil survey, and screenshots of the task interface were printed on a separate sheet of paper to help subjects with accurate recall.

***Statistical analysis.*** A thematic analysis was used to sort and analyze all the survey materials from the subjects[30] so as to determine the decision-making strategy used by each subject to test the hypothetical location. This was carried out in two stages. First, by reading all the text materials obtained from the survey, common themes were determined and different types of decision-making strategies were classified. Second, the content of each subject's survey was carefully evaluated to find keywords related to the identified themes, and the survey content was classified accordingly. The first author led the analysis, and the second and third authors assisted and checked throughout the process. Furthermore, one-way ANOVA were performed using SPSS 22.0 to examine the effect of the strategy on confirmation bias in lost procedures. The dependent variable was the total number of disconfirming choices chosen by the subject across the three scenarios.

### Results

Subjects made 0 ($N = 14$), 1 ($N = 9$), 2 ($N = 1$), or 3 ($N = 2$) disconfirming choices. As a whole, the disconfirmatory feature was chosen 21.79% of the time and more than half (53.85%) of subjects made no disconfirming choice. The mean number of disconfirmatory features chosen by the subjects was 0.65 and the standard deviation was 0.89. In general, this study identified three common decision-making strategies through thematic analysis, as follows:

Strategy 1: Select features according to the attributes of the target object. The subjects using this strategy ($N = 9$) mainly focused on the attributes of the target object (such as a mountain) mentioned in the feature options, such as the distance, the size of the target object, etc., and believed that the attributes of the target object were most helpful for them to determine their own location. For example, the subjects answered, "the high mountain is a big and obvious target, which can help me to judge the location easily", and "I exclude clues that are far away from me, because the distance is too far to make accurate judgments".

Strategy 2: Look for features that confirm the hypothetical location. The subjects using this strategy ($N = 11$) mainly focused on the features that can prove that the assumed location is the correct location. For example, the subjects answered, "the airport is exactly north, and I saw planes taking off and landing also exactly north", and "I can see a railway at the current position, and there is a railway and its branch lines in the white circle".

Strategy 3: Exclude features that appear repeatedly in multiple places on the map. The subjects using this strategy ($N = 6$) mainly used the elimination method to focus on multiple recurring features in the map. For example, the subjects answered, "there is more than one wide river mouth, and there is only one airport on the entire map, so it can be used as the most useful feature", and "I first exclude features that also appear elsewhere on the map, and then make a choice".

The mean and standard deviation of disconfirmatory features chosen by the subjects in the three different strategies are as follows: strategy 1, M = 0.56, SD = 0.53; strategy 2, M = 0.09, SD = 0.30; strategy 3, M = 1.83, SD = 0.98. One-way ANOVA test results showed that different strategies had a significant impact on the total number of disconfirming choices [$F(2, 23) = 17.211$, $P < 0.001$, $\eta^2_p = 0.599$]. Further multiple post hoc comparison results showed that strategy 3 was significantly different from strategy 1 ($M_D = 1.278$, $P < 0.001$, 95% CI = 0.64, 1.92) and strategy 2 ($M_D = 1.742$, $P < 0.001$, 95% CI = 1.12, 2.36), while strategy 1 and strategy 2 were not significantly different ($M_D = 0.465$, $P = 0.092$, 95% CI = −0.08, 1.01).

### Discussion

In Experiment 2, we identified three strategies used by the subjects in completing the scenario-based map-reading tasks. The results showed that different strategies had a significant impact on confirmation bias, which is somewhat similar to the findings of Schriver et al.[28] They showed that better attentional strategy could help pilots' decision-making. Specifically, we found that strategy 3 significantly reduced the degree of confirmation bias compared to strategy 1 and strategy 2. This may be due to the fact that this strategy helps individuals quickly and effectively eliminate the interference of irrelevant information and complete the processing of key information.

## OVERALL DISCUSSION

The primary purpose of this study was to explore the impact of cognitive style, experience, and strategy on confirmation bias in lost procedures. The results showed that the individuals in this study were subject to confirmation bias in lost procedures. Cognitive style was found to affect confirmation bias: visualizers had a lower degree of confirmation bias than verbalizers. Moreover, experience helps individuals with verbal cognitive style to reduce the degree of confirmation bias and the protective effect of experience mainly comes from the specific strategies adopted by individuals. This study makes contributions to the current pilot confirmation bias and aviation safety research through exploring the underlying mechanism of confirmation bias in lost procedures. The results of this study may help to prevent and intervene in the confirmation bias of pilots so as to reduce the pilots' decision-making errors.

This study simulated lost procedures and used three scenario-based map-reading tasks to explore this decision-making process after becoming lost. It was found that individuals were subject to confirmation bias in this decision-making process, in that they demonstrated a preference for using confirmatory evidence rather than disconfirmatory evidence to establish their location. However, the use of disconfirmatory evidence would help pilots quickly determine that their hypothetical location is not the actual location after they get lost, which may prevent them from putting themselves in greater danger and reduce the likelihood of an accident. Our results are consistent with the work of Gilbey and Hill,[6] again proving the negative impact of confirmation bias on aviation decision-making in the context of Chinese culture. Previous studies have shown that confirmation bias is widely present in all areas of human life.[18,25,36] This study further demonstrates the universality of confirmation bias in human decision-making. Compared with decision-makers in other fields, pilots lack sufficient time and cognitive resources to search and process the required information due to the high level of uncertainty and cognitive load in aviation situations,[34] making pilots more susceptible to confirmation bias.[31,32] The consequences of this kind of influence are more harmful and socially influential than the consequences of decisions in other areas. Thus, the results of this study tell us that confirmation bias in pilot decision-making is an important factor affecting flight safety, and this problem should be given substantial attention by managers and researchers.

Based on the specific attributes of the decision-making task after becoming lost, we focused on the influence of verbal-imagery cognitive style on confirmation bias, and found that visualizers exhibited a lower degree of confirmation bias than verbalizers, thus supporting Hypothesis 1. A plausible explanation for this finding would be that compared to individuals with a verbal profile, individuals with an imagery profile show significant advantages in map or picture information processing and spatial navigation.[3,11,24] The decision task in lost procedures involves the processing of map information and spatial information, so the task is easier for individuals with an imagery profile. Their advantage in information processing on this task may save more cognitive resources and reduce cognitive load. According to the cognitive mechanism of confirmation bias, when cognitive resources are sufficient and cognitive load is low, individuals can process more information comprehensively and reduce the use of cognitive heuristics, which may reduce the degree of confirmation bias.[5,31,32] Therefore, this finding extends the research on individual differences in confirmation bias and suggests that, although confirmation bias is a common phenomenon in human decision-making processes, it influences different individuals to different degrees.

Although our study did not find a significant main effect of experience on confirmation bias, we did find that the interaction between experience and cognitive style had a significant effect on confirmation bias. Specifically, the effect of experience on confirmation bias was significantly different in the verbal cognitive style group, but not in the imagery cognitive style group. These results suggest that experience has a protective effect on the confirmation bias of individuals with a verbal cognitive style. Thus, Hypothesis 2 was partially supported. A possible reason for these findings is that, on the one hand, experienced individuals have superior knowledge or strategies that enable them to evaluate hypotheses quickly and effectively and to make correct choices and decisions.[2,4] Consequently, although individuals with verbal cognitive style have an inherent processing disadvantage in this decision-making task, this processing disadvantage may be significantly compensated by rich experience. On the other hand, although individuals with imagery cognitive style have inherent processing advantages in this decision-making task, it is difficult to completely eliminate confirmation bias through experience.[29] This means that the protective effect of experience is not fully and significantly reflected in individuals with imagery cognitive style.

In order to further explore why experience has a protective effect against confirmation bias in individuals with a verbal cognitive style, we further explored the effect of strategy as a core component of experience in Experiment 2. The results showed that there were three main strategies the subjects used to complete the scenario-based map-reading tasks. Strategy 3 (exclude features that appear repeatedly in multiple places on the map) significantly reduced the degree of confirmation bias compared to strategy 1 and strategy 2. Therefore, these results supported Hypothesis 3 and further explained the findings of Experiment 1.

The adverse effects of confirmation bias on decision-making in flight have been confirmed in empirical research[6,32] and accident investigation reports.[20] Therefore, the question of how to reduce or eliminate confirmation bias from pilots' decision-making is of great significance to aviation safety, and a major practical problem to be solved in aviation safety management. Researchers have tried to reduce the confirmation bias in pilots' weather decisions using a debiasing technique called "considering the alternative", but the results showed that the debiasing technique was not an effective intervention against confirmation bias.[33] Most studies using debiasing techniques to reduce cognitive bias have garnered similar results.[14]

Given that this is the case, research on the influence mechanism of pilot confirmation bias may be another potentially effective way to explore how to reduce confirmation bias. If one can deeply understand the generation mechanism and potential influencing factors of confirmation bias, then one may be able to provide effective technical support for pilots' targeted psychological selection and training from the perspective of practical intervention, so as to reduce confirmation bias. This study is based on this purpose and background, and its results provide some potential measures and suggestions for intervention against confirmation bias in the decision-making process after becoming lost.

First, stable psychological variables can be used as an evaluation index for pilot psychological selection to reduce the impact of confirmation bias. The results of this study indicate that the verbal-imagery cognitive style has a significant impact on confirmation bias, and the cognitive style, as a reflection of innate personality differences in information processing, is stable.[26] Thus, one might use verbal-imagery cognitive style as an evaluation index for the psychological selection of pilots and reduce the influence of confirmation bias by selecting individuals with an imagery cognitive style. Second, one might use pilot training to reduce the influence of confirmation bias, targeting malleable psychological variables. The results of this study show that experience may help individuals with verbal cognitive style to reduce their degree of confirmation bias in the decision-making process after becoming lost, and the protective effect of experience mainly comes from the strategies adopted by individuals. This indicated that we can reduce the impact of confirmation bias through adequate training of pilots, especially through strategy training to improve task-related experience. However, we need to combine the characteristics of pilots' different cognitive styles in training, and focus on increasing the training of pilots with verbal cognitive style, so as to improve training efficiency.

Despite the encouraging findings of this study, several limitations should be noted when interpreting its results and contemplating future research. First, in this study, scenario-based map-reading tasks were used as the experimental material. Although these tasks to a large extent simulated the decision-making process in lost procedures, they were still different from the decision-making process in an actual flight situation, which may affect the ecological validity of the conclusion to some extent. In an actual flight situation, pilots need to determine their location while controlling the aircraft,[6] which would further increase cognitive load and lead pilots to rely more on heuristics.[31] Therefore, in future research, a portable eye tracker can be matched with a flight simulator with a high simulation degree for further research, so as to make conclusions with more ecological validity. Second, this study only explored the mechanism of confirmation bias in one kind of flight situation, that is, the lost situation, and this is somewhat one-sided. Future research can further explore the influence mechanism of confirmation bias in other flight situations, such as weather-related decision-making situations,[32] and establish a corresponding theoretical model, so as to provide more comprehensive theoretical guidance for the prevention of confirmation bias in flight. Finally, in this study, only undergraduate students and flying cadets were selected to distinguish between experienced and inexperienced subjects. In the future, more experienced pilots should be selected and compared with inexperienced or low-experienced subjects to further verify our research results.

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# Medical Certification of Pilots Through the Insulin-Treated Diabetes Mellitus Protocol at the FAA

Lynn K. Stanwyck; James R. DeVoll; Joyce Pastore; Zykevise Gamble; Anna Poe; Gabrielle V. Gui

**INTRODUCTION:** In 2019, the Federal Aviation Administration (FAA) announced a protocol to evaluate pilots with insulin treated diabetes mellitus (ITDM) for special issuance (SI) medical certification for first-/second-class pilots. The protocol's aim is improved assessment of ITDM control/hypoglycemia risk and relies on continuous glucose monitoring (CGM) data. This study compares the characteristics of first-/second-class pilots with ITDM and certification outcome.

**METHODS:** Data was collected retrospectively from the FAA Document Imaging Workflow System (DIWS) for pilots considered for a first-/second-class SI under the ITDM program between November 2019 and October 2021. Inclusion criteria required submission of information required for certification decision (SI vs. denial). We extracted data on demographics and CGM parameters including mean glucose, standard deviation, coefficient of variance, time in range (%), time > 250 mg $\cdot$ dl$^{-1}$ (%), and time < 70–80 mg $\cdot$ dl$^{-1}$ (%). We compared these parameters between pilots issued an SI vs. denial with Mann-Whitney U-tests and Fisher exact tests using R.

**RESULTS:** Of 200 pilots with ITDM identified, 77 met inclusion criteria. Of those, 55 received SIs and 22 were denied. Pilots issued SI were statistically significantly older (46 vs. 27 yr), had a lower hemoglobin A1c (6.50% vs. 7.10%), lower average glucose (139 mg $\cdot$ dl$^{-1}$ vs. 156 mg $\cdot$ dl$^{-1}$), and spent less time with low glucose levels (0.95% vs. 2.0%).

**DISCUSSION:** The FAA program has successfully medically certificated pilots with ITDM for first-/second-class. Pilots granted an ITDM SI reflect significantly better diabetes control, including less potential for hypoglycemia. As this program continues, it will potentially allow previously disqualified pilots to fly safely.

**KEYWORDS:** insulin-treated diabetes, continuous glucose monitoring, first class pilot medical certification, second class pilot medical certification.

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Insulin treated diabetes mellitus (ITDM) is a challenge to the Federal Aviation Administration (FAA) and other civil aviation authorities worldwide charged with medically evaluating pilots for performance of safety sensitive flight duties. ITDM is particularly challenging due to variability in pathogenesis, clinical presentation, treatment, side effects, and short- and long-term complications. Of particular concern is the potential for hypoglycemia which may go unrecognized and result in sudden and subtle incapacitation. The aerospace environment also poses challenges to pilots with diabetes. For example, sudden aircraft cabin depressurization may potentially cause insulin pumps to malfunction and release an insulin bolus.[10] Altitude and hypobaric hypoxia cause changes in blood glucose levels.[21] The aerospace environment has also been shown to worsen diabetic cystoid macular edema[6] and spaceflight has been associated with insulin resistance.[23]

For any medical condition, the FAA's main certification goal is to prevent sudden or subtle incapacitation of the pilot in flight that jeopardizes flight safety and endangers the lives of not only the pilots and passengers, but also those on the ground should an aircraft crash. Diabetes presents several mechanisms potentially concerning for incapacitation, including hypoglycemia, hyperglycemia, and macrovascular and microvascular

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complications. Specifically, hypoglycemia is the complication of greatest concern since it may cause impaired decision-making, disorientation, poor performance at cognitive skills, confusion, and loss of consciousness. Additionally, hypoglycemic unawareness has been observed in up to 40% of patients with type 1 diabetes and this unawareness increases the risk of severe hypoglycemia sixfold for these patients.[15] Consequences of severe hypoglycemia may include seizure, coma, cardiac dysrhythmias, and death.[15]

The goal of medical providers outside of aviation is to maintain effective glycemic control to mitigate irreversible diabetic complications, but tighter glycemic control increases the risk of hypoglycemic events.[20] Alternatively, hyperglycemia may cause short term adverse effects, including vision and refractive changes, poor cognition, and diabetic ketoacidosis, as well as long term hazards to aviation safety secondary to end organ complications.[9] Macrovascular and microvascular changes often occur in the heart, eye, kidneys, and peripheral nerves. Of particular concern in pilots is diabetic retinopathy, which, if unrecognized, may result in loss of vision critical to pilot duties. Diabetic neuropathy may subtly affect a pilot's ability to manipulate the controls. While chronic kidney disease is quite unlikely to result in an unforeseen incapacitating event, diabetes is significantly associated with myocardial infarction and other vascular events (e.g., stroke). ITDM also presents logistical challenges for pilots, including maintaining a diet while traveling, in-flight glucose monitoring, and postcrash survival considerations.

Other civil aviation authorities have attempted to address aeromedical concerns of ITDM. Canada was the first country to establish an ITDM protocol for first class pilots in 2002, followed by the United Kingdom in 2012.[21] These two countries relied on multicrew restrictions and/or notification of their copilot of their diabetes. A policy of ITDM for commercial pilots in the United States has been significantly more challenging.

In the United States, ITDM is a "specifically disqualifying" condition under Title 14 of the Code of Federal Regulations part 67 (14 CFR 67). However, pilots with specifically disqualifying conditions may be considered for authorization of a special issuance (SI) medical certificate. Prior to 1996, the FAA did not grant SI certifications to pilots with ITDM mainly due to concern for risk of hypoglycemia. In 1996, the FAA began granting special issuance medical certification for third-class (general aviation) duties for pilots with ITDM using a protocol for monitoring serum blood sugar levels.[21] This protocol requires finger stick blood glucose testing 30 min before takeoff, during flight, and before landing. The protocol recommended pilots maintain glucose levels above 120 $\text{mg} \cdot \text{dL}^{-1}$ during flight to avoid hypoglycemic events in the air. Notably, this recommended blood glucose target during flight is higher than the recommended routine medical management as a mitigation to minimize the risk for hypoglycemia.

Though the FAA experience with third-class medical certification has not proven overtly unsafe, developing a policy for ITDM for first- or second-class commercial pilot duties was challenging. Concerns included: 14 CFR 67 mandates that less risk is acceptable for commercial pilot duties; hypoglycemia risk increases with tight glucose control; inability to assess glycemic variability; and hypoglycemia unawareness and associated autonomic failure. In addition, U.S. case law in 1980 (Delta Airline v. United States) prohibited the FAA from setting operational limitations on first-class medical certificates. However, after several years of consideration, in November 2019 the FAA announced a new protocol to evaluate pilots with ITDM for SI medical certification for first-/second-class pilot duties. The protocol's aim was to introduce an improved method for assessment of ITDM control (especially glycemic variability) and the attendant risks for hypoglycemia. The criteria for the protocol include clinical stability for at least 6 mo on the current treatment regimen and relies in part on pilot continuous glucose monitoring (CGM) data, both in the air and while on the ground. The goal of requiring CGM was in part to align diabetes management both in and out of the flight deck as well as to use longitudinal data demonstrating low risk of sudden or subtle incapacitation. Pilots were required to demonstrate good glucose control, including minimal incidence of low glucose levels, to qualify for an SI through this program.

CGM played a large part in risk mitigation for the new ITDM protocol. CGM automatically tracks glucose levels throughout the day and night with readings every 1 to 5 min,[3] and devices are designed to be worn continuously, including during showering, working, exercise, and sleeping. They work though a tiny sensor that is inserted through the skin, often in the abdomen or upper arm, and monitor interstitial glucose levels. These levels are correlated to blood glucose levels. CGM initially required calibration with finger stick levels, ideally at least daily, though the need for such calibration is greatly reduced or eliminated with current generation devices. The sensors can be worn for several days, often up to 10 d, depending on the sensor type. One CGM device is completely implantable and operates for up to 6 mo. The monitor may be part of a pump and/or may be connected to a smart device for monitoring. CGM can also provide patients with smart features such as glucose rate of change, alarms for hypo-/hyperglycemic events, and trends indicating that such events may be imminent. Overall, CGMs have been shown to be effective in improving patient glucose and diabetes control.[2,3] In 2022, the ADA has recommended CGM usage for all adults who take insulin.[24]

The goal of this study was to examine the outcomes of the new ITDM protocol at the FAA. Specifically, this study compares pilots who applied for an SI through the new ITDM protocol and those who were successfully issued an SI to those who were denied.

## METHODS

### Data Collection

Data was collected retrospectively from the FAA Document Imaging Workflow System (DIWS) for pilots considered for a first- or second-class SI under the ITDM program between November 2019 and October 2021. Inclusion criteria required submission of information specified under the program (including CGM data) and a final certification decision of SI or final denial (FD). Some pilots applied for a medical certificate upgrade from third-class to first- or second-class; those who were not allowed to upgrade were categorized as an FD.

Once pilots are issued an SI for medical certification, they are required to periodically renew this SI. We collected the number of pilots who applied to renew their SI under the ITDM protocol. We also collected the number of pilots who appealed their initial denial.

For each pilot who met our inclusion criteria, we extracted de-identified data in four major categories: demographics, diabetes parameters, CGM parameters, and diabetic complications. Demographic data included sex and age at application in years. Diabetes parameters included duration of diabetes in years and their most recent hemoglobin A1c (HbA1c). CGM parameters included mean glucose (mg · dl$^{-1}$), glucose standard deviation (SD), glucose coefficient of variance (CV), time in range (TIR, %), time above range, defined as > 250 mg · dl$^{-1}$ (%), time below range (TBR), defined as < 70–80 mg · dl$^{-1}$ (%), and device wear (%). These parameters were chosen because good control of many of these metrics is shown to correlate with better diabetes control and lower risk of complications. For this study, diabetic complications included the presence or absence of diabetic retinopathy, cardiac complications, neuropathy, and renal complications. Of note, the FAA defines TIR as between 80 mg · dl$^{-1}$ and 180 mg · dl$^{-1}$; however, not all patients had their devices set to those thresholds, especially early in the protocol. Additionally, settings reflect the clinical recommendations of the pilot's treating endocrinologist specific to the pilot. As a result, the TIR range was not exactly the same for all pilots. Additionally, most low glucose thresholds were defined as < 70 mg · dl$^{-1}$; however, some devices were set for < 80 mg · dl$^{-1}$.

### Data Analysis

We compared these parameters between pilots issued an SI versus those issued an FD. Age, CGM parameters, and diabetes parameters were analyzed as continuous variables. Continuous variables were analyzed with Mann-Whitney U-test to examine the difference in the median values and distributions for each parameter between pilots who were issued an SI versus those issued an FD. We chose Mann-Whitney U-test as our sample size was not large enough in each group to apply the central limit theorem and many of the variables were not normally distributed. Sex and diabetic complications were considered categorical variables. These parameters were analyzed using a Fisher exact test as sample sizes were small in some groups (e.g., in patients with diabetic complications, **Table I**). All data analysis was done in R.

## RESULTS

Of 200 pilots with ITDM identified in the Document Imaging Workflow System (DIWS), 77 met the inclusion criteria. Of these pilots, 55 received SIs and 22 were issued an FD. Demographic details and clinical findings for each pilot are in Table I. Of the 55 pilots who received an SI and were eligible for a continued authorization, 39 were successfully recertificated at the time of the conclusion of data collection. Of those who were denied, three applied for reconsideration, with two ultimately receiving an SI and the third being denied.

Results from the primary analysis are found in Table I. Pilots who received an SI were older (46 vs. 27 yr, $P = 0.002$), had a lower HbA1c (6.50% vs. 7.10%, $P < 0.001$), lower average glucose (139 mg · dl$^{-1}$ vs. 156 mg · dl$^{-1}$, $P < 0.001$), a lower glucose standard deviation (38 mg · dl$^{-1}$ vs. 53 mg · dl$^{-1}$, $P < 0.001$), a

**Table I.** Pilot Characteristics by Final Decision.

| PILOT CHARACTERISTICS | | FINAL DENIAL (*N* = 22) | SPECIAL ISSUANCE (*N* = 55) | *P*-VALUE |
|---|---|---|---|---|
| Demographic Data | | | | |
| Sex (% Male) | *N* (%) | 20 (90.9%) | 53 (96.4%) | 0.574 |
| Age (yr) | Median (IQR) | 27.00 (21.2 to 47.5) | 46.00 (36.0 to 54.5) | **0.002** |
| Diabetes Parameters | | | | |
| Diabetes Duration (years) | Median (IQR) | 11.00 (5.0 to 17.0) | 9.00 (5.0 to 20.0) | 0.667 |
| HbA1c (%) | Median (IQR) | 7.10 (6.8 to 7.4) | 6.50 (6.0 to 6.7) | **<0.001** |
| Continuous glucose monitoring (CGM) parameters | | | | |
| Average Glucose (mg · dl$^{-1}$) | Median (IQR) | 156.00 (145.5 to 163.0) | 139.00 (128.0 to 149.0) | **<0.001** |
| Glucose Standard Deviation (mg · dl$^{-1}$) | Median (IQR) | 53.00 (45.8 to 61.5) | 38.00 (29.5 to 43.5) | **<0.001** |
| Glucose Coefficient of Variance | Median (IQR) | 33.50 (30.2 to 36.6) | 26.90 (21.9 to 30.2) | **<0.001** |
| Time Glucose < 70-80 mg · dl$^{-1}$ (%) | Median (IQR) | 2.00 (1.0 to 4.0) | 1.00 (0.3 to 2.1) | **0.010** |
| Time Glucose > 250 mg · dl$^{-1}$ (%) | Median (IQR) | 7.60 (2.5 to 11.5) | 0.95 (0.0 to 2.0) | **<0.001** |
| CGM use time (%) | Median (IQR) | 91.00 (79.0 to 99.0) | 98.00 (95.0 to 100.0) | **0.002** |
| Time in Range (%) | Median (IQR) | 71.00 (61.2 to 80.9) | 95.00 (82.0 to 97.0) | **<0.001** |
| Diabetic Complications (Yes/No) | | | | |
| Diabetic Retinopathy | *N* (%) | 2 (9.1%) | 5 (9.1%) | 1.000 |
| Cardiac Complications | *N* (%) | 0 (0%) | 1 (1.8%) | 1.000 |
| Neuropathy | *N* (%) | 0 (0%) | 2 (3.6%) | 1.000 |
| Renal Complications | *N* (%) | 2 (9.1%) | 0 (0%) | 0.079 |

HbA1c: hemoglobin A1c; IQR: interquartile range; CGM: continuous glucose monitoring.

**Table II.** Median Values for Pilots Receiving a Final Denial and Special Issuance Compared to the 2022 ADA Recommendations.

| PARAMETER | ADA RECOMMENDATIONS | FINAL DENIAL PILOTS MEDIAN (IQR) | SPECIAL ISSUANCE PILOTS MEDIAN (IQR) |
|---|---|---|---|
| HbA1c (%) | <7 | 7.10 (6.8 to 7.4) | 6.50 (6.0 to 6.7) |
| Time in Range (%) | >70 | 71.00 (61.2 to 80.9) | 95.00 (82.0 to 97.0) |
| Time Glucose < 70–80 mg · $dl^{-1}$ (%) | <4 | 2.00 (1.0 to 4.0) | 1.00 (0.3 to 2.1) |
| Glucose Coefficient of Variance* | <36 | 33.50 (30.2 to 36.6) | 26.90 (21.9 to 30.2) |

ADA: American Diabetes Association; HbA1c: hemoglobin A1c; IQR: interquartile range.

*This metric is mentioned by the ADA; however, it is not part of their recommendations for treatment goal endpoints.

lower CV (26.9 vs. 33.5, $P < 0.001$), and higher CGM use time (98% vs. 91%, $P = 0.002$). Pilots issued an SI also spent less time with low glucose levels (1.0% vs. 2.0%, $P = 0.010$) and high glucose levels (0.95% vs. 7.60%, $P < 0.001$), and spent a higher percent of TIR (95.0% vs. 71.0%, $P < 0.001$). Sex ($P = 0.574$) and duration of diabetes ($P = 0.712$) did not reach statistical significance. There was also no statistical difference in diabetic complications between pilots with an SI and pilots who were denied (Table I).

## DISCUSSION

In general, pilots who received an SI for ITDM had better diabetes control than those who were denied. This is especially true when examining CGM parameters and HbA1c. This is not surprising as the FAA criteria for certification of ITDM pilots includes cutoffs for these parameters to ensure that pilots have well-controlled diabetes with a low risk of complications. These cutoff values were based on both ADA recommendations as well as recommendations from FAA endocrine consults.

An HbA1c < 7% has been shown to reduce microvascular complications.[11,12] Currently, the ADA recommendations include an HbA1c < 7% for many nonpregnant adults without a history of significant hypoglycemia (Grade A recommendation). HbA1C levels < 7% are potentially beneficial if they can be achieved safely without significant hypoglycemia or other adverse effects of treatment (Grade B recommendation).[24] TIR has been shown to correlate well with HbA1c, with TIR > 70% corresponding to an HbA1c of approximately 7%.[1] New data also suggests that increased TIR correlates with a decreased risk of complications.[13,24] Tighter control of diabetes additionally reduces the risk of clinical complications.[18] The ADA also recommends a parallel goal of TIR of > 70% with time below range < 4% and time < 54 mg · $dl^{-1}$ < 1% for nonpregnant adults (Grade B recommendation).[24] Time above 250 mg · $dl^{-1}$ demonstrates an increased risk of diabetic ketoacidosis and long-term complications,[14] and the ADA suggests that time above target (glucose > 180) as well as TBR are both useful for re-evaluation of clinical treatment recommendations (Grade C recommendation).[24] Studies also show that hyperglycemia is associated with changes in the central nervous system white matter over time.[5,19]

Another important CGM metric is the SD of glucose levels and the CV that reflects variability relative to the mean (SD/mean). CV is less vulnerable to influence by hyperglycemic excursions than SD. In general, lower variability as represented by a CV of < 33%[16] up to 36%[17] has been considered good clinical glycemic control and hypoglycemic events have been shown to be less prevalent in patients with a CV < 36%.[7,8,17] A high CV (> 36%) was correlated with multiple clinical variables correlating with poor diabetic control such as GFR < 45 ml · $min^{-1}$, HbA1C > 9%, and a history of hypoglycemia.[7]

Our results show that SI pilots met the ADA's clinical recommendations and the median interquartile range (IQR) values are consistent with clinical and ADA recommendations (**Table II**). This is not surprising, as ADA recommendations were used in creating the certification criteria. However, these results show that the FAA was able to successfully implement a protocol that identified pilots who would be at lower risk for sudden or subtle incapacitation. We also found that denied pilots met (TIR, TBR, CV) or almost met (HbA1c) most ADA criteria (Table II). However, the middle 50% of values (the IQR) for many of the parameters in the denied group often included values outside of the ADA recommendations, demonstrating that at least 25% of denied pilots did not meet ADA criteria for that parameter. Most pilots were denied based on only a few parameters (e.g., they had an acceptable HbA1c, but their TIR or sensor wear time did not meet criteria), which may explain the increased variation of values in denied pilots.

There were no differences in end-organ complications between pilots issued an SI and those who were denied. This is somewhat surprising as there was a large difference in the median time above range [7.60% (IQR: 2.5–11.5%) vs. 0.95% (IQR: 0.0–2.0%)], which generally correlates with diabetic complications.[18] This could be a result of pilots with more severe end-organ damage self-selecting out due to concern of denial or having been denied based on other comorbidities that would preclude certification.

The FAA does not consider age or sex in making certification decisions and duration of diabetes was not one of the parameters used to select pilots eligible for the ITDM. As expected, sex was not significantly different between pilots who received an SI versus those who were denied. The percent of male pilots in this study's population was similar to the percent of male Class 1 and Class 2 pilots (92.4%). Duration of diabetes was also not significantly different between these populations.

Although age at the time of certification is not a factor in decision making by the FAA, there was a statistical difference between the groups. Those pilots who received an SI tended to

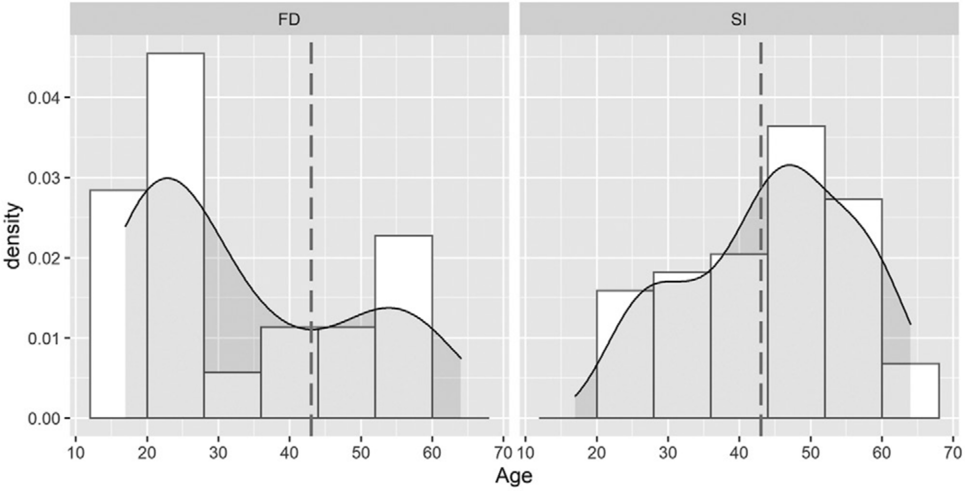

**Fig. 1.** Distribution of age in years for pilots who received a final denial (FD) and a special issuance (SI).

be older than those who were denied. This was surprising to us as older patients might be expected to have a longer duration of illness and therefore greater likelihood for end organ complications. To this point, duration of diabetes was not statistically significant, which would be consistent with the lack of any significant difference in end-organ disease. All pilots in this study age 22 and under (*N* = 7) were denied, and the distribution of denied pilots was bimodal with a second peak near 50 yr old (**Fig. 1**). One explanation is that younger pilots have more trouble with diabetic control. One study showed that younger patients with type 2 diabetes had worse glycemic control;[22] of note, the two age groups were < 60 and > 60 yr of age and this study was done on a type 2 diabetes population, whereas our population is mostly type 1 diabetics. Another study done in New Zealand found that in patients with type 1 diabetes, HbA1c was highest for the age range between 15–29 yr.[4] Additionally, diabetes is a progressive disease and glucose levels are known to increase with age.[22] This means that older pilots may have fewer hypoglycemic events, the major complication of most concern to the FAA. Additionally, those diagnosed with type 2 diabetes at younger ages may have a severe disease, a higher degree of insulin resistance, and worse glycemic control.[22]

This study is limited by its small sample size and the fact that the data collected for initial certification did not provide sufficient in-flight monitoring data for analysis. In the future, analyzing such data from pilots for the periods in which they are flying may be of interest.

Of note, CGM data measures interstitial blood glucose and is an indirect measurement of blood glucose. This does not appear to be a significant concern as CGM parameters have been highly studied and are reliably correlated to diabetes control. In addition, CGM data is far richer and easily accessible with current technology than traditional finger stick methods. Another concern is that CGM measures interstitial glucose and has a 5-to-10-min lag time when compared to blood glucose measurements. This delay is not important when analyzing retrospective glucose data, but might be critical when CGM is used for real-time decision making by pilots. This is partially mitigated by the generally low prevalence of hypoglycemic events in the certified pilots (as demonstrated by a low TBR) and by the CGMs' ability to analyze trends and notify pilots of "impending" lows so that interventions can be taken before a low occurs.

The FAA created strict standards to mitigate against hypoglycemic events, meaning that some pilots were denied who may eventually be shown to have low risk for incapacitation. This conservative approach is employed to assure the safety of pilots, passengers, and the general public, and to maintain the safety of the National Airspace. As technology for diabetes control improves and clinical guidelines evolve, the ITDM program will continue to adapt. Also, many commercial pilots fly in single pilot operations, and advances in automation has raised interest by scheduled air transport operators (major airlines) to consider transition to single pilot operations as well. The current FAA protocol allows ITDM pilots to perform flight duties without the need for a copilot backup.

The data reviewed also highlight the difficulty the FAA faces in risk-based decision making for ITDM. Clinical providers know that the clinical presentation of patients with ITDM is very diverse. "Acceptable clinical control" differs by the needs and circumstances of the individual patient and may not match generally accepted treatment target ranges. Likewise, no two pilots presenting to the FAA are identical. The FAA's challenge is to distill data comprised of combinations of categorical and almost innumerable continuous values to make a go/no-go decision. Because neither ITDM nor clinical control are static, clinicians look for minimized variability within acceptable targets and overall consistent control consonant with reduced short- and long-term health risks. The FAA takes the same approach a step further to look at the risks during flight. Thus, the FAA go/no-go assessment is not based on any single datum or cutoff values, but an overall assessment of effective clinical control and minimized glycemic variability. The results of this study are consistent with this, showing that there are significant differences between pilots found eligible for SI and those who are not.

CGM has allowed the FAA to create a program to medically certify pilots with ITDM. This study evaluated the ITDM protocol and demonstrates that the FAA has successfully medically certificated pilots with ITDM for first-/second-class using CGM devices. Pilots granted an ITDM SI reflect significantly better diabetes control, including less time at glucose levels concerning for hypoglycemia. As this program continues and evolves, it will potentially allow many previously disqualified pilots to fly safely.

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# In-Flight Medical Emergencies Management by Anesthetist-Intensivists and Emergency Physicians

Sylvain Diop; Ron Birnbaum; Fabrice Cook; Roman Mounier

**BACKGROUND:** In-flight medical emergencies (IME) are challenging situations: aircraft cabins are noisy and narrow, medical supplies are scarce, and high-altitude related physiological changes may worsen chronic respiratory or cardiac conditions. The aim of this study was to assess the extent to which anesthetist-intensivists and emergency physicians are aware of IME specificities.

**METHODS:** A questionnaire containing 21 items was distributed to French anesthetist-intensivists and emergency physicians between January and May 2020 using the mailing list of the French Society of Anesthesia and Intensive Care Medicine and the French Society of Emergency Medicine. The following topics were evaluated: high-altitude related physiological changes, medical and human resources available inside commercial aircraft, common medical incidents likely to happen on board, and previous personal experiences.

**RESULTS:** The questionnaire was completed by 1064 physicians. The items corresponding to alterations in the arterial oxygen saturation, respiratory rate, and heart rate at cruising altitude were answered correctly by less than half of the participants (respectively, 3%, 42%, and 44% of the participants). Most responders (83%) were interested in a complementary training on IME management.

**DISCUSSION:** The present study illustrates the poor knowledge in the medical community of the physiological changes induced by altitude and their consequences. In addition to offering specific theoretical courses to the medical community, placing sheets in commercial aircraft summarizing the optimal management of the main emergencies likely to happen on board might be an interesting tool.

**KEYWORDS:** in-flight medical emergency, aviation, cardiac arrest, training, extreme environments, high altitude physiology.

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Commercial air flight is becoming the most popular means of human transportation worldwide. About four and a half billion people traveled by plane in 2019 according to the International Civil Aviation Organization. As a result of the global aging of the population, in-flight medical emergencies (IME) are expected to increase as well.[7] Previous studies reported the IME incidence is 1 per 10,000 to 40,000 passengers traveling each year and, in 50–75% of the cases, a physician is present onboard.[4,5,7]

Managing an IME is challenging for any clinician, especially for those who have had no specific training in emergency medicine.[4] Aircraft cabins are narrow, noisy, and low-resource environments. Patient examination may also be complicated by a language barrier.[5] Available medical supplies are limited and depend on airline companies.[7] Moreover, high altitude exposes passengers to hypobaric hypoxia, and thus a drop in arterial oxygen partial pressure ($P_aO_2$), potentially leading to the worsening of pre-existing medical conditions such as chronic obstructive pulmonary disease (COPD) or chronic heart failure.[1] It would, therefore, be helpful for any physician to understand the physiological changes induced by altitude, be

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aware of the main IME encountered during a commercial flight, and also which medical and human resources are available on board to deal with those. Because of their specific training, anesthetist-intensivists and emergency physicians should be expected to appropriately manage such emergencies. The aim of the present study was to evaluate their current knowledge in the following aspects of IME: high-altitude related physiological changes, medical and human resources available inside commercial aircraft, and knowledge of the most common medical incidents likely to happen on board. Previous personal experiences were also investigated.

## METHODS

### Subjects

We conducted a French prospective observational study from January to May 2020 among French anesthetist-intensivists and emergency physicians (residents and attendings). The primary outcome was the descriptive analysis of the results from a 21-item questionnaire. The answers were provided anonymously. No personal information was recorded. The study obtained a favorable decision from the French Society of Anesthesia and Critical Care Medicine [Société Française d'Anesthésie Réanimation (SFAR)] ethics committee (registration number IRB 00,010,254-2020-003).

### Survey

The following topics were evaluated: 1) air flight physiological changes; 2) medical and human resources available onboard; 3) practical considerations: common medical incidents likely to occur on board; and 4) personal experiences. An e-mail including the rationale of the present study and a link to the survey was sent to the members of the French Society of Anesthesia and Critical Care Medicine (SFAR) and the French Society of Emergency Medicine [Société Française de Médecine d'Urgence (SFMU)]. The survey was edited by SFAR through the website SurveyMonkey© (www.surveymonkey.com). The study lasted 5 mo (from January 1st to May 31st, 2020). Every questionnaire fully completed during this period was included and analyzed. Those that were either incomplete or received too late were not considered.

### Statistical Analysis

We provide a strict report of the answers to our questionnaire. Results are reported as absolute values and percentage. Statistical analysis was performed using Microsoft Excel© (Microsoft Office 2021©).

## RESULTS

A total of 1064 physicians completed the survey: 882 (83%) anesthetists and 182 (17%) emergency physicians; 857 (81%) attendings and 207 (19%) residents (**Table I**). The items corresponding to alterations in arterial oxygen saturation, respiratory rate, and heart rate at cruising altitude were answered correctly by less than half of the participants (respectively, 3%, 42%, and 44% of the responders). Of the participants, 141 (13%) and 184 (17%) were aware that the presence of an automated external defibrillator (AED) on board is not mandatory and that oxygen flow is limited.

Among the participants, 559 (53%) had an accurate knowledge of the most common medical incidents likely to happen on board (**Table II**). There were 476 participants (44.7%) who had already attended during an IME. Among those, 245 (51%) were not confident during their intervention. Finally, 881 responders (83%) were interested in attending a specific training on IME management.

## DISCUSSION

Our results emphasize several points. First, basic physiological changes induced by altitude, such as hypoxia or alterations

**Table I.** Physiological Changes Induced by High Altitude and Medical/Human Resources Available on Board.

| QUESTIONS | CORRECT ANSWER | NUMBER OF CORRECT ANSWERS *N* (%) |
|---|---|---|
| With altitude, partial pressure of arterial oxygen | Decreases | 1012 (95%) |
| The pressure in the aircraft cabin at cruising altitude | Is equivalent to the pressure at an altitude of 6562–8202 ft (2000–2500 m) | 583 (55%) |
| The volume of gas in a closed cavity | Increases when atmospheric pressure decreases | 806 (76%) |
| At cruising altitude, arterial oxygen saturation at rest | Ranges between 88 to 92% | 32 (3%) |
| At cruising altitude, minute ventilation at rest | Is higher than at sea level | 444 (42%) |
| At cruising altitude, heart rate at rest | Is higher than at sea level | 473 (44%) |
| Onboard, the hydration state | Dehydration is higher than at sea level | 904 (85%) |
| Medical/human resources available onboard | | |
| Cabin crew is systematically trained to cardiopulmonary resuscitation | Yes | 1016 (95%) |
| Legally, all airline companies have to be equipped with an automated external defibrillator | No | 141 (13%) |
| Administration of high flow oxygen (flow > 5 $L \cdot min^{-1}$) is possible onboard | No | 184 (17%) |
| Aircraft captain authorization is necessary to open the medical kit | Yes | 660 (62%) |

**Table II.** Practical Considerations and Previous Personal Experiences.

| QUESTIONS | CORRECT ANSWER | NUMBER OF CORRECT ANSWERS *N* (%) |
|---|---|---|
| Preflight medical examination is mandatory for patients with chronic medical conditions | No | 953 (90%) |
| In the following list, which emergency is the most often encountered onboard | Syncope | 559 (53%) |
| A ground medical assistant is available 24 h per day | Yes | 753 (71%) |
| In the event of a cardiac arrest, the decision to divert a flight must be taken | After ROSC* | 262 (25%) |
| In case of an emergency the decision to divert a flight is taken by | The aircraft captain | 842 (79%) |
| | **YES** | **NO** |
| Previous personal experiences | | |
| Have you ever assisted with an IME** (*N* = 1064)? | 476 (45%) | 588 (55%) |
| Did you feel confident during your intervention (*N* = 476)? | 245 (51%) | 235 (49%) |
| Do you think that a complementary training about IME** management would be useful (*N* = 1064)? | 881 (83%) | 181 (17%) |

*Return to spontaneous circulation; **in-flight medical emergency.

in respiratory and heart rates, are ignored by many physicians. Secondly, there is a misconception regarding available medical resources on board. Finally, the majority of the responders are interested in a complementary course regarding this specific topic.

Commercial aircraft cabins cruise at an altitude comprised between approximately 32,808 to 45,932 ft (10,000 to 14,000 m) above sea level. Compared to the values measured on the ground, the atmospheric pressure at such altitudes is diminished, resulting in a lower oxygen partial pressure. In order to mitigate the hypoxia resulting from exposure to this environment, airplane cabins are pressurized to reproduce the atmospheric pressure recorded at an altitude of 6562–8202 ft (2000–2500 m). Although effective, this countermeasure fails to completely prevent the occurrence of a relative hypoxia and mean arterial oxygen saturation often ranges between 88% and 92%.[1] While a healthy patient can easily tolerate such $S_pO_2$ levels, those suffering from chronic medical conditions may not.[3] Relative hypoxia induces compensatory hyperventilation, tachycardia, and an increased hypoxic pulmonary vasoconstriction; the increased cardiac output, resulting from the tachycardia, limits the diffusion of oxygen from the alveoli to the arteriolar blood and, therefore, worsens the hypoxemia. All these phenomena are potentially harmful for COPD patients or those suffering from chronic heart failure.[1,3]

According to the Boyle-Marriot law, a decrease in the atmospheric pressure induces an increase in the volume of gases present in closed cavities, such as the sinuses, intestines, and lungs. It may be responsible for specific benign symptoms such as abdominal, ear, or sinus pain.

The most frequently reported emergency is syncope, which is relatively easy to diagnose and manage.[5,7] Fortunately rare (0.3% of all IME), in-flight cardiac arrest remains one of the most dreaded events by physicians. A previous work reports a total survival rate of 14% among 40 patients experiencing in-flight cardiac arrest.[2] Among those presenting with a shockable ventricular fibrillation or ventricular tachycardia, survival increased to 50%. In contrast, none survived with asystole as the initial rhythm.[2] Few recommendations regarding in-flight cardiac arrest management have been published and some specificities must be considered: high altitude exposure leads to a decreased stroke volume, therefore, intravenous fluid expansion should be promptly considered; and high altitude rapidly increases blood epinephrine level, thus, epinephrine injection may be less efficient.[3,4,6]

The decision to divert a flight is under the sole responsibility of the aircraft commander. It implies additional risks for both crew and passengers, due to an unplanned landing in potentially degraded conditions (overweighted plane and/or poor weather conditions).[4] Moreover, a previous study reported that in the event of an in-flight cardiac arrest with a nonshockable rhythm, the mortality rate was 100%. Diverting a plane for those cardiac arrests might not be appropriate.[2] It seems more reasonable to recommend plane diversion in the event of a cardiac arrest with a shockable rhythm or once the patient resumes a spontaneous cardiac rhythm.[4,6]

Obviously, every situation is unique and should be analyzed as such. On-ground medical assistance is constantly available and may help to make such a decision. An AED is standard and essential equipment to improve survival in case of a cardiac arrest with a shockable rhythm.[2,6] Yet it is not mandatory to have one aboard all commercial aircraft. The U.S. Federal Aviation Administration requires that all planes traveling to or from the United States carry an AED on board, while the European Union Aviation Safety Agency (EASA) does not.[4] EASA recommends carrying an AED according to risk assessment procedures, at the discretion of the operator in charge (number of passengers, flight duration). Fortunately, most of the airlines provide an AED on board.

Respiratory symptoms are the second cause of IME. Hypoxia may exacerbate chronic cardiorespiratory conditions such as asthma, COPD, or chronic heart failure.[1] Preflight medical consultation is not mandatory before flight. However, patients with severe conditions and/or with home oxygen therapy might benefit from a medical examination before boarding an airplane.[1] If necessary, companies may provide supplemental oxygen on demand. Physicians must be aware that in a commercial aircraft, oxygen delivery systems are usually limited to a maximum flow of $4\ \mathrm{L} \cdot \mathrm{min}^{-1}$.[1]

Our study obviously suffers from certain limitations. Any physician, regardless of medical training, can be confronted with an IME; therefore, it could have been interesting to target the whole medical community. We focused on anesthetist-intensivists and emergency physicians because, among all, they are the most trained to adequately face a medical emergency. Even in this highly trained population, we underline the lack of knowledge regarding high altitude physiological changes and the available resources on board.

Our survey highlights that about half of the participants experienced an IME and, among those, half were not confident during their intervention. Moreover, the majority of the participants considered that a complementary training would be beneficial in order to improve IME management.

In conclusion, IME are expected to increase over the years and remain challenging situations for physicians. A complementary training, at least theoretical, seems necessary to improve IME management. For example, didactic online training courses could be offered. Another interesting tool could be to provide simple and clear sheets aboard airplanes summarizing the main physiological changes induced by altitude and the optimal management of the most common emergencies.

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# A Preliminary Analysis of the Costs and Benefits of Physical Therapy and Strength Training for Fighter Pilots

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**BACKGROUND:** Occupational hazards facing high performance aircraft pilots ("fighter" pilots) can cause injury, time lost from flying, and voluntary or involuntary career termination. The high cost of training and retaining fighter pilots has spurred interest in the cost effectiveness of preventative and rehabilitative health solutions.

**METHODS:** We investigated the potential cost effectiveness of a 5-yr, $24.9M U.S. preventative health program using equivalent annual worth (EAW) analysis. The program benefits were assessed with a combination of actual and estimated medical cost data and projected pilot retention improvement rates. Sensitivity analysis of variables such as discount rate, medical cost avoidance, and pilot retention improvement rate was conducted.

**RESULTS:** Annualized costs of approximately $5M U.S. were used as the basis of comparison for annualized benefits. A medical cost database was searched to find expected annual direct medical (outpatient) costs related to injury of roughly $531K U.S. for the pilots covered by the program. Using Centers for Disease Control recommendations, approximately $4.7M U.S. was estimated to be the annual work loss cost. The program would presumably reduce a significant portion of these annual costs, but not all. Assuming various proportions of reduced costs by the program, the EAW was found to be consistently negative. However, when pilot retention improvement is included, EAW is positive using conservative assumptions.

**DISCUSSION:** While outpatient and work loss costs will unlikely be completely covered by preventative health programs in this context, a minor improvement in pilot retention (about 1–3 additional retentions per year) produces a net positive annual benefit.

**KEYWORDS**: fighter aircrew, preventive health program, rehabilitative health solutions, cost benefit analysis, economic analysis.

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Occupational hazards facing high performance military aircraft pilots ("fighter" pilots) can cause injuries, time lost from flying, and, in extreme cases, voluntary or involuntary career termination.[5,9,10] Because of the high cost associated with fully training fighter pilots (estimates range from $3M to $11M, depending upon airframe),[11,15] military organizations such as the North Atlantic Treaty Organization (NATO)[12] and the U.S. Air Force (USAF) are highly interested in mitigating those hazards. Days lost from flying can cause mission readiness issues and costly training delays. Additionally, when pilots leave the cockpit for health reasons earlier than a "natural" progression rate (e.g., promotion, retirement), a replacement must be recruited and trained.

Risks of acute and chronic cervical spine injury are of particular interest and concern. Studies have shown that the offensive and defensive maneuvering required of fighter pilots increases the risks associated with neck and spine injuries.[7,8] Maintaining situational awareness in this environment by turning the head

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during high stress maneuvers requires withstanding pressure many times the normal force of gravity ("g" force). The use of night vision goggles and helmet mounted cueing systems (e.g., the Joint Helmet Mounted Cueing System) has been found to exacerbate neck pain.[10] A recent meta-analysis found the prevalence of neck pain in the fighter pilot community (~50%) to be about 10 times the prevalence in the greater population (~5%).[13]

The high cost of recruiting, training, and retaining these pilots has spurred interest in the cost effectiveness of preventative and rehabilitative health solutions.[11,14] Exercise interventions are widely accepted as the primary rehabilitative treatment modality for chronic musculoskeletal pain in general.[3] Additionally, studies have provided preliminary evidence that rigorous strength training may reduce cervical injury rate and severity in fighter and helicopter pilots.[1,2] In other words, there is evidence that preventative or "prehabilitative" exercise programs can reduce pilot injuries. However, the cost effectiveness of such programs has not been rigorously analyzed. This study is a preliminary attempt to address this gap in the literature by examining the cost effectiveness of a new program launched by the USAF.

In 2017, the USAF held a Dedicated Aircrew Retention Team Summit (sponsored by the Aircrew Crisis Task Force). The summit identified 44 recommendations to aid the Air Force with retention challenges.[15] Many of those recommendations have already been implemented, including "preventative medical care for back and neck injuries." Implementation of the 5-yr, $24.9M Optimizing the Human Weapon System (OHWS) program started with four bases and was then expanded in 2020 across three commands: Air Combat Command, Pacific Air Forces, and U.S. Air Forces in Europe.[6] The OHWS program is designed to meet the unique physical needs of Air Force fighter pilots through a comprehensive "prehabilitative" physical training program that employs focused strength and conditioning, physical therapy, and athletic training.[6]

## METHODS

### Data Sources and Modeling Framework

The Medical Cost Avoidance Model (MCAM), developed by the U.S. Army's Institute of Public Health, provides a useful model for capturing medical costs for U.S. military personnel. Specifically, the medical costs are summed to produce total medical cost ($C_t$) using this simple equation (variables summarized in **Table I**):[14]

$$C_t = C_c + C_h + C_l + C_f + C_d$$

MCAM is specifically tailored to capture return on investment for prevention programs based on medical costs associated with specific International Classification of Disease, 9th Revision codes. Direct access to MCAM data was unavailable at the time of the study; however, the primary database it uses to obtain medical and treatment costs [the Force Risk Reduction Tool (FR2)] was available.

Much of the data for this research were obtained from the Military Injury Medical Treatments and Casualties dashboard provided by the FR2 tool, managed by the Office of the Under Secretary of Defense for Personnel and Readiness. The tool provides comprehensive roll-ups of military injury treatment claims data from military and nonmilitary facilities, including costs incurred by the military medical system to treat injuries in military personnel. The Force Risk Reduction tool is a wide-ranging database with over 400,000 records, numerous dashboards, and extensive filtering capabilities.

**Table I.** The MCAM Medical Cost Components, Definitions, and Descriptions.

| COST COMPONENT | DEFINITION | DESCRIPTION |
|---|---|---|
| $C_c$ | Clinic cost | Outpatient Treatment |
| $C_h$ | Hospital cost | Inpatient Treatment |
| $C_l$ | Lost time cost | Time away from work due to clinic visits, hospital stays, assignment to quarters, convalescent leave, and the limited ability to perform |
| $C_f$ | Fatality cost | Insurance and gratuity pay |
| $C_d$ | Disability cost | VA compensation disability |

### Inclusion/Exclusion Criteria

First, we filtered FR2's Military Injury Medical Treatments and Casualties dashboard for branch of service, installation, and military treatment facility. A total of 21 bases participated in the OHWS program, and FR2 data were available for 20. Each available installation was filtered by component and occupation. The component filter was set to "active duty" to exclude the reserve component. Additionally, the occupation filter was set to "fixed wing fighter/bomber pilot." Using these filters ensured to the greatest extent possible only the fighter pilots eligible for the OHWS program comprised the data retrieved from the tool. Bomber pilots were excluded from the data by default; the 20 bases for which data were collected were fighter bases (i.e., those bases did not have a bomber pilot population).

For the purposes of this research, both ergonomic injuries (e.g., caused by repeated motion, vibration, noise, etc.) and nonergonomic injuries (e.g., orthopedic) were included in the data. Anatomical locations of injuries we included in the data were upper extremities, lower extremities, neck, hip, spinal cord, pelvis and lower back, and the vertebral column. The list of included injury diagnoses is shown in **Table II**. It was not possible to distinguish between occupational injury (cockpit related) and off-duty injury (e.g., sports injury). The OWHS program is also not limited to the treatment of occupational injury, therefore the use of the filtered FR2 data set was appropriate for this research. However, due to the nature of the data, no isolated analysis was possible for occupational injuries.

Ultimately, the filtered data consisted of outpatient information (equivalent to $C_c$ in the MCAM). It did not contain inpatient treatment costs, $C_H$, which presumably were not extensive for typical musculoskeletal injuries, so we excluded this variable in our calculations. Lost time cost, $C_l$, fatality cost, $C_f$, and disability cost, $C_d$, were also not included. Although fatality cost

**Table II.** Primary Injury Diagnoses: FR2 Data.

| INJURY DIAGNOSIS | ANATOMICAL LOCATION |
|---|---|
| Pain in hip<br>Sprain of hip<br>Strain of muscle | Hip |
| Pain in knee<br>Pain in ankle<br>Strain of muscle<br>Sprain of joint<br>Plantar fascial fibromatosis | Lower extremities |
| Cervicalgia<br>Strain of muscle<br>Torticollis<br>Sprain of joints and ligaments of neck | Neck |
| Low back pain<br>Sprain of lumbar spine<br>Sacroiliitis | Pelvis and lower back |
| Pain in thoracic spine<br>Radiculopathy | Spinal cord |
| Pain in shoulder<br>Pain in elbow<br>Pain in hand and fingers<br>Pain in wrist<br>Strain of muscle<br>Sprain of joint<br>Impingement syndrome | Upper extremities |
| Cervical disc disorder<br>Intervertebral disc displacement<br>Cervical disc displacement<br>Spinal stenosis<br>Intervertebral disc disorder<br>Sprain of joints and ligaments of spine<br>Thoracic disc disorder | Vertebral column |

is high when it occurs, we assumed it was a rare occurrence and excluded it. For this research, we made the very conservative assumption that the OHWS program would not reduce disability cost (e.g., Veteran's Affairs disability) and excluded it as a variable. However, we believe an expected reduction in disability cost is a reasonable hypothesis for future researchers to explore. Because lost time costs were not included in FR2, we estimated them using Centers for Disease Control and Prevention (CDC) Cost of Injury Reports statistics.[4] Injury work reports were obtained from the CDC that attribute average work loss costs on a per-injury basis based on anatomical location and type of injury.

### Equivalent Annual Worth Analysis

We investigated the potential cost effectiveness of the OHWS preventative health program using equivalent annual worth (EAW). The most straightforward part of the analysis is the cost of the program, approximately $2.4M in setup costs and annual operating costs of $4.5M for 5 yr. In general, the potential medical costs that can be avoided due to the services provided to fighter pilots under the OWHS program will represent positive cash flows in the analysis ("benefits"). These benefits would come in the form of direct reductions in medical care costs and associated indirect reductions in work loss costs. Another potentially quite large contribution to cost avoidance would be any reduction of voluntary or involuntary career termination caused by the program. While it is difficult to obtain precise estimates for any of these cost avoidance variables, conducting sensitivity analysis with a wide range of assumptions, from optimistic to extremely conservative, allows for meaningful interpretation of the results. For instance, if the expected annual worth of the OHWS program is positive under extremely conservative assumptions, it likely has a positive return on investment.

Other aspects of EAW analysis include the choice of the discount rate and the treatment of inflation. Generally, interest rates used in government cost benefit analysis calculations come from the Office of Management and Budget Circular A-94. Although interest rates in recent years have been quite low, we chose 0–8% as a reasonable range for the discount rate for this study. All data used in the EAW analysis was either inflated to Base Year 2020 dollars or, in the case of the outyears of the contract, deescalated to Base Year 2020 dollars. Inflation indices used for this purpose were obtained from the Office of the Secretary of Defense raw inflation rates.

An EAW is obtained by calculating the net present value (NPV) and then annualizing that value with an annuity factor. Specifically, we calculated our EAW values using the following formulas:

$$\textbf{OHWS NPV} = -\,\textit{OHWS Contract Setup Cost} + \sum_{n=1}^{n} \textit{Anticipated Cost Savings}\left[\frac{1}{(1+i)^n}\right] - \sum_{n=1}^{n} \textit{OHWS Operating Costs}\left[\frac{1}{(1+i)^n}\right]$$

$$\textit{where}: i = \textit{discount rate},$$

$$n = \textit{year of } \frac{\textit{expenditure}}{\textit{savings}},$$

$$\left[\frac{1}{(1+i)^n}\right] = \textit{present value factor}$$

$$\textbf{OHWS EAW} = \textit{OHWS NPV}\left[\frac{i(1+i)^n}{(1+i)^n-1}\right]$$

$$\textit{where}: i = \textit{discount rate},$$

$$n = \textit{year of } \frac{\textit{expenditure}}{\textit{savings}},$$

$$\left[\frac{i(1+i)^n}{(1+i)^n-1}\right] = \textit{annual annuity factor}$$

## RESULTS

### Benefits

We analyzed 2489 total injury cases over a 3-yr period prior to the start of the OHWS program (2016–2018) at the 20 participating bases for which data were available. Among these cases, the most common injuries were low back pain, with 767 cases, and neck pain, with 384 cases. The “Benefits” section of **Table III** summarizes total outpatient and work loss costs associated with these injury cases. The outpatient costs were obtained from the FR2 database. Work loss cost estimates were derived from CDC per-injury cost figures based on the anatomical location of each injury.[4] For the 2489 injury cases that we observed, the total outpatient and work loss costs were ~$5.2M annually. For our EAW analysis, this figure represents the status quo value for health care costs without the OHWS program. It also represents the maximum outpatient and work loss cost savings (“benefits”) the OHWS program could achieve, assuming the OHWS program completely supplanted all musculoskeletal injury related health care visits.

An additional benefit we considered was the potential cost savings derived from an improvement in pilot retention attributable to the OHWS program. Although this benefit is not part of the MCAM model, the cost of training new fighter pilots is so high, this should not be ignored. According to a RAND study, the total cost of training basic qualified fighter pilots over 5 yr ranged from $5.6M to $10.9M (FY2018 dollars), depending on airframe.[11] We calculated the average cost of training one fighter pilot to be about $8.22M over 5 yr (FY2020 dollars), shown in annualized terms in the “Benefits” section of Table III.

### Costs

The “Cost” side of our EAW analysis is the annualized monetary costs needed to fund the OHWS program—primarily the contract costs, but also the anticipated work loss cost. For work loss costs, we considered two extreme possibilities (very pessimistic, very optimistic). At one extreme, we considered that work loss costs could be essentially the same (a “wash” cost) as they were prior to the new program (Table III). At the other extreme, we considered the possibility that the OHWS program may eliminate outpatient and work loss costs entirely (**Table IV**). Neither of these extremes is likely to occur, but they do encompass the entire range of possibilities. Sensitivity analysis labels in Table III (Best Case, Optimistic, Moderate, Pessimistic, Worst Case) correspond to different assumptions about the proportion of outpatient costs replaced by the OHWS program (100%, 90%, 50%, 10%, 0%). The corresponding sensitivity analysis labels in Table IV correspond to different assumptions about the proportion of outpatient and work loss costs supplanted and potentially reduced by the OHWS program. These values were chosen to provide a wide range of potential EAWs for the OHWS program (from extremely optimistic to extremely pessimistic).

### Equivalent Annual Worth

EAW is defined as the expected annual benefit minus the expected annual cost. We considered discount rates between 0% and 8%, in 2% increments, encompassing all plausible scenarios. Under the “wash” cost assumption for work loss costs, and without considering pilot retention changes, the EAW was consistently negative (between –$4.5M and –$5.1M per year). When work loss costs were assumed to be partially to completely eliminated by the OHWS program, the OHWS program achieved a positive EAW for the “Best Case” (between $100K and $237K per year), but was negative for all other levels (between –$300K and –$5.1M per year).

### Breakeven Analysis

The “Breakeven” sections of Tables III and IV provide the improvement in pilot retention required for the EAW to equal $0. For instance, when work loss costs are a wash and a 50% reduction in outpatient costs (the “Moderate” case) is considered at a 2% discount rate, a 2.67 improvement in pilot retention achieves breakeven for the program (see Table III). The equivalent scenario in Table IV (2% EAW, Moderate) requires a 1.35 improvement in pilot retention to achieve breakeven. Under the most conservative assumptions, the highest

**Table III.** Equivalent Annual Worth Summary Table (OHWS Replaces Up to 100% of Outpatient Costs; 0% of Work Loss Costs).

| SUMMARY | EAW 0% | EAW 2% | EAW 4% | EAW 6% | EAW 8% |
|---|---|---|---|---|---|
| **Benefits (B)** | | | | | |
| Outpatient | $530,838 | $530,665 | $530,506 | $530,360 | $530,228 |
| Work Loss (WL) is considered a wash cost | | | | | |
| 1 Pilot Training Year | $1,644,000 | $1,778,821 | $1,958,698 | $2,194,246 | $2,500,156 |
| **Costs (C)** | | | | | |
| OHWS Contract | $ 4,980,263 | $ 5,009,310 | $ 5,039,099 | $ 5,069,606 | $ 5,100,807 |
| **Net (B – C)** | | | | | |
| Best Case 100% | $(4,449,425) | $(4,478,645) | $(4,508,593) | $(4,539,245) | $(4,570,579) |
| Optimistic 90% | $(4,502,509) | $(4,531,712) | $(4,561,644) | $(4,592,281) | $(4,623,602) |
| Moderate 50% | $(4,714,844) | $(4,743,978) | $(4,773,846) | $(4,804,425) | $(4,835,693) |
| Pessimistic 10% | $(4,927,180) | $(4,956,244) | $(4,986,048) | $(5,016,569) | $(5,047,784) |
| Worst Case 0% | $(4,980,263) | $(5,009,311) | $(5,039,099) | $(5,069,606) | $(5,100,807) |
| **Breakeven*** | | | | | |
| Best Case | 2.71 | 2.52 | 2.30 | 2.07 | 1.83 |
| Optimistic | 2.74 | 2.55 | 2.33 | 2.09 | 1.85 |
| Moderate | 2.87 | 2.67 | 2.44 | 2.19 | 1.93 |
| Pessimistic | 3.00 | 2.79 | 2.55 | 2.29 | 2.02 |
| Worst Case | 3.03 | 2.82 | 2.57 | 2.31 | 2.04 |

OHWS: Optimizing the Human Weapon System; EAW: equivalent annual worth.

*Represents the improvement in pilot retention (# pilots) required for EAW to equal $0.

**Table IV.** Equivalent Annual Worth Summary Table (OHWS Replaces Up to 100% of Outpatient and Work Loss Costs).

| SUMMARY | EAW 0% | EAW 2% | EAW 4% | EAW 6% | EAW 8% |
|---|---|---|---|---|---|
| **Benefits (B)** | | | | | |
| Outpatient | \$530,838 | \$530,665 | \$530,506 | \$530,360 | \$530,228 |
| Work Loss (WL) | \$4,686,474 | \$4,685,180 | \$4,683,894 | \$4,682,617 | \$4,681,349 |
| Total | \$5,217,312 | \$5,215,845 | \$5,214,401 | \$5,212,978 | \$5,211,577 |
| 1 Pilot Training Year | \$1,644,000 | \$1,778,821 | \$1,958,698 | \$2,194,246 | \$2,500,156 |
| **Costs (C)** | | | | | |
| OHWS Contract | \$4,980,263 | \$5,009,310 | \$5,039,099 | \$5,069,606 | \$5,100,807 |
| **Net (B − C)** | | | | | |
| Best Case 100% | \$237,048 | \$206,535 | \$175,302 | \$143,372 | \$110,770 |
| Optimistic 90% | \$(284,683) | \$(315,050) | \$(346,139) | \$(377,926) | \$(410,388) |
| Moderate 50% | \$(2,371,607) | \$(2,401,388) | \$(2,431,899) | \$(2,463,117) | \$(2,495,018) |
| Pessimistic 10% | \$(4,458,532) | \$(4,487,726) | \$(4,517,659) | \$(4,548,308) | \$(4,579,649) |
| Worst Case 0% | \$(4,980,263) | \$(5,009,311) | \$(5,039,099) | \$(5,069,606) | \$(5,100,807) |
| **Breakeven*** | | | | | |
| Best Case | – | – | – | – | – |
| Optimistic | 0.17 | 0.18 | 0.18 | 0.17 | 0.16 |
| Moderate | 1.44 | 1.35 | 1.24 | 1.12 | 1.00 |
| Pessimistic | 2.71 | 2.52 | 2.31 | 2.07 | 1.83 |
| Worst Case | 3.03 | 2.82 | 2.57 | 2.31 | 2.04 |

OHWS: Optimizing the Human Weapon System; EAW: equivalent annual worth.

*Represents the required improvement in pilot retention (# pilots) required for EAW to equal \$0.

breakeven ratio was 3.03. In other words, if the program indirectly or directly causes three additional pilots to continue flying for the USAF (than would have otherwise), OHWS pays for itself.

## DISCUSSION

The implications of this preliminary study are promising for preventative medicine programs such as OHWS. Of course, there are many other variables that impact pilot retention, such as airline hiring practices, deployment fatigue, etc., but if preventative medicine programs have even a minor impact, they could be sound investments.[11,15,16] Certainly, the long-term health of fighter pilots is valuable regardless of its cost effectiveness, but finding efficient ways to achieve this goal is worth pursuing for policymakers.

While we have attempted to capture estimates of direct effects from the OHWS program (reductions in visits, less work loss time), it is interesting to consider possible indirect effects. Would having convenient access to health care (located in the squadrons) improve morale? Would pilots get the message from leadership (and by extension, the USAF) that their wellbeing matters? Could this have an impact on variables such as "intentions to stay in the USAF" or "organizational commitment"? This psychological information could perhaps be captured with surveys and interviews, and we recommend future research in this area.

There were many limitations to this study. First, data were available for only 20 of the 21 OHWS-participating bases. Therefore, it is likely that our comparison costs were underestimated. Second, pilot separation data that includes reasons for separation (e.g., to work for an airline, because of extended deployments, or because of chronic neck pain) were unavailable.[16] If this information were available, this study could have made reasonable estimates of likely effects from the OHWS program instead of attempting to encompass the entire range of possibilities. Reasons for separation gathered from exit interviews or other means would be invaluable information for researchers and policymakers. It is possible that this information is tracked by the USAF, but unsystematically and in disparate locations. We recommend the data be systematically gathered, cleared of any identifying, health-related information, and processed to avoid any potential security concerns. Then it should be made available to researchers and policymakers. An additional limitation is that we did not include any estimates for disability costs, fatality costs, or inpatient costs. Disability costs, in particular, may be extensive and preventative medicine programs such as OHWS may very well reduce them. According to a Government Accountability Office report, the average Veterans Administration disability compensation for Department of Defense personnel was about \$13K per year as of 2013.[17] Considering that pilots are officers, it is likely the disability compensation is higher for them. Future researchers should attempt to quantify preventative health program effects on disability.

The results of the current study indicate that from an EAW standpoint, preventative health programs such as OHWS have the potential to pay for themselves. Every circumstance is unique, but the MCAM framework appears to be a useful starting point for researchers, program managers, and decision makers to model the potential cost savings of a program.[14] In addition, factors outside the model may play an outsized role in capturing true benefits (as pilot retention improvement did in this study). While a positive EAW is a worthwhile objective, we caution against its use as a milestone or decision hurdle that must be achieved for program approval. Preventative health programs may have intangible benefits that are difficult to quantify in monetary terms. The intrinsic worth of such programs may be far more important than cost considerations.

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# Challenges in Quantifying Heel-Lift During Spacesuit Gait

Abhishektha Boppana; Steven T. Priddy; Leia Stirling; Allison P. Anderson

**INTRODUCTION:** Heel-lift is a subjectively reported fit issue in planetary spacesuit boot prototypes that has not yet been quantified. Inertial measurement units (IMUs) could quantify heel-lift but are susceptible to integration drift. This work evaluates the use of IMUs and drift-correction algorithms, such as zero-velocity (ZVUs) and zero-position updates (ZPUs), to quantify heel-lift during spacesuited gait.

**METHODS:** Data was originally collected by Fineman et al. in 2018 to assess lower body relative coordination in the spacesuit. IMUs were mounted on the spacesuit lower legs (SLLs) and spacesuit operator's shank as three operators walked on a level walkway in three spacesuit padding conditions. Discrete wavelet transforms were used to identify foot-flat phase and heel-off for each step. Differences in heel-off timepoints were calculated in each step as a potential indicator of heel-lift, with spacesuit-delayed heel-off suggesting heel-lift. Average drift rates were estimated prior to and after applying ZVUs and ZPUs.

**RESULTS:** Heel-off timepoint differences showed instances of spacesuit-delayed heel-off and instances of operator-delayed heel-off. Drift rates after applying ZVUs and ZPUs suggested an upper time bound of 0.03 s past heel-off to measure heel-lift magnitude with an accuracy of 1 cm.

**DISCUSSION:** Results suggest that IMUs may not be appropriate for quantifying the presence and magnitude of heel lift. Operator-delayed heel-off suggests that the SLL may be expanding prior to heel-off, creating a false vertical acceleration signal interpreted by this study to be spacesuit heel-off. Quantifying heel-off will therefore require improvements in IMU mounting to mitigate the effects of SLL, or alternative sensor technologies.

**KEYWORDS:** spacesuit, gait, biomechanics, inertial measurement, extravehicular activity.

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Future planetary spaceflight missions will require spacesuits which not only provide life support and environmental protection for crewmembers, but allow for mobility to perform extravehicular activity (EVA) tasks. However, spacesuit operators frequently report difficulty in working with the spacesuit during EVAs and on-ground training sessions, leading to occupational injuries risking mission success.[4] Poor operator-spacesuit interaction is a symptom of improper fit, hypothesized as one of the leading causes of spacesuit injuries.[4] Improper fit can be a factor of misalignment between the operator's and spacesuit's joints (indexing), and excessive internal gaps between the operator and spacesuit (sizing).[6,12] Poor indexing can lead to overuse of operator joints, risking musculoskeletal injury. Both poor indexing and poor sizing can lead to excessive internal contact between the operator and spacesuit, risking contact injuries such as bruising and abrasions.[4] As future spacesuit designs aim to reduce injury risk, they should target fit issues by understanding operator-spacesuit interactions.

Operator-spacesuit interactions have been shown to be dynamic and are best evaluated objectively with regards to the

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task the operator is expected to perform in the spacesuit.[6,12] Future planetary surface exploration EVAs will rely on crewmember ambulation, requiring that crewmembers are able to walk comfortably in their spacesuits. Therefore, designing spacesuits to accommodate lower body and foot motion while properly fitting an anthropometrically diverse range of crewmembers is crucial in reducing injury risk during suited ambulation.

Ground-based testing of the Mark III Advanced Space Suit Technology Demonstrator EVA Suit (MK III) has resulted in subjective reports of heel-lift, where the operator's heel rises inside the boot before the boot's heel lifts off the ground at heel-off.[6] Heel-lift can be represented as a lag between the operator's and spacesuit's heel-off times, and is an indicator of improper fit; the statically-determined indexing between the operator's and spacesuit's ankle joints does not allow for dynamic alignment during heel-off. Since the foot freely moves within the boot during heel-lift, this could lead to injury through excessive contact or ankle joint overuse when taking a step. Foot contact injuries and discomfort were reported during simulated planetary walkback testing with prototype boot designs.[4] Designing a planetary spacesuit boot to mitigate heel-lift requires a quantitative understanding of its presence and magnitude. However, heel-lift has only been subjectively reported by spacesuit operators and has yet to be quantified through in-suit motion measurement techniques.

Various sensor technologies have been used to estimate relative motion between the spacesuit and operator, including pressure sensors,[4] strain sensors,[13] and inertial measurement units (IMUs).[2,6] IMUs measure acceleration, angular velocity, and magnetic field; estimating orientation from these values. IMU Spacesuit applications include Fineman et al.'s[6] analysis of in-suit lower-body angular velocities of subjects walking with the MK III spacesuit, and Bertrand et al.'s[2] estimation of in-suit upper-body joint angles during isolated joint motions. IMUs can detect heel-off points during gait,[7,11] and therefore may be able to identify heel-lift instances where spacesuit heel-off lags operator heel-off. However, IMUs can be subject to error in their orientation estimates due to the magnetic field inside the spacesuit environment, and integration drift when calculating linear displacement and velocity quantities from acceleration measurements. Digital filtering methods, zero-velocity (ZVUs), and zero-position updates (ZPUs) have been used in the biomechanics field to correct for integration drift at every step,[5,11] but these methods have not been evaluated in their ability to be robust against spacesuit-environment induced error.

Therefore, this work aimed to evaluate the ability of IMUs, ZVUs, and ZPUs to quantify the frequency and magnitude of heel-lift in the spacesuit. Heel-off times were detected using spacesuit lower leg and operator shank IMU data during suited walking trails. Delayed spacesuit heel-off times compared to operator heel-off times were identified as potential occurrences of heel-lift. Then, ZVUs and ZPUs were evaluated for their ability to reduce integration drift and reliability quantify the heel-lift magnitude.

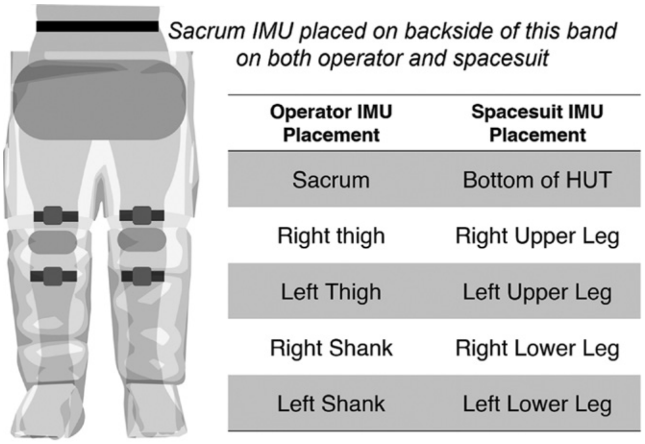
## METHODS

### Data Collection

Experimental data collected by Fineman et al.[6] was reanalyzed for this study. Subject naming was kept consistent with Fineman et al.[6] for cross-reference of results, with subjects numbered 2-4 as Subject 1 did not complete all trials. IMUs were placed on corresponding locations on the lower body of the spacesuit and operator (**Fig. 1**). Padding levels varied across configurations,[6] but were not expected to affect boot fit. It is assumed that the IMUs' x-axis was aligned with the long-axis of the shank and SLL; this axis was considered the vertical task axis. Three subjects walked in the MK III spacesuit along a 10-m walkway in each of four conditions: unsuited, MK III with no padding (configuration 0), MK III with one padding layer (configuration 1), and MK III with two padding layers (configuration 2). All subjects wore the same size MK III lower body assembly, but Subject 3 wore a BOA-laced boot with fit adjustment at the tongue and heel, while other subjects wore a standard strap-laced boot with only tongue fit adjustment. This work only analyzed a total of 216 suited trials, each with data from the left and right sides of the operator and spacesuit, yielding 432 datasets to analyze. Data from Subject 2's left leg during configuration 2 was not included due to data loss from the IMU.

### Data Analysis

The IMUs' vertical acceleration along the shank and SLL's long axis, and the IMUs' pitch angle data were analyzed. It was assumed that the shank and SLL have a rigid connection to their respective ankle joints. Therefore, the difference between the shank's and SLL's vertical position taken after the operator's heel-off time is the magnitude of heel-lift. Data analysis focused on isolating each individual step from the dataset, detecting heel-off points for the operator and spacesuit, and then implementing drift correction techniques to measure the vertical position of the shank and SLL.



| Operator IMU Placement | Spacesuit IMU Placement |
|---|---|
| Sacrum | Bottom of HUT |
| Right thigh | Right Upper Leg |
| Left Thigh | Left Upper Leg |
| Right Shank | Right Lower Leg |
| Left Shank | Left Lower Leg |

**Fig. 1.** Location of IMUs (squares, placed on both the spacesuit and operator) and padding (gray). The sacrum IMU is placed on the back of the operator and spacesuit, where the upper-most black band is located, and is therefore out of view in this diagram. The table on the right outlines the IMUs' corresponding locations between the operator and spacesuit.

Individual steps in each trial were identified to begin analysis. The shank and SLL IMUs' pitch angles were smoothed using a 10-sample window moving average filter. Individual steps for each trial were then identified by detecting peaks in each IMU's pitch angle, corresponding to the max posterior flexion/extension of the shank/SLL during swing phase. Each step was defined as the time between each step's max extension to the following step's max extension. The first and last peaks of the trial were removed from further analysis to ensure only complete steps were analyzed.

Foot-flat phase, where the foot is flat between toe-strike and heel-off, was identified to discriminate heel-off events. This phase is characterized by near-zero anterior-posterior acceleration; since the foot is flat on the ground, there is very little vertical movement of the shank.[11] Raw shank and SLL IMUs' vertical acceleration data was preprocessed for foot-flat detection by

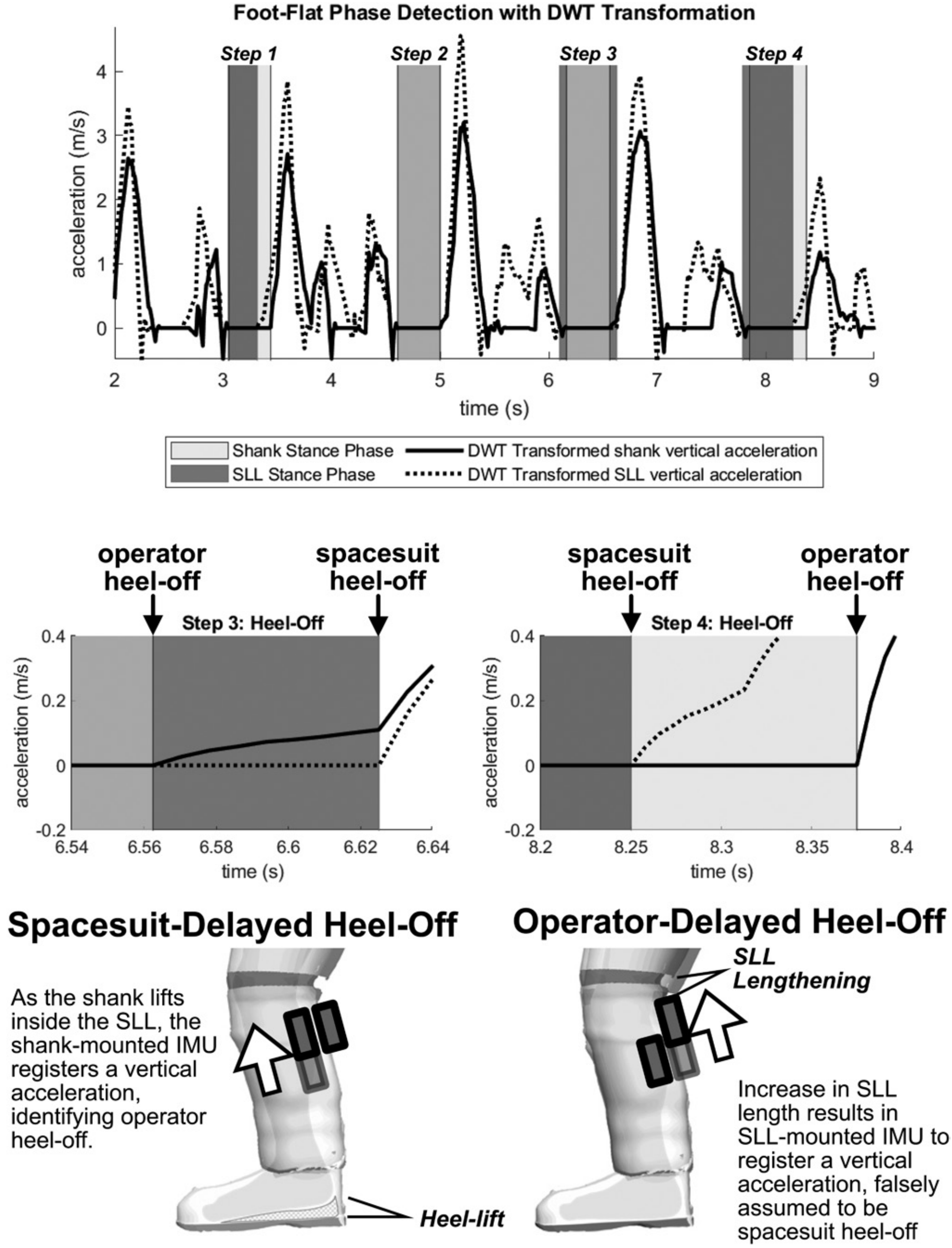


**Fig. 2.** (Top): DWT IMU vertical acceleration data for shank and SLL. Shaded regions represent the detected foot-flat phases of zero-acceleration regions for each step. (Middle) Zoomed-in view of the foot-flat phase for two steps, with annotated spacesuit and operator heel-off points. When the shank IMU registers a vertical acceleration in foot-flat phase prior to the SLL IMU (middle-left), this could suggest heel-lift (bottom-left). When the SLL IMU registers a vertical acceleration in foot-flat phase prior to the shank IMU, this would ordinarily suggest that the SLL experiences heel-off prior to the operator (middle-right). However, there may be pressure forces which allow the SLL to extend, registering a vertical acceleration for the SLL-mounted IMU and falsely suggesting that the spacesuit is experiencing heel-off (bottom-right).

de-trending to remove bias by removing the best straight-fit line from the data vector. A 30-sample window moving average filter, equivalent to 0.23 s, was then used to remove noise, within the range used for walking-speed estimation.[3]

Discrete wavelet transforms (DWT) were used to detect gait events from acceleration signals.[9] A 3-level DWT was applied to the preprocessed shank and SLL anterior-posterior acceleration signals. A Symlets 2 wavelet was then used as the mother wavelet for the transform, due to its high performance in detecting initial-contact and final-contact points during stance phase.[9] After transforming to wavelet space, a threshold was applied where values below 2% of the maximum wavelet coefficient were set to zero. The wavelet coefficients were then reconstructed back into a signal and used to detect foot-flat phase.

Foot-flat phase was detected by looking for the zero regions in the shank and SLL's acceleration's derivative.[10] A threshold of $0.01\ \text{m} \cdot \text{s}^{-1}$ was set to account for small amounts of noise in the DWT signal.[3] Acceleration points within this threshold were identified as zero-acceleration points. Zero-acceleration points less than 3 samples long were removed, since foot-flat phase is expected to be much longer. **Fig. 2** shows an example of isolating foot-flat phase from DWT transformed signals. The difference in shank and SLL heel-off times was used to detect instances of heel-lift; a positive value corresponds to operator heel-off prior to spacesuit heel-off, suggesting heel-lift. Heel-off lag times < -0.2 s and > 0.2 s were manually inspected, and if detection times were visually noted to be misaligned with the zero-acceleration period, these steps were removed from analysis. A total of 32 of the 1381 steps met the criteria for removal.

The vertical acceleration signals from the IMUs are subject to integration drift when converted into positional estimates using double integration. The raw vertical acceleration signals were preprocessed by a 10 Hz low-pass filter to remove high-frequency noise.[1] ZVU and ZPUs were used to reduce integration drift and improve the accuracy of the positional estimate of the shank and SLL. It is assumed that the shank and SLL's vertical velocities were zero just prior to heel-off, when the operator and spacesuit are in stance phase. Using this assumption, a linear correction is applied retroactively for each step between heel-off times. At the identified heel-off times, the vertical velocity was set to zero, and the vertical velocity during the step prior to heel-off was subtracted by the velocity reported at heel-off weighted based on the distance from the heel-off timepoint. The following step's vertical velocity was then corrected to the heel-off velocity. This process is summarized in Eq. 1:

$$v'_{x,i} = \begin{cases} v_{x,i} - v_{HO_c} \times \dfrac{t_i - t_{HO_p}}{t_{HO_c} - t_{HO_p}}, \, for \ HO_p \le i \le HO_c \\ v_{x,i} - v_{HO_c}, \, for \ i > HO_c \end{cases} \qquad \text{(Eq. 1)}$$

where at timestep $t_i$, $v'_{x,i}$ is the corrected velocity, $v_{x,i}$ is the original velocity, $v_{HO_c}$ is the velocity at heel-off, $t_{HO_p}$ is the previous step's heel-off timepoint, and $t_{HO_c}$ is the current step's heel-off timepoint. Integrating the corrected velocity signal to obtain the IMU's position can similarly be subject to integration drift. It was assumed during stance phase that both the operator's foot and the spacesuit boot are flat on the ground and therefore the shank and SLL are not moving vertically. ZPUs can use this to correct for drift by zeroing the position estimate for both the SLL and shank at heel-off. The shank and SLL were assumed to be rigidly connected to their respective ankle joints. Heel-lift magnitude can be then defined as the vertical displacement difference between the shank and the SLL at the SLL's heel-off timepoint.

Drift is not completely eliminated with the outlined methods. An upper bound was calculated to inform the time limit past the heel-off correction point where heel-lift magnitude can be quantified with confidence that the magnitude is not largely due to drift. While drift is not a linear process, an assumption was made that calculating the drift magnitude between two known timepoints, and dividing by the elapsed time, would be a reasonable approximation to quantify drift accumulation. During stance phase, it was expected that both the SLL and shank would have the same vertical position at toe-strike and heel-off. During swing phase, it was expected that both IMUs would return to the same vertical position after each step. Drift magnitude was calculated for each detected step by subtracting the post-ZVU/ZPU position values at the beginning and end of stance phase and swing phase from each other, and then dividing by time of each phase to average drift rate. This rate represents the amount the IMU's positional estimate has drifted over each phase following correction from ZVU/ZPUs, when it is expected to return to zero. Analyzing the distribution drift rates across all trials allowed for the upper time-bound to be defined where drift magnitude is minimal and can ensure accuracy in the calculated position values.

## RESULTS

**Fig. 3** shows the distribution of heel-off lag measurements across conditions, subjects, and sides. Subject 2 experienced spacesuit-delayed heel-off in 97 [20 left (13%), 77 right (33%)] out of 382 (151 left, 231 right) total steps. Subject 3 experienced spacesuit-delayed heel-off in 305 [155 left (76%), 150 right (73%)] out of 410 (204 left, 206 right) total steps. Subject 4

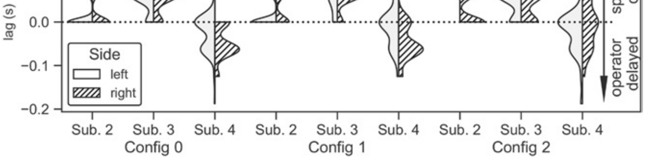


**Fig. 3.** Heel-off lag distributions between all subjects and configurations, with discrete heel-off lag measurements being represented as black dots. Positive lag values are indicative of spacesuit-delayed heel-off, while negative lag values are indicative of operator-delayed heel-off.

**Table I.** Drift Rate Estimations (Mean ± SD) Of Raw, Filtered, and Post-ZVU/ZPU Positional Estimates for IMUs Mounted on the Spacesuit Lower Leg Assembly and Shank.

| PHASE | IMU | RAW | ZVU/ZPU |
|---|---|---|---|
| Stance | Shank | $43 \pm 63\ \mathrm{cm \cdot s^{-1}}$ | $5 \pm 6\ \mathrm{cm \cdot s^{-1}}$ |
| | SLL | $241 \pm 130\ \mathrm{cm \cdot s^{-1}}$ | $16 \pm 11\ \mathrm{cm \cdot s^{-1}}$ |
| Swing | Shank | $67 \pm 59\ \mathrm{cm \cdot s^{-1}}$ | $32 \pm 16\ \mathrm{cm \cdot s^{-1}}$ |
| | SLL | $265 \pm 103\ \mathrm{cm \cdot s^{-1}}$ | $66 \pm 40\ \mathrm{cm \cdot s^{-1}}$ |

experienced spacesuit-delayed heel-off in 45 [21 left (9%), 24 right (10%)] steps, and operator-delayed heel-off in 226 [87 left (37%), 139 right (57%)] steps out of 481 (237 left, 244 right) total steps.

Mean drift rates after correction for both the SLL and shank IMUs are presented in **Table I**. An upper confidence bound of 0.03 s ($1/32\ \mathrm{cm \cdot s^{-1}}$) was found to take a heel-lift measurement with an accuracy of 1 cm, based on the mean shank IMU swing phase. Average step duration across all trials was 1.6 ± 0.2 s; therefore, drift accumulated over 1 cm on average within 2% of the step duration.

Heel-lift magnitude was not calculated due to the operator-delayed heel-off lag noted in Subject 4, and high drift rates following correction resulting in a low upper time-bound for calculating heel-lift magnitude after heel-off.

## DISCUSSION

This study aimed to evaluate the use of IMUs with ZVUs and ZPUs to quantify heel-lift in spacesuit gait. Methods were demonstrated to determine heel-off points on the shank and SLL IMU; where a lag in the spacesuit's heel-off point compared to the operator's heel-off point would suggest heel-lift. All subjects experienced varying amounts of spacesuit-delayed heel-off across conditions, regardless of padding levels. Subject 2 had more counts of spacesuit-delayed heel-off on their right compared to their left side (33% vs. 13%); this could be due to looser boot or spacesuit leg fit on their right side. Heel-lift was subjectively reported only by subject 2.[6] Only subject 4 experienced operator-delayed heel-off. Examples of both operator-delayed and spacesuit-delayed heel-off are shown in Fig. 2.

Operator-delayed heel-off is theoretically impossible; when the spacesuit's boot rises during the spacesuit's heel-off timepoint, it will push on the operator's heel, registering a simultaneous operator heel-off timepoint. The SLL's soft goods can expand and contract in length due to internal pressure forces or interactions from the knee or femur.[8] Longitudinal restraint straps are employed in spacesuit design to balance tension and pressurization forces at joints, but are not usually integrated along non-bending components such as the SLL.[8] Therefore, the initial assumption that the SLL is rigidly connected to the boot is broken. False-positive vertical accelerations due to segment lengthening are not a concern for the shank-mounted IMU, as the shank and ankle are rigidly connected and the IMUs are assumed to be rigidly strapped to their segments. While soft-tissue artifacts may be present, they are likely of a much smaller magnitude.

The SLL may be expanding in length for Subject 4 at heel-off, causing the IMU mounted on the SLL to register a positive acceleration prior to the operator. Subject 4 wore the same size suit lower assembly as other subjects but had taller crotch and knee heights. As such, there would be more room in the lower leg assembly for the soft goods to expand, providing a possible explanation for why only Subject 4 experienced operator-delayed heel-off.

A tighter boot fit, where the heel stays indexed in the boot, allows the operator to overcome expansion forces that push the SLL down, resulting in the SLL extending upwards and registering as operator-delayed heel-off. In contrast, loose boot fit will not allow the operator to overcome these forces, and will push the boot down, keeping it on the ground and registering as spacesuit-delayed heel-off. Fineman et al.[6] summarized that Subject 4 had synchronous motion of the shank and SLL between heel-off and toe-off; Subjects 2 and 3 had motion driven by the suit, suggesting heel-lift. Data from this study similarly suggests that Subjects 2 and 3 experienced more instances of spacesuit-delayed heel-off than Subject 4. Therefore, Subject 4 may have had a tighter boot fit as indicated by operator-delayed heel-off, and operator-delayed heel-off may serve as an indicator for tighter boot fit. Spacesuit boots are graded for a range of sizes (ex. US 8-10), which may not fit as precisely as terrestrial shoes and could contribute to poor boot fit.

Findings from this study suggest that current IMU technology and drift correction techniques alone may not be appropriate for quantifying the presence and magnitude of heel-lift in the spacesuit environment. Drift evaluation showed that the SLL-mounted IMUs had higher drift rates than the shank-mounted IMU. Potential sources of increased drift could be effects from the SLL segment's soft-goods expansion and contraction,[6,8] resulting in different frequency components compared to the shank's movement. While ZVUs and ZPUs did substantially reduce drift in stance and swing phase, drift was still present in this study. Heel-lift magnitude measurements could not be taken with confidence that magnitude differences would be due to heel-lift. Future work may explore the extent of soft-goods expansion on spacesuit kinematics analysis, which may affect positional estimates from optical motion capture. IMUs have been shown to measure spacesuit angular kinematics with a root-mean-squared error of 4.8–5.8°[2] and were used to characterize relative angular coordination within the suit,[6] but have not been evaluated for accuracy in spacesuit positional estimates as conducted in this study. Suit components should only expand longitudinally and should, therefore, not affect angular estimates.[8] Other sensing modalities or improvements to IMU mounting may be more appropriate in quantifying the vertical displacement that defines heel-lift.

Characterization of in-suit motion is desired to develop comfortable and safe planetary EVA spacesuits. This study highlighted the challenges of using IMUs to measure in-suit motion, concluding that IMUs may not be appropriate for measuring in-suit displacement at the magnitude expected during heel-lift. The primary assumption that the SLL was rigidly connected to the ankle joint was not supported; the observed operator-delayed heel-off suggests that the SLL is vertically extending during gait. Fineman et al.[6] hypothesized that lower-body relative coordination may be affected by boot fit issues. Future work can characterize SLL extension throughout the gait cycle, further understanding the forces acting on the SLL due to fit. Sensor technologies can also be evaluated to study heel-lift, such as resistive or capacitive force sensors mounted under the heel to directly measure heel contact, or strain sensors mounted between the human and suit to measure displacement. Such methods can be used to evaluate spacesuit components susceptible to injury, such as the gloves or upper torso.[4] IMUs can be mounted directly to the boot to isolate ankle kinematics from SLL lengthening and accurately detect heel-off points using the presented methods and assumptions. Force plates can directly identify spacesuit heel-off points, therefore not requiring suit-mounted IMUs. Developing and evaluating various in-suit motion measurement techniques will help improve spacesuit design and fit, reducing the risk of injury and ensuring mission success for future planetary EVAs.

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# Breaking the Pilot Healthcare Barrier

William Hoffman; Elizabeth Bjerke; Anthony Tvaryanas

**INTRODUCTION:** It has been proposed that pilots face a perceived barrier to seeking medical care due to what a change in health status might mean to their status as a pilot. While this is often common knowledge to pilots and some physicians, this phenomenon has limited research or characterization in the medical literature. In this commentary, we propose a definition for the barrier pilots face in seeking healthcare in hopes of focusing future research efforts.

**KEYWORDS:** aerospace medicine, preventative medicine, healthcare barrier, healthcare systems.

**Hoffman W, Bjerke E, Tvaryanas A. *Breaking the pilot healthcare barrier*. Aerosp Med Hum Perform. 2022; 93(8):649–650.**

A recent summit with representatives from across aviation met to discuss an important question: why are certain pilots not getting the mental healthcare they apparently need? The death of an undergraduate aviation student in what was thought to be an aircraft-assisted suicide[10] precipitated the gathering, though similar tragedies have made their way into the news over the years.[8] While this sort of incident is relatively rare, it speaks to a broader problem. A subgroup of pilots suffer from symptoms related to mental health conditions[7] and a proportion may go untreated.

Mental health conditions are generally treatable and people can get better. As physicians caring for patients, it is hard not to ask the obvious question: Why are pilots suffering from a treatable condition? Pilots and some physicians may have a reflexive answer to that question: certain pilots are worried about seeking medical care because of what a change in health status might mean to their status as a pilot (when reported during a regulatory medical exam as required by 14 CFR 61.53).[3] Specifically, if a pilot reports a new medical symptom or condition, they may temporarily or permanently lose their medical certificate. Beyond the potential professional or social repercussions, such an event could lead to an expensive and time-consuming medical evaluation with costs that often fall on the pilot. While this certainly may be the case for mental health conditions, it likely extends to other medical issues too.[5]

While some suggest that pilot healthcare-seeking anxiety is common knowledge, it has limited reference in the medical literature. A brief review of some of the available data includes a 2019 cross-sectional study of 613 U.S. military, commercial, and general aviation pilots which reported that 78.6% disclosed a history of ever feeling worried about seeking medical care and 60.2% reported forgoing or delaying care due to concerns related to their status as a pilot.[5] A follow-on subanalysis showed that female pilots were more likely than female nonpilots to delay medical care if they developed new symptoms of chest pain.[4] These findings are not unique to civilian pilots. A 2019 study of 173 active duty U.S. Air Force pilots showed that only 38% felt comfortable sharing a potentially disqualifying medical concern to their flight surgeon.[6] These findings seem to be accounted for by established frameworks of healthcare usage.[1] The Andersen Behavioral Model of Health Services Use has undergone multiple iterations since its initial publication in in the 1960s with an aim to: 1) understand why people use healthcare services; and 2) aid in the development of policies that permit equitable access to healthcare.[2,9] In applying this expanded model to pilots, multiple psychosocial factors in the framework (defined as factors that influence decision making of planned or intended health behavior) could provide partial explanations for these findings.[9] These factors include the attitudes of pilots (i.e., the perceived likelihood of regaining an aeromedical certificate once lost), social norms (i.e., the perceived change in identification in the face of aeromedical certificate loss), and perceived control (i.e., the subjective loss of autonomy while

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awaiting a waiver or special issuance, subsequent anxiety about the process, or lack of knowledge about the special issuance process, etc).

Balancing aviator autonomy against an aviator's risk to others has long been at the heart of the historical duty of a flight surgeon. But while safety certainly must be the foundation, we argue that further research should be done to understand ways to lower the barrier pilots face when seeking care in hopes of encouraging early intervention when needed. While there are likely no easy solutions, aerospace medicine physicians have the opportunity to be leaders in this important issue, including advocating for: 1) rigorous epidemiological research to characterize such a barrier; and 2) prospective research on potential interventions that might permit care-seeking while maintaining safety. Such an effort could have implications in preventative medicine for aviators (i.e., opportunities for early and potentially less expensive intervention to manage a new diagnosis), safety (i.e., the identification of otherwise undisclosed medical symptoms or conditions), and pilot quality of life (i.e., from a pilot's perspective, lowering the perceived risk of seeking medical care).

Research on this topic will likely take place in different settings, so a single definition becomes necessary. The need for such a definition became clear at a recent pilot mental health summit where researchers and industry leaders from around the United States gathered to discuss an effort moving forward. To our knowledge, there is no existing definition for the barrier pilots face when seeking medical care, so we propose one here.

Pilot healthcare barriers are factors that impede healthcare-seeking behavior by individuals who hold a pilot certificate. These barriers include perceptions about potentially negative consequences of new health information on future ability to perform piloting duties.

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## AUGUST 1997

*Human research subjects (74th Medical Group and Armstrong Laboratory, Wright-Patterson AFB, OH):* "The U.S. Air Force has enjoyed the luxury of having dedicated human volunteer subjects for sustained and impact acceleration research for over 50 yr. However, with today's world economy and budgetary cutbacks, this may no longer be a viable option. The onslaught of advanced medical technology, combined with an increasing performance envelope for aircraft and their ejection systems, have created an environment where the validity of research data and the ethics of human-use research are being challenged. Now is an opportune time to reevaluate the way human-use aeromedical research is conducted. The validity of using nonpilots in lieu of pilots in aeromedical research is discussed in light of the following: a) the increased emphasis on performance metrics within sustained acceleration; b) the matching of human subjects (nonpilots) to pilots in the appropriate attributes to ensure validity of data; c) degree of medical screening required given the ethics of human-use research and concerns of pilots; and d) the challenge of evaluating the 'value added' of new technology for medical screening. It is concluded that volunteer panels should be maintained with nonpilots matched with pilots physically and psychologically such that operational performance characteristics are similar."[3]

## AUGUST 1972

*Fasting and hypoxia (Defense and Civil Institute of Environmental Medicine, Downsview, Ontario, Canada):* "Blood pressure response to moderate hypoxia was compared in a fasting and a control (non-fasting) state in 10 seated subjects. End-tidal gas tensions were monitored continuously in the tests. In the control state the mean BP (MAP) was 98% ($P < 0.2$) of its resting value after 45 minutes of exposure to a simulated altitude of 17,000'. When exposed to the same stress after fasting for 18 hours, the MAP fell to 87% ($P < 0.01$) of its resting value. The mean end-tidal $P_{O2}$ was significantly lower in the fasting state…

"We conclude that acute fasting significantly increases the orthostatic, hypotensive response to moderate hypoxia. This synergistic effect was sufficient to induce a syncopal attack in one normal individual during stress by moderate hypoxia while fasting, and this subject's recovery was delayed for more than 20 minutes after return to breathing room air."[1]

*Medical aspects of airport design (Office of Aviation Medicine, Federal Aviation Administration, Washington, DC):* "The flight surgeon and other aviation medicine specialists are being involved to an increasing extent in the design and operation of major aircraft terminals. Accordingly, a series of biologically supported design features are suggested for incorporation in terminal design. Especially involved are considerations of physically handicapped persons, chronically ill persons, small children, the elderly and infirm and the emotionally disturbed. Specific principles are incorporated in the design guide for accommodating the above groups."[2]

## AUGUST 1947

*Illusions in flight (University of Hawaii and Naval School of Aviation Medicine, Pensacola, FL):* "The illusions reported in the study [reviewing 67 pilots with 77 instances] are of five general types which, in practice, are not always separable; namely, visual, non-visual, conflicting sensory cues, dissociational or recognitional, and emotional. Visual illusions include confusion of lights, splitting of lights (diplopia), autokinesis, depth perception, relative motion, and perspective illusions. There is also evidence that visual hallucinations occasionally occur. Non-visual illusions include failure to perceive rotation itself, or the after-effects of rotation, or both, false sensations, after-effects of rotation, and correct perception with wrong reference point. There may also occasionally be non-visual hallucinations. Illusions resulting from conflicting sensory cues may occur in the visual field, in the non-visual field, or in combinations of the two. Dissociational or recognitional illusions include phenomena of *jamais vu*, *déjà vu*, loss of sense of direction, and loss of the sense of time. General emotional disturbance is non-specific and results in generalized disorientation, including perceptual, rather than in specific illusions occurring in flight affords insight into the environment of the aviator, and the adjustment of the aviator to that environment. Adjustment to the flight environment has two aspects, erroneous response to environmental cues (such as illusions), and the psychological, or emotional and cognitive state of the aviator."[4]

*My bubbles! (Ohio State University, Columbus, OH):* "Animals subjected to explosive decompression and subsequent exposure to reduced barometric pressures were examined for evidence of intravascular gas bubbles. Of thirteen guinea pigs which died during such exposure, seven showed intravascular gas bubbles after recompression and autopsy. No bubbles were found in animals surviving the exposure. It is believed that the bubbles observed may have been the result rather than the cause of the fatalities. Intravascular bubble formation is considered to be a negligible hazard in explosive decompression."[5] *[Editor's note: Oh, how our knowledge has changed.]*

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# Abstracts Not Presented

Every year, there are abstracts that could not be presented at our annual meeting for a variety of reasons. Covid-19 and travel restrictions played a significant role in the cancellation of certain abstracts. The fact that the abstracts were printed in the March 2022 issue of *Aerospace Medicine and Human Performance* does not guarantee that they were presented, only that they were accepted for presentation. It is important to remember that if an abstract was not presented, it should not be referenced. A total of 35 abstracts and 1 panel out of a possible 472 abstracts were not presented (~7.4%), which is average for our meeting. There were also additions and corrections to the published abstracts.

The following abstracts were withdrawn or not presented:

**[2] REFLECTIVE PRACTICE IN AVIATION MEDICINE**
Satyam Patel1
1King's College London, London, United Kingdom

**[22] AIRCREW EQUIPMENT ASSEMBLY VERSUS "G-RAFFE" – A COMPARATIVE STUDY OF TWO HIGH-PERFORMANCE ANTI-G SUITS (AGS)**
Carla Ledderhos1, Michael Nehring2, Frank Weber1, André Gens1
1German Air Force Center of Aerospace Medicine, Fürstenfeldbruck, Germany); 2German Air Force Center of Aerospace Medicine, Königsbrück, Germany);

**[42] NAVIGATING INSTITUTIONAL REVIEW BOARDS AND SURVIVING THE JOURNEY**
Michael Wiggins1
1Embry Riddle Aeronautical University, Daytonna Beach, Florida, United States

**[S-17]:PANEL: PAST, PRESENT, & FUTURE OF NASA'S BIOMEDICAL FLIGHT CONTROLLERS**
Chair: Duane Chin
Co-Chair: Jamie Moore

Abstracts 77-80 were nnot printed. in March 2022.

**[85] USAFSAM'S AMRAAM APPLICATION FOR TOTAL FORCE ACCESSIONS**
Rodger Vanderbeek1, Eduardo Rizo2
1Air Force Recruiting Service, San Antonio, Texas, United States); 2Air Force Recruiting Service, Randolph AFB, Texas, United States

**[99] IS IT BETTER TO WATCH OR LISTEN? A RANDOMIZED TRIAL OF VIDEO-MODELLING VS TELEMENTORING FOR INTERVENTIONS PERFORMED BY SEARCH AND RESCUE MEDICS**
Jessica McKee1, Corey Tomlinson2, Nigel Donley3, Juan Wachs4, Andrew Kirkpatrick1
1University of Calgary, Calgary, Alberta, Canada; 2Canadian Forces, Ottawa, Ontario, Canada; 3R19 Wing and 422 Squadron Search Air Rescue, Comox, British Columbia, Canada; 4Purdue University, West Lafayette, IN, USA

**[101] TWO-PHASE MOTION SICKNESS EXPERIMENTATION MODEL AMONG THE MILITARY MEDICAL STUDENT TRAINING IN TAIWAN**
Chung-Yu Lai1, Hsin Chu2, Min-Yu Tu3, Kwo-Tsao Chiang4
1Institute of Aerospace and Undersea Medicine, National Defense Medical Center, Taipei City, Taiwan (Greater China; 2Civil Aviation Medical Center, Taipei City, Taiwan (Greater China; 3Aviation Physiology Research Laboratory, Kaohsiung Armed Forces General Hospital Gangshan Branch, Kaohsiung City, Taiwan (Greater China; 4Kaohsiung Armed Forces General Hospital Gangshan Branch, Kaohsiung City, Taiwan (Greater China)

**[127] BLACK-HOLE APPROACH ILLUSION**
Kevin Gildea1, Harriet Lester2
1Federal Aviation Administration, Norman, Oklahoma, United States); 2Federal Aviation Administration, Jamaica, New York, United States

**[146] CARDIOPULMONARY RESPONSES TO CENTRIFUGE SIMULATED PARABOLIC FLIGHT**
Harshith H S1, Nataraja M S2, Sneha Dinakar3
1Institute of Aerospace Medicine, Bangalore, India); 2Institute Of Aerospace Medicine, Bangalore, India); 3Institute of Aerospace Medicine, Bangalore, India

**[151] THE MORTALITY OF AEROSPACE SPECIALISTS IN RUSSIA**
Igor Bukhtiyarov1, Evgeny Zibarev1, Kristina Betts1, Igor Ushakov2, Yuri Voronkov3, Marina Bukhtiyarova4
1Federal State Budgetary Scientific Institution "Izmerov Research Institute of Occupational Health", Moscow, Russian Federation; 2Russian State Research Center – Burnasyan Federal Medical Biophysical Center of Federal Medical Biological Agency, Moscow, Russian Federation;35State Research Center, Institute of Biomedical Problems, Russian Academy of Sciences, Moscow, Russian Federation; 4Occupational Health Physician and Specialists Association, Moscow, Russian Federation

**[207] LUNAR EVA WALKBACK DISTANCE LIMITS: NASA HAUGHTON-MARS PROJECT-2021 BIOMETRIC STUDY OF SPACESUIT WALKS ACROSS LUNAR TERRAIN ANALOGS, OREGON**
Sawan Dalal1, Pascal Lee2
1Baylor College of Medicine, Houston, , United States); 2NASA Ames Research Center, Moffett Field, California, United States

**[210] CARDIOVASCULAR, AUTONOMIC, AND CEPHALAD DOSE-RESPONSE TO GRADED LOWER BODY NEGATIVE PRESSURE**
Richard S. Whittle1, Hrudayavani S. Vellore1, Eric A. Hall1, Fèlix Real Fraxedas1, Katherine H. Findlay2, Nathan Keller1, Lindsay M. Stapleton1, Bonnie J. Dunbar1, Ana Diaz-Artiles1
1Texas A&M University, College Station, TX, United States; 2Independent Researcher, College Station, TX, United States

**[221] THE APPLICATIONS OF PATHOLOGY IN AVIATION AND AEROSPACE INDUSTRY**
Mustafa Alaziz1
1Wright State University, Dayton, Ohio, United States

**[226] CAN TELEMENTORING EFFECTIVELY TEACH SURGICAL SKILLS TO MEDICAL STUDENTS AND PROFESSIONALS: THE BENEFIT TO RURAL COMMUNITIES**
Matthew Terry1
1University of Edinburgh, Edinburgh, United Kingdom

**[238] CARDIOPULMONARY RESUSCITATION IN HYPOGRAVITY SIMULATION: DO INFLUENTIAL FACTORS EXIST?**
Sindujen Sriharan1, Gemma Kay2, Yu Chan Lee3, Ross Pollock2, Thais Russomano2
1University of Nottingham, King's College London, London, United Kingdom; 2King's College, London, London, United Kingdom); 3King's College, London, Singapore, Singapore

**[253] CLINIC CASE: OPTIC NEUROMYELITIS IN A CIVIL AVIATOR**
Patricia Barrientos1, Giancarlos Conde2, Alexandra Mejia3, Johana Giraldo3, Maria Angelita Salamanca1
1Aerocivil - Civil Aviation Authority of Colombia, Bogotá, Colombia; 2Universidad de Cartagena, Cartagena, Colombia; 3National University of Colombia, Bogotá, Colombia

**[254] MULTIPLE SCLEROSIS IN CIVIL AVIATORS: CASE SERIES**
Johana Giraldo1, Giancarlos Conde2, Alexandra Mejia1, Maria Angelita Salamanca3, Patricia Barrientos3
1National University of Colombia, Bogotá, Colombia; 2Universidad de Cartagena, Universidad Rafael Nuñez, Cartagena, Colombia; 3Aerocivil - Civil Aviation Authority, Bogotá, Colombia

**[257] CARDIOVASCULAR RISK ESTIMATION IN CIVIL AIRCREW: AN OBJECTIVE ANALYSIS**
Devdeep Ghosh1, SS Rao2
1Institute of Aerospace Medicine, Bangalore, India; 2AFCME, New Delhi, India

**[287] A STUDY ON THE EFFECT OF SURYANAMASKAR ON ORTHOSTATIC TOLERANCE AND NEUROVESTIBULAR FUNCTIONING UPON EXPOSURE TO SIMULATED MICROGRAVITY CONDITION**
Gaurab Ghosh, Rahul Pipraiya, Biswajit Sinha
Institute of Aerospace Medicine, Indian Air Force, Bangalore, India

**[290] OPERATIONAL NVG FLYING: TIME TO VISUAL ADAPTATION UNDER VARIOUS ILLUMINATION CONDITIONS POST DE-GOGGLING**
Binu Sekhar Miraj, Vijay V. Joshi, Neeraj Kumar Tripathy
Institute of Aerospace Medicine, Bangalore, Karnataka, India

**[295] RISK MANAGEMENT OF INSULIN TREATED DIABETICS IN CANADA**
Rani Tolton1, Edward Brook2
1Transport Canada, Vancouver, British Columbia, Canada; 2Transport Canada, Ottawa, Ontario, Canada

**[298] STUDY ON THE HEALTH STATUS AND OUTCOME OF AGING PILOTS OF A JAPANESE MAJOR AIR CARRIER DURING THE 5 YEARS FROM 60 YEARS OF AGE**
Kazunori Takazoe, Hideho Gomi
Japan Aeromedical Research Center, Tokyo, Japan

**[306] BLADES OF GLORY: HEMS PAST, PRESENT, AND FUTURE**
Woodrow Sams
Mayo Clinic, Rochester, MN, United States

**[325] MEDICAL DIRECTION AT A COMMERCIAL SPACE COMPANY**
Anil Menon
SpaceX, Houston, TX, United States

**[331] HYPOXIA SIGNATURE: A USEFUL TOOL FOR HYPOXIA RECOGNITION AMONG AIRCREW**
Shivani Kasture, Nataraja MS, Sudhanshu Mohapatra, Biswajit Sinha
Institute of Aerospace Medicine, Bengaluru, India

**[333] HYPOBARIC HYPOXIA MIMICS CARDIAC ISCHEMIA IN THE HISTOLOGICAL EXAMINATION OF AN AIRCRAFT ACCIDENT VICTIM**
Michael Schwerer
Air Force Centre of Aerospace Medicine, Fuerstenfeldbruck/Cologne, Germany

**[386] DoDMERB e-MEDICINE BUSINESS MODELING PROCESS FOR OFFICER APPLICANT MEDICAL QUALIFICATION DETERMINATION**
Michael Rappa, Glenn Dowling, Kenneth Kuhn, William Mann, Lawrence Mullen
Defense Health Agency, Colorado Springs, CO, USA

**[399] SEARCHING FOR RESILIENCE: SELF-ASSESSED COGNITIVE AND PSY-**

**CHOMOTOR FACTORS RELATED TO THE PERFORMANCE OF DAMAGE CONTROL SURGERY IN WEIGHTLESSNESS**
Andrew Kirkpatrick1, Jessica Mckee1, Heather Wright Beatty2
1University of Calgary, Calgary, Alberta, Canada; 2NRC-CNRC, Ottawa, Canada

**[401] RELIABILITY AND VALIDITY OF NASA'S HUMAN FACTORS AND BEHAVIORAL PERFORMANCE EXPLORATION MEASURES (HFBP-EM) IN ISOLATED, CONFINED, AND EXTREME TEAMS**
Carolyn Cunningham1, Nathan Smith2, Emma Barrett2, Pete Roma3, Robert Wuebker4
1University of Warwick, Coventry, United Kingdom; 2University of Manchester, Manchester, United Kingdom; 3Leidos/Naval Health Research Center, San Diego, USA; 4University of Utah, Salt Lake City, UT, USA

**[409] BREATHING RHYTHM COMPLEXITY AS AN INDICATOR TO RESPIRATORY COMPROMISE FOR FUTURE FLIGHT DECK SYSTEMS**
Jeremy Prieto1, Rheagan Horne1, Chad Stephens2, Kellie Kennedy2, Nicholas Napoli1
1University of Florida, Gainesville, FL, USA; 2NASA Langley Research Center, Hampton, Virginia, USA

**[422] PANDEMIC RATIO TRACKING: PREDICTING PANDEMIC TRAJECTORIES**
Walter Dalitsch
Naval Medical Research Unit - Dayton, Wright-Patterson AFB, OH, USA

**[444] WORLD WAR I BRITISH FLYING ACE EXTRAORDINAIRE, MAJOR EDWARD "MICK" MANNOCK, VC, DSO, MC: DID HE REALLY HAVE ONLY ONE GOOD EYE?**
Adrien Ivan1, Douglas Ivan2, Thomas Tredici3
1Vernon College, Wichita Falls, TX, USA; 2ADI Consultants, San Antono, TX, USA; 3(Posthumously) University of Texas Health Sciences, San Antonio, TX, USA

**[446] DESIGNING RESTRAINT SYSTEM FOR SIMULATING LATERAL ACCELERATION**
Parul Goel, Anupam Garwal2
1indian Air Force, New Delhi, India; 2indian Air Force, Allahabad, India

**[448] MEDICAL LESSONS FROM THE UNDERWATER NEPTUNE MISSION**
Shawna Pandya1, Dr. Joseph Dituri2, Paul Bakken3, Doug Campbell4, Kyle Foster5
1University of Alberta, Edmonton, Alberta, Canada; 2International Board of Undersea Medicine, Tampa, FL, USA; 3Bakken Offworld Research Products, Eagan, MN, USA; 4Saskatchewan Health Authority, Saskatoon, Saskatchewan, Canada; 5George Mason University, Fairfax, VA, USA

**[449] SELECTION OF AIR TRAFFIC CONTROLLER TRAINEES**
Krisztina Szabo, Mate Petrekanits, Botond Szucs
Pharmaflight International Science and Service Center, Debrecen, Hungary

**[461] DISCLOSURE RATES OF SARS-COVID19 INFECTION DURING AEROMEDICAL SCREENING AND VACCINATION HESITANCY IN A SAMPLE OF US AVIATORS**
William Hoffman
Brooke Army Medical Center, Ft Sam Houston, TX, USA

**ERRATA:**

**[S-62} PANEL: THE NUTS AND BOLTS OF BEING A CHIEF MEDICAL OFFICER FOR PRIVATE SPACE COMPANIES** will be presented on Thursday, May 26 at 10:00 a.m.

**[456]** Will be presented by **Yoshiaki Inuzuwa**. There was a misspelling of his name in the printed program.

**[210] CARDIOVASCULAR, AUTONOMIC, AND CEPHALAD DOSE-RESPONSE TO GRADED LOWER BODY NEGATIVE PRESSURE**
Richard S. Whittle[1], Hrudayavani S. Vellore[1], Eric A. Hall[1], Fèlix Real Fraxedas[1], Katherine H. Findlay[2], Nathan Keller[1], Lindsay M. Stapleton[1], Bonnie J. Dunbar[1], Ana Diaz-Artiles[1]
[1]Texas A&M University, College Station, TX, United States; [2]Independent Researcher, College Station, TX, United States

*The lower body negative pressure (LBNP) chamber we have been using had a software calibration factor bug, such that the actual applied pressure was only half of the indicated pressure. The measured values for the dependent variables are still correct, however the independent variable (LBNP pressure) is out by a factor of 2. The affected pressures are bolded and underlined below.*

**INTRODUCTION:** (Same as print.) METHODS: Twelve male subjects (age 26.9±2.9 years, height 179.0±8.3 cm, weight 84.7±18.7 kg) were placed in an LBNP chamber in both supine and 15° head down tilt postures. A graded LBNP profile was applied from 0 mmHg to **–25 mmHg in 5 mmHg** increments. Measures of systemic cardiovascular parameters and autonomic indices were taken along with intraocular pressure, ultrasonography of the left and right common carotid arteries and internal jugular veins, and jugular venous pressure. **RESULTS:** The application of **–25** mmHg of LBNP caused a drop in systolic blood pressure from 133.2±14.9 mmHg to 121±15.7 mmHg (p = 0.003), whilst diastolic pressure was maintained. Similarly, cardiac output and stroke volume decreased linearly, from 5.3±1.1 l/min to 4.2±0.7 l/min (p < 0.001) and 76.5±17.9 ml to 58.4±10.1 ml (p < 0.001), respectively. Autonomic indices showed no significant change in vagal activity, but a slight increase in sympathetic nervous activity. Jugular venous pressure and intraocular pressure were reduced with the application of LBNP, however the differential rate slowed at pressures below –10 mmHg. **DISCUSSION**: (Same as print.)

**Additions:**
**Wednesday, 05/25/2022 10:30 AM in Tuscany 5/6**
**[S-46]: POSTERS: HUMAN PERFORMANCE: PAN TOPIC LOOK**

**[477] CAN OPEN ABDOMINAL SURGERY FIT IN THE VOLUME OF THE ORION CAPSULE: A PILOT STUDY**
Tovy Kamine[1], Margaret Siu[1], Arthur Formanek[2], Gladys Fernandez[1], Dana Levin[3]
[1]Baystate Health, Springfield, MA, USA; [2]Brigham and Women's Hospital, Boston, MA, USA; [3]Columbia University, New York, NY, USA
*(Original Research)*

**INTRODUCTION:** This pilot study investigated the minimum volume needed to safely perform an open abdominal procedure to understand if current and planned spacecraft have sufficient volume to handle surgical emergencies should they occur. **METHODS:** The axes of a simulated operating room were marked and cameras placed to capture movements. An expert surgeon, chief surgical resident, junior surgical resident, and a non-surgeon physician each performed a Focused Assessment with Sonography for Trauma and an open appendectomy on a simulated patient. A second participant intubated and monitored the simulated patient. Time and volume data were collected and compared using unpaired t-tests. **RESULTS:** Mean volume needed to complete all tasks was 3.83 m^3±0.47 for standing and 3.68m^3±0.49 for kneeling, p=0.72. There were differences in the x, y, and z dimensions between the two groups, X: 90.1cm±5.0 v. 121.1cm±6.8, p=0.04; Y: 210.5cm±22.7 v. 237.5cm±3.8, p=0.08; Z: 174.4cm±5.0 v. 127.7cm±13.4 p < 0.01. Differences between Seniors (attending and PGY5) and Juniors (PGY2 and non-surgery physician) were not significant (3.78m^3±0.41 and 3.74m^3±0.53, respectively, p=0.90). **DISCUSSION:** The habitable volume of capsules ranges from 8.95m^3 (NASA's Orion) to 916m^3 (International Space Station). Future vehicles range from NASA's Gateway Lunar Station at 125m^3 to SpaceX's Starship at 825m^3. Mean volume to perform kneeling appendectomy was 3.68m^3. Even the smallest of these spacecraft, the Orion Capsule, may accommodate simple open abdominal procedures. However, this study included only 4 participants and does not account for environmental aspects of spaceflight such as microgravity.

**Learning Objectives:**
1.The audience will learn about the minimal spatial volume necessary to perform open abdominal operations.
2. The audience will learn how the volumetric constraints of the Orion capsule affect the ability to perform open abdominal operations.

## Susan Northrup Installed as AsMA President; Joseph Dervay as Presdient-Elect

**Susan E. Northrup, M.D., M.P.H., FAsMA,** was installed as President of AsMA during the Annual Business Meeting, held May 24, 2022 at the Peppermill Resort and Casino in Reno, NV. In 2021 Dr. Northrup was appointed as the first female FAA Federal Air Surgeon. She joined the FAA in April 2007 as the Southern Regional Flight Surgeon. She is now responsible for all aerospace medicine efforts within the FAA including airman medical certification, air traffic control health program, AME designee management, internal and external substance abuse testing, and aeromedical research. She was awarded the FAA's Flight Surgeon of the Year Award in 2008 and Outstanding Manager in 2018. In 2017, she was selected as the Senior Regional Flight Surgeon with operational responsibilities for the entire nation. Prior to joining the FAA, she was Regional Medical Director for Air Crew and Passenger Health Services for Delta Air Lines from 2001 to 2005, Medical Consultant for the National Pilots Association 2005 to 2007, and did other consulting from 2005–2007. Dr. Northrup served in the U.S. Air Force on active duty from 1990 to 2001, and as a Reservist from 2001 to 2010, retiring as a Colonel.

Dr. Northrup obtained a Bachelor of Arts in Chemistry with Honors in Liberal Arts from The Ohio State University in 1985 and stayed on to get her Medical Degree in 1989. She was awarded a Masters in Public Health from the University of Texas, Health Science Center Houston, School of Public Health in 1994. She completed Residencies in Aerospace Medicine and Occupational Medicine in 1995 and 1996, respectively, becoming Board Certified in both disciplines.

A private pilot, she is an acknowledged expert in aviation medicine. While serving in the Air Force, she was the U.S. Head of Delegation to NATO's aeromedical working group. More recently, she has served the FAA as the FAA medical subject matter expert to ICAO's COVID response activities and the COVID IMT and the Office of Aerospace Liaison to the Air Traffic Organization.

Dr. Northrup's awards and honors include TAC Flight Surgeon of the Year, the Air Force Meritorious Service Medal with two oak leaf clusters, the Air Force Achievement Medal with a single oak leaf cluster, and the Air Force Outstanding Unit Award with Valor and a single oak leaf cluster. The Aerospace Medical Association presented her with the John A. Tamisiea Award in 2015 and the Admiral John C. Adams Award in 2020. A Fellow of AsMA, she is a member of the Red River Valley Fighter Pilots Association, the Society of USAF Flight Surgeons, the International Airline Medical Association, the Civil Aviation Medical Association, and the American Society of Aerospace Medicine Specialists. She spent nine years (2007–2016) as a trustee for the American Board of Preventive Medicine in several capacities, including as the Vice Chair Aerospace Medicine. She is also a Selector for the International Academy of Aviation and Space Medicine and was Chair of the Air Transportation Association Medical Committee. She is on the Adjunct Faculty for the USAF School of Aerospace Medicine.

**********

**Joseph P. Dervay, M.D., M.P.H.,MMS, FACEP, FAsMA, FUHMS**, was elected as President-Elect of AsMA during the Annual Business Meeting, on May 24, 2022. He will be installed as President next year. Dr. Dervay is currently a Flight Surgeon at the NASA Johnson Space Center, having served there over 25 years. Completing undergrad at Cornell University, and a Doctor of Medicine at Syracuse - Upstate Medical Center, he subsequently trained to become a Navy Flight Surgeon, serving aboard the aircraft carrier *USS John F. Kennedy*.

Dr. Dervay completed an Emergency Medicine Residency at The George Washington University, Space Medicine Fellowship and Aerospace Medicine Residency at UTMB Galveston/NASA, and Hyperbaric Medicine training at University of Texas Health Science Center, Houston.

Dr. Dervay has served as Crew Surgeon for numerous Space Shuttle and long-duration International Space Station missions, including support of the 2020 NASA/SpaceX Demo-2 test flight as the first Commercial Crew mission. His roles have included work in Russia at the Star City - Cosmonaut training center, and support of U.S. Astronauts during Soyuz launch and landing activities in Kazakhstan. He Co-Chairs the Multilateral Medical Operations Panel, comprised of medical representatives from the Canadian, European, Japanese, and Russian space agencies. He completed research on Bubble Nucleation at Altitude during his Master of Medical Sciences degree and has been deeply involved with development of NASA EVA Prebreathe Protocols.

Retiring with the Navy rank of captain, he completed 35-years of Active and Reserve service with numerous Navy & Marine Corps units worldwide.

Dr. Dervay has been a member of AsMA since 1985. Prior to selection as President-Elect, he served 3 years as an AsMA Vice President. Over his years of service to AsMA, he served four 3-year terms on AsMA council as a Member-at-Large, and several years on the Executive Committee. Dr. Dervay has been a longstanding member of the Scientific Program Committee and was Scientific Program Chair for the 2007 meeting in New Orleans. He has served as Chair of the Communications, Membership, and Resolutions Committees. He has been a member of numerous Constituent and Affiliate organizations, including the Society of U.S. Naval Flight Surgeons and International Association of Military Pilot-Physicians. Dr. Dervay served as President of the Society of NASA FlightsSurgeons and the Space Medicine Association. An AsMA Fellow, he was inducted into the International Academy of Aviation and Space Medicine (IAASM).

**Other elected officials are: Vice Presidents:** Robert Orford, MD, CM, MS, MPH (2-Yr Term), Warren Silberman, DO, MPH (2-Yr Term), and Rebecca Blue, MD (1-Yr Term – to complete Dervay Term); and **Treasurer:** Casey Pruett, BS, MS, MBA. **Members-at-Large are:** Ilaria Cinelli, PhD, W. Brent Klein, MD, MPH, Peter Lee, MD, PhD, MPH, MS, Anthony Wagstaff, MBBCh, DAvMed.

## We're Sorry!

Please accept our apology for the lateness of this issue. Due to a ransomeware attack on our printing company, we are experiencing significant delays in the production of our journal. We hope to be back on track soon.

### Read Current News Online!

**Ever Upward!** The AsMA Online Newsletter is posted monthly: http://www.asma.org/news-events/newsletters. The newsletters go back to 2015.

The News Archives going back to 2004 are also online on the website:
https://www.asma.org/news-events/asma-news-archive

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# The 92nd Annual Scientific Meeting: The Week in Pictures

## SUNDAY, MAY 22, 2022

**The Scientific Program Committee,** chaired be Dr. Charles Reese (above), met to provide orientation to the session chairs.

**The Welcome Reception,** sponsored by the Mayo Clinic, provided great food and a chance to view the exhibits and visit with friends. Among the exhibitors were AsMA Corporate Members, KBR, UTMB, and ETC (bottom row).

## MONDAY, MAY 23, 2022

**(Photos Top row to Bottom row, Left to Right).**

**UHMS President, Dr. Marc Robins, and AsMA President, Dr. James DeVoll, co-opened the annual meeting. AsMA Past President, Dr. Joe Ortega presented the slate of officers for AsMA.**

**The Stanley R. Mohler, M.D., Aerospace Medicine Endowed Scholarship was presented to Lauren Church by Kim Broadwell respresenting the AsMA Foundation and Jim DeVoll, AsMA President for 2021-2022. The Anita Mantri, Ph.D., Memorial Travel Scholarship was presented to Victoria Tucci by Kim Broadwell, representing the AsMA Foundation. The recipient of the AsMA International Scholarship, Ahmed Baraka, could not be present.**

**The Curtis Langdon Group played at Opening Ceremonies.**

**Speed Mentoring Program pairs AsMA members who are established in their careers with younger members and students interested in learning about careers in Aerospace Medicine. It is done like Speed Dating!**

**Gary Gray receives his pin as a Member of AsMA for 50 years. Other 50-yr members who could not be present are: John Bishop, Ernst Hollman, Chandler Phillips, and David Zanick.**

# TUESDAY, May 24, WEDNESDAY, May 25, and THURSDAY, May 26, 2022

**At the Corporate Forum Reception--Pam Day, Adam Sirek, Marian Sides, Katy Samoil, and Ari Epstein.**

**At the International Reception--Eric Sprague and Bob Laurent, representing the sponsors, ETC.**

**Dick Trumbo 5k Run/Walk top 3 female and male winners with UHMS President Marc Robins: Jared Price, Karen Ong, Sheryas Iyer, Joanna d'Arcy, Abigail Vargo, and Alex Wolbrink.**

**The RAM Bowl in action.** Photo by Tom Workman.

**Jim DeVoll and his family at the President's Reception.**

**Sean Daigre, representing Harvey Watt & Co., sponsor of the President's Reception, with AsMA President, Jim DeVoll.**

**(Left) Passing the gavel from outgoing AsMA President, Jim DeVoll, to incoming President Susan Northrup. (Center) Susan Northrup presents the Past President's gift, and Jim DeVoll's daughter, Marguerite, pins him with the Past President's Pin (Right).**

# AEROSPACE MEDICAL ASSOCIATION HONORS NIGHT AWARDS
## Peppermill Resort & Casino, Reno, NV, May 26, 2022

This year our Honors Night Ceremonies were shared between the Aerospace Medical Association (AsMA) and the Undersea and Hyperbaric Medical Society (UHMS). Both organization presented their annual awards. The president of AsMA, James R. DeVoll, M.D., M.P.H. and the president of UHMS, Marc Robins, D.O., presided over each organizations awards.

Dr. DeVoll presented 19 awards to outstanding members during the Honors Night ceremonies at the 93rd Annual AsMA Scientific Meeting, May 26, 2022, at the Peppermill Resort and Casino, Remo, NV. Eric Olins, M.D., Chair of the Awards Committee read the citations, assisted by Dr. Dwight Holland. The names of the awards' sponsors and representatives, when present, are printed in parentheses.

All photos by Pamela C. Day. A photo gallery is available at: https://aeromed.smugmug.com/Honors-Night-2022/.

**James DeVoll, 2021-2022**
**AsMA President**

ADMIRAL JOHN C. ADAMS AWARD
**Lina Maria Sanchez Rubio, M.D., Ph.D., Col.(Ret.)**
(Jonathan Elliott, Society of US Naval Flight Surgeons)

LOUIS H. BAUER FOUNDER'S AWARD
**Marian B. Sides, Ph.D., M.S.N.**
(Clayton Cowl, Mayo Clinic)

BOOTHBY-EDWARDS AWARD
**Ian Hosegood, MBBS, DAvMed**
**(Kate Manderson accepts)**
(Michael Berry for Harvey W. Watt & Co.)

JOHN ERNSTING AWARD
**William P. Butler, M.D.**
(George Anderson, Environmental Tectonics Corporation)

KENT K. GILLINGHAM AWARD
**Peter A. Hancock, D.Sc., Ph.D.**
**(Dwight Holland accepts)**
(Erich Roedig, AMST)

WALTER AND SYLVIA GOLDENRATH AWARD
**Deborah J. White, Ph.D., M.B.A., M.A.**
(AsMA Foundation)

WON CHUEL KAY AWARD
**David Powell, M.D., M.Sc.**
(JounSoon Jang, Aerospace Medical Association of Korea)

JOE KERWIN AWARD
**Serena Auñon-Chancelor, M.D.**
**(Casey Pruett accepts)**
(Keith Kreutzberg, KBR)

SIDNEY D. LEVERETT ENVIRONMENTAL SCIENCE AWARD,
**Jeremy Beer, Ph.D.**
(Bob Laurent, Environmental Tectonics Corp.)

ERIC LILJENCRANTZ AWARD,
**Rebecca Blue, M.D., M.P.H.**
(Jeff Sventek for Aerospace Medical, PLC)

RAYMOND F. LONGACRE AWARD
**Matthew Dumstorf, M.D., M.S.**
(Tom Nesthus, Aerospace Human Factors Assoc.)

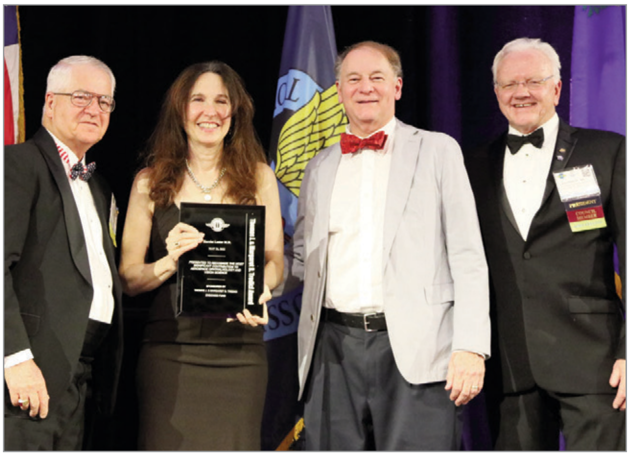
THEODORE C. LYSTER AWARD
**Nereyda Sevilla, M.P.H., Ph.D.**
(Susan Fondy, Society of U.S. Army Flight Surgeons)

MARIE MARVINGT AWARD
**Daniel Berry, D.O., Ph.D.**
(Olivier Manen, Société Francophone de Médecine Aérospatiale)

HARRY G. MOSELEY AWARD
**Todd Dart, Ph.D.**
(Christopher Backus, International Association of Military Flight Surgeon Pilots)

JOHN PAUL STAPP AWARD
**Lindley Bark, B.S.**
(Alper Kus, Environmental Tectonics Corp.)

JOHN A. TAMISIEA AWARD
**Clayton Cowl, M.D., M.S.**
(David Schall, Civil Aviation Medical Association)



THOMAS J. AND MARGARET D. TREDICI AWARD
**Harriet Lester, M.D.**
(Kim Broadwell, AsMA Foundation, and Douglas Ivan, Tredici Endowment Fund)

ARNOLD D. TUTTLE AWARD
**Ross Pollock, B.Sc., M.Sc., Ph.D.**
(Keith Kreutzberg, KBR)

JULIAN E. WARD MEMORIAL AWARD
**Bonnie Posselt, B.Sc., MBChB, DAvMed**
(Christopher Backus, Society of USAF Flight Surgeons)

2020 JOE KERWIN AWARD
**Jeffrey R. Davis, M.D.**
(Joe Ortega, 2020 AsMA President, and Keith Kreutzberg and Genie Bopp, KBR)

2021 LOUIS H. BAUER FOUNDER'S AWARD
**David Newman, M.D.**
(Charles DeJohn, 2021 AsMA President. Sponsored by the Mayo Clinic)

**PRESIDENT'S CITATION:** The Staff of the Aerospace Medical Association received the honor. Left to right: Jeff Sventek, Sheryl Kildall, AsMA President James DeVoll, Pamela Day, Rachel Trigg, and Gisselle Vargas.

# Abridged Minutes of the Aerospace Medical Association 92nd Annual Business Meeting

*Tuesday, May 24, 2022,*
*Peppermill Resort & Casino, Reno, NV*
*(Full minutes can be accessed in the Members Section of the AsMA website: www.asma.org. You must log in to access.)*


**DeVoll**


**Sventek**

**Call to Order (James Devoll)** A quorum of more than 100 members in attendance was met and the meeting started at 12:00 pm PDT on Tuesday, May 24, 2022.

**In Memoriam (DeVoll):** The president asked attendees to pause to remember those members who passed away this year.

**Recognition of Past Presidents (DeVoll:)** Dr. DeVoll invited the Past Presidents of AsMA to rise and be recognized.

**Report of the President (DeVoll):** Welcome to everyone and thank you for being here today. This in person meeting in Reno during our usual May time frame has been a long time coming. A typical governance year would have only two Council meetings, but this year we are having three: August in Denver, our usual mid-year meeting in November, and now. This is a breath of fresh air to communicate with people in person. We are returning to normalcy.

AsMA has continued to support the work of CAPSCA as part of ICAO and the efforts to improve aviation safety in the era of COVID and beyond. Dr. Kris Belland serves as AsMA representative to CAPSCA and continues to do an outstanding job. In January, AsMA representatives (Drs. Salicrup, Schroeder, Wilkinson, and Blocker) provided commentary on a proposed Electronic Bulletin regarding the return to duty, fitness to fly, and/or control post COVID infection. This has been an important effort highlighting the contributions of AsMA to the international aviation industry.

The Home Office staff has continued to be fantastic throughout a hectic year of unique challenges, not to mention the additional planning and coordination challenges of the joint meeting with the Undersea & Hyperbaric Medical Society.

In the February 2022 Newsletter, Pam Day laid out the approved change in the Journal previously approved: the online version will be the primary member benefit starting in July, with an added benefit of greatly reduced cost for color images.

ACGME: The movement to provide definition and separation between the three preventive medicine specialties has certainly been tortuous but we are continuing to see progress. Comments were due to ACGME by Mar 30. [Ed. Note: This was approved in June.]

ACOEM has proposed hosting two virtual roundtables (each 1.5 to 2 hours in length) and an online survey to explore the impact of obesity in the aerospace and defense industry, provide awareness of programs to fight obesity, and identify the feasibility of implementing a comprehensive obesity benefit for employees in this industry. Among other meetings, we are planning a meeting with the Indian Society of Aerospace Medicine this week.

Future issues: A review and update of our dues structure.

**Report of the Executive Director (Sventek):** Mister President, officers, and members of the Aerospace Medical Association, I am happy to report that the Aerospace Medical Association is slowly recovering the negative impact of the COVID-19 pandemic. Organizations around the world were negatively impacted by this deadly virus; AsMA was equipped, organized, and operating remotely for several years. The AsMA HQ team business model included working in the AsMA office building 3 days each week and remotely 2 days per week. When government agencies recommended a shelter in place prevention plan, Gisselle Vargas and I built a schedule that required one AsMA employee in the office in the morning, one morning per week. The AsMA employee would arrive at normal opening time and work in the office until the mail was delivered. The employee would sort the mail and distribute appropriately. Once completed, the AsMA employee would then return home and work the remainder of the week safely from home. We are continuing this work schedule until it is clear the virus is completely under control. It should be noted that all AsMA Staff members are full vaccinated against the COVID-19 virus and all of us have received the recommended booster shots as well. I would like to publicly thank the incredible AsMA Staff and our Journal independent contractors for their strong work during the pandemic.

The work of the Association also continued during the pandemic through the efforts of the AsMA Council and AsMA volunteers. I want to thank all who volunteered this past two plus years to help move the Association forward. Thank you for your continued strong support of the Aerospace Medical Association.

AsMA membership dropped during the pandemic but has recovered to around 2,000 active and paying members. As of this report, AsMA membership totals 1,999. We believe part of the reason for the drop in membership was due to not being able to host an in-person Annual Scientific Meeting in 2020 and a mostly U.S. attended meeting in August 2021 in Denver, CO. Many of our members take the opportunity to renew their memberships during the Annual Scientific Meeting and even though our AsMA Staff sent out dues renewal notifications, many members may have waited to renew, hoping an in-person Annual Scientific Meeting would happen. Thanks to all who renewed when notified by the AsMA Staff. We will continue to work toward getting our membership back to the 2,100 number we had prior to the COVID-19 pandemic.

To offer our membership Continuing Education opportunities, AsMA continues to offer virtual continuing education via webinars. AsMA, in collaboration the International Academy of Aviation and Space Medicine (IAASM), hosted a total of three webinars in 2021. Those webinars offered participants updates on the impact of COVID 19 on aviation and space operations as well as plans for preparing to manage the next pandemic. The three webinars offered physicians up to 8.75 hours of CME credits. In 2022, AsMA collaborated with the Mission-Next Foundation in hosting a webinar focused on 'Air Purification Strategies and Technolgies to Defeat COVID Today and the Biothreats of Tomorrow.' This webinar offered 3.75 CME credits to physicians. Finally, AsMA collaborated once again with our IAASM colleagues in organizing "Aeromedical Aspects of Civilian Evacuation: Preparation, Reaction and Response." This was another well-attended webinar and offered physicians up to 2.75 CME credits. AsMA will continue to evaluate areas of interest that can be offered via webinar throughout the year so those who cannot attend our Annual Scientific Meeting in person can still benefit from the many Aerospace Medicine experts within our membership.

The 1st International Conference of Aerospace Medicine, scheduled for September 2020, was cancelled, and rescheduled for September 2021. The four organizing associations for this joint international conference includes the Aerospace Medical Association (AsMA), IAASM, the European Society of Aerospace Medicine (ESAM), and La Societe Francaise de Medecine Aerospatiale (SOFRAMAS). These four organizations continued to work toward a successful September 2021 event but realized that international travel would likely be a problem through 2021 and possibly into 2022, so the ICAM was postponed again to September 2022. I encourage you to mark your calendars for September 22 through 24, 2022 to attend the 1st International Conference of Aerospace Medicine in Paris, France. Registration for this conference is now open via the AsMA website as well as the ICAM 2022 website.

As of this morning, total registration for this year's joint AsMA/UHMS meeting is 1487. Of this total 1,195 (80.4%) are registered as AsMA attendees and 292 (19.6%) are registered as UHMS as UHMS attendees. This registration total is about the normal number of the registrations we would receive for an AsMA Annual Scientific Meeting during a year without COVID-19. However, the total registrations include a large number of UHMS attendees who might not normally attend an AsMA Annual Scientific Meeting. The 1,195 AsMA registrants represents about 80% of a normal AsMA Annual Scientific Meeting attendance. We are very pleased to have our UHMS colleagues joining us this year Reno.

Finally, I am required to report the Aerospace Medical Association financial status for 2021. Details are in the Treasurer's report, but the 2021 financial records received completed a full audit by Gross, Mendolosohn & Associates, P.A. on April 4, 2022. According to the Audit Report:

"In our opinion, the financial statements referred to above present fairly, in all material respects, the financial position of Aerospace Medicine Association as of December 31, 2021 and 2020 and the changes in its net assets and its cash flow for the years then ended in accordance with accounting principles generally accepted in the United States of America. The financial statement disclosures are neutral, consistent, and clear. We encountered no significant difficulties in dealing with management in performing and completing our audit."

**Report of the AsMA Foundation Chair (Kim Broadwell):** Dr. Broadwell thanked members for donating $2,805 during the annual meeting registration to the AsMA Foundation, with a grand total of $105,000 in the last 15 years.

AsMA members were saddened by the untimely passing of Dr. John B. Charles in February 2021. To honor Dr. Charles' leadership and scientific contributions to Space Medicine, the Space Medicine Association (SMA) established the JB Charles Research Scholarship which will be awarded at the annual SMA luncheon.

Dr. Mark Campbell has been a leader in the formation of the Space Surgery Association (SSA), an AsMA affiliate organization. The SSA is an international organization of surgeons and other physicians, procedural medicine specialists, and engineers working to develop capabilities to perform operative care in microgravity. In December 2021, Dr Campbell and his wife Betsy signed an agreement with the Foundation creating and funding the Mark and Betsy Campbell Endowed Fund to support the SSA Future Researcher Award.

The AsMA Foundation continues to serve AsMA and its members to provide CME and Genie Bopp, Foundation Secretary/Treasurer, reports that the Foundation is solid financially with assets on December 31, 2021 totaling $662,746, up from $563,540 at the close of 2020.

**GOVERNANCE (Susan Northrup)**

**Report on ASMA Bylaws Changes (Eilis Boudreau):** A large number of sections within the bylaws urgently need to be corrected. Our bylaws need to be changed to accommodate virtual meetings or hybrid meetings. Thanks to Dr. DeVoll and Dr. Baisden for their review and input. These changes have been vetted through the Executive Committee and the AsMA Council. Jim Devoll asked for a motion to approve the AsMA Bylaws changes reflecting new ethics guidance. A motion was made by the Bylaws Committee to make bylaws changes to allow for virtual and hybrid meetings. Both motions were seconded and passed.

The proposed bylaws changes will be published in the Newsletter and are in the Reno AsMA meeting APP and presented on screen during the business meeting. Approved changes into the AsMA Bylaws can be found at: (https://www.asma.org/asma/media/AsMA/Governance/AsMA-Bylaws.pdf) and the AsMA Policies and Procedures Manual: (https://www.asma.org/asma/media/AsMA/Governance/AsMA-P-P-Manual.pdf).

**Nominating Committee Report (H. Ortega):** The Slate of Officers was assembled between Sept 2021 and Dec 2021. The President Elect is Joseph Dervay; Vice Presidents - Rebecca Blue (1 yr to replace Joe Dervay), Robert Orford (2 yr) and Warren Silberman (2 yr), Treasurer - Casey Pruett; Members at Large Ilaria Cinelli, W. Brent Klein, Peter Lee. and Anthony Wagstaff.

**AsMA Treasurer's Report (Nereyda Sevilla):** In 2021 we ended the year $135K in the red. The 2021 budget was approved with concessions made for lower revenue and expenses as we get back to a post-COVID world. Cancelling Denver 2021 would have incurred a $500,000 penalty and loss of revenue, usually in the hundreds of thousands of dollars per conference, ultimately costing AsMA approximately $1M. Keeping the Denver conference was a break-even success yielding a net revenue of $25K. The convention revenue was $349K less than budgeted, with the expenses $118K over budget. Since the convention provides the primary source of revenue, it is expected that the overall revenue is less than budget. The webinar offerings provided another $19K in revenue new in 2021. Due to COVID, the Home Office was able to apply for and received two Payroll Protection Program funding. This are federal grants that do not have to be repaid. AsMA received a total of two PPP payments (the first $94K and the second $75K) totaling $169K of additional revenue for 2021. Efforts for an automatic payment plan for membership could help in a sustained avenue of revenue. The journal did well at $23K above budget with increases in royalties while the membership hit $143K above budget despite the lower individual and corporate membership. The increase in membership revenue is primarily due to the PPP of $169K. Journal expenses essential hit target but we were under budget for AsMA Management expenses due to IT and travel savings. Overall, we had hoped to break even this year, but ended $211K below budget. The goal remains to have $1M in the Investment Portfolio to be used for down years and unanticipated expenses. The $280K withdrawal in 2021 covered final Denver expenses, Payroll, Hosting of Council Meeting, and Scientific Review.

**Recommendations:** Reassess ASMA financial position after Reno and perhaps replenishing the investment portfolio to regain our $1M posture. Use the lessons learned from 2020 and 2021 and increase revenue with a potential virtual convention, meetings, and workshops. We will also continue to leverage the cost saving efforts from the membership and journal committees.

**REPRESENTATION AND ADVOCACY (DeVoll/Jeff Sventek for Barry Shender)**

Update on Aerospace Medical Association Resolution 2020 – 01: Resolution entitled "Vital Nature of Board-Certified Physicians in Aerospace Medicine," co-sponsored by Kris Belland, Joe 'Bugs," Ortega with Warren Silberman, and Dan Berry, approved in 2021. Approval by AsMA aligned perfectly with the American Osteopathic Association (AOA), AOCEM, FAA House of Delegates meeting. The resolution went to Commercial Space Companies and the National Transportation Board (NTSB). President of the AMA, Dr. Harmon, was extremely happy about the letter and will compose a letter to be sent out to organizations under the AMA.

**Communications Committee Report:** A proposal was presented and accepted by the AsMA Council during the 2021 Annual Scientific Meeting in Denver, for an enhanced communications strategy for our Association. The proposal included improving AsMA web page user experience, reinforcing AsMA's STEM outreach and science communications, creating engaging content in a regular and consistent manner for all our existing and potential audiences, and teaming up with HQ staff and journal staff to produce and publish short videos, podcasts, visual abstracts, and Q&A sessions.

**Scientific Program** abstract mentorship update: Letters were sent to residents and students to submit presentation and posters for feedback on their posters and presentations.

*Continued on p. 664.*

*Continued from p. 663.*

**EDUCATION & RESEARCH (Warren Silberman)**

**Education and Research Committee:** Susan Fondy has done a great job with well-organized Zoom meetings and notes. She is stepping down as chair.

**Science and Technology Watch** is being reinvigorated and will be placing articles for the Blue Journal headed by Ryan Mayes.

**MEMBER SERVICES (Joe Dervay)**

**Awards Committee Report (Joe Dervay):** Eric Olins has done outstanding work in crafting changes to the rules for submitting awards. The approved changes to the award rules include not nominating one individual for more than two awards per year. The committee will review the 21 current awards to determine if there are awards that should be consolidated due to addressing the same general criteria.

**Membership Committee Report (Joe Dervay):** Dana Windhorst is stepping down as chair. Auto Dues with ACH (automated clearing house) has been established.

**INTERNATIONAL SERVICES (Robert Orford)**

Despite the travel restrictions that are still in place during the pandemic we have a significant international presence here in Reno.

**AsMA-ESAM-IAASM-SoFRAMAS International Conference in Aerospace Medicine ICAM (Paris - Sep 2022) (Robert Orford):** The conference center will be at the City of Science and Industry, it is large venue with easy access to the Metro. AsMA will be managing all the registration for ICAM. Hotels near the venue, in the Northeast part of the city, are more reasonable than the hotels downtown.

**AsMA Allied Membership (Robert Orford):** The program, which we expect to be sustainable if we reach 50, currently has 21 members and will be reviewed by council at the end of the year.

**Unfinished Business – none**

**New Business – none**

**Closing remarks (Jim DeVoll):** Thank you for being here. It shows enormous support. Please contact me at JRDevoll@aol.com with any suggestions on how to increase membership, outreach and other new ideas.

Motion made and seconded to adjourn meeting at 1:10 pm PDT.

Respectfully Submitted,
**Jeffrey Sventek, MS, CAsP, Executive Director**
**J. Karen Klingenberger, MD, MPH, MS, Secretary**

## ANNUAL LECTURES

**Both AsMA and UHMS provided their annual lectures in plenary sessions throughout the week.**

**(Top left) 67th Louis H. Bauer Lecture--Dr. Michael A. Berry (center) delivered the lecture. Representing the sponsor, KBR, is Keith Kreutzberg (left), with AsMA President, Jim DeVoll (right).**

**(Top right) Eric P. Kindwall Memorial Lecture--Lindell Weaver, M.D., delivered the lecture, Monday, May 23.**

**(Center) 8th Eugen Reinartz Panel (left to right)--Joe Dervay (moderator), Jon Clark, Jay Dean, Richard Moon, and Mike Gernhardt, were the panelists discussing Pressure.**

**(Bottom left) Christian J. Lambertsen Memorial Lecture--UHMS President, Marc Robins, introduces the lecturer, Robert Sanders.**

**(Bottom right) 56th Harry G. Armstrong Lecture--Melchor Antunano, M.D, the lecturer, receives a memento from Bob Laurent and George Anderson of ETC, sponsors of the lecture along with James DeVoll, AsMA President.**

**All of the lectures can be viewed at: https://www.asma.org/scientific-meetings/asma-annual-scientific-meeting/proceedings**

**MEETING PHOTO GALLERIES**–For more photos from the annual meeting in Reno, please visit our Photo Gallery page via the AsMA website: https://aeromed.smugmug.com
All photos by Pamela C. Day.

August 2022

# Aerospace Medicine and Human Performance
# INFORMATION FOR AUTHORS
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*Aerospace Medicine and Human Performance* is published monthly by the Aerospace Medical Association. The journal publishes original articles that are subject to formal peer review as well as teaching materials for health care professionals. The editor will not ordinarily review for publication work that is under consideration or has been accepted or published by another journal except as an abstract or a brief preprint.

### TYPES OF PAPERS

The five types of articles specified below should be submitted through the web site and will undergo peer review. Other submissions including **Letters to the Editor, Book Reviews,** and teaching materials should be submitted by e-mail to the Editorial Office. Letters to the Editor are limited to 500 words of discussion and/or criticism of scientific papers that have appeared in the journal within the past year. *If your manuscript does not fit the parameters layed out below, an exception may be granted. Please contact the Editoiral Office to discuss your submission.*

***Research Articles*** present the results of experimental or descriptive studies with suitable statistical analysis of results. They should contain an Introduction, Methods, Results and Discussion with a statement of conclusions. Such manuscripts should not exceed 6000 words with approximately 25 references.

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***Case Reports*** and ***Case Series*** describe interesting or unusual clinical cases or aeromedical events. They should include a short Introduction to provide perspective, the Presentation of the Case, and Discussion that includes reference to pertinent literature and/or review of similar cases. Such manuscripts should not exceed 3000 words with approximately 12 references.

***Short Communications and Technical Notes*** describe new techniques or devices or interesting findings that are not suitable for statistical analysis. They should contain the same sections as a Research Article but should not exceed 3000 words with approximately 12 references.

***Commentaries*** are brief essays that set forth opinion or perspective on relevant topics. Such manuscripts may not exceed 1000 words with approximately 10 references without tables or figures.

We also accept ***Historical Notes,*** and ***Aerospace Medicine Clinic*** (formerly **You're the Flight Surgeon**) articles.

### RULES FOR DETERMINING AUTHORSHIP

Each person designated as an author should have made substantial intellectual contributions as specified in the Instructions for Authors.

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The language of the journal is standard American English. Authors who are not perfectly fluent in the language should have the manuscript edited by a native speaker of English before submission. Measurements of length, weight, volume and pressure should be reported in metric units and temperatures in degrees Celsius. Abbreviations and acronyms should be used only if they improve the clarity of the document.

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Tables and figures should be used strictly to advance the argument of the paper and to assess its support. Authors should plan their tables and figures to fit either one journal column (8.5 cm), 1.5 columns (12.5 cm), or the full width of the printed page (18 cm). Tables should be assigned consecutive Roman numerals in the order of their first citation in the text. Tables should not ordinarily occupy more than 20% of the space in a journal article. Figures (graphs, photographs and drawings) should be assigned consecutive Arabic numerals in the order of their first citation in the text. Line drawings of equipment are preferable to photographs. All graphics should be black & white: 1200 dpi for line art; 300 dpi for photos; 600 dpi for combination art. They must be sent electronically, preferably as high resolution TIFF or EPS files. See Documents to Download online for further instructions.

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The style for references is the National Library of Medicine (NLM) format, using name-sequence, i.e. alphabetical by author.

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When the paper is ready for publication, the printer places on its web site a PDF file depicting the typeset manuscript. The Corresponding Author will be notified by e-mail and is responsible for correcting any errors and for responding to any "Author Queries" (Qs).

### EDITORIAL OFFICE

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