

HIGH ALTITUDE MEDICINE & BIOLOGY  
Volume 19, Number 3, 2018  
Mary Ann Liebert, Inc.  
DOI: 10.1089/ham.2018.0050

# The Use of E-Learning in Medical Education for Mountain Rescuers Concerning Hypothermia

Paweł Podsiadło,<sup>1,2</sup> Sylwester Kosiński,<sup>3,4</sup> Tomasz Darocha,<sup>2,5</sup> Kinga Sałapa,<sup>6</sup>  
Tomasz Sanak,<sup>7</sup> and Hermann Brugger<sup>8,9</sup>

## Abstract

Podsiadło, Paweł, Sylwester Kosiński, Tomasz Darocha, Kinga Sałapa, Tomasz Sanak, and Hermann Brugger. The use of e-learning in medical education for mountain rescuers concerning hypothermia. *High Alt Med Biol.* 19:272–277, 2018.

**Objective:** Victims of mountain accidents are often exposed to wet and cold environments which may increase the risk of hypothermia. Mountain rescuers should be able to recognize and manage hypothermia. We aimed to assess relevant knowledge in professional and volunteer mountain rescuers, as well as to evaluate the efficacy of an e-learning platform for continuing medical education.

**Methods:** An e-learning platform was developed to provide access to updated information about hypothermia. Volunteer and professional mountain rescuers participated in an e-learning course. Pretest, post-test, and specific lesson test scores were compared. After 1 year, a follow-up course was performed.

**Results:** In total, 187 rescuers, comprising 136 (72.7%) volunteers and 51 (27.3%) professionals, were enrolled. Ahead of the course, no difference in knowledge was found between professionals and volunteers. After the course, one's knowledge of hypothermia increased significantly ( $p < 0.001$ ). The scores achieved in the field management of hypothermia were better among professional rescuers than among volunteer rescuers ( $p = 0.003$ ), whereas in post-traumatic hypothermia half of the results were insufficient in both groups. Moreover, 57 rescuers repeated the course after 12 months. While professionals partially retained the achieved level of knowledge, the volunteers had dropped back to their initial level.

**Conclusions:** The e-learning course increased the knowledge of hypothermia among mountain rescuers. The poor retention after 1 year indicates that the interval between lectures should be reduced. An e-learning platform is an effective tool for the medical education of mountain rescuers.

**Keywords:** e-learning; emergency medicine; hypothermia; mountain rescue

<sup>1</sup>Department of Emergency Medicine, Jan Kochanowski University, Kielce, Poland.

<sup>2</sup>Polish Medical Air Rescue, Warsaw, Poland.

<sup>3</sup>Faculty of Health Sciences, Jagiellonian University Medical College, Kraków, Poland.

<sup>4</sup>Tatra Mountain Rescue Service, Zakopane, Poland.

<sup>5</sup>Department of Anesthesiology and Intensive Care, Medical University of Silesia, Katowice, Poland.

<sup>6</sup>Department of Bioinformatics and Telemedicine, Jagiellonian University Medical College, Kraków, Poland.

<sup>7</sup>Department of Disaster Medicine and Emergency Care, Jagiellonian University Medical College, Kraków, Poland.

<sup>8</sup>Institute of Mountain Emergency Medicine, EURAC Research, Bolzano, Italy.

<sup>9</sup>Department of Anesthesiology and Critical Care Medicine, Medical University of Innsbruck, Innsbruck, Austria.

## Introduction

VICTIMS OF MOUNTAIN ACCIDENTS are often exposed to harsh environments and thus at risk of developing hypothermia. Although the incidence of hypothermia in mountainous environments remains unknown, cold exposure has been reported as a cause of up to 13.8% emergency calls and 10% of deaths in mountain rescue missions (Hearns, 2003; Kordi et al., 2012). The factors associated with the occurrence of hypothermia include bad weather conditions (temperature, humidity, and wind speed), immobilization (e.g., due to trauma), exhaustion, poor clothing insulation, and long exposure duration (Ainslie and Reilly, 2003). Therefore, mountain rescuers should have sufficient knowledge of hypothermia to timely recognize and manage this potentially life-threatening condition.

Rescue operations in the mountains in Poland are provided by eight mountain rescue teams (MRTs) located in the main mountain ranges, staffed with 150 professionals and 977 volunteers (GOPR; TOPR). Polish law stipulates that mountain rescuers need to be trained as “qualified first aid” providers, which is an intermediate level between basic and advanced life support, comparable with emergency medical technicians. However, the curriculum is primarily intended for firefighters rather than mountain rescuers, and does not include sufficient information on hypothermia. Hence, MRTs have developed their own, specifically mountain-rescue-related training modules. With the establishment of a Severe Hypothermia Treatment Centre, an e-learning platform for hypothermia was developed to provide higher quality training for MRT members (Darocha et al., 2016).

In this study, we aimed to assess the knowledge on hypothermia among professional and volunteer mountain rescuers, and to evaluate the efficacy of the e-learning platform.

## Materials and Methods

In this study, we compared the pretest and post-test scores of an e-learning course offered to mountain rescuers. The course had been established by professionals experienced in prehospital care and hypothermia treatment, before being reviewed by the chief physician of the Polish MRT. It comprised of a pretest (13 questions), 6 lessons, each followed by a test (4 questions each), and a posttest (13 questions). The lessons covered pathophysiology, post-traumatic hypothermia, avalanches, field management, insulation, and temperature measurement.

Each multiple-choice question consisted of three distractors and one correct answer. The pretest and post-test were identical. After completion of the pretest, participants did not have access to the correct answers. The results of the pretest did not affect the results of the subsequent lessons. Each participant was required to achieve a correct response rate of at least 75% (three of four questions) in the test at the end of each lesson to have access to the next lesson; if not, then the participant had to repeat the lesson and perform a retest. The post-test was considered to be successfully completed if at least 75% (10/13) of the answers were correct. If the participant failed the post-test, the posttest or the entire course could be repeated. As the platform is an educational tool, participants were permitted to repeat the course and the post-test several times to enhance their knowledge and improve their post-test results (achieve the best post-test score). However, the participants were not informed about such a possibility before completing the final test.

Twelve months after the course, participants were asked by e-mail to repeat the course. The median results of initial test in both groups were analyzed to assess the long-term effect of the training session.

## Participants

MRTs were encouraged to participate in the training session. In the registration process, participants indicated their occupation and place of work. We enrolled participants who indicated their job as a “mountain rescuer,” provided the name or location of their rescue organization, and had completed the entire course. These data were sent to the respective training officer of the MRT, who identified participants as volunteers or professionals. Individuals who did not provide complete personal information were excluded, as their membership in MRT could not be confirmed; moreover, those who had not completed the entire course were excluded. Medical doctors and paramedics were also excluded from the study (Fig. 1). The data were collected from December 2015 to November 2016.

## Statistical analysis

The main outcome was the comparison of test scores (pretest and post-test; pretest and follow-up). The comparison of test scores between volunteers and professionals was the secondary outcome.

First, we examined whether experience could affect the knowledge of the participant before the training. Second, we evaluated the increase (on average) in knowledge due to the course by using the results of pretest and the results of the first attempt of post-test, and assessed this value based on the group. As the final test could be repeated many times, we have only presented the best result for reference. The proportions of correct answers regarding the pretest, post-test, and best post-test are presented as mean  $\pm$  standard deviation, and as minimum and maximum values. Moreover, the median and interquartile range (IQR) are provided due to the skewed distribution of the outcomes. The differences in the median results of the pretest and post-test were analyzed using the Wilcoxon signed-rank test in the groups of volunteers and professional mountain rescuers separately, whereas the differences in the median results of the pretest and post-test between these groups were verified using the Mann–Whitney test. Nonparametric methods, rather than parametric two-way repeated-measures analysis of variance, were adopted due to the non-normal data distribution.

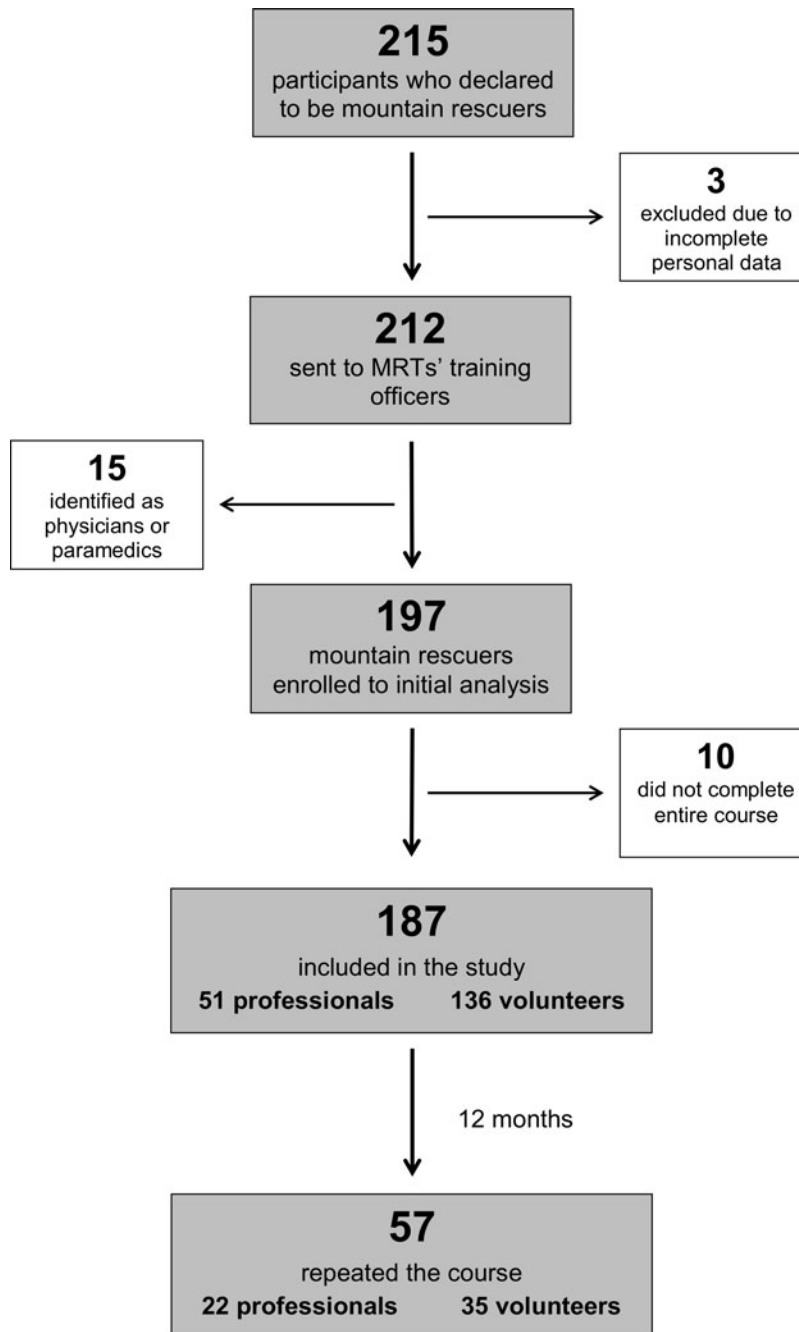
The Mann–Whitney test was used to compare the two groups of rescuers in terms of age and experience. The association between the two quantitative measures was assessed using Spearman’s rank correlation coefficient, while the Shapiro–Wilk test was applied to assess the degree of normality.

Discrete data are presented as frequencies and percentages, while the relationship between discrete data was verified using independent chi-square tests.

Results with a  $p$ -value lower than a significance level  $\alpha=0.05$  were considered as statistically significant. Statistical measurements were conducted with R program version 3.3.2 ([www.r-project.org](http://www.r-project.org)).

## Results

Seven of the eight Polish MRTs—comprising 112 professional and 858 voluntary rescuers—participated in the training program. Subsequently, 197 mountain rescuers took



**FIG. 1.** Flowchart of the participants. MRTs, mountain rescue teams.

part in the training session, including eight who did not complete the pretest and two who did not complete the post-test. In total, 187 (94.9%) mountain rescuers were enrolled, 136 (72.7%) volunteer and 51 (27.3%) professional mountain rescuers. The median age of the volunteers was 36 years (IQR, 30–50 years; range, 20–77 years) and not different from the age of the professional rescuers (36 years; IQR, 31.5–41 years; range, 23–61 years;  $p=0.556$ ). There was no difference in the median experience between volunteers (10 years; IQR, 4–23.5 years; range, 0–50 years) and professionals (10 years; IQR, 7–15 years; range, 0–40 years;  $p=0.943$ ).

We did not find any significant correlation between experience and the pretest results either in the professional mountain rescuer group ( $R=0.10$ ,  $p=0.493$ ) or in the volunteer group ( $R=0.06$ ,  $p=0.521$ ).

The results of the pretest, post-test, best post-test, and follow-up in both groups are presented in Table 1.

The proportion of professional mountain rescuers (10/51, 19.6%) who had to repeat the post-test due to an insufficient score did not significantly differ from that in the volunteer group (17/136, 12.5%;  $p=0.218$ ). In total, 13.7% (7/51) of professional rescuers and 11% (15/136;  $p=0.610$ ) of volunteers repeated the course voluntarily to improve their post-

TABLE 1. STATISTICS OF THE OUTCOMES OF PRETEST, POST-TEST, BEST POST-TEST, AND FOLLOW-UP IN PROFESSIONAL RESCUERS AND VOLUNTEERS

	<i>Professionals</i>	<i>p</i>	<i>Volunteers</i>
Pretest (%)	<b>71.9 ± 18.9</b> 69 (53–84) <i>23–100</i>	0.062	<b>66.2 ± 17.4</b> 69 (53–76) <i>7–100</i>
Post-test (%)	<b>85.5 ± 11.5</b> 84 (76–96) <i>61–100</i>	0.834	<b>84.8 ± 11.4</b> 84 (76–92) <i>53–100</i>
<i>p</i> (pretest/post-test)	<b>&lt;0.001</b>		<b>&lt;0.001</b>
Best post-test (%)	<b>91.2 ± 8.4</b> 92 (84–100) <i>76–100</i>	0.085	<b>88.9 ± 8.1</b> 92 (84–92) <i>76–100</i>
Follow-up (%)	<b>76.2 ± 18.9</b> 77 (61–92) <i>23–100</i>	0.1	<b>69.9 ± 14.7</b> 69 (53–84) <i>38–92</i>
<i>p</i> (pretest/follow-up)	<b>0.023</b>		0.106

Data are presented as mean ± standard deviation (upper row, bold), median (lower and upper quartile) (middle row), and minimum and maximum values (lower row, italic).

test result, even though they had already passed the training session in the first attempt.

The proportion of participants who obtained the required amount of points to pass a lesson on their first attempt was estimated, and compared between volunteers and professionals (Table 2).

Regarding the lesson covering post-traumatic hypothermia, only half of the rescuers in each group achieved the sufficient number of correct answers to pass the lesson on their first attempt. Similarly, only approximately half of the volunteers could correctly answer at least three of four questions concerning the lesson about the field management of hypothermia, in contrast to 76.5% of professional rescuers (*p* = 0.003).

No difference was found between the volunteers and professionals in the percentage of correct answers to particular questions from the first attempt to the post-test.

Fifty-seven rescuers repeated the course after 12 months. While the professionals showed an increase of knowledge from the initial pretest to the follow-up pretest (from 69% to 77%, *p* = 0.023), the score of the volunteers remained unchanged (69%).

TABLE 2. PERCENTAGE OF RESCUERS WHO ACHIEVED THE REQUIRED AMOUNT OF POINTS TO PASS A LESSON IN THE VOLUNTEER AND PROFESSIONAL RESCUER GROUPS

<i>Lessons</i>	<i>Professionals, n (%)</i>	<i>Volunteers, n (%)</i>	<i>p</i>
Pathophysiology	49 (96.1)	118 (86.8)	0.066
Post-traumatic hypothermia	29 (56.9)	69 (50.7)	0.455
Avalanches	51 (100)	135 (99.3)	0.539
Field management	39 (76.5)	71 (52.2)	<b>0.003</b>
Insulation	47 (92.2)	126 (92.6)	0.910
Temperature measurement	44 (86.3)	106 (77.9)	0.203

Bold indicates statistically significant *p* value.

Discussion

In this study, we did not find a significant difference in the basic knowledge concerning hypothermia between professional and volunteer mountain rescuers ahead of the course. After the course, we found that the knowledge of hypothermia increased in all surveyed mountain rescuers. After 1 year, professionals partially retained their level of knowledge, while the volunteers had dropped back to their initial level.

Although hypothermia can be a life-threatening condition, appropriate management and coordination of the rescue chain can lead to survival without any sequelae, even in patients presenting with cardiac arrest (CA) (Darocha et al., 2015; Kosinski et al., 2016). Hypothermic CA often occurs during the rescue procedure and transport (rescue collapse), and requires sufficient knowledge and experience among the rescuers. In the French Alps, >50% of hypothermic CA cases admitted to a level 1 emergency room sustained rescue collapse (Debaty et al., 2015). Although hypothermia-related topics are included in regular training in the majority of MRTs, most MRTs desire to improve medical education (Elsensohn et al., 2009). The transport of patients with hypothermic CA to a hospital without extracorporeal life support, which is clearly in contrast to the guidelines, is common (Podsiadło et al., 2017). These studies indicate the need for revision of curricula in medical training.

In this study, half of the volunteers and one-third of professionals failed the test regarding the field management and transport of hypothermic patients. Similarly, the questions regarding the guidelines for the evacuation of hypothermic patients seemed too difficult for volunteer rescuers.

Post-traumatic hypothermia also seemed a difficult topic for all rescuers as only half of the answers were correct in the first attempt (Table 2). Heat loss in an individual at rest is ~60–75 kcal/h, but may be as high as 400 kcal/h in a trauma patient due to the loss of blood, the presence of open wounds (direct exposure of deep tissues), and severe head trauma leading to impaired consciousness and thermoregulation (Perlman et al., 2016). A decrease in the core body temperature is strongly associated with increased mortality (Arthurs et al., 2006; Klauke et al., 2016). A study concerning a 2-year period of activity of Scottish mountain rescue services showed that trauma was the cause of 78.4% of all interventions (Hearns, 2003). In areas with many skiing routes, the percentage of trauma as a cause of all MRT interventions was >90% (Siodlak and Pastwa, 2005). Hence, the inclusion of post-traumatic hypothermia in the course curriculum is essential.

We found that after 1 year, professionals retained their level of knowledge only partially, while the volunteers had dropped completely back to their initial level. This may be caused by the different levels of experience of the two surveyed groups. Professional rescuers are more often involved in mountain rescue operations than volunteers, and they are regularly trained to maintain a constant level of competence for rescue operations (Siodlak and Pastwa, 2005). In fact, in 1997/98, 56% of 389 volunteer mountain rescuers from the Beskidy MRT were not involved in any rescue operation. In Poland, 13% of all mountain rescuers are professionals, similarly to a previous survey in 14 countries (Brugger et al., 2005). Enrolled MRTs are ground rescue teams that occasionally collaborate with the helicopter emergency medical system. The poor retention of knowledge indicates that the

interval between lectures should be reduced for both groups, especially for volunteer rescuers.

E-learning is a recognized training method with comparable effectiveness with traditional methods of teaching (Cook et al., 2008). The most important elements when assessing e-learning training in medicine include one's acquired knowledge and practical skill, changes in therapeutic behaviors (such as strict guideline adherence), treatment results as well as student satisfaction (Ruggeri et al., 2013; Nesterowicz et al., 2014; Nicastro et al., 2015). Of 214 studies included in the analysis of Cook et al. (2008) on Internet-based learning in health professions education, 206 evaluated acquired knowledge by using a final test; 126 of them compared the final test result with the result from an initial test at the beginning of the course.

In this study, the online training program offered different information compared with traditional courses provided by rescue organizations. Hence, although we could not compare both forms of teaching, we instead compared knowledge before and after the e-learning course.

This form of e-learning platform has the advantage that the curriculum and specific content can easily and periodically be adapted to the current state of knowledge. A regular analysis of the completed tests gives the teaching team feedback about the competence of the rescue teams and reveals specific weaknesses (Ruggeri et al., 2013). Recommendations regarding the management of victims of mountain accidents, provided by the International Commission for Alpine Rescue, the European Resuscitation Council, the Wilderness Medical Society, and other medical publications, are published in English, which presents a major limitation for accessing this information in non-English-speaking communities. The creation of an e-learning platform in the local language facilitates free access to current knowledge regarding hypothermia.

#### *Limitations of the study*

This study included 45% of professionals and only 16% of volunteers in enrolled MRTs. It is likely that these individuals had the greatest interest in education, which might cause one to overestimate the assessment of the general level of knowledge of volunteers. For the same reason, a low number of rescuers who repeated the course after 12 months may affect the assessment of knowledge retention. The increase in adherence to the guidelines in rescue operations was also not assessed in this study, and should be investigated in future studies.

#### **Conclusions**

We did not find a significant difference in the basic knowledge about hypothermia between professional and volunteer mountain rescuers ahead of the course. After the course, the knowledge of hypothermia increased in all surveyed mountain rescuers. The most problematic issue for participants included the lessons on post-traumatic hypothermia and the algorithm concerning prehospital management and transport of hypothermic patients. After 1 year, professionals partially retained their level of knowledge, while the volunteers had dropped back to their initial level. This indicates that the interval between lectures should be reduced, especially among volunteer rescuers. The compliance to the course repetition should be also improved.

The e-learning platform is an effective tool for theoretical training regarding hypothermia for mountain rescuers.

#### **Acknowledgements**

The authors thank the Departments of Innovation and Research and University of the Autonomous Province of Bozen/Bolzano for covering the Open Access publication costs.

#### **Author Disclosure Statement**

No competing financial interests exist.

#### **References**

- Ainslie PN, and Reilly T. (2003). Physiology of accidental hypothermia in the mountains: A forgotten story. *Br J Sports Med* 37:548–550.
- Arthurs Z, Cuadrado D, Beekley A, Grathwohl K, Perkins J, Rush R, and Sebesta J. (2006). The impact of hypothermia on trauma care at the 31st combat support hospital. *Am J Surg* 191:610–614.
- Brugger H, Elsensohn F, Syme D, Sumann G, and Falk M. (2005). A survey of emergency medical services in mountain areas of Europe and North America. *High Alt Med Biol* 6: 226–237.
- Cook DA, Levinson AJ, Garside S, Dupras DM, Erwin PJ, and Montori VM. (2008). Internet-based learning in the health professions: A meta-analysis. *J Am Med Assoc* 300:1181–1196.
- Darocha T, Kosinski S, Moskwa M, Jarosz A, Sobczyk D, Galazkowski R, Slowik M, and Drwila R. (2015). The role of hypothermia coordinator: A case of hypothermic cardiac arrest treated with ECMO. *High Alt Medicine Biol* 16:352–355.
- Darocha T, Kosinski S, Podsiadlo P, Jarosz A, and Drwila R. (2016). EMS, HEMS, ECMO center, ICU team: Are you ready for hypothermic patients? *JACC Hear Fail* 4:829–830.
- Debatty G, Moustapha I, Bouzat P, Maignan M, Blancher M, Rallo A, Brun J, Chavanon O, Danel V, Carpentier F, Payen J-F, and Briot R. (2015). Outcome after severe accidental hypothermia in the French Alps: A 10-year review. *Resuscitation* 93:118–123.
- Elsensohn F, Niederklapfer T, Ellerton J, Swangard M, Brugger H, and Paal P. (2009). Current status of medical training in mountain rescue in America and Europe. *High Alt Med Biol* 10:195–200.
- GOPR. Available at <http://www.gopr.pl> (accessed April 3, 2018).
- Hearns S. (2003). The Scottish mountain rescue casualty study. *Emerg Med J* 20:281–284.
- Klauke N, Gräff I, Fleischer A, Boehm O, Guttenthaler V, Baumgarten G, Meybohm P, and Wittmann M. (2016). Effects of prehospital hypothermia on transfusion requirements and outcomes: A retrospective observational trial. *BMJ Open* 6: e009913.
- Kordi R, Rostami M, Heidari P, Ameli S, Foroughifard L, and Kordi M. (2012). Fatalities among Iranian high-altitude outdoor enthusiasts: Causes and mechanisms. *Asian J Sports Med* 3:285–290.
- Kosinski S, Darocha T, Jarosz A, Migiel L, Zelias A, Marcinkowski W, Filip G, Galazkowski R, and Drwila R. (2016). The longest persisting ventricular fibrillation with an excellent outcome—6h 45 min cardiac arrest. *Resuscitation* 105:e21–e22.
- Nesterowicz K, Librowski T, and Edelbring S. (2014). Validating e-learning in continuing pharmacy education: User acceptance and knowledge change. *BMC Med Educ* 14:33.
- Nicastro E, Lo Vecchio A, Liguoro I, Chmielewska A, De Bruyn C, Dolinsek J, Doroshina E, Fessatou S, Pop TL, Prell

- C, Tabbers MM, Tavares M, Urenden-Elicin P, Bruzzese D, Zakharova I, Sandhu B, and Guarino A. (2015). The impact of e-learning on adherence to guidelines for acute gastroenteritis: A single-arm intervention study. *PLoS One* 10:1–13.
- Perlman R, Callum J, Laflamme C, Tien H, Nascimento B, Beckett A, and Alam A. (2016). A recommended early goal-directed management guideline for the prevention of hypothermia-related transfusion, morbidity, and mortality in severely injured trauma patients. *Crit Care* 20:107.
- Podsiadło P, Darocha T, Kosiński S, Sałapa K, Ziętkiewicz M, Sanak T, Turner R, and Brugger H. (2017). Severe hypothermia management in mountain rescue: A survey study. *High Alt Med Biol* 18:411–416.
- Ruggeri K, Farrington C, and Brayne C. (2013). A global model for effective use and evaluation of e-learning in health. *Telmed e-Health* 19:312–321.
- Siodłak J, and Pastwa G. (2005). Bezpieczniej w Beskidach [in Polish]. *W Górach* 3.
- TOPR. Available at <http://topr.pl/lista> (accessed April 4, 2018).

Address correspondence to:  
*Paweł Podsiadło*  
*Polish Medical Air Rescue*  
*Ul. Jana Pawła II 9A*  
*Mastów 26-001*  
*Poland*

*E-mail:* p.podsiadlo.01@gmail.com

Received April 11, 2018;  
accepted in final form May 30, 2018.