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Investigating the Impact of FAA Cockpit Regulations on Kidney Stones in American Airline Pilots

Noor Said

Following the incidents of 9/11, the FAA implemented safety regulations that restricted pilots from exiting the cockpit. While pilots and other individuals from the commercial aviation industry speculated that these regulations prevented pilots from using the lavatory, thereby exacerbating dehydration and kidney stone prevalence, the issue remains relatively unexplored. To address this gap, a survey involving 280 American cargo and passenger airline pilots was conducted. Based on the results, passenger pilots intentionally reduced fluid intake in-flight due to FAA protocol, and the rate of nephrolithiasis amongst passenger pilots was higher than that of cargo pilots, who do not have a cockpit door and therefore were representative of a control group. From these findings, it is recommended that further investigation is conducted on this issue and that current FAA protocol be remedied to protect the safety of pilots and passengers.

Keywords: nephrolithiasis, FAA, aerospace medicine, airline pilots, dehydration

Introduction

The most exigent health issues impacting developed countries today are not the plagues which dominate discussions; rather, this age faces the onslaught of chronic disease and a rise in preventable health conditions. Amongst these overlooked issues lies the rise in kidney stones, deposits of minerals and acid salts which crystallize in the kidney and fall into the ureter (Ford-Martin & Cataldo, 2015). In recent years, the United States has faced a steady increase in the prevalence of kidney stones, and a National Health and Nutrition Examination Survey (NHANES) (2012) estimates that the condition will affect approximately one in ten Americans during their lifetime (Scales, et al., 2012). If untreated, kidney stones cause severe physical discomfort and hinder daily activities. It has been confirmed that nephrolithiasis, or kidney stone formation, is influenced by several modifiable lifestyle factors, which may stem from occupation.

Within the realm of exposomics, defined as the cumulative exposures to health issues a person has during their lifetime, individuals are more susceptible to nephrolithiasis as a result of their work and the behaviour that it requires. According to Dr. Goldfarb (2016), a nephrologist (kidney specialist) at New York University who investigated 2012 NHANES data, workers in the American transportation sector face high exposure to kidney stones, with an average rate of nephrolithiasis that is significantly higher than the general population (Goldfarb, 2016). While several factors render these individuals more susceptible to the condition, the proportion of those afflicted with nephrolithiasis in one particular group has seen a troubling increase within the past two decades: commercial airline pilots.

Defined as aviators who operate aircraft carrying passengers or cargo, commercial pilots are a particularly crucial group to monitor because they may experience renal colic, the sudden onset of pain from nephrolithiasis, while operating a plane. Renal colic's symptoms include nausea, vomiting, a radiating sense of pain, and fainting. Therefore, pilots may become incapacitated, posing danger not only to themselves but also to passengers. A unique and unexplored reason for the suggested high kidney stone rate in pilots may lie in federal policy. Following the attacks of September 11th, 2001, new safety regulations were implemented by the Federal Aviation Administration (FAA). As a result of this intricate set of rules, a pilot may not exit the cockpit to use the restroom without calling in flight attendants. As described in an FAA handbook (2004), attendants open and lock the cockpit (while one attendant remains inside with the co-pilot), block the aisle as the pilot uses the lavatory, and escort the pilot back into the cockpit ("Crew Resource Management Training," 2004). Those in the aviation industry have complained about the process and speculated that it may contribute to nephrolithiasis in pilots by preventing them from using the lavatory, though little research has evaluated the validity of such a claim. In a 2015 interview, president of the Aviation Medicine Advisory Service Dr. Snyder disclosed that "more pilots have been calling… about kidney stones in recent years than in the period before September 2001" (Werfelman, 2014). Additionally, Silberman (2016), a former FAA medical certification manager, notes that those who fail to eliminate all traces of kidney stones or have recurrent nephrolithiasis may not be certified for aviation (Silberman, 2016). Therefore, while the issue is overlooked, the consequences of a pilot having kidney stones are rather significant and complex.

In the attempt to explore the cause of nephrolithiasis in American airline pilots, this paper investigates the impact of the aforementioned FAA policies, guided by the question: to what extent has the implementation of post-9/11 cockpit regulations by the FAA influenced kidney stone prevalence in American airline pilots? Extensive research was conducted to arrive at the justification of this question, and in order to fully understand its significance, it is necessary to examine the interconnected perspectives which revolve around it.

Literature Review

The issue of nephrolithiasis in airline pilots was derived from a pre-existing body of literature discussing the rise in nephrolithiasis, FAA policies, and pilot health. This literature review provides a comprehensive understanding of the trends and modifiable risk factors for nephrolithiasis and a range of perspectives on the rise of kidney stones in pilots. In this review, it is important to understand some background circumstances. Firstly, it should be established that pilots are put through rigorous testing to receive a medical certification and operate a commercial plane. Additionally, while factors such as heredity, global warming, gender, and location influence nephrolithiasis, as demonstrated by researchers who analyzed 2012 NHANES data at the Cleveland Clinic's Glickman Urological & Kidney Institution, this paper will only investigate primary modifiable risk factors (Roudakova & Monga, 2014). With regard to gender, only six percent of active commercial pilots are female according to a recent FAA study, although the following studies did not separate pilots by gender (FAA, 2018). Following the notion that overall kidney stone prevalence has been increasing, it is first necessary to understand these factors and how they differ in American pilots.

Obesity

Body mass and dehydration have dominated the discussion surrounding the increase in nephrolithiasis, and there exists a considerable body of evidence showing that pilots have a greater susceptibility to these risk factors, such as high Body Mass Index (BMI). High BMI is associated with intensified excretion of uric acid and oxalate in the urine, which causes nephrolithiasis. Harvard Medical School professors Ferraro, Taylor, and Curhan (2015) worked in collaboration with nephrologists Sorenson and Gambaro in a risk-factor study. After analyzing National Health Surveys I and II and categorizing data by factors including BMI, they concluded that BMI had a strong direct correlation with nephrolithiasis (Ferraro et al., 2015). Supported by extensive evidence, these findings are particularly unsettling when the population is narrowed to U.S. pilots, who have been suggested to have unusually high BMIs.

Bryman and Mills (2007), doctors of Aerospace Medicine, searched FAA medical databases to establish a pilot obesity rate. After analyzing the files of 630,670 pilots, they found that nearly 70% of American pilots were overweight or obese, a rate considerably higher than that of the general population at the time of publishing, which was a possible result of prolonged sitting (Bryman & Mills, 2007). While the study is outdated, it involved a large sample size and was the first to determine a BMI distribution for U.S. pilots. Though American pilots appear to have higher

BMIs than non-pilots, this does not hold true globally.

The findings of cardiologists Syburra et al. (2017), who wrote and published an article in the peer-reviewed *European Journal of Cardio-Thoracic Surgery* on European pilot obesity in collaboration with Swiss and British federal aviation branches, differ from those of Bryman and Mills (2007). From searching the MEDLINE database for cardiovascular disease, the researchers found that the average pilot BMI was equal to or lower than that of other Europeans (Syburra et al., 2017). This implies that flying an airplane alone is not associated with high BMI, contrary to the suggestion made by Bryman and Mills (2007). While the suspected American pilot BMI may be a reason for pilot nephrolithiasis, water intake also plays a critical role.

Dehydration

With consistent dehydration, uric acid dilution is inhibited, raising acidity levels in the kidney (Ford-Martin & Cataldo, 2015). This acidic environment is the primary cause of nephrolithiasis. According to an article from *The Gale Encyclopedia of Medicine*, the primary method of kidney stone prevention recommended by health organizations such as the National Kidney Foundation was to simply drink over eight cups of water daily (Ford-Martin & Cataldo, 2015). Yet, the aforementioned article by Goldfarb (2016) found that transportation workers were most likely to develop kidney stones from dehydration (Goldfarb, 2016). Goldfarb (2016), who cited a large, representative survey of Americans (NHANES), has practiced nephrology for decades, and while this may contribute to personal bias, the source offered relevant information on nephrolithic exposomics. Goldfarb's (2016) findings are applicable to the general transportation sector; however, several recent sources note that American pilots have avoided water in-flight.

According to an article by Werfelman (2014), senior editor for the Flight Safety Foundation, American pilots are severely dehydrated and must drink more water. After interviewing Dr. Snyder and evaluating data previously acquired by researchers from the *Aviation Medicine* journal, Werfelman noted that nearly two-thirds of pilots avoided drinking liquids while flying, contributing to fatigue and chronic health issues (Werfelman, 2014). While Werfelman (2014) was heavily reliant on the interview of Snyder in her article, she included survey data showing that pilots consumed less water than recommended, and disclosed that more research should be done on the subject. Werfelman's perspective gave this research direction, as it was possible that pilots avoided liquids due to cockpit regulations. Despite the idea that pilots are more susceptible to these risk factors, there is inconsistency in establishing a rate for pilot nephrolithiasis.

Rate of Pilot Nephrolithiasis

Due to these factors and their apparent exacerbation the aviation medical community believes that American pilots are highly susceptible to nephrolithiasis. However, there are discrepancies in establishing a stone rate. In Werfelman's (2014) article, data included from the aforementioned NHANES shows that pilots were 6.5 percent more likely to be affected by kidney stones than the general population, which is significant given the non-pilot rate of nine percent; in his interview, Dr. Snyder claims that this rate has been growing in the past decade (Werfelman, 2014). However, a source from the peer-reviewed *Journal of Urology* refutes this claim. In response to airline companies claiming that pilots have had more kidney stones as a result of strict cockpit rules, the FAA funded researchers to investigate the issue. CAMI, the Civil Aerospace Medical Institute, is the research branch for the FAA. Using its data, researchers Hyams, Nelms, and Silberman (2014) found that pilots had a rate of nephrolithiasis which was nearly equivalent to that of other Americans. Furthermore, they claim that the rate has not been rising, refuting airline company complaints (Hyams, Nelms, & Silberman, 2014). However, suspension may arise as a result of nephrolithiasis detection, and this data excluded inactive pilots. In a 2016 article, Silberman, former FAA medical certification manager, disclosed that "many pilots with kidney stones were unable to receive recertification" in past years, meaning FAA data may have been biased in favoufr of healthier pilots (Silberman, 2016). Therefore, there are discrepancies in the establishment of pilot nephrolithiasis rates, and no research has been published showing changes in this rate over time, further complicating the current status of the issue.

Hypothesis

The holistic review of this literature determines that, while pilots are susceptible to the same risk factors as non-pilots, these factors are likely more prevalent in pilots. Still, the true rate of pilot nephrolithiasis is unclear, and a pilot-specific cause influencing nephrolithiasis and risk factors has yet to be validated. Though pilot nephrolithiasis is a significant issue, current literature on the subject is sparse. Dehydration has not been attributed to a root cause, and only one outdated American pilot BMI analysis was found, meaning these factors should be accurately evaluated. Furthermore, nephrolithiasis and its risk factors have not yet been analyzed to address how different genres of commercial pilots are influenced. Cargo pilots, who lack a cockpit door and may therefore use the lavatory freely, may be influenced differently than passenger pilots, who have a cockpit door and must accordingly adhere to the aforementioned FAA protocol. These issues, combined with anecdotal evidence and complaints from the aviation industry connecting cockpit regulations to nephrolithiasis, render further investigation necessary.

Given that these risk factors are modifiable, identifying a pilot-specific cause may bring forth a viable solution. This research aimed to identify the impact of post-9/11 FAA cockpit protocol on nephrolithiasis in American pilots, by establishing a BMI distribution and addressing how the cockpit rules have influenced dehydration. Furthermore, this study aimed to establish the frequency of nephrolithiasis for American commercial pilots, grouped by their assignment and resulting adherence to the cockpit protocol. Based on existing literature, this research investigates the hypothesis that pilots are more overweight and obese than the general population, and that passenger pilots consume less water than recommended as a result of the FAA rules. Most importantly, passenger pilots were hypothesized to have a higher susceptibility to kidney stones than cargo pilots, as a result of cockpit regulations altering pilot behaviour and exacerbating pre-existing risk factors for the condition.

Method

Study Design

For the purpose of addressing the influence of FAA regulations on pilots, it was necessary to obtain a sample of commercial pilots employed by the United States. There was no control over variables and subjects reported all information, meaning that this study was descriptive in nature (Kobayashi, n.d.). Because this research ultimately explored a relationship dependent on the individual habits of its population of interest, the study included both qualitative and quantitative elements. Experimentation to identify true causation was neither ethical nor plausible, and it was impossible to control nephrolithiasis and pilot assignment. Therefore, a survey was conducted to identify nephrolithic prevalence and address all aspects of the research question.

To establish large, representative samples that could be used for hypothesis testing, probability sampling was used: random selection occurred after collecting all pilot surveys and separating cargo pilots from passenger pilots. The modifiable risk factors addressed in the survey were water intake (additionally measured through lavatory usage), and BMI. In addition to BMI, the survey identified some external factors which could be influencing nephrolithiasis, such as family history of kidney stones, gender, and age. The survey addressed the overall nephrolithiasis rate in American pilots, where cargo pilots were compared to passenger pilots to identify whether significant differences could be found based on FAA rules.

Ethical Considerations

Given the need for many pilots to provide information on a potentially sensitive topic, all measures were taken to keep the research ethical. Pilots could feel uncomfortable answering questions regarding their lavatory usage and kidney stone affliction. To address these components as noninvasively as possible, only a yes/no response to kidney stone history was recorded, no surgical procedures or complications were addressed, and a minimal number of questions addressed lavatory usage. Prior to the administration of the online surveys, all research materials, including the survey and an email for participants detailing the purpose of this research, were submitted to the student's high school Institutional Review Board (IRB) for a full review. With the addition of background to the email message, along with minor modifications to the wording of survey questions, the project was approved by the IRB.

The final approved survey (see Appendix A) was anonymous and featured the least invasive questions which aligned with the research question. To preserve respondent confidentiality, the survey was stored on a password-protected account belonging to the researcher. Following the conclusion of the research project, the survey was discarded digitally by erasing the content files on the researcher's computer, ensuring that respondent records were absolutely confidential.

All participants were given contact information for the researcher and advisor, informed of the background and nature of the research project, and allotted a space in the survey for additional questions or concerns. Moreover, subjects were informed that the survey was voluntary and anonymous, no questions were required, the survey could be withdrawn at any time without repercussions, and the electronic records would be safely stored and destroyed at the conclusion of the project by the researcher.

Participants

In accordance with the population of interest, American commercial pilots, the primary requirement for the survey respondents was that they were commercial airline pilots employed by the United States. Retired pilots were removed to avoid potential confounding variables such as old age, which influences likelihood of illness. The study frame included all cargo or passenger pilots over eighteen years of age, with the goal of establishing samples representative of the current pilot population.

These subjects comprised two simple random samples (SRS) of cargo and passenger pilots who provided basic information, which addressed the key components of the study. Because subjects would not be met in-person, it was necessary to verify that only American commercial pilots would complete the survey. For greater variation amongst participants, the survey was both emailed and shared with pilot forum users. Prior to survey administration, a minimum sample size of 100 pilots was established to yield more accurate results. Emails were acquired from a passenger pilot information list: the Delta, American, and United rosters (which included pilot names, flight hours, and activity status) were searched and compiled into an email list of those who would receive the survey. In addition, an FAA database naming all pilots with certifications was used to add individuals to the email list, for a total of fifty pilot emails. Aside from receiving it by email, pilots could access the survey through the AOPA Hangar, ProPilotWorld.com, and Airline Pilot Central forums. The split-distribution method allowed pilots from numerous locations and airlines to participate, contributing to a representative sample.

Procedure

The independent variable examined was the adherence to the FAA cockpit rules. Commercial cargo pilots, who did not have a cockpit door and could use the restroom freely, were the control group representing all pilots if the post-9/11 FAA rules were not in place. The primary dependent variable was the presence of kidney stones; however, due to the complexity of nephrolithiasis and its reliance on several risk factors, fluid intake and BMI were also addressed. Given its observational nature, there was no control over the other existing variables in my survey. In addition, the year of kidney stone diagnosis, airline, age, sex, and retirement status were recorded to verify subject inclusion. While questions based on pilot judgment regarding the effect of FAA cockpit rules on their behaviour employed a Likert scale, others, such as flight hours, were multiple choice or free response. The primary areas of interest were:

- Airline, to identify cargo pilots from passenger pilots
- Presence of nephrolithiasis and year of diagnosis
- BMI
- Influence of FAA regulations on lavatory use and water consumption

For comparison and hypothesis testing, subjects were categorized into one of two samples based on whether they flew cargo or passengers. After the online *Google Forms* survey was drafted and approved by the IRB, proper contact information and permissions were obtained. Prior to posting the surveys on the aforementioned forums, consent was obtained from the AOPA (Aircraft Owners & Pilots Association) Director of Medical Certification and forum administrators. Titled "Research Survey Opportunity for U.S. Pilots," the survey was posted with a description of the research project. The ProPilotWorld.com survey was posted once by the administrator, while the other sites permitted me to post the survey several times. Because the Airline Pilot Central site was divided into sub-forums, I posted in the popular, yet relevant, "Pilot Health" and "Major Airlines" categories, ensuring that many pilots could access the survey.

To avoid bias towards forum users, fifty Delta, American Airlines, and United Airlines passenger pilots were emailed the survey with a detailed message on the nature of this research. Emails were acquired from the aforementioned FAA "Pilots with Certifications" database and airline rosters. If the email was not immediately located, pilot names and airlines were input through Skrapp.io, a contact finder program for those with business emails. Absolutely no subjects were coerced into participation, and all premises for the research and confidentiality were disclosed.

Once two weeks had passed from the start date of survey collection, the survey link was deactivated for analysis. Cargo pilots were separated from passenger pilots, and a total of ten military pilots, non-American pilots, or individuals who failed to verify their current occupation as a pilot were excluded from the sample. Pilots were not excluded for non-response to certain questions, including height, weight, and geographical residence, as their opinion on FAA protocol remained valuable. After separation, the resulting 146 passenger pilot surveys were assigned numbers 1-146 and the 134 cargo pilots were numbered 1-134. One-hundred pilots of each group were selected for analysis using the random number generator on a TI-Nspire calculator.

A 2-proportion z-test was performed using the random samples to determine whether the passenger pilot population had greater frequencies of nephrolithiasis, and pilot stone diagnoses were graphed by year to observe potential trends. In addition to kidney stone rate differences, risk factors were addressed for each group. The BMIs and opinions on FAA policy influence were analyzed from each sample of active pilots. While BMI, a confounding variable that could be causing high pilot nephrolithiasis, was used for comparison to the general population and to ensure similarity amongst the samples, questions on hydration and lavatory habits provided insight on the extent of FAA policy influence. Average water intake and the differences in water consumption in and out of work were calculated for each group. To determine whether pilot dehydration was influenced by the policies, responses to the opinion statements were graphed and compared. These measures allowed for a comprehensive analysis of the influence of the cockpit protocol on pilot nephrolithiasis.

Results

The collection of 280 cargo and passenger pilot surveys resolved several crucial questions about the impact of FAA regulations on pilot nephrolithiasis. To properly interpret the findings of this study and establish a focus on the FAA regulations' influence on nephrolithiasis in pilots, it is first necessary to establish the differences identified between the two sample groups. As mentioned previously, both cargo pilots and passenger pilots were sampled, and the final randomized groups which were analyzed consisted of 100 individuals each. The following table displays basic background information for each group:

	PASSENGER PILOTS	CARGO PILOTS
Mean Age	40.1	45.1
Mean # of Years Spent as Pilot	13.9	21.0
Mean Flight Hours Accumulated	7,533	10,088
Gender Distribution	6% female 94% male	1% female 99% male

Table 1
Comparison of Cargo and Passenger Pilot Samples

Cargo pilots had a higher mean age and number of piloting years. Accordingly, the cargo flight hour mean was 2,555 greater than that of passenger pilots.

Although both groups were disproportionately male, a considerable difference was that the passenger pilot sample consisted of five more females.

The primary objective of this project was to identify the true proportion of pilots who have had kidney stones, so this frequency was established for each sample group. Of the 200 individuals in the samples, a total of nine cargo and eighteen passenger pilots reported having had kidney stones, a proportion that appears to be increasing for passenger pilots when graphed:

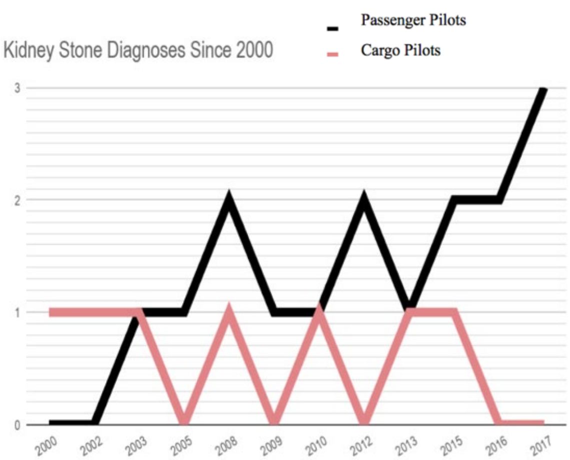

Figure 1. Kidney Stone Count by Year (cases before 2000 not depicted on graph)

A 2-proportion z-test for $P_{passengerpilot}$-$P_{cargopilot}$, where P represented the true proportion of pilots with kidney stones, was performed to determine whether passenger pilots had a higher nephrolithic rate, which would imply that the adherence to FAA policies was correlated with exacerbated kidney stone development. Based on the test (see Appendix B), conducted at the five percent significance level, passenger pilots experienced a greater rate of kidney stones, with a P-value of .031 being lower than the alpha of .05.

While the incidence of nephrolithiasis appeared rather different amongst the two groups, it was also necessary to evaluate pilot opinions, as pilots are ultimately responsible for determining how FAA policies impact their in-flight habits. Fluid intake and bathroom usage were addressed to determine both current and prospective risk for nephrolithiasis. Based on survey responses, 85% of passenger pilots reported that FAA rules deterred them from using the bathroom, making them more susceptible to nephrolithiasis:

In conjunction with avoiding the lavatory more often, passenger pilots were more likely to report that they intentionally decreased their fluid intake while flying a plane: these subjects reported drinking an average of 3.7 cups on piloting days, compared to 6.3 cups outside of work. In contrast, cargo pilots slightly increased fluid intake while flying, drinking 5.1 cups on workdays and 5.0 cups on non-workdays. These factors, combined with the large gap in kidney stone prevalence between the samples, suggest that FAA policies have made passenger pilots more susceptible to nephrolithiasis.

As mentioned previously, one of the additional goals of this survey was to identify a BMI distribution for

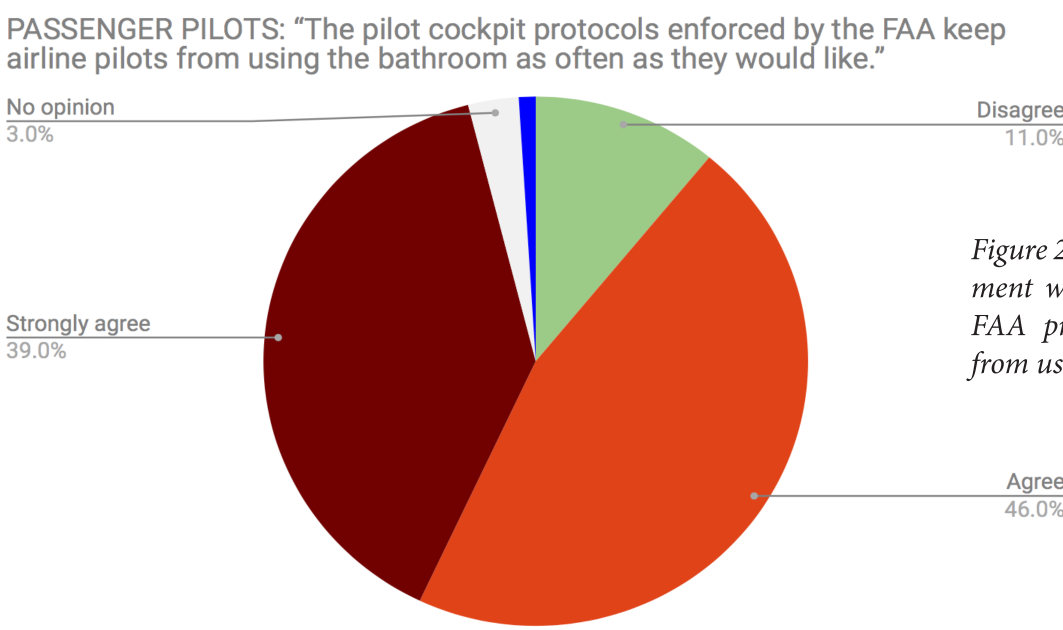

Figure 2. Passenger pilot agreement with the statement that FAA protocol prevents pilots from using the lavatory.

pilots, since high BMI was identified as a risk factor unrelated to FAA policies that could be exacerbating nephrolithiasis. Here, the samples were only somewhat similar, as 66% of passenger pilots and 78% of cargo pilots were overweight or obese.

Discussion

Analysis of Results

Based on extensive investigation, it was found that the post-9/11 cockpit protocol enforced by the FAA has exacerbated in-flight dehydration in passenger pilots, and is, therefore, a likely promoter of pilot nephrolithiasis. The results of this study addressed the rate of kidney stone development as well as the influence of modifiable risk factors for pilots. According to the aforementioned hypothesis test conducted, there was statistically significant evidence to suggest that passenger pilots have a higher rate of nephrolithiasis than cargo pilots. Considering the idea that the FAA cockpit protocol is the only systematic difference between the two populations, this supports the primary hypothesis that FAA rules cause higher stone rates. While overall nephrolithic prevalence was greater amongst passenger pilots, the samples were not large enough to truly support hypothesized time trends for stone development, though this would have been ideal. Alongside the finding a rate of kidney stones, the understanding of BMI and dehydration in pilots was also refined.

Contrary to the findings of Bryman and Mills (2007), both pilot samples displayed rather normal BMI distributions, disagreeing with the hypothesis that BMI would be higher amongst pilots than non-pilots. Surprisingly, the cargo pilot group, which reported a slightly higher rate of obesity than passenger pilots, experienced a lower incidence of nephrolithiasis, though this difference may have been due to small sample size. While this shows that high BMI was generally common, neither group was unusual in comparison to non-pilots. According to a report by the Center for Disease Control (2017), 70.7% of American adults are overweight or obese, implying that commercial pilots do not have substantially greater risk for kidney stones as a result of high BMI than does the general population ("Obesity and Overweight," 2017). Therefore, other modifiable factors have been aggravating pilot nephrolithiasis, of which the most notable appears to be dehydration.

The results of this survey suggest that the majority of passenger pilots avoided water as a direct result of the FAA cockpit regulations. In conjunction with the findings of Werfelman (2014), both samples consumed less than the recommended eight cups of water daily, implying that dehydration is an issue for all pilots regardless of FAA rules. More significant to this research, this survey showed that passenger pilots deliberately reduced water consumption while working, a habit identified by Goldfarb (2016) as the primary mechanism for nephrolithiasis in transportation workers due to uric acid accumulation (Goldfarb, 2016). Furthermore, 85% of passenger pilots agreed that FAA cockpit rules deter pilots from going to the lavatory, verifying that FAA cockpit protocol is a hindrance for passenger pilots who wish to use the bathroom. These pilots have accordingly reduced water intake, making them more susceptible to nephrolithiasis.

Limitations

Several limitations to this research should be considered, with the most prominent being the potential for voluntary response bias: pilots who have had nephrolithiasis may have been more interested in the research and participated more frequently than others, implying that the samples may not have been fully representative. Furthermore, most participants were forum users: pilots who were not active on forums during the two weeks of survey collection lacked representation. Due to potential bias and the survey's reliance on participant honesty, further studies should be done to verify results.

In addition to bias, there exists the issue of underlying risk factors which were not controlled for: diet and other health issues may have been different between the two samples due to sampling variability. Such factors were not examined due to limited time and resources, meaning the analysis of risk factors was incomplete. Finally, due to small sample size, the results may contain inaccuracies, and could not be used to identify time-trends in nephrolithiasis. Nonetheless, this project gives direction to the issue of the FAA regulations' influence on pilot nephrolithiasis.

Conclusion and Future Directions

The findings of this survey provide several interesting implications for the aviation industry. Most importantly, it is apparent that passenger pilots are likely more susceptible to nephrolithiasis as a result of FAA cockpit regulations, which have amplified the prevalence of a modifiable risk factor, dehydration, by causing pilots to reduce fluid intake to use the lavatory less frequently. Additionally, this study contradicts former hypotheses that American pilots are more overweight and obese than non-pilot Americans (Bryman & Mills, 2007).

From this study, there remain several questions regarding the future of American airline pilots, and additional research should be conducted to address the extent of FAA influence on nephrolithiasis. The FAA's CAMI research branch, given its resources and access to pilots, should most likely address this issue. A time-trends analysis should be conducted to estimate current and future nephrolithiasis rates, and this survey or a similar study should be repeated on a larger scale. Furthermore, if future research supports the findings of this survey, a solution to the issue of nephrolithiasis must be established, via an acceptable amendment to FAA protocol granting pilots unhindered access to the lavatory. If a high rate of nephrolithiasis persists, thousands of pilots will not only be physically harmed but also face losing certification. Additionally, undetected pilot kidney stones may result in the endangerment of hundreds of passengers. Further investigation into this issue is critical: without it, the health and safety of countless individuals may suffer, and the future of the aviation industry may be compromised as it ascends into this new stone age.

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Appendix A

Airline Pilot Survey
2018

*All responses to this survey will be anonymously recorded and stored safely by the researcher. Your participation in this research study is voluntary. You may choose not to participate. If you decide to participate in this research survey, you may withdraw your survey at any time. If you decide not to participate in this study or if you withdraw from participating at any time, you will not be penalized. You are not obligated to answer every question in this survey. The data acquired from this survey will be used in a research paper and presentation regarding kidney stone prevalence in pilots and FAA cockpit rules, in which no survey participant names will be disclosed. Thank you for your time, and with any questions or request to cancel survey, please submit in the questions section of this survey or contact the author or research advisor at: ********@******** and ********@********.*

Please provide age and gender:

AGE: ________________________

GENDER: ______________________

Please verify your current occupation:

Airline Pilot (passenger)

Airline Pilot (cargo)

Retired Airline Pilot

Other (please specify)______________________

Under what Airline are/were you most recently employed?________________

Under which country are you currently employed? Please select all that apply.

United States of America

Other (please specify)_____________________

How many years have you been a pilot? If retired, please include date of retirement:___________________________________

Have you ever had a kidney stone?

Yes

No

Prefer not to answer

If your answer to the previous question was yes, in what year were you diagnos ed?___________________________________

Have you ever been treated for a kidney stone?

Yes

No

Prefer not to answer

Please select your current flight route type:

Domestic

International

Both domestic and international

Approximately how many hours of flight have you accumulated? ________

How many cups of water (8 fluid ounces), on average, do you drink on a day where you are in flig ht?__________________________________

How many cups of water (8 fluid ounces), on average, do you drink daily outside of work?___________ _______________________

What is your approximate height ?_____________ ft_____________in

What is your approximate weig ht?____________________________lbs

Do you use the bathroom less frequently during your flight as a result of FAA cockpit rules?

Yes

No

To what extent do you agree or disagree with the statement: "*I avoid drinking beverages while flying a plane to avoid needing to go to the lavatory*"

Strongly disagree

Disagree

Agree

Strongly agree

No opinion

To what extent do you agree or disagree with the statement: "*The pilot cockpit protocol enforced by the FAA keeps airline pilots from using the bathroom as often as they would like.*"

Strongly disagree

Disagree

Agree

Strongly agree

No opinion

Does your family have a history of kidney stones?

Yes

No

Not sure

Which region of the United States do you currently live in?

West

Midwest

South

Northeast

Alaska

Hawaii

Other (please specify)______________

If you have any questions for the researcher, please include them in the following response box, along with your e-mail:

____
____
____
____
____
____
____
____
____

All data is stored in a password protected electronic format. To help protect your confidentiality, the surveys will not contain information that will personally identify you. The results of this study will be used for scholarly purposes only. By clicking "Submit my responses," I understand that my survey answers may be used in a research paper and presentation. I verify that my answers are as I wish them to appear.

If you do not wish to participate in the research study, please decline participation by clicking on the "Cancel" button.

Appendix B

Inference procedure: 2-Prop z-Test for P(Passengerpilot)-P(Cargopilot)

Let P(Passengerpilot) = the true proportion of American passenger pilots who have had kidney stones

Let P(Cargopilot)= the true proportion of American cargo pilots who have had kidney stones

Null hypothesis: P(Passengerpilot)=P(Cargopilot)

Alternate hypothesis: P(Passengerpilot)>P(Cargopilot)

Conditions:

Pilot surveys included in both samples are randomly selected

Each pilot being diagnosed with kidney stones is likely independent of other pilots both within and between the samples

The 100 cargo pilots and 100 passenger pilots in the samples include less than 10% of the total pilot population for their respective group

I expect both successes and failures to result in at least

.14(100)= 14 and .14(100)=14 successes, and

.86(100)= 86 failures and .86(100)= 86 failures.

Both successes and failures of both groups are at least 10, so sample size is large enough for us to proceed with the procedure.

Mechanics: z=1.86

p^(cargopilot)=.09 and p^(passengerpilot)= .18. p^(pooled)=.135. P-value: .0321279.

Conclusion: I reject the null hypothesis that the true proportion of American passenger pilots who have had kidney stones is equal to the true proportion of American cargo pilots who have had kidney stones, with an alpha of .05>p-value of .03. There is statistically significant evidence at the 5% level to support the hypothesis that the true proportion of American passenger with kidney stones is greater than the true proportion of American cargo pilots with kidney stones.