Pilot Domain Task Experience in Night Fatal Helicopter Emergency Medical Service Accidents

Bryan B. Aherne; Chrystal Zhang; David G. Newman

INTRODUCTION: In the United States, accident and fatality rates in helicopter emergency medical service (HEMS) operations increase significantly under nighttime environmentally hazardous operational conditions. Other studies have found pilots' total flight hours unrelated to HEMS accident outcomes. Many factors affect pilots' decision making, including their experience. This study seeks to investigate whether pilot domain task experience (DTE) in HEMS plays a role against likelihood of accidents at night when hazardous operational conditions are entered.

METHODS: There were 32 flights with single pilot nighttime fatal HEMS accidents between 1995 and 2013 with findings of controlled flight into terrain (CFIT) and loss of control (LCTRL) due to spatial disorientation (SD) identified. The HEMS DTE of the pilots were compared with industry survey data.

RESULTS: Of the pilots, 56% had ≤2 yr of HEMS experience and 9% had >10 yr of HEMS experience. There were 21 (66%) accidents that occurred in non-visual flight rules (VFR) conditions despite all flights being required to be conducted under VFR. There was a statistically significant increase in accident rates in pilots with <2 and <4 yr HEMS DTE and a statistically significant decrease in accident rates in pilots with >10 yr HEMS DTE.

CONCLUSION: HEMS DTE plays a preventive role against the likelihood of a night operational accident. Pilots with limited HEMS DTE are more likely to make a poor assessment of hazardous conditions at night, and this will place HEMS flight crew at high risk in the VFR night domain.

KEYWORDS: decision-making, HEMS, rotary wing, expertise, risk.

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Fatal accident rates in the U.S. helicopter emergency medical service (HEMS) sector from 1997 to 2001 were highest compared to all other categories of aviation. In one study, the fatality rate of HEMS crewmembers was 75 per 100,000 person years, 16 times the occupational injury fatality rate of 4.6 for all U.S. workers during the period of the study.[1] In addition, during the same period, 68% of HEMS fatalities occurred at night, and 77% of accidents in instrument meteorological conditions (IMC) were fatal.[1]

Most HEMS aircraft are flown by a single pilot[1] and operate regularly at night. Night HEMS operations represent a unique and specialized domain. HEMS pilots must identify and avoid threats while controlling the aircraft and communicating.[1] This high cognitive workload is compounded by the limited time available for flight planning, operating to unsurveyed locations, or where requests may occur 'on the run' during positioning flights. There is also implicit pressure, such as the task itself, to save human life or mitigate a patient's condition. Flights are not regularly scheduled, but operate on demand, relying on the pilot to make the final decision whether to accept the task.

Decision-making performance is a critical risk control and poor decisions can develop into situations where working memory capacity is reached or saturated. Most operations are conducted under visual flight rules (VFR),[13] which requires pilots to separate themselves from obstacles and weather. Where pilots fail to make correct assessment of hazardous

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operational conditions (HOC), such as flight over featureless terrain devoid of man-made lighting and/or the presence of cloud or fog, and commence or continue the mission, it is highly likely they will enter conditions often described as a degraded visual environment.[20] Night flying in VFR conditions of reduced visibility or at night, where no horizon is visible, presents ideal conditions for spatial disorientation (SD).[14] Adverse weather can remove all visual cues and the weather effects can be underestimated.[5] In total darkness, the pilot must rely on instruments for spatial orientation to prevent many hazards, particularly visual illusions inherent in night visual flight.[9] Visual cues required for spatial orientation are not always available in the external night environment and render helicopter pilots susceptible to SD.[14] As a result, pilots are susceptible to visual illusions[11,18,19] and SD[15] when a lack of visual cues such as man-made lighting exists. SD accounts for many accidents in civilian[15] and military aviation.[20]

From a pilot perspective, high cognitive workloads decrease the capacity to resolve disorientation episodes.[15] In a VFR operation, a helicopter pilots' instrument rating is a recovery risk treatment if HOCs are entered. In the event of inadvertent IMC, prolonged controlled flight for a nonproficient instrument pilot would be difficult to sustain and even more so in a helicopter not equipped for instrument flight. Inadvertent IMC for a pilot who is unprepared for where to recover and how to get there increases the demands on working memory. HEMS pilots reported over 78% never or hardly ever filing an instrument flight rules (IFR) flight plan.[13] Maintaining control in inadvertent IMC, or when degraded visibility prevails, depends on an instrument proficient pilot.[9,14,15,24]

Susceptibility of pilots to SD is made up of several factors:

1. Environment (degraded visual environment and night flying).[20]
2. Psychological and physiological (overconfidence, fatigue, and health-related conditions or medications).[15,20]
3. Anxiety and stress (which increases the likelihood of SD as well as incorrect recognition and recovery from SD).[15]

Previous studies have demonstrated that helicopter accidents with the combination of night and adverse weather have a higher risk of a fatal outcome, particularly for HEMS.[1,5] In overall terms, dealing with the HEMS operating environment safely and effectively requires experience. Even though a standard of 2000 total flight hours (TFH) appears a common minimum in industry data,[13] research shows that TFH is not related to fatal HEMS accidents.[1] TFH is not a settled indicator of pilot performance.[25] One study of general aviation accidents in the United States found more experienced pilots made less errors, but also found the likelihood of being in a fatal accident increased with pilot experience.[2] No correlation between TFH and flight control parameters of air transport fixed wing pilots performing manual handling instrument approaches[6] was found. TFH has been found to predict gaze parameters, but not accuracy or error in simulated helicopter overland navigation studies.[25]

Other factors affecting decision making performance in this challenging environment play a role. Domain task experience (DTE) measured in years is likely to influence decision making. This study sought to determine if low DTE has an effect on accident rates for nighttime operational HEMS accidents.

METHODS

A cross-sectional analysis of fatal HEMS accidents in the United States between 1995 and 2013 was conducted by accessing the database of the National Transportation Safety Board (NTSB), searching under rotorcraft for terms such as 'EMS', 'HEMS', 'aeromedical', 'ambulance', and 'medevac.' Identified were 189 accidents. Single pilot operations are the most common in the U.S. HEMS profile[1] and operations with a dependent variable of controlled flight into terrain (CFIT) or loss of control (LCTRL) were used during nighttime missions. For the purposes of this analysis, years of HEMS experience, age, and TFH were identified against a 2010 National EMS Pilots Association industry demographic[13] and stratified into groups. All data were tabulated into a PC-based spreadsheet program (Microsoft® Excel 2007) and compared with the industry demographic data using a 2×2 contingency table and analyzed via a statistical software tool (SPSS Statistics, version 20, IBM Corp, New York, NY). Fisher's Exact Test was the statistical test of choice and an alpha level of $P < 0.05$ was considered significant.

RESULTS

Of the 32 accidents identified there were 100 fatalities, giving a rate of 3.12 deaths per accident. VFR procedures were used on all flights. **Fig. 1** shows the multiengine and single engine helicopters, their IFR certification, and the pilot's instrument proficiency status. Of the flights, 22 (69%) occurred between 22:00 and 06:00. There were 22 (69%) that were either to-patient or with-patient mission tasks. CFIT was causal for 15 flights, LCTRL as a result of SD causal to 13 flights, and 4 were attributed to unspecified LCTRL. There were 21 (66%) accidents which occurred in non-VFR conditions. One flight changed category to IFR just prior to CFIT. All 32 pilots were men. The ages ranged from 30 to 65 yr (mean 47.6 yr, SD ± 9.23). Of the pilots, 21 (64%) were less than 50 yr of age. There were 20 flights conducted under Part 91 and 12 flights under Part 135 of the Federal Aviation Regulations (FAR).

The pilots' helicopter TFH ranged from 1902 to 20,537 h (mean 5283, SD ± 3893) and averaged 29 h/d (SD ± 15) and 13.02 h/night (SD ± 8.19) in the previous 90 d. The average for the previous 30 d was 9 h/d (SD ± 8.31) and 5.4 h/night (SD ± 3.015). **Fig. 2** shows accident pilot DTE in years compared with the industry demographic data. The average HEMS DTE of all pilots was 4.10 yr (SD ± 6.23). Of the pilots, 14 had <1 yr with an average of 4.6 mo (SD ± 3 mo) HEMS experience. **Table I** shows this study's demographics compared with the industry.

The ≤4000 and ≤6000 TFH pilots make up 53% (17) and 69% (22) of the study, respectively. Pilots with ≤2 yr (18) had 11 with ≤4000 TFH, 2 between 4000-6000 TFH, and 5 pilots had

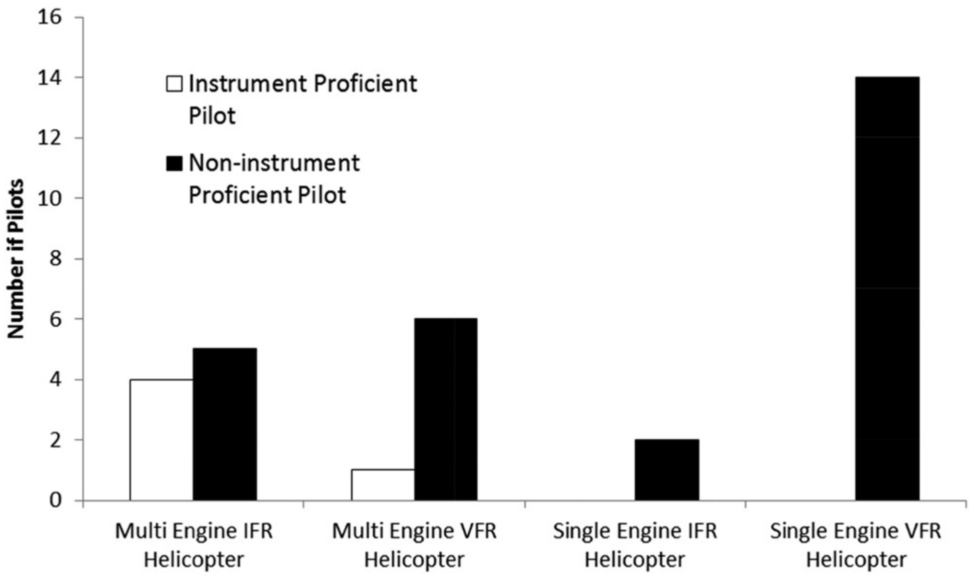

Fig. 1. Number of IFR proficient and nonproficient pilots in VFR and IFR certified single and multiengine helicopters.

≥6000 TFH. Pilots with ≤4000 ($P < 0.01$) and ≤6000 TFH ($P < 0.05$) and 50 yr of age and below ($P < 0.05$) were also overrepresented. The ≤4000 TFH group average was 2875 TFH (SD ± 583, average 1.56 yr HEMS, SD ± 1.66) and the ≤6000 TFH group average was 3271 TFH (SD ± 911, average 3.08 yr HEMS, SD ± 5.6). Regression analysis showed significant evidence of a relationship between ≤4000 (r = 0.49, $P = 0.045$) and ≤6000 TFH pilots (r = 0.62, $P = 0.001$) and their HEMS DTE. Age also showed significant evidence of a relationship to HEMS DTE (r = 0.43, $P = 0.013$) and TFH (r = 0.47, $P = 0.006$). Regression analysis of the >4000 TFH (r = 0.14, $P = 0.61$) and >6000 TFH (r = 0.19, $P = 0.59$) groups showed no evidence of a relationship to HEMS DTE. Eight (25%) pilots with military helicopter training were underrepresented ($P < 0.01$) compared with industry data.[3] Of the eight military trained pilots, seven (87%) had 4 yr or less of HEMS DTE.

All pilots possessed a helicopter instrument rating. Only five (16%) pilots had recorded an instrument proficiency check in the prior 6 mo required for a pilot to use the rating in flight, with four recording instrument flights within 90 d prior to the accident. Four of the instrument proficient pilots occupied IFR-certified helicopters (IFRH). Seven of the IFRH (all multiengine) and two of the VFR-only certified helicopters (VFRH; both single engine) were equipped with an autopilot. There were 27 pilots (84%) who were noninstrument proficient. The 27 noninstrument proficient pilots significantly ($P < 0.05$) operated VFRH. VFRH were significantly ($P < 0.05$) associated with the NTSB finding of LCTRL. Pilots with <2 and <4 yr HEMS DTE had a statistically significant (both $P < 0.01$) increase in accident rate and there was a statistically significant ($P < 0.01$) decrease in accident rate in pilots with >10 yr HEMS DTE.

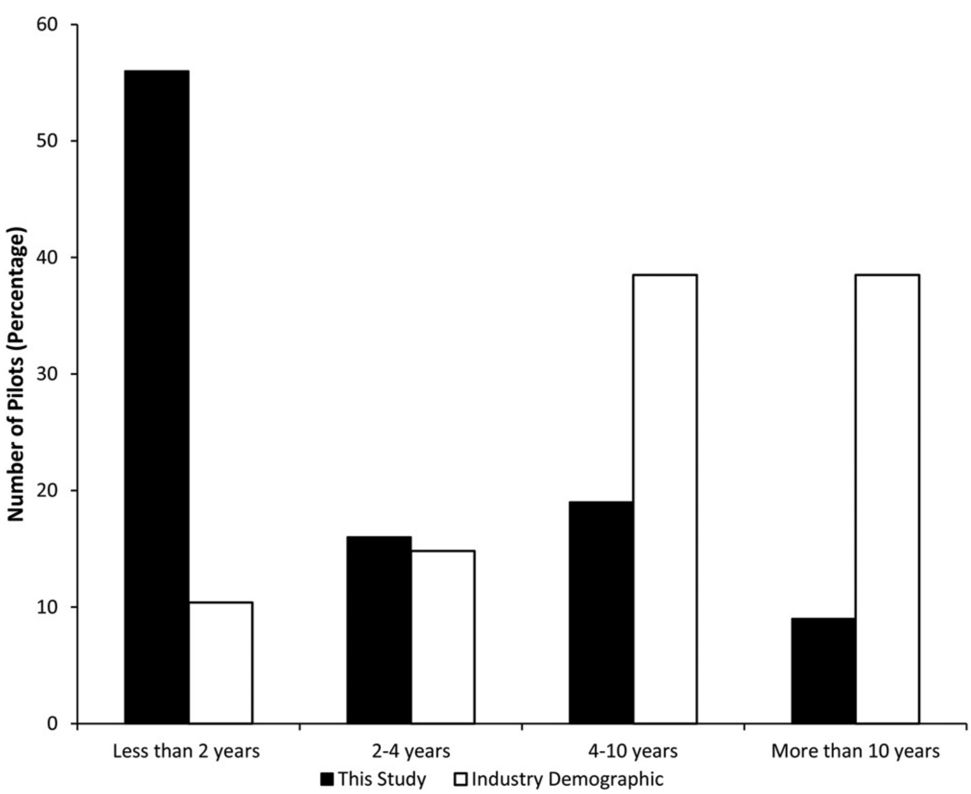

Fig. 2. Percentage (%) HEMS domain task experience in years of pilots in this study vs. industry demographics.

DISCUSSION

This study found that there was a relationship between low HEMS DTE and a high likelihood of an operational night accident. This finding has safety implications for the whole HEMS industry, as a high fatality rate is unsustainable.

The significance of TFH (≤4000 and ≤6000) to HEMS DTE is a product of the high number of entry level (when a pilot meets the minimum required TFH) and career change pilots (who have other helicopter experience in excess of the minimum and commence HEMS) in both groups. The ≤2 yr pilots make up

Table I. Pilot Demographics and 2010 Industry Demographic Comparison (Percentages).

DEMOGRAPHICS	THIS STUDY	HEMS INDUSTRY DATA
Pilot Age (yr)		
≤ 30	3	2.5
31-40	19	11.3
41-50	44*	32.9
51-60	22	34.5
61 +	12	18.8
Total Helicopter Flight Hours		
<2000 h	3	0.5
2000-4000 h	50**	20.2
4000-6000 h	16	27.9
>6000 h	31	51.4
HEMS Domain Task Experience		
Less than 2 yr	56 **	10.4
2-4 yr	16	14.8
4-10 yr	19	38.5
More than 10 yr	9**	38.5

* $P < 0.05$; ** $P < 0.01$.

over half (56%) of the accident demographic and the majority (13 of the 18) of those pilots are in both TFH groups. This significance to HEMS DTE is seen with the moderate and large correlation of the ≤4000 and 6000 TFH pilots, respectively. The low accumulated average flight hours in the previous 30 and 90 d reflect the reactive on-demand nature of the HEMS task.

The 32 pilots average TFH and the significance of both ≤4000 and ≤6000 TFH groups to HEMS DTE reflects the average age and its overrepresentation. As both higher TFH and higher HEMS DTE are underrepresented and age is significant to HEMS DTE and TFH, the higher age demographic expected in that relationship also remains underrepresented. The moderate correlation of age to TFH and HEMS DTE were both similar and the overrepresentation of pilots <50 yr of age is the result of their TFH and lower HEMS DTE, not of accident outcomes. This is consistent with other studies on the age of pilots[25] and other research where HEMS accident outcomes were unrelated to TFH.[1]

Given the challenging nature of the HEMS environment, DTE gives a pilot the ability to make good decisions in terms of whether to fly or not. Low DTE clearly reduces the ability of the pilot to appropriately assess all the possibilities and make a safe and justifiable operational decision. DTE can be considered as preventative risk control for operational purposes.

HEMS DTE >10 yr appears most effective as a preventative risk control, whereas HEMS DTE <4 yr appears less effective. These results support other research, which identified noninstrument proficient pilots as crashing more often than proficient ones.[24] While the finding of noninstrument proficient pilots may appear to offer reason for LCRTL due to SD or CFIT, it offers no insight into the decision-making performance causal to entering the HOC.

When using a risk based approach in the VFR night environment, it can be seen that the noninstrument proficient pilot finding relates mainly to consequence mitigation in treating the HOC once entered. As all flights in this study were planned under VFR, the pilots were responsible for remaining in VFR and avoiding entering an HOC.

There were two types of risk treatment available for addressing the HOC:

1. A preventive risk control to avoid entering the HOC.
2. A recovery risk control as a consequence mitigation measure if the HOC is entered.

Preventative risk treatment activities such as preflight assessment of HOCs, routes to identify high terrain and protection height, interpreting weather forecasts, reports, or observations in the case of HOCs would normally result in either rejecting or delaying the mission, a route change, or changing the category to IFR if that option was available. Even though the flights were planned under VFR, the majority (66%) of accidents occurred in non-VFR conditions (IMC).

When analyzed within the HEMS domain, the literature on expertise[4,8] and its application within the Recognition Primed Model of decision making[12] offers an explanation why the preventative risk treatment has been ineffective. Deliberate practice involves attempting higher levels of performance, which has been associated with frequent poor performance, not just executing and repeating skills.[8] Up to 10 yr of deliberate practice is considered necessary prior to obtaining expertise.[4,8] The definition of 'expert' is varied and influenced by the domain in which the expert is to be defined. A general description is defined at 6 to 10 yr[4] and others 10 yr[8] of deliberate practice and is neither obtained by holding a senior position or by job environment.[19]

In the HEMS domain, higher levels of performance could include acquiring knowledge about the type of information which is most associated with successful scene assessments following previous unsuccessful ones, for example, when executing night cross country routes, descents, and landings at unsurveyed locations, both within and away from man-made lighting. The information acquired may have occurred previously prior to dispatch, on departure, or en route. This information may include knowledge of the area, including elevation terrain features, man-made obstacles, expected conditions, and hazards where local emergency services are first on scene. This knowledge relieves demand on working memory, allowing more complex decisions to be analyzed.

In the Recognition Primed Model,[12] situation assessment is made from familiar pattern recognition in the environment and response.[16] Pattern recognition and search techniques are specific skills of experts and are built from stored cues in long-term memory (LTM). These cues respond to specific stimuli.[12,21] The repetition of events, features, or objects establish these cues[21] and their use means working memory is free for accurate and timely scene assessment,[23] and for more sophisticated strategies that may be used in assessing the situation.[10] The learning and skill acquisition period is where most mistakes are made,[17] and where learners develop relatively imprecise associations between features, events, and objects.[7] The overrepresentation of the <2 yr pilots is consistent with this.

The 14 pilots with <1 yr (average 4.6 mo HEMS) were likely afforded little opportunity of deliberate practice needed to acquire the higher performance.

Decision-making and scene assessment depends largely on domain specific experience.[10] In particular domains, effective collection and use of cues differ with the nature of the individuals and the domain-related (DRE) experiences they have acquired.[23] Certain types of military flying have a relationship with HEMS, such as standby search and rescue, medical evacuation operations in day/night, and instrument flying. The effective use of cues is characterized by how an operator collects and responds to the information within their specific domain.[23] Industry survey findings[3] reported that 80% of surveyed HEMS pilots were military trained. This study found 75% of the accident pilots were nonmilitary trained. As senior position or job environment[19] alone does not make for expertise, holding a position as a HEMS pilot does not infer expertise in that domain. Rather, deliberate practice[8] in the HEMS domain beyond 6 yr[4] and 10 yr[4,8] does.

Scene assessment, such as accurate compilation of multiple sources of information regarding adverse weather, routes which have featureless areas devoid of man-made lighting, high terrain or environment are stimuli, and activate the repertoire of cues in the pilot's LTM. The repetition of stimuli triggers pattern recognition and identifies them as a condition. A response with correct risk treatment (delaying mission or mission termination and safe recovery action) would then be expected. DTE increases as pilots collect events, features, and objects as cues which accumulate into the LTM and form a percentage component of the pilots TFH. Pattern recognition, therefore, is not exclusive to only flying activities.

In the absence of cues, the LTM of a nonexpert would have more limited pattern recognition of the scene, and working memory would be placed under high demand with previously unseen or infrequently seen features, events, and objects. In this case, the situation assessment can be overwhelming and risk treatment response applied incorrectly, too late, or not applied at all. High workload situations decrease the capacity to deal with in-flight problems and resolve any episodes of disorientation.[15] SD due to loss of situation assessment caused by task saturation was reported by 67% of military helicopter pilots in one study.[11]

Given the low HEMS DTE of the majority of pilots in this study, it is likely their working memory was on the complex task at hand and operated without the benefits of cue repertoire recall, which would have enabled a more rapid and accurate interpretation of the scene[23] and subsequent decision making.[18] The high cognitive demand required of this domain would likely have contributed to onset of SD due to loss of situational assessment and ultimately the subsequent CFIT or LCTRL.

Other domains, such as night offshore helicopter operations, have constrained similar cognitive task workload situations with the risk treatment of multicrew instrument proficient pilot operations in IFRH.[14] In that domain, multicrew helicopter pilots reported visual and instrument 'switching' scan techniques (to prevent SD under visual flight on approach) that required high levels of mental resources. Those pilots expressed concerns over its potential to contribute to deteriorating task execution.[14] This type of 'switching' scan increases the likelihood of confusion and SD, as does late 'switching' to instruments after entering the HOC.[15] SD has been found to negatively impact the cognitive performance of helicopter pilots.[20] This impact is consistent with the high cognitive workload of HEMS. The single pilot majority of U.S. HEMS operations[1] demonstrate a largely absent multicrew risk treatment, and the results of this study demonstrates only four instrument proficient pilots in IFRH that other domains[14] use to treat deteriorating cognitive performance.

As the pilots in this study were all engaged in VFR operations and were mostly noninstrument proficient, Wiggins et al.[22] suggests the reasons why IMC is entered for visual pilots (VFR), i.e., deliberate or inadvertent, may be as a result of a relationship between previous hazardous events and behaviors. Four explanations are offered by Wiggins et al. and appear to be most likely within this study:

1) Failure to perceive the association between the loss of visual reference and the loss of aircraft control.
2) Misperception of the likelihood of the loss of aircraft control given the loss of visual reference to the horizon.
3) Recognition of the association between the loss of visual reference and the loss of aircraft control, but belief that they have the capacity to exercise successful control over the aircraft.
4) Recognition of the association between loss of visual reference and the loss of control, but consider the risks associated with maintaining visual reference to the horizon greater than the risks associated with entry into IMC.[22]

It is likely the pilots failed to associate the lack of man-made lighting with a lack of visual cues as an HOC and subsequently experienced LCTRL (1), or incorrectly assessed the likelihood (2) of LCTRL when entering the HOCs, or assessed the consequence (3) differently, believing LCTRL would not occur. It may have been that some pilots assessed the risk associated with maintaining visual reference (either delaying or cancelling the mission task) may have presented greater total risk (a perceived outcome) than that associated with the total risk of entry into the HOCs and its consequences (4). Risk perceptions of instrument rated pilots who enter IMC deliberately have been found to be lower than that of noninstrument rated pilots.[22] LCTRL was due to SD; however, CFIT was a result of loss of situational awareness or unrecognized SD. CFIT is a form of unrecognized SD.[20]

There are some methodological limitations in this study. For example, one helicopter accident was found by reading a non-database NTSB special report which listed the helicopter as an 'airplane' in the NTSB database. The database search may not have retrieved all accidents which fitted the requirements of this study and, therefore, like other HEMS research limitations,[1] all night HEMS LCTRL and CFIT fatal accidents may not have been accessed.

Extracting exact data from the NTSB records was not possible for all items being assessed. Three pilots' years of HEMS DTE was estimated from their hours on the specific accident helicopter type. Night hour history or IFR experience was not discriminated between fixed wing time and rotary wing time for 25 dual rated pilots (7 helicopter rated only). As such, the difference between the inherent instability of rotary wing[15] and the more stable fixed wing aircraft[6,15] and the operating spectrum between the two different aircraft under night and IFR conditions warrants discrimination in IFR and VFR night pilot hours. During the period of this study, HEMS were permitted to operate under Part 91 without and Part 135 with patients. As such, the night VFR visibility and vertical as well as horizontal distance from cloud were less restrictive for helicopters than fixed wing aircraft during this period under FAR Part 91 and Part 135, allowing a broader operational usage spectrum. Under Part 91, night VFR fixed wing cloud clearance is 500 ft below, 1000 ft above, and 2000 ft horizontal from clouds and visibility of 3 mi. Helicopters require a visibility of 1 mi in Class G airspace and "clear of cloud" below 1200 ft. Since 2014, new requirements under Part 135.609 for HEMS include a more restrictive weather requirement for night operations in 'local' (3-mi visibility) and 'nonlocal' (5-mi visibility), and mountainous (1500-ft cloud ceiling) and non-mountainous (1000-ft cloud ceiling) flying areas.

Only nine helicopters in this study were equipped with an autopilot. Fixed wing aircraft are more likely to have an autopilot system[15] and generally operate above the heights above terrain of HEMS rotary wing aircraft at night. Operating at higher altitudes also assist with a lower level work load[15] and radar protection height monitoring. Without discrimination, it is not feasible to discuss night and IFR hours in the current study objectively. The 2010 survey data has TFH, but may contain responses by pilots with both fixed wing and helicopter hours.

Using a risk-based approach, the results of this study suggest some recommendations that the HEMS industry could consider adopting in an effort to reduce the VFR operational accident rate. Preventative risk treatments to consider for low time DTE pilots are:

1. To be supervised closely as part of an industry-wide mentoring approach to building DTE by extended periods of 'nesting' an expert with nonexperts.
2. Nonexperts first obtain experience by operating into areas where man-made lighting exists.
3. A graduated risk based approach to areas which identify where man-made lighting is sparse or does not exist.
4. Defined weather criteria above regulatory or operators' minimums.
5. Operating under close supervision where experts are able to provide advice on decision making before flight.
6. Increasing the scope of operations commensurate with increasing DTE.
7. Identify DRE in pilots' employment history.
8. Identify non-DRE in career change pilots.

Recovery risk treatments for night VFR HEMS operations are:

1. IFR flight planning contingencies.
2. Maintain instrument pilot proficiency and operate an IFRH.

The main finding of this study shows low HEMS DTE has a higher likelihood of accident and high HEMS DTE has a lower likelihood of accident in HOC. Other findings agree with other research that pilots of any TFH,[15] whether instrument proficient or not,[15,24] can lose control of the helicopter or suffer CFIT. A finding of many night HEMS accidents is that the pilots were noninstrument proficient, as were 27 (84%) pilots in this study. However, as demonstrated, noninstrument proficiency only explains the ineffective recovery risk treatment, not why the pilot entered the HOC. The increased chance of LCTRL for nonproficient pilots is well documented. What has been less understood is the relationship of expertise within the application of a highly specialized aviation domain task and its effect on decision making performance under real life operational conditions.

Accumulated HEMS DTE $>$10 yr acts as a preventative risk treatment and has been shown to be statistically underrepresented in the majority of these decision making accidents. It is likely that, without additional constraints in place for nonexpert pilots of any TFH with limited HEMS DTE, poor assessment of HOC at night will continue to place flight crew and occupants at high risk in the VFR night HEMS domain.

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REFERENCES

1. Baker SP, Grabowski JG, Dodd RS, Shanahan DF, Lamb MW, Li GH. EMS helicopter crashes: what influences fatal outcome? Ann Emerg Med. 2006; 47(4):351–356.
2. Bazargan M, Guzhva VS. Impact of gender, age and experience of pilots on general aviation accidents. Accid Anal Prev. 2011; 43(3):962–970.
3. Boschert G, Dery MA, Hustwit J. Pilot safety survey 2005: what pilots are saying. Air Med J. 2007; 26(1):34–37.
4. Brooker P. Experts, Bayesian belief networks, rare events and aviation risk estimates. Saf Sci. 2011; 49(8–9):1142–1155.
5. de Voogt A. Helicopter accidents at night: causes and contributing factors. Aviat Psychol Appl Hum Factors. 2011; 1(2):99–102.
6. Ebbatson M, Harris D, Huddlestone J, Sears R. The relationship between manual handling performance and recent flying experience in air transport pilots. Ergonomics. 2010; 53(2):268–277.
7. Ellis J. Retrieval cue specificity and the realization of delayed intentions. Q J Exp Psychol. 1996; 49(4):862–887.
8. Ericsson KA, Roring RW, Nandagopal K. Giftedness and evidence for reproducibly superior performance: an account based on the expert performance framework. High Abil Stud. 2007; 18(1):3–56.
9. Gibb RW. Visual spatial disorientation: revisiting the black hole illusion. Aviat Space Environ Med. 2007; 78(8):801–808.

10. Goh J, Wiegmann DA. Relating flight experience and pilots' perceptions of decision making skill. Proceedings of the 46th Annual Meeting of the Human Factors and Ergonomics Society; Sept. 30–Oct. 4, 2002; Baltimore, MD. Santa Monica (CA): Human Factors and Ergonomics Society; 2002.
11. Holmes SR, Bunting A, Brown DL, Hiatt KL, Braithwaite MG, Harrigan MJ. Survey of spatial disorientation in military pilots and navigators. Aviat Space Environ Med. 2003; 74(9):957–965.
12. Klein GA. A recognition-primed decision (RPD) model of rapid decision making. In: Klein GA, Orasanu J, Calderwood R, Zsambok CE, editors. Decision making in action: Models and methods. Norwood (NJ): Ablex; 1993:138–147.
13. National EMS Pilots Association. Op Spec A021 Survey Results. October 9, 2010. [Accessed Jan. 2014]. Available from: www.NEMSPA.org.
14. Nascimento FAC, Majumdara A, Jarvis S. Nighttime approaches to offshore installations in Brazil: safety shortcomings experienced by helicopter pilots. Accid Anal Prev. 2012; 47:64–74.
15. Newman DG. An overview of spatial disorientation as a factor in aviation accidents and incidents. Canberra (Australia): Australian Transport Safety Bureau; 2007. Transport Safety Investigation Report.
16. Noble D. A model to support development of situation assessment aids. In: Orasanu J, Calderwood R, Zsambok CE, editors. Decision making in action: models and methods. Norwood (NJ): Ablex; 1993:287–305.
17. O'Hare D, Wiggins M, Batt R, Morrison D. Cognitive failure analysis for aircraft accident investigation. Ergonomics. 1994; 37(11):1855–1869.
18. Schriver AT, Morrow DG, Wickens CD, Talleur DA. Expertise differences in attentional strategies related to pilot decision making. Hum Factors. 2008; 50(6):864–878.
19. Thomson ME, Onkal D, Avcioglu A, Goodwin P. Aviation risk perception: A comparison between experts and novices. Risk Anal. 2004; 24(6):1585–1595.
20. Webb C, Estrada A, Kelly AM. The effects of spatial disorientation on cognitive processing. Int J Aviat Psychol. 2012; 22(3):224–241.
21. Wiggins MW. The role of cue utilisation and adaptive interface design in the management of skilled performance in operations control. Theor Issues Ergon Sci. 2014; 15(3):283–292.
22. Wiggins MW, Hunter DR, O'Hare D, Martinussen M. Characteristics of pilots who report deliberate versus inadvertent visual flight into instrument meteorological conditions. Saf Sci. 2012; 50(3):472–477.
23. Wiggins MW, Azar D, Hawken J, Loveday T, Newman DG. Cue-utilisation typologies and pilots pre-flight and in-flight weather decision-making. Saf Sci. 2014; 65:118–124.
24. Wuerz RC, O'Neal R. Role of pilot instrument proficiency in the safety of helicopter emergency medical services. Acad Emerg Med. 1997; 4(10):972–975.
25. Yang JH, Kennedy Q, Sullivan J, Fricker RD. Scan patterns on overland navigation in varying route difficulty: Is total-flight-hours (TFH) a good measure of expertise? Proceedings of the Human Factors and Ergonomics Society Annual Meeting; Oct. 22–26, 2012; Boston, MA. Santa Monica (CA): HFES; 2012:1406.