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Selecting E-Mobility Transport Solutions for Mountain Rescue Operations

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Abstract: This study introduces e-mobility for humanitarian purposes and presents the first investigation of innovative e-mobility transport solutions (e.g., e-bike, e-stretcher, and drone) for mountain rescue. In practice, it is largely unclear which e-mobility transport solutions might be suitable and what selection attributes are to be considered. The subsequent study supports the technology selection process by identifying and measuring relevant selection attributes to facilitate the adoption of e-mobility in this domain. For the purpose of this study, a multi-method research approach that combines qualitative and quantitative elements was applied. In the first step, results of a systematic search for attributes in literature were combined with inputs gained from unstructured expert interviews and discussions. The perceived importance of the identified selection attributes was then measured by analyzing survey data of 341 rescue workers using the best-worst scaling methodology. Finally, the results were reiterated in another expert discussion to assess their overall validity. Study results indicate that e-mobility transport solutions need to primarily enhance operational performance and support the safety of mountain rescue personnel. Surprisingly, economic and sustainability aspects are less of an issue in the process of technology selection.

Keywords: e-mobility; mountain rescue operations; emergency response; multi-method-research; best–worst scaling

1. Introduction

E-mobility, which includes every means of transport powered by an electric powertrain [1], has recently been gaining momentum due to its promising potential for tackling the ecologic problems of today's society. It has the capability to reduce greenhouse gas emissions, increase energy efficiency, and foster renewable power production, which are well-recognized properties by governments and policymakers [2]. European countries regularly play a leading role in the wide-ranging implementation of e-mobility [3]. This trend is slowly taking hold on a global scale. Various countries and organizations pursue an intensified adoption of e-mobility, which is not only limited to automobiles. In many other application areas, performance gains can also be achieved in terms of logistics and transportation due to novel e-mobility transport solutions [4]. In this regard, the fields of disaster relief and humanitarian logistics are focused on not only harnessing the ecologic benefits of e-mobility but also creating entirely new technological solutions to improve their performance when supporting people in need [5–7], as do mountain rescue (MR) services.

MR services are the primary responders in accident cases in alpine areas as well as in humanitarian disasters, where they become an integral part in the alleviation of human suffering. Prominent examples of such cases are earthquakes, such as the Amatrice earthquake in 2016 [8], large-scale avalanches, landslides and floods. During their operations, the MR services are often exposed to a multitude of challenges when taking care of and evacuating patients from remote locations. Relevant operations include patient localization and transportation, which regularly take place in isolated and potentially dangerous terrains and under harsh weather conditions [9]. These challenges negatively affect the overall logistics and transportation performance of MR services, often resulting in relatively time-consuming ascents and descents to the prior location of the patient [10]. Furthermore, no two emergencies are the same; rather, they can be described as heterogeneous and dynamic in nature, involving numerous and varied combinations of actors, skills, equipment, and environmental conditions. With the equipment currently available, rescue services often reach their operational limits when it comes to efficiently handling these drivers of complexity [11]. Additionally, alpine leisure activities are rising in popularity due to increased accessibility to remote mountainous areas [12]; thus, they now attract millions of people annually [13]. This growing enthusiasm for active pursuits in mountainous areas, in turn, leads to an even steeper increase in related accidents [14]. The corresponding logistical challenges are highly diverse and tackling them demands scientific assessments and the implementation of novel approaches. Therefore, modern technology is investigated and applied in most professional MR services [15].

The implementation of e-mobility transport solutions may be a viable option to achieve required performance gains. In the case of MR services, electric drones are a sound alternative for the emergency transport of medical equipment [16,17], and several other approaches, such as e-bikes and e-stretchers, also exist. E-bikes (i.e., bicycles with an additional electric propulsion) can be used for performing reconnaissance, locating patients, or getting faster access to emergency sites. Similarly, e-stretchers also make use of electric propulsion technology and are a variant of the common stretchers used to transport patients or operational equipment. Here, in particular, differences in the altitude and distance between an accident site and emergency vehicle can be more easily overcome. Furthermore, this technology positively affects the stabilization of the stretcher, ensuring safer transport conditions for patients while sparing the physical strength of the mountain rescuer [18].

The starting point of this scholarly effort is ascertaining that practitioners and various other stakeholders involved in MR cannot fully rely on the decision-making experience with respect to novel transport modes and technologies. Thus, it is largely unclear which e-mobility transport solutions might be suitable and what attributes are to be considered when selecting an adequate e-mobility transport solution, in accordance with the requirements of the MR services. As public views on e-mobility and new modes of electric transportation for civilian and commercial purposes have been evaluated in recent years, it follows naturally that their application to other purposes should come under consideration too. According to [19], technology transfer in humanitarian emergencies is a critical issue, but, so far, no conclusive investigation has been undertaken regarding the applicability of e-mobility transport solutions in humanitarian logistics. The study at hand aims at extending scientific knowledge to the relatively new sphere of e-mobility for humanitarian purposes and offers a first exploration in that direction based on the case of MR services. With a special focus on the technology selection process, we formulated the following research questions (*RQs*):

- RQ1: What are the decision-relevant attributes for selecting e-mobility transport solutions for mountain rescue personnel?
- RQ2: What is the perceived importance of the identified attributes for selecting e-mobility transport solutions for mountain rescue personnel?

The research questions were formulated during the course of the joint Interreg project Smart Test for Alpine Rescue Technology (SMART) involving Italian and Austrian MR services. For the corresponding analysis, a multi-method research approach consisting of qualitative and quantitative elements was chosen. Firstly, results of a systematic search for attributes in literature were combined with inputs gained from unstructured expert interviews and discussions with representatives of the participating MR services. Then, the perceived importance of the identified selection attributes was measured by analyzing survey data of 341 MR personnel using the best–worst scaling (BWS) methodology. Finally, the results were reiterated in another expert discussion to assess their overall validity. The applied research approach as well as the achieved results can provide a good orientation for both academics and practitioners in the context of transport technology assessment in (mountain) rescue operations and related fields. The article continues with the setting of the scientific background by analyzing the existing body of knowledge in the field. Then, the applied research methods are described, and the results of the analysis are presented and discussed. The article concludes with an overview about the limitations and implications of this study and potential future lines of research.

2. Related Work

Due to the novelty of the topic under consideration, specific research in the field of e-mobility for MR is sparse. Consequently, this section instead offers a general outline of the present study's scholarly context where we first delve into the current body of knowledge regarding the general adoption of e-mobility transport solutions. Then, closing in on the core topic of the present study, we present literature on the selection of e-mobility for various purposes and then connect this literature to the MR context, illustrating scholarly work that discusses the selection of equipment in this domain. This, consequently, guides us to the apparent gap in the existing body of knowledge that lays the foundation for subsequent analysis.

In recent years, various studies on the adoption of e-mobility for different applications have been published. A comprehensive overview about recent literature in that regard is presented by [20]. Here, special attention is dedicated to papers that assess factors that are linked to the successful adoption of electric vehicles. Papers in this research domain, for instance, have investigated the impact of innovation policies on the future development of international electric vehicle industries and markets [21,22]. Research results reveal that purchase subsidies, purchase restrictions and driving restrictions are the most effective policies to push e-mobility adoption. Ref [23] provided insights into incentives that promote the purchase and use of electric vehicles in the Norwegian market. The authors pointed out that the diffusion of electric vehicles is largely driven by economic incentives (e.g., exemption from toll charges) set by the government. Filtering adequate policies and incentives is only one of the many possible ways of guaranteeing an accelerated transition towards e-mobility. Similarly, quantitative modelling studies by [24,25] have underlined the importance of policies that address the visibility and familiarity of e-mobility in society and thus lead to increased acceptance and adoption of e-mobility transport solutions. As market penetration of e-mobility increases, a range of studies clearly shows that selection processes will extend beyond the above-mentioned mostly economical aspects to include considerations of environmental aspects and sustainability [26–34]. It is not surprising to find that the list of relevant aspects to be considered in the adoption of electric vehicles will obviously include the characteristics of the vehicles themselves. In this respect, ref [35] were able to show that the price and range of electric vehicles have an impact on the adoption of this technology, whereby price is a more significant barrier than vehicle range. This then inevitably links to perceptions of the individual, as not all features of an electric vehicle might be of the same importance to prospective consumers.

Several studies have investigated individual level predictors of the selection process with respect to electric vehicles. For example, ref [36] investigated customers' evaluations of electric vehicles for daily use. They found that human–machine interaction (i.e., design of displays and charging systems), traffic and safety implications and ecological aspects play an important role in the evaluation of electric vehicles. Ref [37] analyzed the factors that influence the selection process of an individual with certain technical background or knowledge when adopting electric vehicles. They found that general interest in technology, the distance driven, appreciating both the looks and environmental qualities of an electric vehicle positively affected the intention to adopt, while perceptions of electric vehicles being slow were negatively associated with the intention to adopt. Another study focusing on the perceptions of passengers towards electrified buses is presented by [38]. Through an online survey and subsequent BWS analysis, the authors found that safety, eco-friendliness, and ride comfort are important when using electrified buses. Extending this research beyond certain features of an electric vehicle, scholars have included personal variables such as attitudes and social determinants relying on social-psychological theories. Ref [39], for example, have analyzed personal factors that influence the selection of electric vehicles using the theory of planned behavior, finding that subjective norms and attitudes towards technology are significant drivers. Other studies by [40–44] provided a deeper analysis of the critical personal dimensions that impact the selection of e-mobility transport solutions from the customers' perspective, underlining the importance of individual attitudes, experience, information level, acquisition costs and social environment (e.g., family and friends) in the process of e-mobility selection.

Only a handful of scientific articles have provided insights into the selection of equipment in the MR domain. Through surveys, ref [45] analyzed the equipment of medical backpacks in MR operations and pointed out several important selection criteria, with a special focus on equipment properties and quality standards. Others have further recognized equipment weight as important in this context [46–48]. In detail, ref [46] assessed MR casualty bags using an experimental evaluation process with a special focus on applicability in cold and windy environments. According to the authors, the equipment selection process is not only restricted by weight and bulk of the used equipment but also by the necessity to withstand extreme climatic conditions. Ref [47] conducted a usability trial (including focus groups and surveys) of MR stretchers. Aside from the light weight, the equipment should furthermore be easy to use and be able to transport and feature a high payload. In the usability assessment of specialized medical equipment, ref [48] identified, through questionnaire analysis, the weight of the equipment and the time taken to apply it as important factors for an eventual equipment selection.

Combining the literature on the adoption and selection of e-mobility concepts and that of equipment for MR organizations, this study, to the best of our knowledge, is the first to address the selection of e-mobility transport solutions for MR. Our study is unique in the sense that it is the first that introduces e-mobility to the MR domain. With this, we aim to add to the establishment of a new strain of research by studying the applicability of e-mobility for humanitarian purposes.

3. Study Context and Methodology

The study at hand was conducted as part of the joint Interreg START project with Austrian and Italian MR services. The main objective of the project is to strengthen tactical cooperation and improve coordination between MR services in cross-border emergencies. Aside from this, the project pursues the objective of identifying, evaluating and implementing innovative e-mobility transport solutions that offer potential approaches to enhance the operational performance of MR teams in challenging response missions [49]. Driven by the novelty of electrification in the MR domain, key decision makers require support in the selection of suitable e-mobility transport solutions. Here, special interest lies in e-mobility transport solutions that facilitate easier access of MR teams to isolated patient locations while sparing the physical strength of the rescue personnel. Furthermore, e-mobility transport solutions should speed up the transportation of injured people, keeping in mind the environmental aspects.

3.1. Research Design

A multi-method research approach was employed for this study, combining qualitative and quantitative empirical research methods under the methodological guidance of Louviere and Islam [50]. This method allows for a comprehensive, bottom-up approach involving practitioners' perspectives, with the aim of providing applicable insights guided by the exigencies of the targeted stakeholder group. To answer the first research question (*RQ1*), attributes for selecting e-mobility transport solutions for MR services had to be identified. Therefore, as is visible in the process map depicted in Figure 1, we started our research with a systematic search for attributes in literature to elicit already documented attributes that are relevant in the context of e-mobility and mountain rescue. The identified attributes were then used in unstructured interviews with two MR experts to gather feedback from their applied perspectives and further elaborate on the evaluation attributes. A subsequent expert discussion reversed the initial broadening scope in an effort to arrive at a shortlist of attributes, which were then quantitatively tested using a BWS survey in the fourth and penultimate empirical phase, aiming to answer *RQ2*. This collection of primary data becomes, according to [51], increasingly important in the context of humanitarian research. Returning to a qualitative level of analysis, the last methodological step reiterated the results obtained from the previous steps in another expert discussion. The following paragraphs provide an in-depth look at the methodological aspects of these concatenated methodological components.

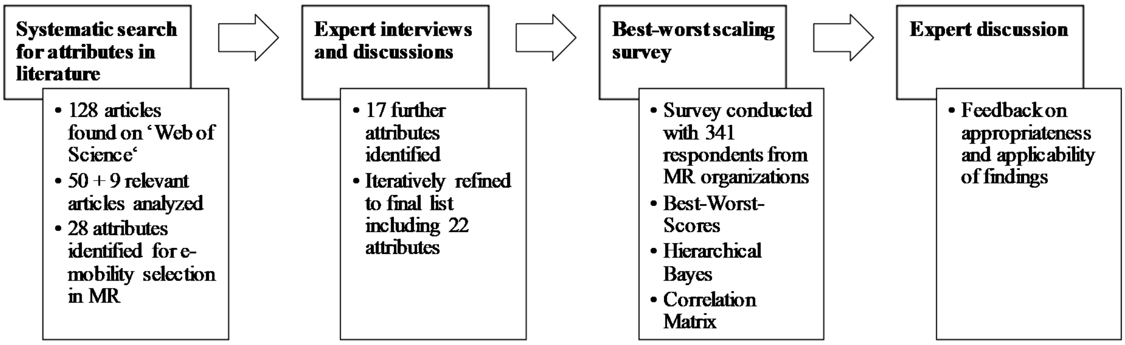

Figure 1. Process map of the applied multi-method research approach.

3.2. Systematic Search for Attributes in Literature

While Section 2, "Related Work", served to position our paper in the research landscape and to justify our research aim, we now start out with the systematic search for attributes in literature, as the second stage of the applied methodology. Ref [52] recommends starting a systematic search by designing a search string to develop a reproducible and transparent mode of finding relevant literature sources. In the case of this systematic search, literature concerning the assessment of e-mobility transport solutions as well as that focusing on technology assessment in the MR domain was scanned to find characteristic attributes. As scientific literature specifically focusing on MR is sparse, the search was expanded to include literature regarding other rescue services as well. Therefore, we identified adequate search terms and combined them using Boolean operators (e.g., "AND"; "OR") as suggested by [53] to form the final search string as shown in Appendix A. A systematic article title search (denoted by "TI" in the search string) of the "Web of Science" database, concluded in September 2019, yielded 128 articles.

After the initial search, all article titles and abstracts were scanned for their suitability to the subject under review and to eliminate irrelevant articles, as recommended by [54]. Ref [55] explained that clearly defining inclusion criteria helps to transparently identify relevant literature during a systematic search process. The applied inclusion criteria for this study are likewise listed in Appendix A. Articles that did not fit these inclusion criteria were subsequently excluded. Examples of excluded articles encompass but are not limited to those focusing on route selection problems for e-vehicles, charging station location optimization problems or biological articles that were inadvertently found by the search string (i.e., six articles including the biologic terms "entomobryidae" or "elasmobranch" that will also be returned by the search term "e*mob*"). This step was independently performed by two researchers to reduce bias, as recommended by [56]. After the independent evaluation of the articles, inconsistencies were jointly assessed, and the corresponding articles were reexamined to arrive at a pre-ultimate list of the 50 articles that remained.

Then, we expanded this limited body of literature with further peer-reviewed articles published in contextually relevant journals, a strategy that was previously applied by [57] as well as [58] who have also conducted systematic searches in the realm of humanitarian logistics and supply chain management. Therefore, journals such as "*High Altitude Medicine & Biology*" and "*Wilderness & Environmental Medicine*" were explicitly scanned for technology selection articles from the mountain rescue domain. This resulted in nine additional articles being considered for the identification of the evaluation attributes. The final 59 articles were subjected to a full-text analysis to extract decision-relevant attributes concerning the technology selection process. Based on this body of sources, a list of 28 attributes was generated, 14 of which were related to e-mobility and 14 to (mountain) rescue operations.

3.3. Unstructured Expert Interviews and Discussion

Similarly to [59], the next step served to collect feedback on and expand the list of attributes. Therefore, unstructured expert interviews and open discussions were held with two representatives from the MR services. The interviews and subsequent discussions lasted for approximately three hours and were conducted in the campus of the university at the end of September 2019. One of the involved experts was the head of operations of the local MR service for 40 years and the other one held a leading position within the service and was responsible for new technology implementation at the national level since 2005. Both have long-term experience in the MR domain and are still involved in response missions on the ground. Furthermore, both experts have been actively involved in the work package "E-mobility", led by the research team as part of the project described above. It is, therefore, safe to assume that both experts were highly knowledgeable in the study context and, as involved partners, were motivated to contribute to the study to the best of their abilities. The interviews were conducted by two researchers and held separately with each expert. Initially, the interviewees were introduced to the study's background, aims and research design. After this first input from the research team, the list of 28 attributes obtained from the systematic search for attributes in literature was handed out in printed form. The experts were invited to review the attributes in sequence and share their individual judgments and opinions with respect to their relevance for the selection of e-mobility concepts for MR services. In addition to commenting on the list of attributes, they were further invited to manually extend or reduce the list if necessary, according to their evaluation. In case the expert pointed to a yet undocumented attribute, this new attribute was noted, and the expert was asked to describe it in more detail. Both experts independently mentioned further MR-specific relevant attributes that were not yet included in the list. In total, 17 additional attributes (5 attributes for e-mobility and 12 for MR) were added, resulting in a total of 45 attributes.

Following these independent assessments, the two experts then joined a discussion with the two researchers to critically re-evaluate the 45 attributes from scientific as well as applied perspectives. This helped us arrive at the condensed final list of attributes to be presented to the survey participants involved in the next methodological phase. Specifically, the aim was to arrive at a list composed of decision-relevant attributes that are fully understandable, relevant, clearly delimited and completely evaluable. A reflection on the individually contributed attributes from the experts should therefore guarantee that every respondent had the same understanding of the presented attributes [60]. Every attribute was scrutinized taking these requirements into consideration; upon that, decisions were made concerning which attributes should be included, merged, or excluded. Attributes that were merged are for instance, "Environmental footprint" and "CO_2 emission" to "Enhances sustainability"; "Topography", "Disposition" and "Infrastructure" to "Applicable in every terrain"; "Lighting conditions" and "Usable at day and night" to "Applicable under all light conditions"; or "Low basic training effort" and "Low post-implementation training effort" to "Low training effort". Some attributes, such as "Recharging infrastructure", were deemed irrelevant, as the MR personnel transports all the necessary equipment to the operation site and back. Therefore, recharging can easily be performed at the base-station of the MR unit. Furthermore, the establishment of recharging stations in high alpine environments seems impractical. Through the joint re-evaluation, the initial 45 attributes were reduced to a total and final list of 22 attributes (see Table 1) that formed the basis for the BWS in the next research stage. The involved researchers acted as moderators and documented relevant statements accordingly.

Table 1. Relevant attributes as identified in scientific literature and expert discussion sessions.

Category	Attribute	Description	Source
E-mobility	High range	A high distance range that can be covered with the e-vehicle; subject to technologic, communication or legal limitations.	[20,61–64]
	High payload	A high amount of payload that can be transported or towed as well as seating capacity and trunk space.	[65,66]
	Long battery life	High battery capacity and long runtime with one charging.	[63]
	Low purchase costs	Costs associated with purchasing e-mobility transport solution are low.	[20,65–68]
	Enhances sustainability	The applied e-mobility transport solution enhances sustainability related aspects. Especially concerning the CO_2 emissions and raw material sourcing.	[62,64,66], [67,69–73]
	Low noise generation	Noise emission generated during the usage of the e-mobility transport solution is low.	[63,64]
	Conforms to legal requirements	Legal frameworks and (developing) requirements for the application of e-mobility transport technology are conformed.	Expert discussion; [45]
Mountain rescue service	Light weight	Weight of e-mobility transport solution.	[45–48]
	Low training effort	Amount of training effort associated with acquiring skills to handle new e-mobility transport solutions.	Expert discussion; [20,63]
	Ready-to-use	E-mobility transport solution can be used spontaneously. There is no need for expansive planning before usage during actual response missions (e.g., due to charging or assembly).	Expert discussion; [20,47,62]
	Meets quality certification	E-mobility transport solution meets quality certification requirements (e.g., CE or ISO).	Expert discussion
	High application variety	E-mobility transport solution can be used for multiple application purposes.	Expert discussion
	Easy to transport	Transportability of e-mobility transport solution.	[45,47]
	Long usability	The duration the e-mobility transport solution can remain in use in the mountain rescue service (i.e., product-life-cycle).	Expert discussion
	Easier access to remote locations	E-mobility transport solution facilitates the access to remote locations.	[74]
	Applicable in every terrain	E-mobility transport solution can be used in challenging terrain.	Expert discussion; [66]
	Applicable under all weather conditions	Technological reliability of the e-mobility transport solution in challenging weather conditions.	[46,66]
	Applicable under all light conditions	E-mobility transport solution is applicable under all light conditions.	Expert discussion; [75]
	Supports safety of MR personnel	Safety impacts for mountain rescue personnel concerning operational activities as well as technological aspects.	Expert discussion; [63,64]
	Provides speed advantage	Acceleration and speed of e-mobility transport solution.	[61]
	Supports mission documentation	The e-mobility transport solution enables enhanced documentation efforts during mountain rescue missions.	Expert discussion; [76]
	Compatible with other equipment	E-mobility transport solution is compatible with already existing equipment.	Expert discussion

3.4. Best–Worst Scaling Survey

To facilitate a discussion of the above-listed evaluation attributes and answer *RQ2*, a survey following the BWS approach was conducted. BWS is applied in a wide range of different research areas, including marketing [77], health care [78] and international business research [79]. However, in the context of transportation and logistics, BWS can be regarded as a fairly new research approach [80]. Ref [60], for example, used it to analyze attributes that customers prefer from a third-party logistics provider, while [81] applied BWS to measure the relative importance of the six initially equally weighted logistics performance indicators introduced by the World Bank in 2007. Based on the BWS results, significant differences in attribute importance were found.

BWS is underpinned by the random utility theory, which assumes that an individual's relative preference for object A over object B is a function of the relative frequency with which A is chosen as better than or preferred to B [82]. This methodology involves a cognitive process by which respondents repeatedly choose, from varying sets of attribute combinations, the attributes that they believe exhibit the largest perceptual difference in an underlying continuum of interest [83]. This is performed by observing the best and worst choices in a set of multiple options by repetitively combining the two choices. In a simple example of three choices "A", "B" and "C", "A" can be considered the best and "C" the worst. This ranking implies that "A" should be chosen for the pairs "AB" and "AC", and "B" should be chosen for the third pair "BC". Thus, the best and worst choices provide information that can be expanded to several pairs of choices [77]. This approach is called the case 1 BWS [84] and has previously been applied in the e-mobility domain in a study conducted by [85], wherein BWS was used to assess the importance of complementary mobility services to consumer behavior. Although contextually different, the study served as methodological guidance for the BWS analysis as presented in this article. Additionally, we followed the BWS steps as proposed by [86]. Accordingly, the first step comprised the setting of the study context followed by the identification of attributes. Then, the experimental design was formulated, and a survey was created and conducted. Ultimately, the acquired data were analyzed.

To answer *RQ2*, an online questionnaire comprising the 22 identified attributes, which is a reasonable number of attributes for a BWS according to [77], was developed using the software Sawtooth. The design of the German language questionnaire included 14 sets, each displaying six attributes in varying combinations. We showed each attribute 4 times per respondent ($n = 4$) in order to ensure that every attribute is visible to the respondent with the same frequency. The number of sets was calculated following Equation (1), where K is the total number of attributes ($K = 22$) in the survey and k is the number of items ($k = 6$) per set [87].

$$Number\ of\ sets = n \times \frac{K}{k} \tag{1}$$

The selection of attributes for each set is not conducted manually, instead the design algorithm of the software follows predefined guidelines, which assure that all of the attributes appear in combinations that serve as reliable representations of all possible combinations [87]. We distributed the survey to the personnel in the MR service of Tyrol (Austria), Carinthia (Austria) and South Tyrol (the northernmost Italian–German speaking province of Italy). The Tyrolian MR service is divided into 91 subdivisions with independent administration, the Carinthian MR service into 19 subdivisions and the MR service of South Tyrol into 35 subdivisions. The BWS survey (for an example, see Figure 2) was sent to each head of operations. In addition to answering the survey themselves, the heads of operations were asked to function as contact persons and pass on the survey to their respective group of mountain rescuers. After an interval of 14 days, the data acquisition was concluded following a predefined closing date; in summary, 341 completed questionnaires were collected. The group of respondents was composed of 319 (93.5%) male and 22 (6.5%) female MR personnel. They were, on average, 42.6 years old (Standard deviation (StdDev) = 13.4; min = 18, max = 79) and have been working in MR for 16.8 years on average (StdDev = 14.1; min ≤ 1; max = 60). Regarding their position within the MR service, 45 (13.2%) were in training and education, 181 (53.1%) were general operational staff without leading positions and 115 (33.7%) were in leading operational positions. Here, a person in a leading position takes over coordinative activities and the communication with representatives of other rescue organizations in large-scale operations (i.e., head of operations, officer-in-charge). Furthermore, they perform administrative tasks, which involve organizing training, negotiating annual budgets, processing internal settlements, and communicating with externals (such as local authorities). Non-leading personnel are not directly involved in such processes but have a consulting role in the decision making of leading personnel. Furthermore, non-leading personnel constitute the main body of active members that execute the operations on the ground. To ensure representativeness of the sample, we gathered data on the average age of the rescuers' population in the three regions, which closely matched the age structure represented in the sample.

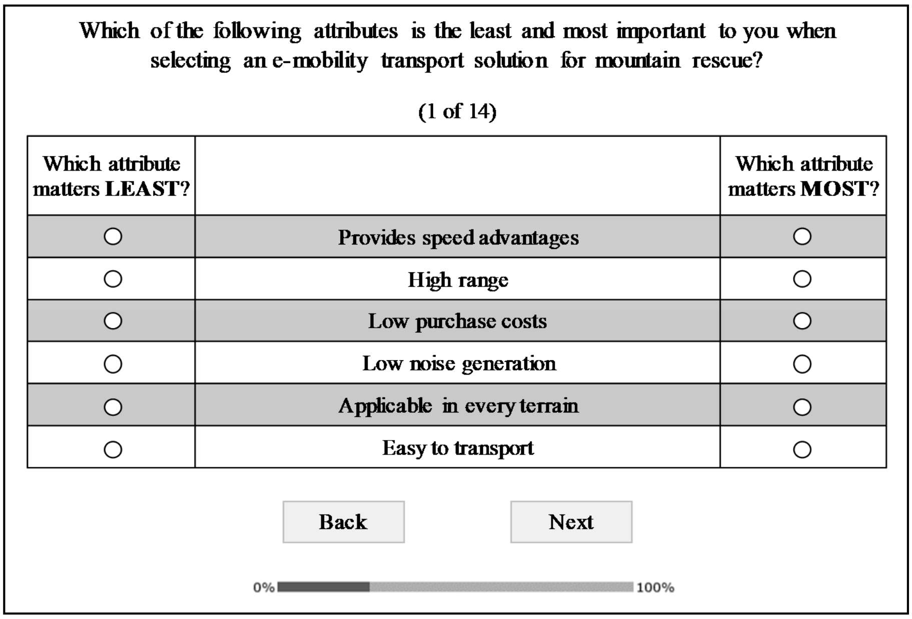

Figure 2. Example of the best–worst combination.

4. Results and Discussion

For the purpose of preliminary analysis, ref [84] recommend calculating the so-called best–worst scores to gain an initial understanding of the survey results. Therefore, for each option, the number of times it was chosen as best in the study minus the number of times it was chosen as worst are divided by the total number of options that appeared (Equation (2)).

$$Best - Worst\ Scores = \frac{Times(Best) - Times(Worst)}{Number\ of\ option\ appears} \tag{2}$$

According to [83], one of the main advantages of BWS, as compared to other common rating-based evaluation methods, is that it also accounts for information about negative evaluations. Hence, a positive best–worst score means that an attribute was evaluated as the most important attribute more often than it was as the least important, while the inverse leads to a negative best–worst score. The best–worst scores were calculated for the leading and non-leading rescue workers (rescue workers in training and general operational staff) separately in order to gain an initial idea about potential differences in attribute selections. A graphical representation of the survey results featuring the best–worst scores can be found in Figure 3.

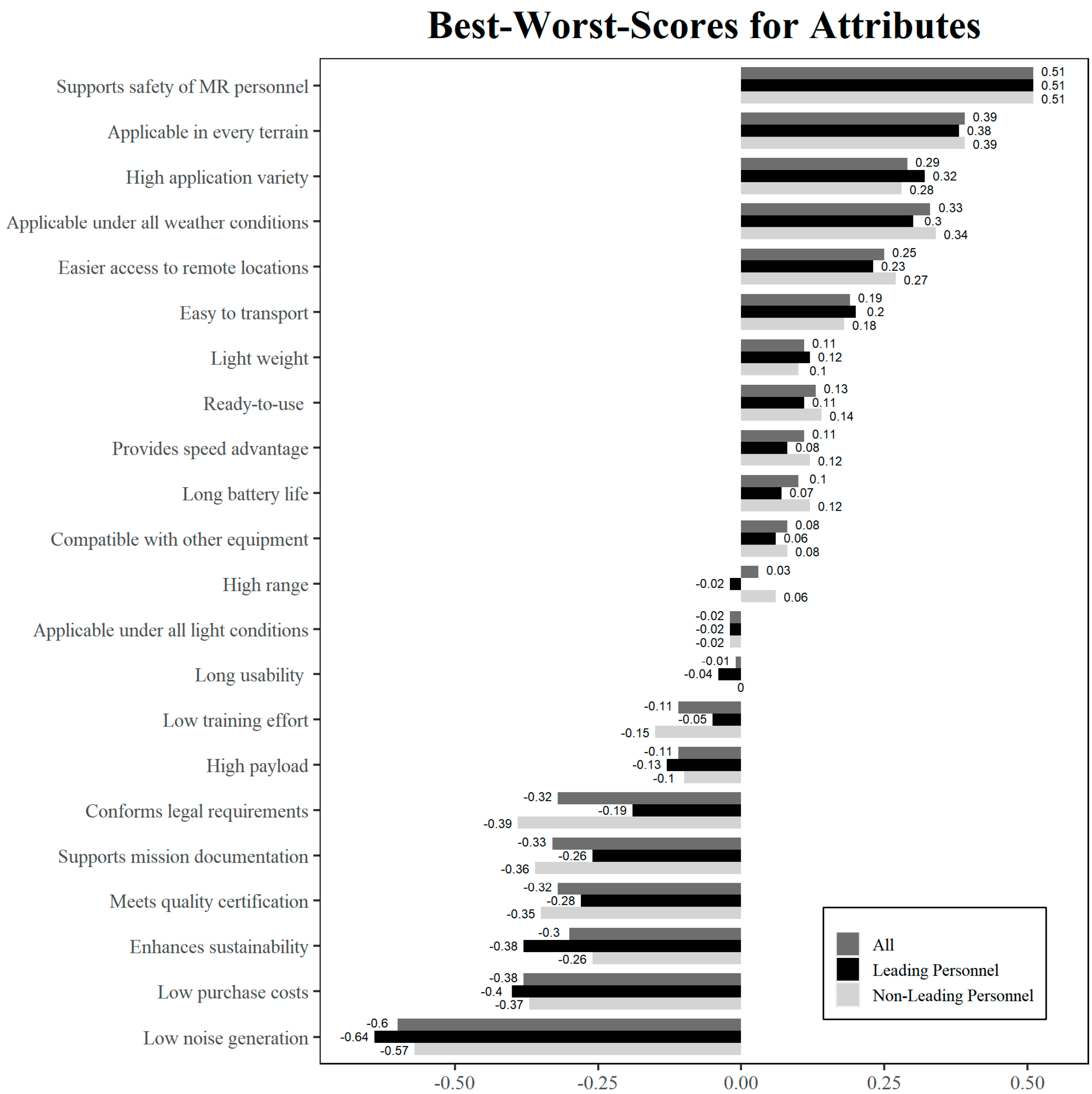

Figure 3. Graphical representation of the best–worst scores.

Several interesting implications can be derived from the calculation of the best–worst scores, we start by analyzing the results of the entire sample ("All"). First, the safety of the MR personnel is by far the most important attribute when assessing e-mobility transport solutions (best–worst score = 0.512). This means that the attribute "Supports safety of MR personnel" was chosen as most important in three out of four relevant attribute combinations. This seems intuitive, but previous studies have not paid too much attention to this aspect to date. Hence, the identification of the requirement for an e-mobility transport solution to actually support the safety of the MR personnel can be regarded as a major finding of this study. The next main implication is that the MR personnel regard it as highly important that the e-mobility transport solution is applicable under different conditions, because "Applicable in every terrain" (best–worst score = 0.387), "Applicable under all weather conditions" (best–worst score = 0.327) and "High application variety" (best–worst score = 0.294) were the next most important attributes. This desire might be grounded in the circumstances that MR operations often take place in harsh conditions, and that predictions about the terrain, the weather conditions or the actual intended use of the technology are hard to make in advance. The two attributes "Easy to transport" (best–worst score = 0.187) and "Light weight" (best–worst score = 0.108) are highly correlated (Correlation (corr) = 0.87 at $p < 0.001$), and they are both well-established factors in the realm of equipment assessment for (mountain) rescue services. Attributes related to technical specifications of e-mobility transport solutions are, according to the results, less important when compared to the operational attributes described above. Here, the attributes "Long battery life" (best–worst score = 0.102), "Compatible with other equipment" (best–worst score = 0.077) and "High range" (best–worst score = 0.033) are of lower relative importance when it comes to the selection process of adequate e-mobility solutions. On the other end of the table of best–worst scores, it is interesting to find that "Low purchase costs" (best–worst score = −0.380) is the second least important attribute. This contradicts the common picture of MR services (and other voluntary organizations) facing limited financial resources that might impede costly investments. Considering this, the results point towards the conclusion that attributes relevant to rescue operations are far more important than possible economic considerations. The same holds true for sustainability aspects that are somehow related to the core benefits of e-mobility. Both "Low noise generation" (best–worst score = −0.596) and "Enhances sustainability" (best–worst score = −0.302) also rank at the bottom of the list of attribute importance. This finding indicates that the ecological advancements of e-mobility (e.g., lower CO_2 emissions), which, according to [80], actually represent one of the main sales arguments for commercial applications, are not critical drivers for selection in the context of MR. Surprisingly, this points out that the actual project intention to also meet ecological dimensions when implementing e-mobility transport solutions is less important than initially expected. Concerning the differences between leading and non-leading MR personnel, it is surprising to observe in Figure 3 that results are rather homogeneous. To better assess potential variations among the groups concerning significance, the subsequent analyses provide more detailed insights.

In consequence, survey results were used to identify attribute weights [50,85]. For this task, the hierarchical Bayes (HB) approach was applied as supported by the Sawtooth software package, which was used to create and conduct the survey at hand. During the application of Bayes' rule, posterior probabilities are produced by updating prior probabilities with likelihoods obtained from the data [88]. This means that, instead of estimating each respondent's utilities individually, the algorithm estimates how different each respondent's utilities are from those of the other respondents in the study. It estimates the average utilities for the entire sample and then uses the respondent's individual data to determine how each respondent differs from the sample average. The algorithm then adjusts each respondent's utilities so that they reflect the optimal mix of the individual respondent choices and sample averages [89]. This procedure is conducted in a hierarchical manner with two levels: on the higher level, the individual's parameters are described by a multivariate normal distribution, and on the lower level, the individual's parameters are governed by a particular model, such as multinomial logit or linear regression [90]. The HB approach has to be run over multiple iterations, as every time the individual utilities are updated, the sample average needs to be updated as well until the model converges at the final values [89]. Table 2 shows the results of the HB analysis for the entire sample as well as separately for leading and non-leading personnel, comprising 30,000 iterations applied to the collected survey data. Table 2 further indicates whether differences between the leading and non-leading MR members regarding attribute weights are statistically significant, reporting *t*- and *p*-values for mean comparisons. *t*-tests were conducted by applying boot strapping with bias-corrected accelerated confidence intervals.

Results indicate that most attribute weights did not differ significantly between leading and non-leading personnel. The only two significant differences were found for "High range" ($t(256.64) = 2.74$; $p = 0.01$) and "Conforms to legal requirements" ($t(187.38) = -2.48$; $p = 0.02$). For the attribute "High range", non-leading personnel yielded a higher average attribute weight ($M = 3.91$, $SE = 0.16$) than leading personnel ($M = 3.20$, $SE = 0.20$). The opposite was true for "Conforms to legal requirements", where, on average, attribute weights were higher for leading personnel ($M = 1.17$, $SE = 0.17$) than for non-leading personnel ($M = 0.69$, $SE = 0.09$). Furthermore, in the HB analysis, the attribute importance rankings did not change considerably compared to the best–worst score ranking. The computed attribute weights, however, were found to yield great benefits when intending to work with these results in potential future practical or scientific undertakings. They can be used for the actual assessment of e-mobility transport solutions for MR practitioners, serve as input variables for related simulation studies or even offer guidance for similar studies in related fields.

Table 2. Comparison of average attribute weights as derived from hierarchical Bayes (HB) analysis of the online best–worst scaling (BWS) survey between leading and non-leading mountain rescue (MR)-members including *t*-statistic and *p*-value.

	Attribute Weights				Mean Difference	
Attributes	**All**	**Columns Graph**	**Leading**	**Non–Leading**	t	p
Supports safety of MR personnel	11.51		11.54	11.49	−0.12	0.91
Applicable in every terrain	10.6		10.6	10.6	0	1
Applicable under all weather conditions	9.33		8.91	9.54	1.78	0.08
High application variety	8.62		8.91	8.47	−1.1	0.29
Easier access to remote locations	8.08		7.94	8.16	0.53	0.58
Easy to transport	6.67		6.92	6.54	−0.97	0.34
Ready-to-use	5.67		5.53	5.75	0.68	0.48
Provides speed advantage	5.59		5.28	5.75	0.95	0.36
Light weight	5.17		5.34	5.08	−0.62	0.52
Long battery life	4.97		4.52	5.19	2	0.05
Compatible with other equipment	4.8		4.9	4.75	−0.36	0.72
High range *	3.67		3.2	3.91	**2.74**	**0.01**
Applicable under all light conditions	3.08		2.98	3.13	0.48	0.66
Low training effort	3.01		3.6	2.71	−1.83	0.06
Long usability	2.97		2.85	3.04	0.72	0.47
High payload	1.41		1.33	1.44	1.15	0.28
Meets quality certification	1.29		1.62	1.12	−1.54	0.11
Enhances sustainability	1.13		1.03	1.17	0.64	0.55
Supports mission documentation	0.95		1.16	0.84	−1.56	0.12
Conforms to legal requirements *	0.85		1.17	0.69	**−2.48**	**0.02**
Low purchase costs	0.51		0.55	0.49	−0.66	0.54
Low noise generation	0.14		0.13	0.14	0.51	0.62
Total	**100**		**100**	**100**		

* Attributes differ significantly at $p < 0.05$.

To further deepen our understanding of the achieved results, correlations between the attributes were analyzed using the programming language "R". In Figure 4, a correlation matrix of the six most important attributes according to the BWS analysis and three attributes concerning participant characteristics can be found. The circle size stands for the magnitude of the correlation, and the hue indicates if it is positive or negative.

In Figure 4, we included the attribute "Gender", and a negative correlation (corr = −0.25 at $p < 0.001$) between this attribute and the position within the MR service exists. This means that women are more likely to be in a lower ranking position within the MR service than men. Taking a closer look at this, however, reveals that women only have a "Service Time" of 5.2 years on average, while their male counterparts have been in MR for 17.3 years on average. In this context, it has to be pointed out that, in the sample, there were only 22 female respondents, and 13 of them were relatively new to MR (service time ≤ 3 years). Additionally, of interest is the position of the "Supports safety of MR personnel" attribute. The applicability of the e-mobility transport solution in every terrain correlates (corr = 0.39 at $p < 0.001$) with the perceived safety support. Additionally, "Easier access to remote locations" (corr = 0.24 at $p < 0.001$) features a similar relationship. Another interesting finding from analyzing attribute correlations is that "Position" and "Conforms to legal requirements" (corr = 0.28 at $p < 0.001$) are positively correlated. This means that personnel in leading positions assign more value to this attribute than the operational staff or the personnel in training.

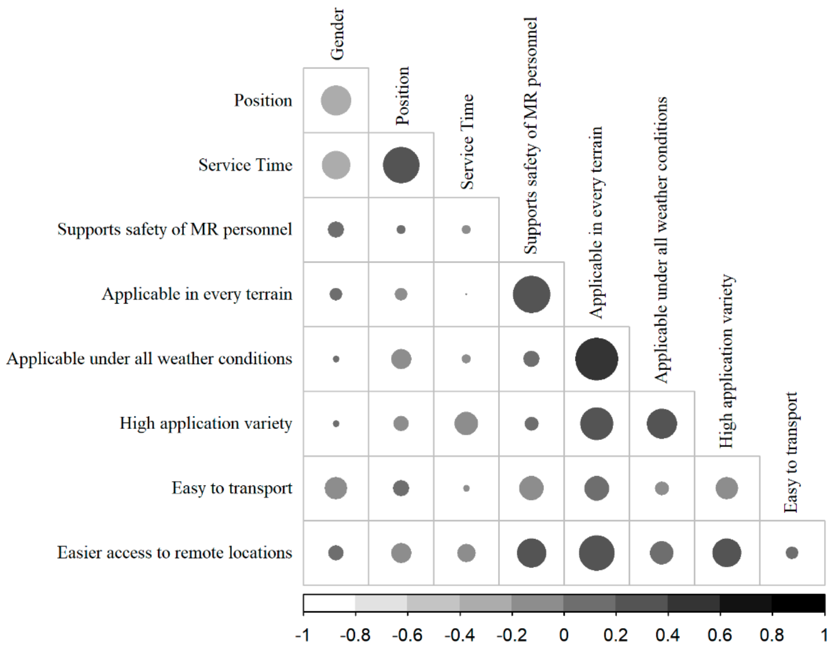

Figure 4. Correlation matrix of most important attributes and participant characteristics.

Expert Discussion

The final methodological step comprised a second expert discussion with experts familiar with the topic under study to collect feedback on the results of the BWS and to assess the validity of the overall findings [91]. Special attention was dedicated to gathering insights on the appropriateness and applicability of the findings from the practitioners' points of view. During practical tests for drone technology at the end of July 2020 at Brenner Pass (Austria), the research team arranged for a group of five high-ranking functionaries from the MR services of South Tyrol and Tyrol. It comprised the head and deputy head of the MR service of South Tyrol, two heads of MR bases and the chief financial officer of the MR service of Tyrol. All of them have long-term experience in the MR domain and have been substantially involved in the development of the respective MR services including technological advancements and purchasing decisions. They are still involved in response missions on the ground. The involved researchers acted as moderators and documented the relevant statements. The expert discussion opened with the researchers giving a comprehensive overview of the BWS and the HB results. Then, the experts were asked for their opinion on the fact that the attribute "Low purchase costs" was ranked as the second least important. According to the experts' statements, costs are less of an issue in the equipment selection. This was underlined by one expert mentioning, "*. . . if the technology supports safety, is applicable in every terrain and under all weather conditions, offers a high application range and enables easier access to remote locations, then costs are completely irrelevant*". This indicates that the findings of the BWS exactly reflect the real situation and can therefore adequately explain this observation. Furthermore, the experts are highly aware that equipment in the context of MR is not mass produced, preventing potential lower purchase costs. Additionally, MR services receive ample annual budgets, which allow them to make equipment decisions relatively independently from monetary dimensions. As this is, to a certain degree, in contrast to other humanitarian organizations that often face resource constraints, a reflection of potential contextual factors revealed two possible reasons. First, the study regions in Italy and Austria are economically dependent on mountaineers and a safe alpine environment. This is of high relevance for the responsible authorities, which therefore commonly provide sufficient financial support. Second, due to the perceived importance of MR services in the focal regions, voluntary financial support is common. In the region of Tyrol alone, more than 25,000 private individuals donate to the local MR service on an annual basis, which might stem from a living culture surrounding alpine life and mountaineering. As a reference, the regarded e-mobility solutions range in price from EUR 400–3000 for standard portable drones and EUR 15,000–60,000 for high-quality and high-performance drones with specialized equipment such as night vision or thermal cameras. The considered e-bikes, which were specifically designed for MR operations, have a starting price of EUR 6000. The e-stretcher is more expensive than a standard wheel-bearing stretcher but when considering rescue costs, it yields the potential to even decrease costs overall.

The discussion was then continued with a reflection on why "Provides speed advantage" is not among the most important attributes. Two experts pointed out that, aside from speed gains provided by a new technology, the safety and applicability of the technology still have top priority in response missions. The general perception is that safety and high applicability to different circumstances will always outweigh speed advantages. This shared culture may also explain the relative unimportance of the attribute "Enhances sustainability" compared with other attributes. In this regard, one of the experts stated that "*sustainability can only be considered, when there is no negative impact on the performance of the entire rescue mission*". Another expert concurred and added that *"emergency organizations' main objective should not be put on sustainability, but on efficiently designing response operations"*. Next, the experts' attention was steered to the differences between leading and non-leading personnel in the evaluation of the attributes "Conforms legal requirements" and "High range". Concerning the legal requirements, the experts were in complete agreement that the difference basically stems from the lower level of involvement and responsibility of the operational staff in associated administrative and organizational activities, which are generally the subjects for leading personnel. The difference in the attribute weight of "High range" can, according to the expert judgment, be explained by the more intense involvement of non-leading personnel in the actual handling of technologies during response missions.

Afterwards, the experts were asked about the appropriateness of the results. Overall, they confirmed the appropriateness of the results; however, one expert noted that costs do still play a role, especially for investments at the national level. Neglecting costs is, according to his opinion, only reasonable when comparing and selecting among specific technological solutions. Finally, remarks concerning the applicability of the findings in practice and other decision-making problems were collected. While for one expert the results were rather specific in the context of e-mobility transport solutions, others pointed towards their generalizability and adoption to alternative decision-making contexts. As a whole, they saw the list of attributes and corresponding weights as transparent and objective support in their decision making, which was up to now mainly driven by intuition and personal experience.

5. Conclusions and Future Research

In this study, decision making in the selection process of e-mobility transport solutions in MR was analyzed. From the practitioners' points of view, several interesting insights were gained. First, the most decision-relevant attributes for selecting e-mobility transport solutions in MR services were identified. These attributes offer guidance on what MR services should consider when selecting new e-mobility technology. Here, we can say that e-mobility transport solutions need to support the safety of MR personnel and have to be applicable in many different environments. Economic and sustainability concerns are less of an issue in this context. Second, the perceived importance of the identified attributes was identified. This can help in creating evaluation tools or other decision-support tools when facing a selection problem for e-mobility transport solutions. Providers of e-mobility transport solutions may also benefit from the results as we support them in addressing the specific needs of the MR services. We make them aware of the fact that MR services devote a lot of attention to the flexible use of technologies and to a lesser extent to ecological attributes.

From an academic point of view, a major contribution of this study is that it provides the first analysis of e-mobility for humanitarian and emergency purposes. Our findings enrich the scientific literature concerning e-mobility selection and lay out an insightful starting point for intensified research in the field of humanitarian research. In this regard, we provide a comprehensive list of decision-relevant attributes that equally incorporates aspects of e-mobility and MR services. The BWS analysis enabled us to identify attribute weights, which can be used by humanitarian researchers to assess other technological or equipment-related decision problems in the context of the (mountain) rescue domain. Furthermore, the separate analyses of the leading and non-leading MR personnel provided insights into the differences in decision making within voluntary organizations, which is another clear academic contribution of this study.

Limitations of this study include the fact that the analyzed sample is culturally rather homogenous and limited to one geographic region. Repeating such technological assessments with other (humanitarian) organizations in a different cultural or geographical setting might provide further valuable insights. Furthermore, the circumstance that the focal MR organizations do not face stringent budgetary constraints might be a limiting factor concerning the generalizability of the achieved results. Additionally, the vast majority of the participants of this study were male, and potential variations in the gender distribution in MR services may lead to different results when it comes to the valuation of assessment attributes. Future work should address this matter by collecting more gender-balanced samples. Furthermore, the shared values among members in MR services might be slightly different compared to other emergency organizations, potentially impacting the set of attributes for selecting e-mobility transport solutions. This could be the subject of future research where results from similar application studies stemming from other fields, such as first aid, firefighting, naval rescue, etc., would increase the reach of the derived implications. Additional research topics may also comprise the analysis of the actual effects of e-mobility transport solutions on the performance of MR services during field applications and rescue missions once the new technologies are in use. Further developments in battery capacity and battery weight are needed in order to increase the attractiveness of e-mobility for MR services. Battery weight plays a crucial role because mountain rescuers have to carry all necessary equipment on their own. Using light-weight batteries for e-mobility transport solutions can minimize total equipment weight and extend the operational performance of MR personnel.

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Appendix A

Table A1. Search string used for initial attribute selection.

Search Criteria	Inclusion Criteria
TI = ("E*mob*" OR "electric vehicle*" OR "electric mob*")	Articles clearly focusing on e-mobility.
AND TI = ("selection" OR "adoption" OR "best*worst" OR "maximum difference" OR "rescue" OR "humanitarian" OR "first response" OR "first aid" OR "emergency" OR "mountain" OR "alpine")	Articles that focus on either technology selection, the BWS research methodology, rescue operations, or the technology application in alpine areas.
AND LANGUAGE = English AND DOCUMENT TYPES = Article	Only scientific articles published in English.
INDEXES = ("SCI-EXPANDED" OR "SSCI" OR "A&HCI" OR "ESCI")	Articles must be published in journals listed in an established index.
TIMESPAN = All years	No restriction on the year of publication.

Supporting data will be made available upon request by the authors.

References

1. Harrison, G.; Gómez Vilchez, J.J.; Thiel, C. Industry strategies for the promotion of E-mobility under alternative policy and economic scenarios. *Eur. Transp. Res. Rev.* **2018**, *10*, 438. [CrossRef]
2. Lo Schiavo, L.; Delfanti, M.; Fumagalli, E.; Olivieri, V. Changing the regulation for regulating the change: Innovation-driven regulatory developments for smart grids, smart metering and e-mobility in Italy. *Energy Policy* **2013**, *57*, 506–517. [CrossRef]
3. Egnér, F.; Trosvik, L. Electric vehicle adoption in Sweden and the impact of local policy instruments. *Energy Policy* **2018**, *121*, 584–596. [CrossRef]
4. Klumpp, M. Electric mobility in last mile distribution. In *Efficiency and Innovation in Logistics*; Springer: Berlin/Heidelberg, Germany, 2014; pp. 3–13.
5. Adderly, S.A.; Manukian, D.; Sullivan, T.D.; Son, M. Electric vehicles and natural disaster policy implications. *Energy Policy* **2018**, *112*, 437–448. [CrossRef]
6. Austrian Red Cross. Wiener Rotes Kreuz: Auf die Segways–fertig–los! Start für Rasche Hilfe auf Zwei Rädern. Available online: https://www.roteskreuz.at/news/datum/2011/08/17/wiener-rotes-kreuz-auf-die-segways-fertig/ (accessed on 14 May 2020).
7. Ustun, T.S.; Cali, U.; Kisacikoglu, M.C. Energizing microgrids with electric vehicles during emergencies—Natural disasters, sabotage and warfare. In Proceedings of the IEEE International Telecommunications Conference (INTELEC), Osaka, Japan, 18–22 October 2015; pp. 1–6. [CrossRef]
8. Foti, F.; Milani, M. Earthquake in Amatrice (Italy), 24 August 2016: The Role of the Medical Teams of the National Alpine Rescue Corp (CNSAS). *Prehosp. Dis. Med.* **2017**, *32*, S112–S113. [CrossRef]
9. Podsiadło, P.; Darocha, T.; Kosiński, S.; Sałapa, K.; Ziętkiewicz, M.; Sanak, T.; Turner, R.; Brugger, H. Severe Hypothermia Management in Mountain Rescue: A Survey Study. *High Alt. Med. Biol.* **2017**, *18*, 411–416. [CrossRef]
10. Li, Y.-y.; Dong, X. Mountain Disaster Incidents and Corresponding Emergency Rescue Measures. *Proc. Eng.* **2014**, *71*, 207–213. [CrossRef]
11. Shimansky, C. *Accidents in Mountain Rescue Operations*; Mountain Rescue Association: Evergreen, CO, USA, 2008.
12. Apollo, M. The true accessibility of mountaineering: The case of the High Himalaya. *J. Outdoor Recreat. Tour.* **2017**, *17*, 29–43. [CrossRef]
13. UNWTO. *Sustainable Mountain Tourism—Opportunities for Local Communities*; World Tourism Organization (UNWTO): Madrid, Spain, 2018; ISBN 9789284420261.
14. Soulé, B.; Lefèvre, B.; Boutroy, E. The dangerousness of mountain recreation: A quantitative overview of fatal and non-fatal accidents in France. *Eur. J. Sport Sci.* **2017**, *17*, 931–939. [CrossRef]
15. Yarwood, R. Risk, rescue and emergency services: The changing spatialities of Mountain Rescue Teams in England and Wales. *Geoforum* **2010**, *41*, 257–270. [CrossRef]
16. Wankmüller, C.; Truden, C.; Korzen, C.; Hungerländer, P.; Kolesnik, E.; Reiner, G. *Optimal Allocation of Defibrillator Drones in Mountainous Regions*; OR Spectrum: Basel, Switzerland, 2020; pp. 1–30.
17. Tatham, P.; Ball, C.; Wu, Y.; Diplas, P. Long-endurance remotely piloted aircraft systems (LE-RPAS) support for humanitarian logistic operations. *J. Hum. Logist. Sup Chain Manag.* **2017**, *7*, 2–25. [CrossRef]
18. Greischberger Rescue System. Retten mit System. Available online: http://www.grs-rescue.at/wp/wp-content/uploads/2019/05/GRS_Prospekt.pdf (accessed on 10 February 2020).
19. Santos, A.L.R.; Wauben, L.S.G.L.; Goossens, R.; Brezet, H. Systemic barriers and enablers in humanitarian technology transfer. *J. Hum. Logist. Supply Chain Manag.* **2016**, *6*, 46–71. [CrossRef]
20. Coffman, M.; Bernstein, P.; Wee, S. Electric vehicles revisited: A review of factors that affect adoption. *Transp. Rev.* **2017**, *37*, 79–93. [CrossRef]
21. Su, Y.-S.; Lin, C.-J.; Li, C.-Y. An assessment of innovation policy in Taiwan's electric vehicle industry. *Int. J. Technol. Manag.* **2016**, *72*, 210–229. [CrossRef]
22. Yu, J.; Yang, P.; Zhang, K.; Wang, F.; Miao, L. Evaluating the effect of policies and the development of charging infrastructure on electric vehicle diffusion in China. *Sustainability* **2018**, *10*, 3394. [CrossRef]
23. Aasness, M.A.; Odeck, J. The increase of electric vehicle usage in Norway—Incentives and adverse effects. *Eur. Transp. Res. Rev.* **2015**, *7*, 2018. [CrossRef]

24. Silvia, C.; Krause, R.M. Assessing the impact of policy interventions on the adoption of plug-in electric vehicles: An agent-based model. *Energy Policy* **2016**, *96*, 105–118. [CrossRef]
25. Mirhedayatian, S.M.; Yan, S. A framework to evaluate policy options for supporting electric vehicles in urban freight transport. *Transp. Res. Part D Transp. Environ.* **2018**, *58*, 22–38. [CrossRef]
26. Faria, R.; Moura, P.; Delgado, J.; de Almeida, A.T. A sustainability assessment of electric vehicles as a personal mobility system. *Energy Convers. Manag.* **2012**, *61*, 19–30. [CrossRef]
27. Lave, L.B.; MacLean, H.L. An environmental-economic evaluation of hybrid electric vehicles: Toyota's Prius vs. its conventional internal combustion engine Corolla. *Transp. Res. Part D Transp. Environ.* **2002**, *7*, 155–162. [CrossRef]
28. Jochem, P.; Babrowski, S.; Fichtner, W. Assessing CO_2 emissions of electric vehicles in Germany in 2030. *Transp. Res. Part A Policy Pract.* **2015**, *78*, 68–83. [CrossRef]
29. Prud'homme, R.; Koning, M. Electric vehicles: A tentative economic and environmental evaluation. *Transp. Policy* **2012**, *23*, 60–69. [CrossRef]
30. Lemme, R.F.F.; Arruda, E.F.; Bahiense, L. Optimization model to assess electric vehicles as an alternative for fleet composition in station-based car sharing systems. *Transp. Res. Part D Transp. Environ.* **2019**, *67*, 173–196. [CrossRef]
31. Hawkins, T.R.; Singh, B.; Majeau-Bettez, G.; Strømman, A.H. Comparative environmental life cycle assessment of conventional and electric vehicles. *J. Ind. Ecol.* **2013**, *17*, 53–64. [CrossRef]
32. Noshadravan, A.; Cheah, L.; Roth, R.; Freire, F.; Dias, L.; Gregory, J. Stochastic comparative assessment of life-cycle greenhouse gas emissions from conventional and electric vehicles. *Int. J. Life Cycle Assess.* **2015**, *20*, 854–864. [CrossRef]
33. Ahmadi, P.; Cai, X.M.; Khanna, M. Multicriterion optimal electric drive vehicle selection based on lifecycle emission and lifecycle cost. *Int. J. Energy Res.* **2018**, *42*, 1496–1510. [CrossRef]
34. Das, M.C.; Pandey, A.; Mahato, A.K.; Singh, R.K. Comparative performance of electric vehicles using evaluation of mixed data. *OPSEARCH* **2019**, *56*, 1067–1090. [CrossRef]
35. Adepetu, A.; Keshav, S. The relative importance of price and driving range on electric vehicle adoption: Los Angeles case study. *Transportation* **2017**, *44*, 353–373. [CrossRef]
36. Cocron, P.; Bühler, F.; Neumann, I.; Franke, T.; Krems, J.F.; Schwalm, M.; Keinath, A. Methods of evaluating electric vehicles from a user's perspective-the MINI E field trial in Berlin. *IET Intell. Transp. Syst.* **2011**, *5*, 127–133. [CrossRef]
37. Egbue, O.; Long, S.; Samaranayake, V.A. Mass deployment of sustainable transportation: Evaluation of factors that influence electric vehicle adoption. *Clean Technol. Environ. Policy* **2017**, *19*, 1927–1939. [CrossRef]
38. Kwon, Y.; Kim, S.; Kim, H.; Byun, J. What Attributes Do Passengers Value in Electrified Buses? *Energies* **2020**, *13*, 2646. [CrossRef]
39. Alzahrani, K.; Hall-Phillips, A.; Zeng, A.Z. Applying the theory of reasoned action to understanding consumers' intention to adopt hybrid electric vehicles in Saudi Arabia. *Transportation* **2019**, *46*, 199–215. [CrossRef]
40. Schmalfuß, F.; Mühl, K.; Krems, J.F. Direct experience with battery electric vehicles (BEVs) matters when evaluating vehicle attributes, attitude and purchase intention. *Transp. Res. Part F Traffic Psychol. Behav.* **2017**, *46*, 47–69. [CrossRef]
41. Rahmani, D.; Loureiro, M.L. Assessing drivers' preferences for hybrid electric vehicles (HEV) in Spain. *Res. Transp. Econ.* **2019**, *73*, 89–97. [CrossRef]
42. Morton, C.; Anable, J.; Nelson, J.D. Assessing the importance of car meanings and attitudes in consumer evaluations of electric vehicles. *Energy Effic.* **2016**, *9*, 495–509. [CrossRef]
43. Carley, S.; Siddiki, S.; Nicholson-Crotty, S. Evolution of plug-in electric vehicle demand: Assessing consumer perceptions and intent to purchase over time. *Transp. Res. Part D Transp. Environ.* **2019**, *70*, 94–111. [CrossRef]
44. Bühne, J.-A.; Gruschwitz, D.; Hölscher, J.; Klötzke, M.; Kugler, U.; Schimeczek, C. How to promote electromobility for European car drivers? Obstacles to overcome for a broad market penetration. *Eur. Transp. Res. Rev.* **2015**, *7*. [CrossRef]
45. Elsensohn, F.; Soteras, I.; Resiten, O.; Ellerton, J.; Brugger, H.; Paal, P. Equipment of medical backpacks in mountain rescue. *High Alt. Med. Biol.* **2011**, *12*, 343–347. [CrossRef]
46. Grant, S.J.; Dowsett, D.; Hutchison, C.; Newell, J.; Connor, T.; Grant, P.; Watt, M. A Comparison of Mountain Rescue Casualty Bags in a Cold, Windy Environment. *Wilderness Environ. Med.* **2002**, *13*, 36–44. [CrossRef]

47. Hignett, S.; Willmott, J.W.; Clemes, S. Mountain rescue stretchers: Usability trial. *Work* **2009**, *34*, 215–222. [CrossRef]
48. Runcie, H.; Greene, M. Femoral Traction Splints in Mountain Rescue Prehospital Care: To Use or Not to Use? That Is the Question. *Wilderness Environ. Med.* **2015**, *26*, 305–311. [CrossRef] [PubMed]
49. Mountain Rescue Tyrol. START-Smart Test of Alpine Rescue Technology. Available online: https://bergrettung.tirol/php/interreg,1411.html (accessed on 6 March 2019).
50. Louviere, J.J.; Islam, T. A comparison of importance weights and willingness-to-pay measures derived from choice-based conjoint, constant sum scales and best–worst scaling. *J. Bus. Res.* **2008**, *61*, 903–911. [CrossRef]
51. Kovács, G.; Moshtari, M.; Kachali, H.; Polsa, P. Research methods in humanitarian logistics. *JHLSCM* **2019**, *9*, 325–331. [CrossRef]
52. *Research Methods for Operations Management*, 2nd ed.; Karlsson, C., Ed.; Routledge: New York, NY, USA, 2016; ISBN 9781138945425.
53. Sauer, P.C.; Seuring, S. Sustainable supply chain management for minerals. *J. Clean. Prod.* **2017**, *151*, 235–249. [CrossRef]
54. Jahangirian, M.; Eldabi, T.; Naseer, A.; Stergioulas, L.K.; Young, T. Simulation in manufacturing and business: A review. *Eur. J. Oper. Res.* **2010**, *203*, 1–13. [CrossRef]
55. Petticrew, M.; Roberts, H. *Systematic Reviews in the Social Sciences*; A Practical Guide, 12th Print; Blackwell Publishing: Malden, MA, USA, 2012; ISBN 978-1-4051-2110-1.
56. Seuring, S.; Müller, M.; Westhaus, M.; Morana, R. Conducting a Literature Review—The Example of Sustainability in Supply Chains. In *Research Methodologies in Supply Chain Management: With 67 Tables*; Kotzab, H., Seuring, S., Mūller, M., Reiner, G., Eds.; Physica-Verl.: Heidelberg, Germany, 2005; pp. 91–106, ISBN 978-3-7908-1636-5.
57. Kunz, N.; Reiner, G. A meta-analysis of humanitarian logistics research. *J. Hum. Logist. Sup. Chain Manag.* **2012**, *2*, 116–147. [CrossRef]
58. Wankmüller, C.; Reiner, G. Coordination, cooperation and collaboration in relief supply chain management. *J. Bus. Econ.* **2020**, *90*, 239–276. [CrossRef]
59. Cheung, K.L.; Wijnen, B.F.M.; Hollin, I.L.; Janssen, E.M.; Bridges, J.F.; Evers, S.M.A.A.; Hiligsmann, M. Using Best-Worst Scaling to Investigate Preferences in Health Care. *Pharmacoeconomics* **2016**, *34*, 1195–1209. [CrossRef]
60. Coltman, T.R.; Devinney, T.M.; Keating, B.W. Best-worst scaling approach to predict customer choice for 3PL services. *J. Bus. Logist.* **2011**, *32*, 139–152. [CrossRef]
61. Ewing, G.O.; Sarigöllü, E. Car fuel-type choice under travel demand management and economic incentives. *Transp. Res. Part D Transp. Environ.* **1998**, *3*, 429–444. [CrossRef]
62. Haustein, S.; Jensen, A.F. Factors of electric vehicle adoption: A comparison of conventional and electric car users based on an extended theory of planned behavior. *Int. J. Sustain. Transp.* **2018**, *12*, 484–496. [CrossRef]
63. Langbroek, J.H.M.; Cebecauer, M.; Malmsten, J.; Franklin, J.P.; Susilo, Y.O.; Georén, P. Electric vehicle rental and electric vehicle adoption. *Res. Transp. Econ.* **2019**, *73*, 72–82. [CrossRef]
64. Priessner, A.; Sposato, R.; Hampl, N. Predictors of electric vehicle adoption: An analysis of potential electric vehicle drivers in Austria. *Energy Policy* **2018**, *122*, 701–714. [CrossRef]
65. DellaValle, N.; Zubaryeva, A. Can we hope for a collective shift in electric vehicle adoption? Testing salience and norm-based interventions in South Tyrol, Italy. *Energy Res. Soc. Sci.* **2019**, *55*, 46–61. [CrossRef]
66. Dua, R.; White, K.; Lindland, R. Understanding potential for battery electric vehicle adoption using large-scale consumer profile data. *Energy Rep.* **2019**, *5*, 515–524. [CrossRef]
67. Chakraborty, A.; Kumar, R.R.; Bhaskar, K. A game-theoretic approach for electric vehicle adoption and policy decisions under different market structures. *J. Oper. Res. Soc.* **2020**, 1–18. [CrossRef]
68. Kim, S.; Lee, J.; Lee, C. Does Driving Range of Electric Vehicles Influence Electric Vehicle Adoption? *Sustainability* **2017**, *9*, 1783. [CrossRef]
69. Clinton, B.C.; Steinberg, D.C. Providing the Spark: Impact of financial incentives on battery electric vehicle adoption. *J. Environ. Econ. Manag.* **2019**, *98*, 102255. [CrossRef]
70. Jenn, A.; Laberteaux, K.; Clewlow, R. New mobility service users' perceptions on electric vehicle adoption. *Int. J. Sustain. Transp.* **2018**, *12*, 526–540. [CrossRef]
71. Sierzchula, W.; Bakker, S.; Maat, K.; van Wee, B. The influence of financial incentives and other socio-economic factors on electric vehicle adoption. *Energy Policy* **2014**, *68*, 183–194. [CrossRef]

72. Yang, S.; Cheng, P.; Li, J.; Wang, S. Which group should policies target? Effects of incentive policies and product cognitions for electric vehicle adoption among Chinese consumers. *Energy Policy* **2019**, *135*, 111009. [CrossRef]
73. Chatzikomis, C.I.; Spentzas, K.N.; Mamalis, A.G. Environmental and economic effects of widespread introduction of electric vehicles in Greece. *Eur. Transp. Res. Rev.* **2014**, *6*, 365–376. [CrossRef]
74. Deeb, J.G.; Walter, N.; Carrico, C.; Gašperin, M.; Deeb, G.R. Helicopter Mountain Rescue in Slovenia from 2011 to 2015. *Wilderness Environ. Med.* **2018**, *29*, 5–10. [CrossRef] [PubMed]
75. Perusich, K.; Tepper, H.; Marca, J.R.B.D.; Lefevre, R.; Baseil, R. Linking technologists and humanitarians. *IEEE Technol. Soc. Mag.* **2009**, *28*, 25–31. [CrossRef]
76. Pfau, L.; Blanford, J.I. Use of Geospatial Data and Technology for Wilderness Search and Rescue by Nonprofit Organizations. *Prof. Geogr.* **2018**, *70*, 434–442. [CrossRef]
77. Louviere, J.; Lings, I.; Islam, T.; Gudergan, S.; Flynn, T. An introduction to the application of (case 1) best-worst scaling in marketing research. *Int. J. Res. Mark.* **2013**, *30*, 292–303. [CrossRef]
78. Flynn, T.N.; Louviere, J.J.; Peters, T.J.; Coast, J. Best-worst scaling: What it can do for health care research and how to do it. *J. Health Econ.* **2007**, *26*, 171–189. [CrossRef]
79. Buckley, P.J.; Devinney, T.M.; Louviere, J.J. Do managers behave the way theory suggests? A choice-theoretic examination of foreign direct investment location decision-making. *J. Int. Bus. Stud.* **2007**, *38*, 1069–1094. [CrossRef]
80. Beck, M.J.; Rose, J.M.; Greaves, S.P. I can't believe your attitude: A joint estimation of best worst attitudes and electric vehicle choice. *Transportation* **2017**, *44*, 753–772. [CrossRef]
81. Rezaei, J.; van Roekel, W.S.; Tavasszy, L. Measuring the relative importance of the logistics performance index indicators using Best Worst Method. *Transp. Policy* **2018**, *68*, 158–169. [CrossRef]
82. Thurstone, L.L. A law of comparative judgment. *Psychol. Rev.* **1927**, *34*, 273. [CrossRef]
83. Finn, A.; Louviere, J. Determining the Appropriate Response to Evidence of Public Concern: The Case of Food Safety. *J. Public Policy Mark.* **1992**, *11*, 12–25. [CrossRef]
84. Marley, A.A.J.; Flynn, T. Best Worst Scaling: Theory and Practice. *Int. Encycl. Soc. Behav. Sci.* **2015**, *2*, 548–552. [CrossRef]
85. Hinz, O.; Schlereth, C.; Zhou, W. Fostering the adoption of electric vehicles by providing complementary mobility services: A two-step approach using Best–Worst Scaling and Dual Response. *J. Bus. Econ.* **2015**, *85*, 921–951. [CrossRef]
86. Garver, M.S.; Williams, Z.; LeMay, S.A. Measuring the importance of attributes in logistics research. *Int. J. Logist. Manag.* **2010**, *21*, 22–44. [CrossRef]
87. Sawtooth Software, Inc. Sawtooth Software Technical Paper Series: The MaxDiff System Technical Paper. 2020. Available online: https://sawtoothsoftware.com/resources/technical-papers/maxdiff-technical-paper (accessed on 28 July 2020).
88. Johnson, R. *Understanding HB: An Intuitive Approach*; Sawtooth Software, Inc.: Sequim, WA, USA, 2000.
89. Howell, J. *CBC/HB For Beginners*; Sawtooth Software, Inc.: Sequim, WA, USA, 2009.
90. Orme, B. Hierarchical Bayes: Why All the Attention? Sawtooth Software, Inc.: Sequim, WA, USA, 2000.
91. Brink, H.I.L. Validity and reliability in qualitative research. *Curationis* **1993**, *16*, 35–38. [CrossRef]