

Under-reporting of self-reported medical conditions in aviation

- A cross-sectional survey among individuals in safety critical positions

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ABSTRACT

Background: The applicants' self-declaration of medical history is crucial for adequate and safe aero-medical assessment. Clinical experiences, anecdotes, autopsy studies, accident reports, and knowledge of human behaviour indicate that under-reporting of medical conditions exists.

Methods: A total of 9941 applicants for medical certificate/attestation for aviation related safety functions, during the last 5-years up to December 2019, were registered at the Civil Aviation Authority Norway. E-mail addresses were known for 9027 of these applicants who were invited to participate in a web based survey.

Results: Among the 1616 respondents, 726 (45%) were commercial pilots, 457 (28%) private pilots, 272 (17%) air traffic controllers and the remaining cabin crew or crew in aerodrome/helicopter flight information service (AFIS or HFIS respectively). A total of 108 were initial applicants. The age group 50+ constituted the largest proportion of respondents (53%). Aeromedical certification in general was believed to improve flight safety "to a high" or "very high extent" by 64% of the respondents. A total of 188 individuals (12%) admitted having under-reported information related to one or more categories including mental (3%) or physical health (4%), medications (2%), drug including alcohol use (5%). Among these, 21 participants believed their own under-reporting "to some" or "to a high extent", affected flight safety. In total 50% of non-initial applicants reported that they knew colleagues who had under-reported information. Analyses revealed that being a commercial pilot showed a higher risk for under-reporting compared with other classes and the perception of Aero-medical examiner in a supportive or authoritative role reduced the risk.

Conclusions: Under-reporting could be significant in aviation. Further studies should be conducted to investigate the true extent of under-reporting, and its impact on flight safety and what mitigating measures might be recommended.

INTRODUCTION

Annually world-wide there are millions of personnel, in different branches from military, to transportation, space exploration and other safety or performance related industries undergoing medical certification in order to perform related duties or tasks. Usually the person is required to undergo a health examination and assessment which also includes thousands of certified medical professionals. In addition to the individuals directly involved (applicant and assessor) the process usually involves employers, administrative bodies and/or regulatory bodies. Overall, the system draws a significant amount of resources from several parties. In aviation alone, it is estimated about 300 000 airline pilots in addition to an even bigger group of other safety critical personnel are undergoing annual mandatory examinations to achieve their privileges.

Aviation is considered a safe system due to high standards and to a high degree of compliance with procedures and regulations for all subparts of the system. From accident investigations 70-80% of all accidents could be attributed, at least in part to, human error^{17,19}. Medical conditions have been found to jeopardize flight safety for one accident per two million flight hours⁶. Particularly medical incapacitation related to disturbance of consciousness, neurological conditions, gastrointestinal system, heart disease or medical impairment reducing essential functions such as vision and cognitive processes all pose a risk to flight safety. It has been reported that medical factors constitute the root cause in about 4.7% of all aviation accidents⁵.

Medical certification can be regarded as an important factor for the prevention of aircraft accidents. To reduce the risk of medical conditions as the main or contributory cause of fatal accidents in aviation the International Civil Aviation Organization (ICAO) sets standards for

medical certification of aircrew and other personnel in positions related to safety for aviation activities. Even mild pathology could be a hazard and thus it is important to declare it and for it to be assessed by professionally trained aeromedical examiners. In Europe to become an Aero-medical examiner (AME) the applicant must be medically qualified and hold a certificate of specialist training in any speciality. In addition, the applicant must attend a basic course in aviation medicine to become a Class 2 AME. This allows an AME to certify all aircrew classes except medical class (MC) 1 (commercial pilots) and MC 3 (Air traffic controllers (ATCOs)). To certify these two classes an additional course in aviation medicine (advanced) including practical training is mandatory to become a Class 1 AME. In Norway, most AMEs there are primarily general practitioners (GPs), but are qualified to examine and assess aircrew. As with any medical assessment the medical history in medical certification examinations constitute a large and important part of the final assessment¹⁰. The medical history is traditionally and for all practical purposes achieved through self-declaration from the applicant. This system of medical certification is thus, based on trust where the applicant self-declares his or her medical conditions. This is followed by a physical examination by the aeromedical examiner (AME). As with other medical assessments the medical history is crucial for the end result.

The Germanwings crash in the French Alps in 2015 with 150 fatalities is one of the most important modern accidents where aeromedical certification and underreporting of conditions were key contributions that led to the event⁶. The pilot in command deliberately crashed the plane. He had struggled with anxiety, depression and suicidal thoughts for years, and was seen by a psychiatrist while attending his pilot training. During the period of eight months before the crash the pilot had visual problems and a sleep disorder, and he was referred to psychiatric hospital for assessment and treatment for a possible psychosis.

He was prescribed Mirtazapine, Escitalopram, Dominal, and Zolpidem without reporting these facts to his AME³. According to Commission Regulation (EU) No 1178/2011 the pilot should have sought aero-medical advice and by not doing so this was clearly a serious example of under-reporting a medical condition.

Although AMEs are the front line workers, regulators in defined cases directly take part in the certification process of more complicated cases and also oversee the process. They report that they regularly become aware of applicants withholding crucial information that could have consequences for safety. Official statistics are not available to display the magnitude or severity of such issues.

Clinical experiences, anecdotes, autopsy studies and knowledge of human behaviour indicate that underreporting of medical conditions exists even in the high compliance culture of aviation, but the magnitude and impact on the certification process is unknown. However, in medical certification there are limited studies available to highlight the scope of underreporting.

One large autopsy study by Canfield and co-authors, found after autopsy of 4143 pilots who died in an aviation accident, that psychotropic drugs were only reported by 14 (6%) of 223 pilots, cardiovascular drugs were reported by 69 (46%) of 149 pilots and only 1 (7%) of 15 pilots reported taking neurological medications⁴. Similar Sen et al. found under-reporting of anti-depressants in 52 (88%) of 61 aviators post mortem¹⁵. Botch and Johnson found that disqualifying substances were present in 21 accidents (all general aviation) among the 2184 accidents in the period under study (2000-2006)².

The main aim of this study was to estimate the prevalence of under-reporting of medical conditions in the aeromedical certification process. Secondly, the study examined different

predictors of under-reporting including the type of licence and the relationship with the AME.

METHODS

Participants and procedure

We conducted a cross-sectional web-based survey for all holders or applicants of medical certificates or attestations registered at the Civil Aviation Authority Norway in the five-year period preceding December 2nd 2019. This included commercial pilots who held medical certificate class 1 (MC 1), private pilots who held medical certificate class 2 (MC 2) and air traffic controllers (ATCOs) who hold medical certificate class 3 (MC 3). The remaining categories were either cabin crew (holder of a medical attestation), crew in aerodrome/helicopter flight information services (AFIS/HFIS) or national pilots of smaller aircraft holding either light-aircraft-pilot-licensing (LAPL) medical or national certificates (MC other).

A total of 9 441 individuals with Norwegian social numbers were identified and thus eligible for inclusion. Of these, email address could be retrieved for 9 027 by linkage to the public contact and reservation registry, and they were invited to participate in February 2020. Responses were accepted in a window of two weeks and no reminders were sent out. The study closed March 4th 2020. The proportion responding was 17.9%. Age and gender for all the invitees could be derived from the social number including birth-date which was used to link each case to an e-mail address through the contact registry. Age distribution among the invited was as follows: <30 years 22.4%, 30-39 years 22.2%, 40-49 years 20.8% and 50+ years 34.4%. Gender distribution among the invited was 30.3% females (Table S-1).

Participation in the study was voluntary and anonymous. This was stated in the information letter to the participants and thus Institutional Review Board (IRB) approval was not required. By accepting to participate the invitees gave their consent.

Forms were created in a web based application Nettskjema, a secure solution for online data collection (<https://www.uio.no/english/services/it/adm-services/nettskjema/>), and a link to the survey was distributed with Mailchimp. Nettskjema was used in anonymous mode meaning that it was not possible to link responses to email addresses used for distributing the invitation. The invitees or the public were not involved in the design, analysis or the writing up of this study. Demographic variables were restricted to age in categories to secure anonymity to the respondents.

Questionnaire

The survey consisted of three forms. One for holders of certificate in Norwegian language and a second one translated to English, the third form was a slightly adapted version, only in Norwegian, dedicated to those having undergone initial application only without subsequent aeromedical assessments. One question about insurance was omitted in this form. The main difference was the wording of the questions which referred to the initial assessment which applicants had previously completed which was then compared to any previous assessments that the licence holders had experienced. After a screening question, the participant was directed to the correct form and language version.

A total of 27 questions were included (all questions with responses and number of missing responses are shown in – Table S-I). An open free text field was reserved for comments at the end of the questionnaire. Questions were designed so that the respondents remained anonymous. Regarding the free text field, the respondent was explicitly advised against

submitting data that could identify the questionnaire to a particular individual in order to ensure the respondent's anonymity.

Under-reporting was defined as having answered yes to any of the questions # 19-22: Have you ever under-reported/withheld information for an AME about your 1) physical health, 2) mental health, 3) use of medication or 4) drug use including alcohol?

Statistical analyses

Descriptive statistics were used to describe the basic features of the data. Chi-squared test was used to determine whether there is a statistically significant difference in the expected frequencies and the observed frequencies between groups.

Missing data was omitted for analyses. Cronbach's alpha (internal consistency) was estimated for two scales identified by principal components analysis (Varimax rotation). Alpha values $> .70$ are considered satisfactory⁷. Scale 1 included questions # 7, 9, 10, 11 and 12 and scale 2 questions # 8, 13, 14, 15 and 16 as referred to in supplemental Table S-I. Scale 1 (AME support) was based on items with high loadings on the first component and was a collection of questions on how the respondent perceived the setting with the AME particularly in relation to raising issues about his/her health. The second component was a collection of questions to map the perceived effect of check-ups in detecting problems. These questions were combined to Scale 2 (AME authoritative). Cronbach's alpha showed alpha levels of .90 for scale 1 and .81 for scale 2, indicating good to excellent reliability for the two computed scales.

Logistic regression analysis was applied to investigate the association of the dependent variable "have or have not under-reported" against independent variables (age groups (age

<30, 30-39, 40-49 and 50+ coded as numeric 1-4), loss-of-licence insurances (yes/no) (“not relevant” was coded as “no”), medical certificate class (1, 2, 3 and other), extent of perceived AME support (numeric, mean of scale 1) and extent of perceived AME authoritative (numeric, mean of scale 2). The interaction terms age*AME support, age*AME authoritative, insurance*AME support and insurance*AME authoritative was included in a separate step. An interaction effect exists when the effect of an independent variable on a dependent variable changes, depending on the value(s) of one or more other independent variables¹¹. The interactions terms we included were the ones believed to have potential to change the values of others pre-analysis. Statistical package used was R version 3.6.1. A priori no potential confounders or effect modifiers were suspected.

RESULTS

Among the 1616 respondents 108 (6.7%) completed the form for initial applicants and 29 (1.8%) used the form in English language. A total of 726 were Class 1 commercial pilots/MC 1, 457 private pilots/MC 2 and 272 air traffic controllers/MC 3. The remaining 160 (10.0%) were either cabin crew, crew in aerodrome/helicopter flight information service (AFIS/HFIS) or national pilots of smaller aircrafts/MC other except for one case where the data was missing. The age group 50+ constituted the largest proportion (overall 52.7%) of respondents in all classes except MC 3 (Fig. 1).

Loss-of-licence insurance is an insurance that compensates the licence holder, usually economically if the licence is revoked due to medical conditions. The terms might vary among different insurance companies and usually operators provide such insurance for commercial pilots and ATCOs. Among those where loss-of-license insurance was relevant

(excluding initial applicants, MC 2 and those in other classes where reporting this was not relevant) a total of 81.1% within MC 1 group had this insurance, 78.0% within MC 3 and 55.1% within MC other.

[Fig. 1 here]

A total of 188 individuals (11.6%) admitted having under-reported information for the AME related to one or more of the conditions, including mental health (3.3%), physical health (4.2%), medications (1.7%), or drug including alcohol use (5.4%) (percentages listed at each condition represent the proportion of responders having under-reported related to the given condition).

Most frequently commercial pilots admitted they under-reported (15.9%), while corresponding numbers for private pilots was 4.6%, ATCOs 8.8%, and other medical classes 14.0%. For commercial pilots a total of 30 of 702 answered that loss-of-licence insurance was not relevant for them. Among the remaining 671 with complete data on under-reporting, 17.6% of the 544 having insurance, and 10.2% among the 127 who did not have insurance admitted under-reporting ($p = .04$).

The proportion of respondents having under-reported varied between 10.1% and 13.6% in the different age groups ($p = .24$).

Among those admitted having under-reported, 21 participants believed their own underreporting could have affected flight safety “to some” or “to a high extent”.

Characteristics of these responders are shown in Fig. 2.

[Fig. 2 here]

When excluding 108 initial applicants, 49.0% ($n = 739$) responded that they knew colleagues who had underreported information, and 229 (31.0%) of them believed this “to a high extent” affected flight safety. The 229 were distributed among different classes as follows: 109 (15.7%) MC 1, 54 (13.2%) MC 2, 12 (8.1%) MC 3, and 54 (23.4%) MC other.

A total of 6.0% of all respondents reported they knew someone who had been classified as unfit by the AME and still carried out the activity they were assessed unfit for. The largest proportion of respondents reporting this were found among the two groups MC 1 and MC other (including cabin crew), respectively 6.2% and 12.2%. On the contrary, only 2.5% of respondents within MC 3 were aware of others having performed their duty while being considered unfit by professionals. The participants provided feedback related to possible reasons for underreporting (Table I).

[Table I here]

Participants were asked to score a) to what extent the medical check-ups being carried out are ‘charting’ different conditions and b) when visiting the AME, to what extent they feel they can address issues related to the condition. By ‘charting’ we mean to map out the condition and with ‘address’ we mean that the applicant can initiate a discussion about issues related to the condition. Results for both are displayed in Figure 3.

In response to question a) ('charting'), "to a very low" or "low extent" was most frequently reported for mental health conditions (49.8% of participants) and correspondingly for drug use was 31.5%, physical health 12.0%, and for use of medication 26.4%. Further, the response to question b) ('address'), "to a very low" or "low extent" was most frequently reported for mental health conditions (22.1% of participants) and correspondingly for drug use was 14.7%, physical health 10.4%, and for use of medication 8.4%.

[Fig. 3 here]

The vast majority of responders anticipate that aeromedical certification is important for increased flight safety. A total of 46.1% of the responders believe aeromedical certification, in general affects flight safety "to a high extent" and 17.7% "to a very high extent". The distribution of responses was not significantly different between the groups of those 188 responders having under-reported compared with the remaining who stated they had not under-reported ($p = .30$).

In separate questions as many as 61.0% of all respondents reported that the aeromedical examiner (AME) "to a high" or "very high extent" as supportive, while 57.9% were aware that AME "to a high" or "very high extent" was an authoritative examiner.

A total of 31.6% of all respondents replied that if the aeromedical examination was performed by the general practitioner (GP) assigned to that person, they believed "to a high" or "very high extent" that flight safety would be improved as revealing medical conditions was more likely. Further, a total of 36.7% answered "to some extent".

Among the 1436 respondents with complete data for all variables, we found it more likely that private pilots (MC 2) and ATCOs (MC 3) under-reported medical conditions compared to commercial pilots based on the logistic regression analysis (Table II). The results also indicated that individuals scoring high on the two scales assessing the AME as supportive (Scale 1) or authoritative (Scale 2) were less likely to under-report (Table II). Model fit was $\chi^2(7) = 138.2$ ($p < .01$) and Pseudo- R^2 (McFadden) = .013. An additional step with the four interaction terms included, did not improve the model significantly and was therefore excluded from the table.

[Table II here]

DISCUSSION

A total of 11.6% responders to this survey admitted under-reporting their own medical conditions during the process of initial or renewal of their medical certificate. This is a serious finding which undermines the system of medical certification and thus potentially jeopardises flight safety.

The results are thus not unexpected as they coincide with beliefs both from authorities and certificate holder across different member states. Results are now better documented and systematically assessed. However, this is most likely not the whole picture and only represent the minimum level because this survey only addresses under-reporting that could be known to the responder (intended errors) and which they are willing to admit. In addition, unintended under-reporting happens quite frequently, and it is understandable

that some conditions, particular the ones that are considered trivial, are forgotten. Even in a clinical setting where reporting of medical conditions (co-morbidities) is important for the patient, it is well known that they forget to report their diagnoses⁹. One reason could be that chronic diseases they live with are not regarded as a disease, but as an inherent part of life.

In this study most of those respondents admitting under-reporting believe the condition to be of less importance for flight safety. In responders who admitted under-reporting, both their own and others, 40% of them believed the condition was not relevant to flight safety. As many as 69% of responders believe that the consequences for their own career was the reason for under-reporting.

One could argue that under-reporting would be more frequent among those not protected by a loss-of-licence insurance. Such insurance means the insured will be economically compensated if the medical certificate is lost due to medical reasons. Among commercial pilots the opposite was observed as there was a larger proportion of respondents admitting under-reporting in the group of those having loss-of-licence insurance. Correspondingly, in the regression analyses loss-of-licence insurance was not identified as an important factor when predicting under-reporting. The financial aspect may not be the only reason for under-reporting as many pilots and other professionals in aviation have a strong professional identity. This means that loss of licence may not be only about losing income, but also an important part of the loss of professional status.

While the regression analyses identified that medical class and how applicants perceived the AME (supportive or authoritative) as important for under-reporting, it is important to state

that that there was much unexplained variance in the analyses. This means that other factors, not included in the model, would be of importance to explain the variable outcome.

From other studies in psychology and behavioural sciences we know that people sometimes lie, on the average twice per day⁸, and conceal health information¹³. The decision to lie or withhold information is influenced by many factors including personality traits, external factors, the chances of getting caught, and available self-justifications¹⁶. Most people seek to appear fair and honest and will negotiate a balance between self-interests and available self-justifications when facing a situation where withholding information about health problems may seem beneficial. Possible self-justifications may be that the condition was not relevant to flight safety, as listed as a possible reason by many in this study. The decision to withhold information may also be influenced by optimistic biases which is the tendency for people to think that they are less at risk than the average person¹⁴. This may also apply to aviators when assessing the risk of having a medical problem causing an accident. Factors that in this study reduced the likelihood of under-reporting was having a supportive or authoritative AME or not being commercial pilot.

The finding that more than half of the responders believed “to some” or “higher extent” that the whole certification process would be improved if it was conducted by the GP, must be interpreted in light of the national system. In Norway every citizen is assigned to a specific GP and this physician will usually be involved in most of the medical events occurring to the assigned person. The GP will by default receive medical reports or summaries from almost all private specialists and all hospitals involved in medical care of the person assigned to them. This is probably the basis for the belief in the GPs role to enhance the system. Most AMEs in Norway are GP’s, and some of the applicants for a

medical certificate would thus experience that their GP is an AME. However, they are free to choose any AME they wish.

To our knowledge there are no other comparable studies published with results of applicants admitting underreporting of medical conditions within aviation medicine.

However, if we look to other sectors, Dow and Turmel conducted a study to check degree of voluntary declaration for drivers (automobiles)¹². They did so by linking registries of medical data (provincial health insurance agency and the Ministry of Health and Social Services) and crash, infractions and licensing data from the Société de l'Assurance Automobile du Québec.

They concluded that there is serious underreporting of medical conditions considered negatively to affect driving. Under-reporting was found in 84-99% of the different groups of medical conditions such as visual disorder, epilepsy, diabetes, psychiatric disorder, drug/alcohol abuse etc. Many drivers with conditions that may influence driving report their more benign condition while omitting to report the condition that could affect their permit status. We believe crew members and other individuals covered by medical licensing in aviation are more likely to report than drivers for several reasons. Firstly, there is a mature safety culture where human factors and impact of errors are more emphasized. Secondly, many of the individuals have loss-of-licence insurance Thirdly, licence holders in aviation are often working in teams where medical issues or conditions could be difficult to Also, the medical certification process is more thorough, and they are more frequently reminded at annual check-ups about the need for mandatory reporting.

Limitations of the study include no link between the invitation and the response. This means there was no actual control on who responded and who did not. However, this concern seems not very relevant, as there is no obvious advantage to be gained for some former

licence holders who are no longer requiring medical certification to take part in this survey. We are aware that mass distribution of emails could lead to invitations entering spam filters and thus never reaching the attention of the invitee which could account for low response rate. Since the recruitment included all individuals who had held a certificate for the last five years, some of the responders had been out of business for a period of time. Surveys are prone to recall bias and this is one of the main limitations in this study. Given the setting of the questions recall bias is believed to underestimate rather than overestimate the current finding¹.

In the invitation of the current study, association to a regulatory body (Civil Aviation Authority Norway) would presumably make underreporting, which could be considered a violation of regulations, less likely. The study was thus designed to be anonymous and we stated this clearly to invitees. The results indicate that many were not affected by the association to a governmental authority as they still admitted under-reporting which for some probably could be classified as fraud. Anyway, we believe the magnitude of under-reporting that is evident in these results just represent a minimum share of the actual magnitude.

While this study has a cross sectional design, conducted in one country and the age groups are skewed towards the older part of the population we have to take some precautions regarding the generalization of the results. However, there are no reasons for underreporting to be higher in Norway than other countries as there is beneficial social security agreements and insurances for the population. Also, the group of older respondents who are finishing their careers might be more prone to admit their

underreporting and thus just to a higher degree reveal the true extent – while at the same time this group might have more conditions to report.

Strengths of the study show that as the population is limited, and we were able to access emails for almost every certificate holder in the country. The fact that it is not an interview situation, but self-administered response is believed to raise the rate of actual trustworthy responding to sensitive questions¹⁸.

Finally, this study shows under-reporting is confirmed by the applicants and holders themselves. Actions must be taken to understand further the extent and impact of under-reporting in medical certification and how it could be mitigated as it could have fatal consequences for flight safety and other safety critical systems.

REFERENCES

1. Althubaiti A. Information bias in health research: definition, pitfalls, and adjustment methods. *J Multidiscip Healthc.* 2016; 9:211–217. doi: 10.2147/JMDH.S104807
2. Botch SR, Johnson RD. Antiemetic and Sedative Levels Found Together in 26 Civil Aviation Pilot Fatalities, 2000-2006. *Aviat Space Environ Med.* 2008; 79:607-610.
3. Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile. Final report Accident on 24 March 2015, at Prads-Haute-Bléone (Alpes-de-Haute-Provence, France), to the Airbus A320-211, registered D-AIPX, operated by Germanwings. [Internet] [cited 2021 Oct 7]. Available from https://www.bea.aero/uploads/tx_elyextendttnews/BEA2015-0125.en-LR_08.pdf
4. Canfield DV, Salazar GJ, Lewis RJ, Whinnery JE. Pilot Medical History and Medications Found in Post Mortem Specimens from Aviation Accidents. *Aviat Space Environ Med.* 2006; 77:1171-1173.
5. Cullen SA, Drysdale HC, Mayes RW. Role of medical factors on 1000 fatal aviation accidents: case note study. *BMJ.* 1997; 314:1592. doi: 10.1136/bmj.314.7094.1592
6. DeJohn CA, Wolbrink AM, Larcher JG. In-flight medical incapacitation and impairment of airline pilots. *Aviat Space Environ Med.* 2006; 77:1077-1079.
7. European Federation of Psychologists' Association (EFPA). EFPA Review model for the description and evaluation of psychological tests: Test review form and notes for reviewers, v 4.2.6. [Internet] [cited 2020 Nov 1]. Available from: <http://assessment.efpa.eu/download/650d0d4ecd407a51139ca44ee704fda4>

8. Halevy R, Shalvi S, Verschuere B. Being honest about dishonesty: Correlating self-reports and actual lying. *Human Communication Research*. 2014; 40:54-72. doi: 10.1111/hcre.12019
9. Ho PJ, Tan CS, Shawon SR, Eriksson M, Lim LY, et al. Comparison of self-reported and register-based hospital medical data on comorbidities in women. *Sci Rep*. 2019; 9:3527. doi: 10.1038/s41598-019-40072-0.
10. Hudson M, Herbert K. The practicalities of fitting mental health screening into the time-limited annual medical check and the problems of confidentiality. In: Bor R, Eriksen C, Oakes M, Scragg P, editors. *Pilot mental health, assessment and support. A practitioner's guide*. London: Routledge. 2017:208-25.
11. Interaction Effects in Regression. 2021 [Internet][Cited 2021 Oct 7] Available from: <https://stattrek.com/multiple-regression/interaction.aspx>
12. Nickel WR, Montere-i-Bort H, editors. Voluntary declaration of a medical condition by drivers in Quebec. Proceedings of the 6th Fit to drive International Traffic Expert Congress; 2012 Apr 25-27; Bonn, Germany. Kirschbaum Verlag GmbH; 2012.
https://www.vdtuev.de/dok_view?oid=397340
13. O'Connor AM, Evans AD. Dishonesty during a pandemic: The concealment of COVID-19 information. *Journal of Health Psychology*. 2020 Aug. doi: 10.1177/1359105320951603
14. Rothman A J, Klein WM, Weinstein ND. Absolute and relative biases in estimations of personal risk. *Journal of Applied Social Psychology*, 1996; 26:1213-1236. doi 10.1111/j.1559-1816.1996.tb01778.x

15. Sen A, Akin A, Canfield DV, Chaturvedi AK. Medical Histories of 61 Aviation Accident Pilots with Postmortem SSRI Antidepressant Residues. *Aviat Space Environ Med.* 2007; 78:1055-1059.
16. Shalvi S, Jason D, Handgraaf MJJ, De Dreu CKW. Justified ethicality: Observing desired counterfactuals modifies ethical perceptions and behavior. *Organizational Behavior and Human Decision Processes.* 2011; 115:181-190. doi: 10.1016/j.obhdp.2011.02.001
17. Shappell SA, Wiegmann DA. U. S. Naval Aviation mishaps 1977-92: Differences between single- and dual-piloted aircraft. *Aviat Space Environ Med.* 1996; 67:65-69.
18. Tourangeau R, Yan T. Sensitive questions in surveys. *Psychol Bull.* 2007; 133:859-883. doi: 10.1037/0033-2909.133.5.859
19. Wiegmann DA, Shappell SA. Human error and crew resource management failures in Naval aviation mishaps: a review of U.S. Naval Safety Center data, 1990-96. *Aviat Space Environ Med.* 1999; 70:1147-1151.

TABLES

Table I: Percentages of responses according to assumed causes of underreporting.

Assumed cause of under-reporting (self and others)	Percentage	MC	Age
Consequences for own career	69		
Consequences for the operator	7		
Personal reasons for not sharing information	24		
Do not want to share with an AME	19		
The process was not facilitated to reveal the information	7		
Self-assessment that the condition was not relevant to flight safety	40		
Other	12		

The columns medical class (MC) and age display the characteristics of respondents related to each cause within the following categories from right to left respectively: MC 1, 2, 3 and other and age <30, 30-39, 40-49 and 50+ years.

Table II – Logistic regression of underreporting as the dependent variable (not having underreported is reference)

	Odds ratio	<i>p</i> -value	95% CI
Intercept	8.79	<.01	3.25 , 23.78
Age group (cont*)	0.92	.39	0.76 , 1.11
Loss-of-licence insurance			
Yes (ref)	1.00	-	
No	0.76	.21	0.50 , 1.17
Medical class (MC)			
1 (commercial) (ref)	1.00	-	
2 (private)	0.21	<.01	0.11 , 0.42
3 (ATCO)	0.47	.01	0.25 , 0.86
Other	0.90	.66	0.56 , 1.44
Supportive AME (cont)	0.68	.01	0.50 , 0.91
Authoritative AME (cont)	0.51	<.01	0.40 , 0.64

Note: *cont = continuous variable.

SUPPLEMENTAL MATERIAL

Table S-I : Variable specification – Questionnaire

#	Question	Response alternatives	N
1.	What is your age?	30 or younger 30-39 40-49 50 or older Missing	163 274 327 851 1
2.	How many years have you been holding a medical certificate for aviation activity?	1-5 years 6-10 years 11 years or more Missing	152 193 1163 108
3.	What type of medical certificate do you hold?	Class 1 Commercial Pilot Class 2 Private Pilot Class 3 Air Traffic Controller Other Missing	726 457 159 272 2
4.	Do you have a Loss of License insurance?	Yes No Not relevant Initial applicants not asked this question Missing	773 555 176 108 4
5.	To what extent do you think that medical certification contributes to increased flight safety?	To a very little extent To a little extent To some extent To a large extent To a very large extent Missing	24 104 455 743 286 4
6.	Indicate which of the suggestions below you believe could contribute to increased flight safety. Several crosses are possible	[more than one answer possible] Better education of aeromedical examiners Liberalization of aeromedical regulations and their application Stricter aeromedical regulations Stricter sanctions and measures for individuals withholding information about their medical conditions Less waiting time for proceedings of applications More information to employers and organizations about the certification process More information to holders of and applicants to medical certificate about their	 347 294 128 366 483 194 827

	obligations to report about decrease in medical fitness	
	Missing	212
7.	To what extent do you experience that the Aero-Medical Examiner (AME) is supporting you?	
	To a very little extent	41
	To a little extent	123
	To some extent	466
	To a large extent	716
	To a very large extent	267
	Missing	3
8.	To what extent do you perceive the AME as authoritative?	
	To a very little extent	30
	To a little extent	121
	To some extent	528
	To a large extent	731
	To a very large extent	204
	Missing	2
9.	When you are visiting the AME - to what extent do you feel you can address all issues related to your physical health?	
	To a very little extent	49
	To a little extent	119
	To some extent	366
	To a large extent	747
	To a very large extent	333
	Missing	2
10.	When you are visiting the AME - to what extent do you feel you can address all issues related to your mental health?	
	To a very little extent	125
	To a little extent	230
	To some extent	440
	To a large extent	565
	To a very large extent	243
	Missing	13
11.	When you are visiting the AME - to what extent do you feel you can address all issues related to your use of medication?	
	To a very little extent	45
	To a little extent	89
	To some extent	325
	To a large extent	785
	To a very large extent	349
	Missing	23
12.	When you are visiting the AME - to what extent do you feel you can address all issues related to your drug use? Including alcohol.	
	To a very little extent	90
	To a little extent	142
	To some extent	380
	To a large extent	649

	To a very large extent	314
	Missing	41
13.	To what extent do you think that the medical check-ups that are being carried out are charting your physical health?	
	To a very little extent	43
	To a little extent	151
	To some extent	502
	To a large extent	726
	To a very large extent	190
	Missing	4
14.	To what extent do you think that the medical check-ups that are being carried out are charting your mental health?	
	To a very little extent	251
	To a little extent	549
	To some extent	506
	To a large extent	230
	To a very large extent	70
	Missing	10
15.	To what extent do you think that the medical check-ups that are being carried out are charting your use of medication?	
	To a very little extent	112
	To a little extent	309
	To some extent	532
	To a large extent	470
	To a very large extent	171
	Missing	22
16.	To what extent do you think that the medical check-ups that are being carried out are charting your drug use? Including alcohol.	
	To a very little extent	145
	To a little extent	353
	To some extent	562
	To a large extent	373
	To a very large extent	150
	Missing	33
17.	Have you ever disagreed with the AME regarding his or her assessment of your medical condition?	
	Yes	99
	No	1405
	Missing	112
18.	If you are aware that colleagues or other applicants have underreported/withheld information for an AME, to what extent may this have affected flight safety? Consider the most significant cases when answering.	
	To a very little extent	108
	To a little extent	178
	To some extent	224
	To a large extent	154
	To a very large extent	75

	Not familiar to me	749
	Missing	128
19.	Have you ever underreported/withheld information for an AME about your physical health?	
	Yes	67
	No	1544
	Missing	5
20.	Have you ever underreported/withheld information for an AME about your mental health?	
	Yes	54
	No	1558
	Missing	4
21.	Have you ever underreported/withheld information for an AME about your use of medication?	
	Yes	27
	No	1578
	Missing	11
22.	Have you ever underreported/withheld information for an AME about your drug use? Including alcohol.	
	Yes	87
	No	1522
	Missing	7
23.	If you answered yes (to at least one of the questions 19-22) about yourself having underreported/withheld information for an AME, did you consider the situation to be such that it could have an impact on flight safety?	
	To a very little extent	147
	To a little extent	49
	To some extent	27
	To a large extent	10
	To a very large extent	5
	Have not underreported/withheld information	1038
	Missing	340
24.	If you answered yes (to at least one of the questions 19-22) about yourself having underreported/withheld information for an AME, did you consider the possibility of addressing the problem to a support group?	
	Yes, and I presented it to a support group	7
	Yes, but I did not wish to involve a support group	8
	Yes, but I don't have admission to a support group	6
	No, I did not wish to involve a support group	32
	No, but I had done it if a support group was available	13
	No, I am not familiar with a support group or if it is available	53

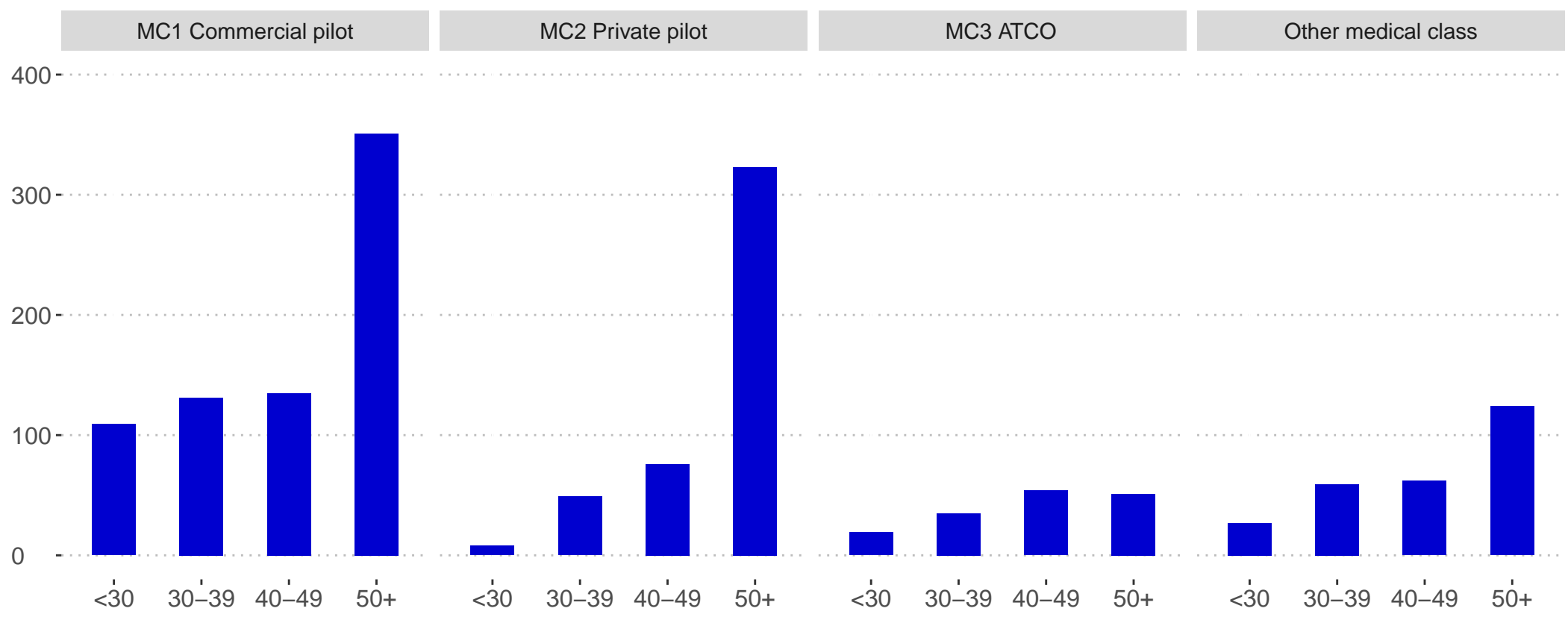
	No, not relevant	1102
	Missing	395
25.	Do you know of someone who has completed activity they are unfit for, despite unfit assessment by an AME?	
	Yes	97
	No	1513
	Missing	6
26.	Do you think that the level of safety would have been higher with regard to discovering health conditions if the check-up was carried out by a General Practitioner who is familiar with the individual's medical history?	
	To a very little extent	178
	To a little extent	332
	To some extent	590
	To a large extent	353
	To a very large extent	154
	Missing	9
27.	If you are familiar with underreporting by yourself or others, what do you think is the reason for it? Several crosses are possible.	[more than one answer possible]
	Consequences for own career	806
	Consequences for operator	88
	Personal reasons for not sharing information	286
	Don't want to share with an AME	222
	The process was not facilitated to reveal the information. (Please elaborate more in the open space below.)	84
	Self-assessment that the condition was not relevant to flight safety	467
	Other	148
	Missing	455
28.	If you have any comments to the survey or the aeromedical certification process, please feel free to enter them below. If necessary, refer to the relevant question. Make sure that what you write don not identify you.	
	[Free text field]	366
	Missing	1250

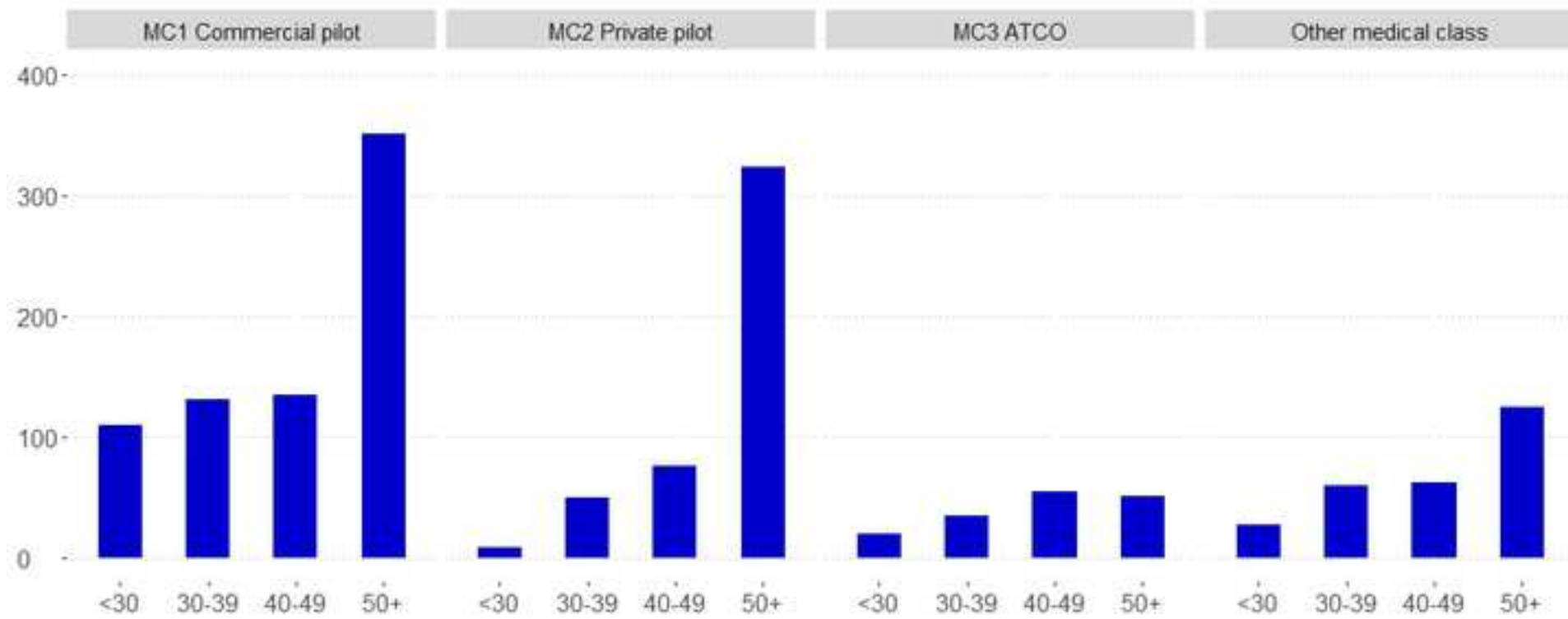
CAPTION FOR FIGURES

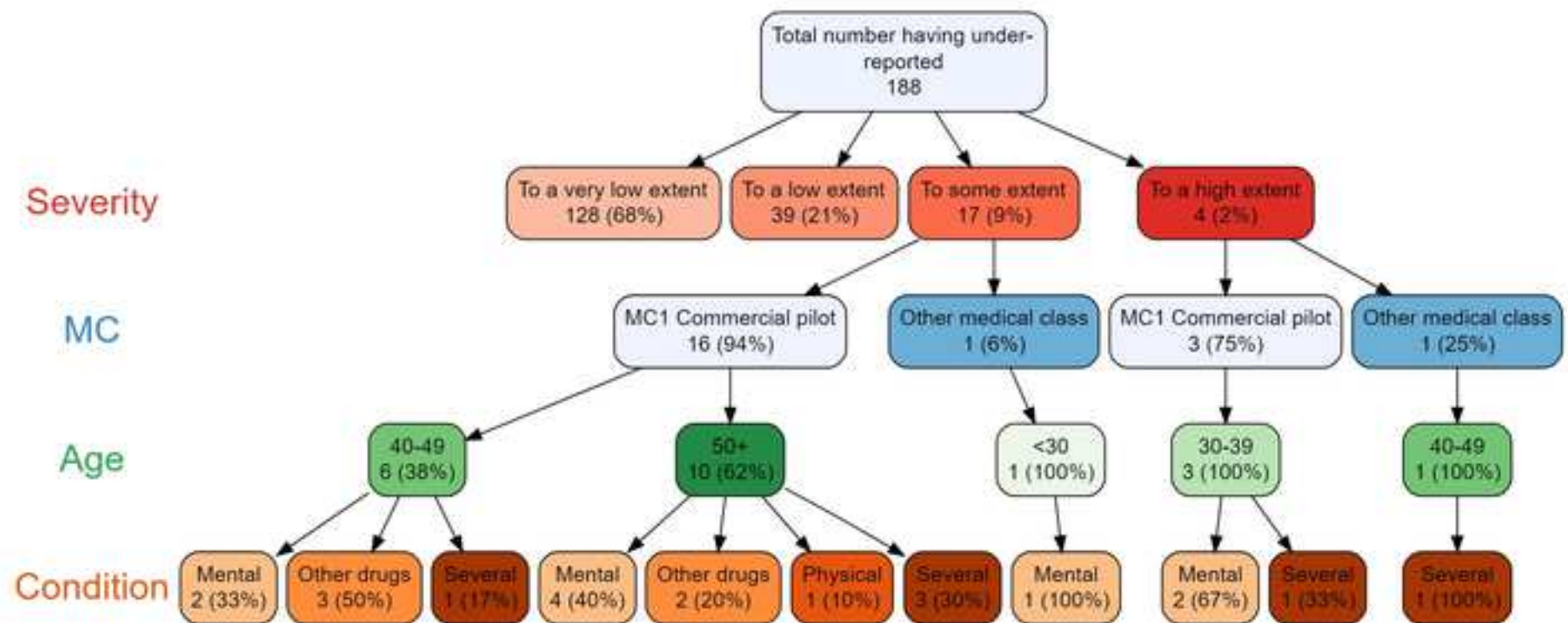
Figure 1: Number of respondents in different age groups, stratified by medical class

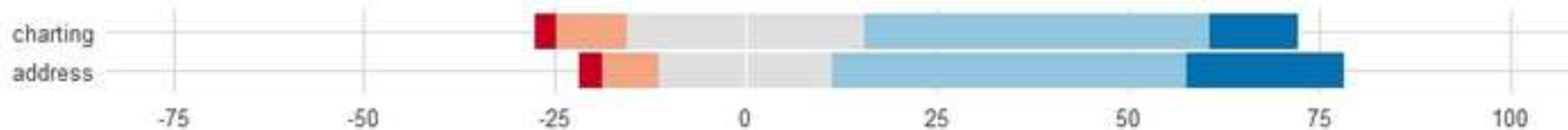
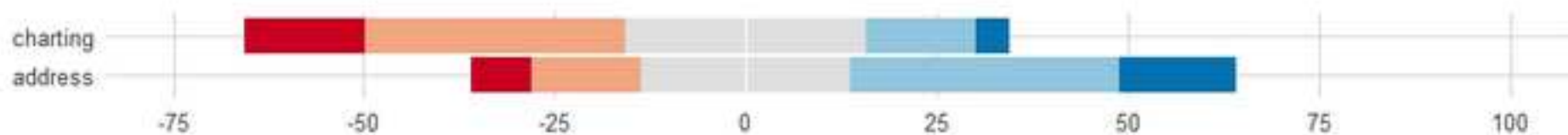
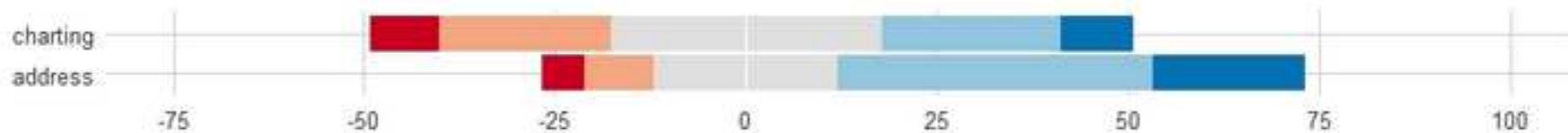
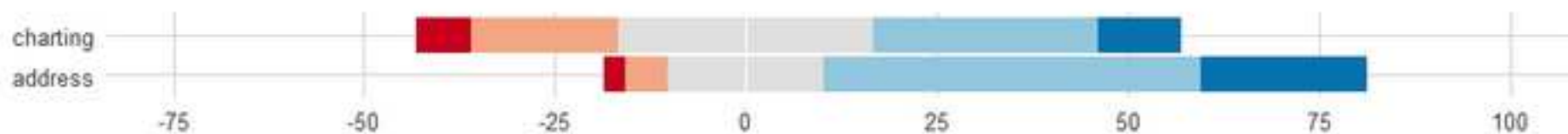
Figure 2: Visual tree of those 188 having underreported and whom considered the situation could impact flight safety to some or to a high extent (severity). MC: Medical class.

Figure 3: To what extent respondents feel they can address all issues when visiting their AME and to what extent they think that the medical check-ups are charting their health related to physical health, mental health, drugs and alcohol use and medication use.







Physical health*Mental health**Drugs incl alcohol**Medications*

■ To a very low extent
 ■ To a low extent
 ■ To some extent
 ■ To a high extent
 ■ To a very high extent

Assumed cause of under-reporting (self and others)	Percentage	MC	Age
Consequences for own career	69		
Consequences for the operator	7		
Personal reasons for not sharing information	24		
Do not want to share with an AME	19		
The process was not facilitated to reveal the information	7		
Self-assessment that the condition was not relevant to flight safety	40		
Other	12		