Incidence and Challenges of Helicopter Emergency Medical Service (HEMS) Rescue Missions with Helicopter Hoist Operations: Analysis of 12,000 Daytime and Nighttime Missions in Switzerland

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Abstract

Objective

We aimed to investigate the medical characteristics of helicopter hoist operations (HHO) in HEMS missions.

Methods

We designed a retrospective study evaluating all HHO and other human external cargo (HEC) missions performed by Swiss Air-Rescue (Rega) from 1 January 2010 to 31 December 2019.

Results

During the study period, 9,963 (88.7%) HEMS missions with HHO and HEC were conducted during the day, and 1,265 (11.3%) at night. Of the victims with time-critical injuries (NACA ≥4), 21.1% (n=400) reached the hospital within 60 min during the day, and 9.1% (n=18) at night. Nighttime missions, a trauma diagnosis, intubation on-site, and NACA Score ≥4were independently and highly significantly associated with longer mission times ($p<0.001$). The greatest proportion of patients, who needed hoist or HEC operations in the course of the HEMS mission during daytime, sustained moderate injuries (NACA 3, n=3,731, 37.5%) while practicing recreational activities (n=5,492, 55.1%). In daytime HHO missions, the most common medical interventions performed were an insertion of a peripheral intravenous access (n=3,857, 38.7%) and administration of analgesia (n=3,121, 31.3%).

Conclusions

Nearly 20% of patients, who needed to be evacuated by a hoist, were severely injured, and complex and lifesaving medical interventions were necessary before the HHO procedure. Therefore, only adequately trained and experienced medical crew members should accompany HHO missions.

Introduction

Involvement of a helicopter emergency medical service (HEMS) can significantly shorten rescue times, especially in mountaineous areas, and improve the outcome of severely injured patients (1, 2). Due to the challenging terrain in the mountains, landing the helicopter is not always possible, and alternative patient evacuation methods must be used. Helicopter hoist operation (HHO) to extricate patients in difficult terrain is a common operational rescue technique in mountain emergency medical services (MEMS) if landing at the scene of the incident is not possible. This helicopter procedures enable both immediate professional medical care onsite and an immediate safe evacuation of the patient to ensure further outcome-relevant timely treatment at an appropriate hospital. Only approx. 11% of all HHO missions take place during the night. Thus, there is less experience in night HHO missions per se. Nonetheless, severe incidents or accidents in Rega's HHO missions day and night have not been reported in the observation period.

The topic of HHO in HEMS missions is very rarely addressed in the scientific medical literature (3-5). We do know, however, that nighttime imposes, due to reduced visible cues, an additional, but manageable, risk for HEMS operations. To improve our understanding of HHO in HEMS, especially in night operations, we investigated the medical characteristics of HEMS missions with HHO.

Methods

Data and Ethics

We conducted a retrospective study of all consecutive HHO missions performed by Swiss Air-Rescue (Rega) from January 1, 2010, to December 31, 2019. Data were extracted from Rega's HEMS staff mandatory electronic medical record system (SAP database) and an additional chart review was conducted. The cantonal ethics committee of St. Gallen (EKOS) reviewed the study design and granted permission for the use of patient data without individual patient consent according to the Federal Act on Research involving Human Beings and the Ordinance on Human Research except for Clinical Trials. The permission covers the processing of patient data from Rega's HEMS operation (EKOS St. Gallen 10.2.2020, BASEC Nr. 2020-00252 EKOS 20/020).

Setting and Population

In Switzerland, five organisations provide 24/7 physician-staffed HEMS operations and carry out primary (pre-hospital retrieval; about 2/3) and secondary (inter-hospital transfer; about 1/3) missions. Rega, the largest of these organisations with more than 88,000 HEMS missions in the observation period, provides operations for and in all cantons, and for some regions in neighbouring countries. Rega operates 12 helicopter bases, located throughout Switzerland as well as a partner base in Geneva, and can reach any location in the operational area within 15 minutes flight time day and night, provided the respective weather conditions are met. Since August 2019, it also has a training base in Grenchen, in Canton Solothurn. The helicopter fleet comprises seven Airbus H145 at the midland bases in Zurich, Basel, Bern, Lausanne and St. Gallen, and 11 AgustaWestland AW109SP "Da Vinci" helicopters (performance-enhanced version for Rega of the AW109S Grand) at the alpine bases in Untervaz, Locarno, Erstfeld, Samedan, Wilderswil, Mollis, and Zweisimmen. With Rega's helicopters more than 11,000 HEMS missions are conducted per year and all are equipped with a certified rescue hoist and avionics that permit night operations with and without night vision goggles (NVG) under visiual flight rules (VFR) but also under instrument flight rules (IFR), including state-of-the-art satellite-based high-precision procedures to and from major hospitals and HEMS bases to provide relevant medical care to patients also in bad visibility.

In Switzerland, the HEMS crew includes a pilot, a HEMS physician and a paramedic, who serves as technical crew member and hoist operator. Inter alia, the requirements for HEMS physicians are a board-certification in anesthesiology and a certification in pre-hospital emergency medicine. Several HEMS physicians hold additional certifications in intensive and critical care medicine and/or mountain emergency medicine. In missions, when challenging terrain is expected, a rescue specialist with basic life support education is added to the crew on board. The HEMS physician is either winched down to the site

first or after the rescue specialist's initial safety assessment of the environment and situational circumstances.

Definitions and Statistics

We analysed mission characteristics including mission duration, time of day, season (6), the National Advisory Committee for Aeronautics score (NACA) (7), and the medical interventions performed on scene (e.g., intubation). Nighttime was defined according to the European Union Aviation Safety Agency (EASA) (8) as the period between the end of evening civil twilight and the beginning of morning civil twilight.

Continuous variables were summarised by mean ± standard deviation if normally distributed, or by median and interquartile range if skewed. Normality was tested using the Shapiro-Wilk test. Categorical variables were summarised with counts and percentages for each level of the variable. Changes in the number of missions per year were assessed by linear regression, and the total number of missions per base type was compared using Pearson's Chi-squared test. The Wilcoxon-Mann-Whitney test was used to assess differences in the duration of daytime and nighttime HHO missions. To further investigate factors that are potentially associated with a prolonged duration of HHO missions (mission time was defined as the time between an emergency call and arrival at the hospital), a multivariable linear regression model was built including the binary variables intubation, daytime/nighttime, and trauma versus medical diagnosis as well as the NACA score as a factor variable. To obtain a more homogeneous sample, unharmed patients (NACA 0) were excluded from this analysis; minor to moderately injured patients (NACA 1-3) were merged; and deceased patients (NACA 7) were excluded, as rescue missions differ substantially for these patients and there was not a clear end-of-mission time point defined for a substantial proportion of these patients. Two-sided p-values of <0.05 were considered statistically significant. All statistical analyses were performed using R Studio 3.6.0 on macOS 10.15.4.

Results

Number of HHO Missions in Switzerland

During the study period, 88,213 HEMS missions were recorded; 11,228 of which were registered as HHO missions. The majority of HHO missions (9,963; 88.7%) were conducted during the day. There were 1,265 (11.3%) nighttime missions (Table 1), most of which took place before midnight (n=1,050, 83%). All patients were winched up accompanied by either a rescue specialist or the HEMS physician. All patients and rescuers safely boarded the helicopter, without any procedure-related injuries or other adverse events to patients or crew members, as recorded for observation period.

Regional Distribution

There was a significant increase in the total number of HHO missions over the study period for all types of HEMS bases (i.e., lowland, intermediate, alpine; Figure 2). The number of HHO night missions did not significantly increase over the study period (Figure 3), but there was a positive tendency (i.e., positive

regression coefficients for alpine and intermediate bases). The total number of HHO missions and the number of nighttime HHO missions was significantly higher in alpine bases compared to intermediate or lowland bases (p<0.001 for both comparisons).

Mission Duration

The overall median time from emergency call to landing at the hospital in a HHO mission was significantly shorter during the day compared to the night as well (67 min; IQR 54 to 83 min versus 83 min; IQR 73 to 129 min, p < 0.001) (Table 1). Of the victims with time-critical and possibly life-threatening injuries (NACA ≥4), 21.1% (n=400) reached the hospital within 60 min in the daytime, and 9.1% of patients (n=18) reached the hospital within 60 min during the night. A trauma diagnosis, night missions, intubation on-site, and NACA Score ≥4 were independently and highly significantly associated with longer mission times (p <0.001 for all variables in univariate and multivariate analysis) (Table 3, Figure 1). In the univariate analysis, intubation prolonged the overall mission time by roughly 27 min. Multivariate analysis revealed that intubation itself is only accountable for an additional 13 min when adjusted for trauma diagnosis, night mission, and NACA score. The other variables (night mission, trauma diagnosis, and NACA score) were less affected by the multivariate adjustments.

Characteristics of HHO Missions and Medical Condition of Patients

About half of the HHO missions taking place at night in this study were performed for uninjured patients (NACA 0, n=610, 48.2%), whereas during the daytime only 22.7% (n=2,259) were uninjured. Most HHO missions during daytime were due to winter or summer sport-related injuries of moderate severity (NACA 3, n=3,731, 37.5%). The greatest proportion of patients requiring hoist operations during the daytime were practicing recreational activities in the mountains during the summer (hiking, mountaineering, climbing, etc.) (n=5,492, 55.1%), whereas 975 patients (9.8%) were doing winter sports such as skiing, snowboarding or free riding. Road accidents accounted for 1,388 (14.0%) evacuations by HHO (Table 1). A substantial number of patients in HEMS missions with HHO during day or night were dead on arrival on scene or died on scene (NACA 7, n=859, 8.6%, and n=106, 8.4%, respectively). Return of spontaneous circulation (ROSC) could be achieved in 5% (n=56) of patients with cardiac arrest. Trauma victims were in significantly worse conditions according to the NACA score compared to medical patients (p <0.001, Chi2-test).

Medical Interventions during HHO Missions

In daytime HHO missions, the most common interventions performed onsite before evacuation were insertion of peripheral intravenous access (n=3,857, 38.7%) and analgesia (n=3,121, 31.3%). Cardiopulmonary resuscitation was performed in 176 patients (1.8%), 196 patients (2.0%) had to be endotracheally intubated, and 27 patients (0.3%) required decompression of a pneumothorax (Table 1). Insertion of intravenous access (n=268, 21.2%) and analgesia (n=202, 16.0%) were also the most common procedures recorded at night. Only 11 patients (0.9%) at night needed cardiopulmonary

resuscitation, 13 patients (1.0%) had to be intubated, and 2 patients (0.2%) required decompression of a pneumothorax (Table 1).

Discussion

This study of 11,228 HHO rescue missions performed day and night and is the largest known study to date. Our data show that HHO missions in Switzerland occur frequently, even at night. Although most of the patients evacuated by HHO had no or minor injuries, almost one fifth was in severe condition, with NACA scores between 4 and 6, and in many cases advanced medical interventions had to be performed at the scene before HHO evacuation. Night missions, a trauma diagnosis, intubation on-site, as well as NACA Score ≥4 were independently and highly significantly associated with longer mission duration. Nevertheless, the aforementioned factors increase in general the mission time, regardless of a hoist mission or not. With regard to Rega's additional safety procedures for night flight operations, there is a natural increase of the mission time owed to flight and patient safety. These operational safety procedures are usually mitigating measures to address the operational risks resulting from with the lack of daylight and the subsequent natural deficiencies of the human eye in dark environments. Flight and patient safety must never be compromised. Thus, a safety compromise for a potential benefit to save 2 or maybe 4 minutes is not an eligible or recommendable option.

Need for HEMS Crews with Advanced Skills

A relevant observation in our study is that the proportion of severely injured patients (NACA 4-6) is similar in daytime and nighttime HHO missions. This emphasises the need for HEMS teams with advanced critical care capabilities 24/7, and adds weight to the discussion of personal skills in HEMS services (9). In our study, the condition of trauma vs. medical victims was more critical judged by the NACA score ($p < 0.001$). This finding contradicts a previous Swiss study which showed that in HEMS, patients with medical emergencies had higher NACA scores than trauma patients (10, 11). A possible explanation is an overall predominance of trauma in our study population, due to the fact that the greatest proportion of patients in need of HHO rescue are practicing recreational activities in the mountains.

We found that most of the basic medical interventions we provide - such as vascular access (n=4,125; 36.8%), analgesia (n=3,323; 29.6%) and immobilisation (n=2,179; 19.4%) - were performed on the scene and before the HHO procedure. In 425 patients (3.8%), advanced critical care interventions (cardiopulmonary resuscitation, ventilation, rapid sequence induction, endotracheal intubation, pleural decompression) had to be performed urgently due to immediate life-threatening conditions such as cardiac arrest, acute respiratory failure, cardiocirculatory collapse, or pneumothorax. These findings are in accordance with previous reports and again emphasize that the medical team being involved in the HHO rescue missions must be able to perform the entire spectrum of life-saving emergency procedures in often extremely difficult environmental conditions, and with limited skilled human resources (12, 13). In Europe, primarily anesthesiology and intensive care medicine physicians have the experience needed to perform these invasive procedures safely (14). Health systems in other countries may have different legal

settings that render other specialties or professions more relevant for HEMS staffing, but the goal should always be to provide the highest level of care possible.

There are some studies analysing prehospital times in alpine HEMS (5, 15, 16). Several factors are discussed, which potentially contribute to longer time intervals for alpine rescue compared to urban or suburban rescue missions. These include the necessity for complex HHO rescue procedures to gain access to the patient, bad weather conditions, and longer flight times from remote areas to level 1 trauma centres. Recent data support conducting medical interventions prehospital rather than upon hospital arrival (15, 17). This might be even more important in rescue missions with in general longer pre-hospital times such as alpine or night HEMS missions.

Data from the international alpine trauma registry show that prolonged pre-hospital times are not necessarily harmful per se, an argument supported by data showing that in-hospital mortality in trauma patients transported from alpine regions is comparable to that of patients from urban areas, despite longer pre-hospital times and higher injury severity scores (15, 18). Furthermore, Kulla et al. reported that the overall time from the accident until the end of emergency department (ED) treatment is equal for severely injured patients undergoing procedures such as endotracheal intubation and pleural decompression, regardless of the location (pre-hospital or in-hospital) at which these interventions are performed (16).

We found a significantly higher proportion of HHO missions in the alpine HEMS compared to the intermediate and lowland bases. Additionally, there was a tendency towards an increase in HHO mission volume over the 10 year study period in the alpine HEMS bases. Both findings could be connected to an increase in recreational activities in the mountains, and more extreme and more remote leisure behaviour over time.

Strengths

This is the first study analysing >10,000 HHO missions including data of night missions (3, 11, 19).

Limitations

Our study has limitations inherent to a retrospective chart review, as data quality depends on documentation quality. Second, we were unable to validate the pre-hospital diagnosis made by the HEMS team, or to determine in-hospital outcome because of the lack of related hospital follow-up in our database. Finally, composition of HEMS crews and legal aspects elsewhere may have an impact as well.

Conclusions

Nearly 20% of patients, who needed to be evacuated by a hoist, were severely injured, and complex and lifesaving medical interventions were necessary before the HHO procedure. Therefore, only adequately trained and experienced medical crew members should accompany HHO missions.

Abbreviations

ACLS: Advanced cardiac life support

ALS: Advanced life support

ATLS: Advanced trauma life support

BLS: Basic life support

BVM: Bag-valve-mask

CPR: Cardiopulmonary resuscitation

ETC: European trauma course

HCS: Human cargo sling

HEC: Human external cargo;

HEMS: Helicopter emergency medical service

HHO: Helicopter hoist operation

ICAR MEDCOM: Medical commission of the international commission for alpine rescue

ICAR: International commission for alpine rescue

ISMM: International society for mountain medicine

ISS: Injury severity score

NACA: National advisory committee for aeronautics

PHTLS: Prehospital trauma life support

RSI: Rapid sequence intubation

SAR: Search and rescue

SOP: Standard operating procedure

TBI: Traumatic brain injury

TCCC: Tactical combat casualty care

UIAA: Union Internationale des associations d’alpinisme

Declarations

Ethics approval and consent to participate

The cantonal ethics committee of St. Gallen (EKOS) reviewed the study design and granted permission for using patient data without individual consent, according to the Federal Act on Research involving Human Beings and the Ordinance on Human Research with the Exception of Clinical Trials. The permission covered the use of patient data regarding the HEMS operation. (EKOS St Gallen 10.2.2020, BASEC Nr. 2020-00252 EKOS 20/020)

Consent for publication

Not applicable

Availability of data and material

Please contact author for data requests.

Competing interests

None

Funding

None

Authors' contributions

UP, JK and MM performed the study; UP wrote the manuscript; LM performed the statistical analyses; VL, JK, SR, SS, SB and VW made substantial contributions to conception and design of the study and critically revised the article for important intellectual content. All authors read and approved the final manuscript.

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References

1. Tomazin I, Ellerton J, Reisten O, Soteras I, Avbelj M. Medical standards for mountain rescue operations using helicopters: official consensus recommendations of the International Commission for Mountain Emergency Medicine (ICAR MEDCOM). High Alt Med Biol. 2011;12(4):335-41.

2. Andruszkow H, Hildebrand F, Lefering R, Pape HC, Hoffmann R, Schweigkofler U. Ten years of helicopter emergency medical services in Germany: do we still need the helicopter rescue in multiple traumatised patients? Injury. 2014;45 Suppl 3:S53-8.
3. Samdal M, Eiding H, Markengbakken L, Roislien J, Rehn M, Sandberg M. Time Course of Hoist Operations by the Search and Rescue Helicopter Service in Southeast Norway. Wilderness Environ Med. 2019;30(4):351-61.
4. Smith RM, Conn AK. Prehospital care - scoop and run or stay and play? Injury. 2009;40 Suppl 4:S23-6.
5. Pietsch U, Strapazzon G, Ambuhl D, Lischke V, Rauch S, Knapp J. Challenges of helicopter mountain rescue missions by human external cargo: need for physicians onsite and comprehensive training. Scand J Trauma Resusc Emerg Med. 2019;27(1):17.
6. Alpine Sicherheit. Available from: https://wwwalpinesicherheitat/de/Unfallstatistik/ (Accessed at 15052020).
7. Weiss M, Bernoulli L, Zollinger A. [The NACA scale. Construct and predictive validity of the NACA scale for prehospital severity rating in trauma patients]. Anaesthesist. 2001;50(3):150-4.
8. Easy Access Rules for Standardised European Rules of the Air (SERA). EASA. 15.05.2020.
9. Pham H, Puckett Y, Dissanaike S. Faster on-scene times associated with decreased mortality in Helicopter Emergency Medical Services (HEMS) transported trauma patients. Trauma Surg Acute Care Open. 2017;2(1):e000122.
10. Bonatti J, Goschl O, Larcher P, Wodlinger R, Flora G. Predictors of short-term survival after helicopter rescue. Resuscitation. 1995;30(2):133-40.
11. Pasquier M, Geiser V, De Riedmatten M, Carron PN. Helicopter rescue operations involving winching of an emergency physician. Injury. 2012;43(9):1377-80.
12. Pietsch U, Knapp J, Kreuzer O, Ney L, Strapazzon G, Lischke V, et al. Advanced airway management in hoist and longline operations in mountain HEMS - considerations in austere environments: a narrative review This review is endorsed by the International Commission for Mountain Emergency Medicine (ICAR MEDCOM). Scand J Trauma Resusc Emerg Med. 2018;26(1):23.
13. Pietsch U, Lischke V, Sollid SJM, Pruckner S, Theiler L, Greif R, et al. Efficacy and efficiency of indoor nighttime human external cargo mission simulation in a high-fidelity training Centre. Scand J Trauma Resusc Emerg Med. 2020;28(1):61.
14. Sollid SJM, Rehn M. The role of the anaesthesiologist in air ambulance medicine. Current Opinion in Anesthesiology. 2017;30(4):513-7.
15. Ausserer J, Moritz E, Stroehle M, Brugger H, Strapazzon G, Rauch S, et al. Physician staffed helicopter emergency medical systems can provide advanced trauma life support in mountainous and remote areas. Injury. 2017;48(1):20-5.
16. Kulla M, Helm M, Lefering R, Walcher F. Prehospital endotracheal intubation and chest tubing does not prolong the overall resuscitation time of severely injured patients: a retrospective, multicentre

study of the Trauma Registry of the German Society of Trauma Surgery. Emerg Med J. 2012;29(6):497-501.

17. Fischer M, Kehrberger E, Marung H, Moecke H, Prückner S, Trentzsch H, et al. Eckpunktepapier 2016 zur notfallmedizinischen Versorgung der Bevölkerung in der Prähospitalphase und in der Klinik. Notfall + Rettungsmedizin. 2016;19(5):387-95.
18. Rauch S, Dal Cappello T, Strapazzon G, Palma M, Bonsante F, Gruber E, et al. Pre-hospital times and clinical characteristics of severe trauma patients: A comparison between mountain and urban/suburban areas. Am J Emerg Med. 2018;36(10):1749-53.
19. Guinzburg A, Epstein D, Cohen J, Kiso S, Aviram E, Shapira S, et al. Emergency Care Provided by the Israeli Military Airborne Combat Evacuation Unit during Helicopter Winch Rescue Operations. Prehosp Emerg Care. 2020:1-7.

Tables

Table 1. Characteristics of HHO Missions (n=11,228)

Variable	Day n= 9,963 (88.7%)	Night n= 1,265 (11.3%)
Age, mean years ± SD	46.8 ±19.2	40.5 ±19.2
Neonate <1 day, n (%)	22 (0.2)	2 (0.2)
<18 years, n (%)	498 (5)	103 (8.1)
80+ years, n (%)	297 (3.0)	23 (1.8)
Unknown/Missing	57 (0.6)	12 (0.9)
Accident Occurrence, n (%)		
Hiking	3,568 (35.8)	411 (32.5)
Climbing / mountaineering	1,522 (15.3)	245 (19.4)
Paragliding	402 (4.0)	27 (2.1)
Winter sports (skiing, freeriding, etc.)	975 (9.8)	123 (9.7)
Road accident	1,388 (13.9)	56 (4.4)
Other	1,393 (14.0)	306 (24.2)
Unknown / missing	715 (7.2)	97 (7.7)
NACA Score^{+}, n (%)		
0 = No injury or disease	2,259 (22.7)	610 (48.2)
1 = Minor disturbance	395 (4.0)	80 (6.3)
2 = Slight to moderate disturbance	820 (8.2)	51 (4.0)
3 = Moderate to severe, not life-threatening	3,731 (37.5)	219 (17.3)
4 = Serious incident, life-threatening	1,466 (14.7)	149 (11.8)
5 = Acute danger	380 (3.8)	46 (3.2)
6 = Respiratory and/or cardiac arrest	53 (0.5)	4 (0.3)
7 = Death	859 (8.6)	106 (8.4)
Diagnosis, n (%)		
Trauma	6,430 (64.5)	528 (41.7)
Medical	1,119 (11.2)	104 (8.2)
Uninjured	2,414 (24.2)	633 (50.0)
Procedures Performed, n (%)		

Analgesia	3,121 (31.3)	202 (16.0)
Peripheral vascular access	3,857 (38.7)	268 (21.2)
Endotracheal intubation	196 (2.0)	13 (1.0)
Cardiopulmonary resuscitation	176 (1.8)	11 (0.9)
Mucosal atomisation device	73 (0.7)	11 (0.9)
Immobilisation vacuum mattress	1,994 (20.0)	185 (14.6)
Needle thoracostomy	19 (0.2)	1 (0.1)
Surgical thoracostomy	8 (0.1)	1 (0.1)
Mission Times, median minutes (IQR)		
Emergency call to take-off at base	9 (7 to 15)	22 (11 to 36)
Take-off at base to hospital	52 (40 to 67)	69 (50 to 94)
Emergency call to hospital	67 (54 to 83)	83 (73 to 129)
Reached the hospital ≤60 min		
Overall	2,668 (26.8)	71 (5.6)
NACA 1 - 3 (Day: n = 4946; Night: n = 350)	2,206 (44.6)	43 (12.3)
NACA 4 - 6 (Day: n = 1899; Night: n = 199)	400 (21.1)	18 (9.1)

Data were complete if not otherwise stated. SD = standard deviation; NACA = National Advisory Committee for Aeronautics; $^{+}$Trauma patients had significantly severer conditions in terms of NACA score compared to non-trauma patients ($p < 0.001$).

Table 2: Linear Regression Models on Duration of HHO Missions

Variable	Multivariate Adjusted			Univariate Analysis		
	Estimate	95% -C.I.	p-value	Estimate	95% - C.I.	p-value
Night mission	10.76	8.54 to 12.98	<0.001	12.72	10.34 to 15.10	<0.001
Trauma	8.93	7.26 to 10.60	<0.001	6.36	4.58 to 8.15	<0.001
Intubation	13.00	8.68 to 17.32	<0.001	27.30	23.65 to 30.96	<0.001
NACA 4	15.10	13.84 to 16.37	<0.001	15.02	13.74 to 16.30	<0.001
NACA 5	19.81	17.24 to 22.39	<0.001	23.19	20.92 to 25.46	<0.001
NACA 6	17.50	10.84 to 24.16	<0.001	24.06	18.08 to 30.05	<0.001

Complete case analysis of 6,427 patients (excluded from the analysis were patients with NACA 0 and 7). Unit of estimates: minutes. Fit of the multivariate model: $p<0.001$, Adj. $R = 0.148$. Night mission: day missions served as the reference group.

Trauma: Medical diagnosis served as the reference group. NACA: NACA was analysed as a factor variable, scores 1-3 were merged and served as the reference group.

Figures

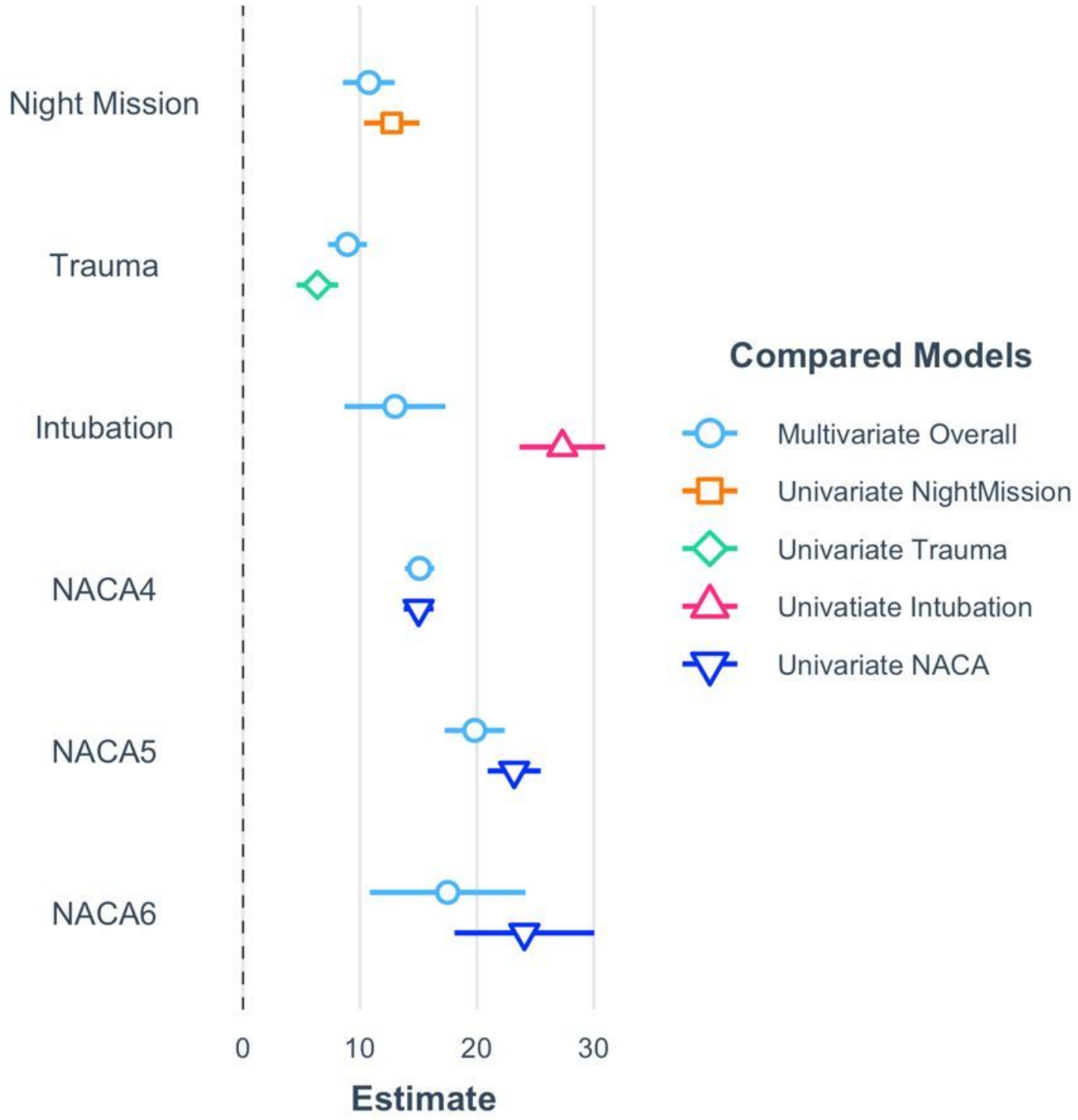

Figure 1

Linear regression models on duration of HHO-Missions Visualisation of the multivariable and univariate linear regression models as presented in table 2. Estimates are in minutes. Reading Example: Intubation prolonged the total mission time by 27 min. (95% CI 24 - 31 min.) in the univariate analysis; adjusted for trauma, night¬time mission and NACA score intubation prolonged the overall mission time by 13 min. (9 - 17 min.).

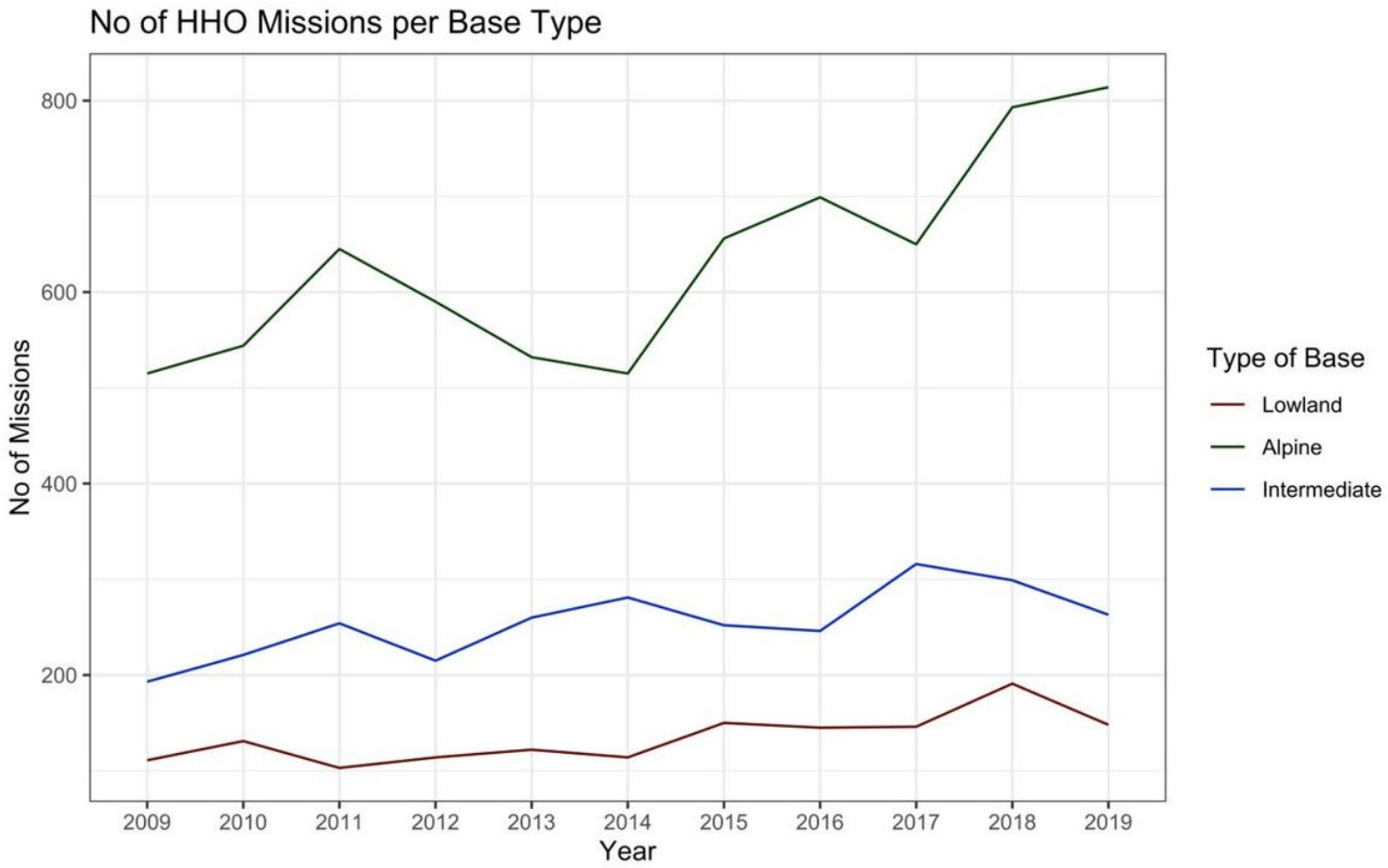

Figure 2

Total Number of HHO Missions per Base Type during the Study Period. No missing data. P-values for slope within each group calculated with linear regression models.

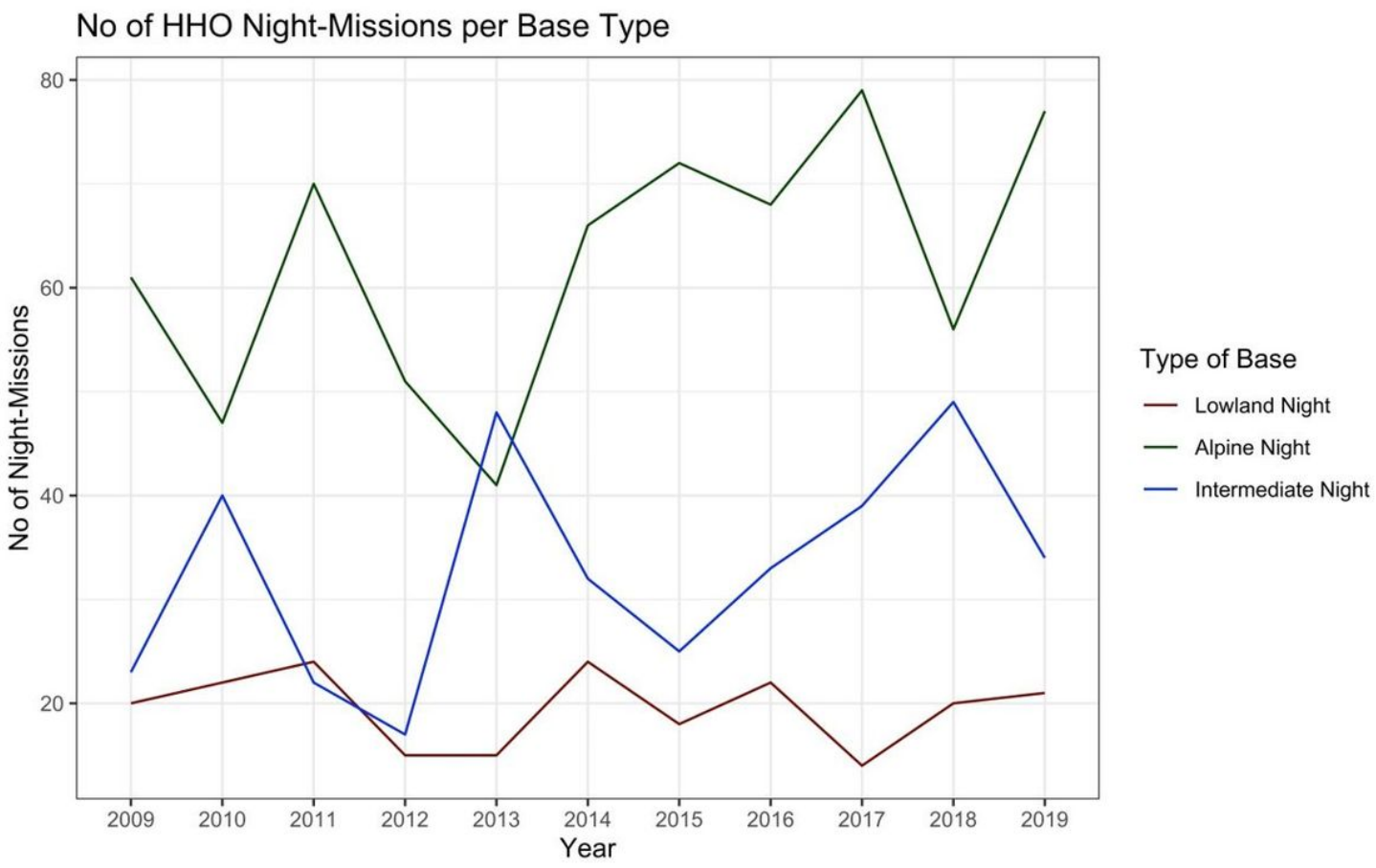

Figure 3

Number of Nighttime HHO Missions per Base Type during the Study Period. No missing data. P-values for slope within each group calculated with linear regression models.