International Journal of Disaster Risk Reduction 106 (2024) 104384

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr

Proof of principle: An animal field triage protocol for livestock and horses caught in natural disasters and major incidents

Anne M. Dubbink [a,*], Jolianne M. Rijks [b], Derek H. van Dongen [c], Joris J. Wijnker [d]

[a] *Faculty of Veterinary, Medicine, Utrecht University, The Netherlands, Yalelaan 1, 3584, CL, Utrecht, the Netherlands*
[b] *Department of Biomolecular Health Sciences, Dutch Wildlife Health Centre, Faculty of Veterinary Medicine, Utrecht University, The Netherlands, Yalelaan 1, 3584 CL, Utrecht, the Netherlands*
[c] *Mindgame, Amsterdam, The Netherlands, Panamalaan 7a, 1019 AS, Amsterdam, the Netherlands*
[d] *Department of Population Health Sciences, Institute for Risk Assessment Sciences, Faculty of Veterinary, Medicine, Utrecht University, The Netherlands, Yalelaan 1, 3584 CL, Utrecht, the Netherlands*

A R T I C L E I N F O

Keywords:
Animal triage
Veterinary disaster management
Primary triage
Mass casualty incidents
Animal triage training game

A B S T R A C T

Field triage systems are available to address mass casualty incidents involving humans, but lack for animals caught in disasters. This study aimed to develop, as a proof of principle, an animal field triage protocol for livestock, horses and wildlife based on an existing human triage system. A literature review was completed, resulting in choosing the human SALT triage algorithm as a starting point, followed by an expert consultation using a two-round Delphi study to evaluate and create the final version of the triage protocol. Finally, a group of first responders were familiarized with the protocol and triage injured animals in a simulated disaster environment using a purpose-built training game and provide written feedback. For livestock and horses, consensus was reached on the use of global sorting based on the criteria ‘autonomously mobile without obvious major injuries’, and on five of six appropriate physiological criteria applied for individual health state assessment. Triaged animals were placed in one of four categories developed for applicable veterinary care, being beyond saving (black), immediate/urgent (red), delayed (yellow) and minor (green). The expert panel agreed that the veterinary triage model is probably workable for livestock and horses but not for wildlife, and has added value in natural disasters and mass casualty incidents involving animals. Validation of the protocol with first responders on the usability of the triage protocol as a proof of principle warrants a careful introduction for practical use and further evaluation during disasters affecting livestock and horses in the field.

1. Introduction

Disasters, both man-made and natural, are a threat to humans and animals alike. Animals, especially livestock and wildlife, both kept and free ranging, can end up in disaster situations resulting in many victims. A recent example is the flood of June 2021 in the south of the Netherlands and parts of Belgium and Germany [1]. In such situations, the evacuation of large groups of animals, injured or not, is very complex. Because of this complexity, it is important to prepare ahead for a possible course of action with animals during a disaster situation.

Triage is a method used in human medicine to facilitate the decision-making process aimed to prioritize the medical treatment of

* Corresponding author.
E-mail addresses: anne@dubbink.net (A.M. Dubbink), j.m.rijks@uu.nl (J.M. Rijks), derek@mindgame.nl (D.H. van Dongen), j.j.wijnker@uu.nl (J.J. Wijnker).

https://doi.org/10.1016/j.ijdrr.2024.104384
Received 11 June 2023; Received in revised form 6 March 2024; Accepted 6 March 2024
Available online 26 March 2024

victims in a mass casualty situation. Effective triage should result in as many people as possible receive the best care available [2]. Triage was originally developed for use in a military context but is also applied in clinical, emergency room settings or during disasters [3]. Performing animal triage on-site by responding emergency services could be a possible solution to manage and allocate limited resources associated with the immediate veterinary care and evacuation of large groups of animals caught in the disaster.

Research directed towards an appropriate animal field triage system is therefore an important aspect of possible veterinary care during disasters and emergency animal management. Disasters can cause major losses to livestock and therefore have a significant economic impact to its owners and families [4]. Limiting economic losses could be facilitated by snapshot health assessments of apparently healthy animals, allowing for quick evacuation from the area at risk. In addition, prompt intervention and treatment of injured animals during an emergency is a critical component to prevent unwanted excessive animal suffering [5,6] Using a suitable triage protocol, emergency services can act quickly after arriving on-site, even if little or no veterinary expertise is available at that time.

Apart from the economic and welfare aspect, the social aspect related to injured animals is also important to consider. The relationship people have with their animals can greatly influence their behaviour during emergencies [7–9]. If there is no proper procedure to help the animals, people will not evacuate or they may even return after being evacuated to the disaster area to take care of their animals that were left behind [10]. It is therefore of great importance for the safety of people affected by disasters, that animals are also included in emergency aid programmes. According to the World Organisation for Animal Health (WOAH, founded as OIE), having well-prepared guidelines and protocols available is of great importance in being able to respond quickly and efficiently [11]. An available animal field triage protocol could therefore contribute to this disaster preparedness.

Field triage is also known as primary triage. Primary triage is performed at the scene of an incident, disaster, or accident [12]. At the moment, the only triage systems that have been described and evaluated for animals are secondary triage systems of use in veterinary hospitals and clinics. Ruys et al. *2012* [13]. showed that a secondary triage system, based on a human triage system, can help to categorize emergency patients more accurately compared to intuitive triage by veterinary nurses. Ash et al. [14] evaluated the animal trauma triage score (ATT) and a modified Glasgow Coma Scale (GCS) and showed that the ATT provided a good predictive value of trauma severity in animals. Although its usefulness is well described for clinic settings, these known secondary animal triage systems are not as useful in the field, major outdoor incidents or disasters, as these secondary systems require a high degree of professional skill and/or available medical equipment. In addition, these studies focus mainly on the usage of secondary triage in companion animals. Livestock and wildlife on the other hand, are more likely to have remained behind in disaster areas, due to limited access and (logistical) difficulties to evacuate these animals to the nearest veterinary treatment facility. Moreover, these secondary triage methods take too long to triage large groups of animals. The only known reference to field triage on animals was made by Wingfield et al. [15], although no specific guidelines or triage details were provided. It can therefore be concluded that there is no recent peer-reviewed

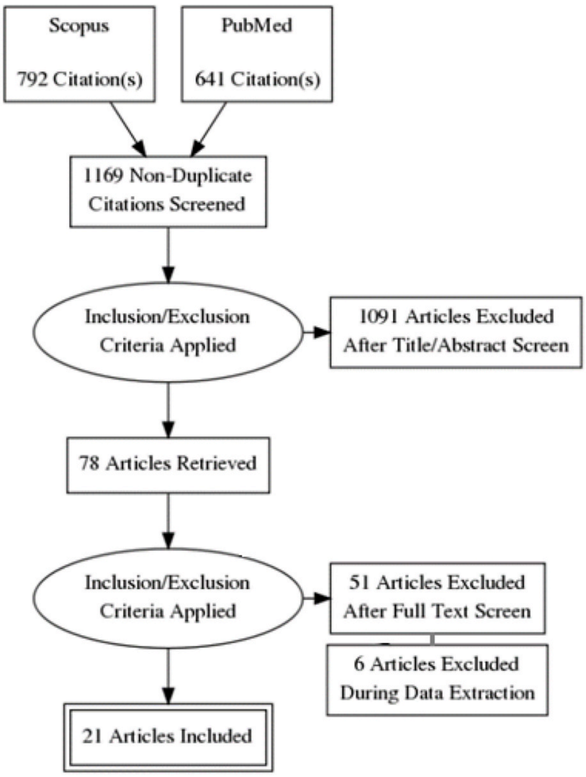

Fig. 1. PRISMA flow diagram of the literature review.

animal field triage (primary triage) protocol currently available for animals caught in disasters or major incidents.

In human medicine, different primary triage methods have been developed over the years and implemented effectively. In addition, the accuracy of several of these human triage methods have been evaluated. One of these human primary triage methods may therefore be a suitable starting point for an animal field triage model. In addition, an already familiar standard operating procedure applied in humans could facilitate implementation of an animal field triage protocol by regular emergency services and first responders. The aim of this study therefore was to develop an animal field triage protocol as a proof of principle, based on a well-used and approved human field triage protocol, that can be applied in the field on livestock (poultry excluded), horses and wildlife during a disaster situation.

2. Methods

2.1. Literature review for protocol selection

A comprehensive literature search was performed as a first phase in developing an animal field triage protocol. Recent studies that covered human field triage systems, especially those focussing on accuracy and used in mass casualty incidents, were reviewed. PubMed and Scopus were searched using the following terms: Triage AND Disaster AND Mass Casualty Incidents. Inclusion criteria were: (1) peer reviewed articles on human triage systems used in the field during mass casualty incidents and/or their accuracy; (2) articles published after 2000; (3) articles available fully in English or Dutch. Articles about pediatric triage systems [16] or triage on children were excluded from the study because these are more elaborate secondary triage systems that may make them less applicable to animals. Additional literature was provided either by the co-authors and experts that participated in this research or retrieved from the reference lists of the articles found with the inclusion criteria discussed earlier. A flow diagram of the literature review following the PRISMA guidelines is provided in Fig. 1.

Based on this literature review, potential human triage methods that could serve as a possible model for an animal field triage protocol were identified. Selection criteria were: (1) used on adults; (2) widely used; (3) approach; (4) accuracy percentages. After comparison of key features and accuracy of these methods, one was selected based on good performance in humans and likelihood of applicability to animals under disaster conditions.

2.2. Protocol development with consultation of experts

The second phase of this study consisted of a consultation with three experts on the physiological variables of the selected human protocol, for prioritization of these factors and advice on the practical application to animals. The three experts were members or employees of the network of the European Wildlife Disease Association, the animal welfare organization Four Paws or the Royal Netherlands Army. The experts selected had experience with at least one non-epidemic disaster, had contributed to disaster management or were expert in a specific field of veterinary medicine. Based on the selected human triage method and the advice of the consulted experts, an initial version of the animal field triage protocol was developed and visualised in a flowchart.

2.3. Delphi study

To further develop and evaluate the validity of the initial version of this protocol, a modified Delphi study was performed (Fig. 2). This study type is considered to be a suitable research method intended to answer specific research questions previously applied to define a mass casualty conceptual model, to create a consensus-based gold standard for the evaluation of mass casualty triage systems and to define major trauma by reaching consensus among a panel of subject matter experts (SMEs) [17–19].(see. Fig. 2)

Similar in size to the expert groups included in two of the afore-mentioned studies, a panel of twenty-four SMEs in the field of animal disaster response, emergency veterinary medicine and/or wildlife medicine were invited, of which twenty-three confirmed to participate (Table 1). The three original experts that were involved in creating the initial version of the animal field triage protocol, were excluded from the SME panel.

A two-round Delphi study was presented to the SMEs, from whom twenty complete responses in the first round and eighteen in the

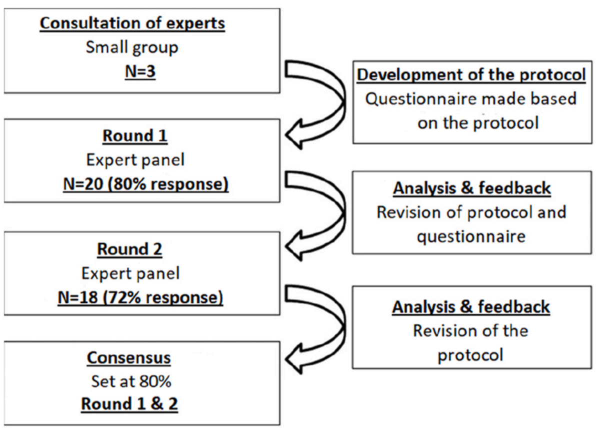

Fig. 2. Process of expert consultation and modified Delphi study.

Table 1
Experts and first responders included in Delphi and validation surveys.

Study group	Professional backgrounds	Experience with	
		animal groups	type of incidents
Delphi survey	Veterinarian (#19)	Wildlife	Barn fires
	Animal scientist (#1)	Livestock (bovine, porcine, small ruminants)	Bush fires
		Horses	Floods
		Fish	
Validation survey	Firefighter (#10)	Wildlife	Barn fires
	Technical animal rescuer/Veterinary technician (#3)	Livestock (bovine, porcine, small ruminants)	Bush fires
	Veterinarian (#3)	Horses	Floods
	Animal disaster manager (#3)	Companion animals	Hurricanes
		Poultry	Trapped livestock & horses
		Wild birds	Transport accidents

second round were received. During both rounds of the Delphi study, a questionnaire of approximately twenty questions (Appendix A and C) was sent with survey tool Qualtrics XM. In the tool the option was available to add comments to any of the questions. Questions from the first round that reached agreement among the experts were removed in the second survey.

In the second round, questions based on the remarks from the first round were added for refinement of the protocol.

The SMEs were asked to score every question on a five-point Likert scale to determine whether they 'strongly disagree' (1) up to 'strongly agree' (5) with the statement made on a specific element of the proposed animal field triage protocol, again with the possibility to place comments to any of the questions.

After the first survey round, data was analysed and adjustments to the initial version of the protocol were made based on the comments received, in order to improve on the protocol for the second survey round. To prevent any bias, the analysed data was presented anonymously to the SMEs in a summarized form (Appendix B). The process was repeated during the second round. The summarized data analysis of the second round can be found in Appendix D. One question from the second round was removed due to lack of clarity, as the question was found to be subject to multiple interpretations based on the responses given by the SMEs. Consensus was defined as reached when ≥80% of the participating SMEs agreed or strongly agreed with the statement made. This percentage was based on the average consensus rate of several Delphi studies [17–21].

2.4. Validation survey with first responders

To further validate the completed version of the triage protocol based on the Delphi study for the intended target audience, a total of thirty-five first responders with known extensive practical experience in animal disaster management and animal rescue were invited to participate, from whom nineteen complete responses were received (Table 1). The purpose of this validation step was to determine if the target audience of first responders would support the consensus reached by the SMEs participating in the Delphi study, on whether the completed animal field triage protocol is useful and to confirm whether the protocol would have added value and be executable in real-life situations.

The survey was developed to provide a response to the triage protocol, after familiarisation in a simulated environment. For this purpose, a serious game was created as a specific training tool, applying a similar development strategy as described in the Educator's blueprint [22], resulting in the Animal Triage Training Game (ATTG) [23]. Serious games are known for their capability of training specific professional competencies with knowledge and skills performance superior to conventional educational interventions [24]. The ATTG is a new digital training game that allows players, under time pressure, to set priorities for the necessary treatment of animals based on the triage protocol described in this paper. In various, regularly occurring scenarios, including a barn fire, livestock transport accident and flooding, the player examines multiple animals and uses colours to indicate the priority of each animal. A visual language of icons leads the player on the trail of hints that you can see, hear and feel. After each level, the player receives feedback based on the choices made and conclusions drawn by the player whilst playing the game, allowing the player to improve on his actions when the level is replayed. By playing multiple levels, the player is able to understand and implement the triage protocol described in this paper in a safe environment. In addition, no negative consequences will occur for the animal patients portrayed in the training game in case mistakes are made, similar to a flight simulator for pilot training or the health and safety training game in underground mines (MINING-VIRTUAL [25]). This way the trained first responder gets to know the triage priorities that are actually decisive for effective action by the attending veterinarian at the site of a real-life emergency.

The nineteen participating first responders were invited to play the barn fire scenario, which includes taking protocol-based triage decisions and then evaluate the animal field triage protocol using the questionnaire. The questionnaire consisted of fourteen open and closed questions, some also with the option to add comments (Appendix E).

3. Results

3.1. Literature review leads to the SALT protocol selection

There are many different human field triage protocols used worldwide [12] Based on the literature search done, three primary tirage systems used in adults were identified as a possible starting point for an animal field triage protocol. These are START, Sieve and SALT.

3.1.1. START (simple triage and rapid treatment)

The START triage system (Fig. 3), developed in the 1980s, is one of the first civilian triage systems. It was previously adopted as the standard algorithm for primary triage and is therefore the most widely used triage system in the United States, but it is also used in Canada and Australia. Victims are assessed in 60 s or less on ability to walk, respiratory rate, capillary refill, radial pulse and the ability to follow commands. After primary assessment, the patient is marked red (immediate), yellow (delayed), green (minor), or black (deceased) [2,3,12,26,27].

3.1.2. Sieve triage

The Sieve triage system (Fig. 4), developed in 1995, is widely adopted as triage algorithm in Europe, United Kingdom, Australia and South Africa [3]. This triage method is very similar to the START system. Sieve triage starts by assessing the ability to walk. Subsequently respiration and pulse/capillary refill are evaluated. Victims are tagged red (immediate and first priority), yellow, (urgent and second priority), green (delayed and third priority) and dead [3,12,28,29].

3.1.3. SALT (sort, assess, lifesaving intervention, treatment/transport)

A more recently developed triage system is the SALT-system (Fig. 5). This algorithm was introduced in 2008 by the Centers for Disease Control and Prevention (CDC) as a new national standard for mass casualty incident triage in the United States [30]. It is part of the Model Uniform Core Criteria (MUCC), which serves as a national guideline for mass casualty triage in the United States. This guideline has been developed to standardize triage and thereby increase interoperability [31,32]. SALT is very similar to the START-system in terms of assessment of the physiological criteria [12]. The difference with the START-system is that the SALT-system first globally prioritizes the victims in three categories. This step was introduced to prevent victims from leaving the accident scene and seeking medical attention themselves while waiting for individual assessment, thereby overwhelming the nearest medical facility [30]. Based on this first prioritization, further individual triage or life-saving interventions will take place if necessary [2].

3.1.4. Comparison and accuracy

Nine studies were found describing accuracy, under-triage and/or over-triage percentages of the START, SIEVE and SALT triage algorithms (Table 2). No standardized methods were used [3], complicating comparison of accuracy other than through the three studies that had compared accuracy among systems [26,33,28]. Seven of the studies also described over- and under-triage levels. Over-tirage and under-triage are the incorrect placing of victims in a respectively more severe or less severe category than the actual severity of their injuries would require.

The accuracy percentages of START triage varied greatly between the studies (36–85%), as did the over- and under-triage percentages when assessed. On average the accuracy percentage of START was 58% [26–28,33,34]. Sieve triage accuracy percentages showed less variation among the different studies (37–47%). On average the percentage of accurately assessed victims was around 40% [28,33,35]. However, one study showed high accuracy levels after refresher training of the triage method (77–90%) [35]. Most studies have been done on the accuracy of SALT triage. The mean percentage of overall accuracy was circa 70% (52–83%) [26,31,33,36,37]. In the one study that compared all the three algorithms, the SALT algorithm had the highest accuracy of 52% compared to 36% and 37% accuracy of START and SIEVE respectively [33].

All three triage algorithms are very similar in their approach. Three of the assessment criteria are the same in all triage methods described (Table 3). With START and SALT triage there is a fourth assessment criteria of following commands, absent in Sieve. One of the most important differences between SALT and the other triage algorithms is global sorting prior to individual assessment of victims. START and Sieve start with individual triage immediately.

Of the criteria used in all the triage systems discussed here, the motor component (ability to walk en follow commands) of the Glasgow Coma Scale and systolic blood pressure (radial pulse) were found to have the strongest association with life-threatening injury [28]. This is consistent with the outcome of a study published in 2017, which concludes that the Glasgow Coma Scale was a good predictive value for major trauma. In this study, respiration rate was also a significant predictive value for major trauma [38].

With all information combined the choice was made to have the SALT-system as the starting point for an animal field triage

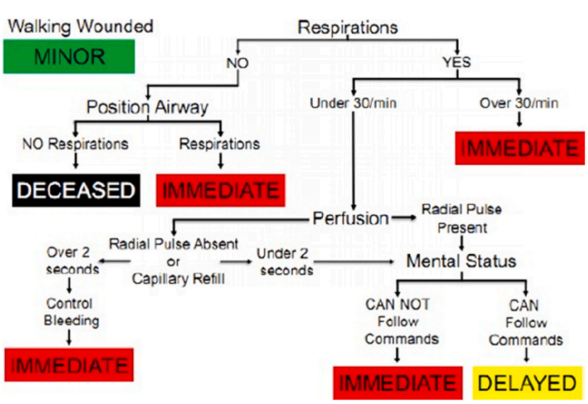

Fig. 3. START triage system [26].

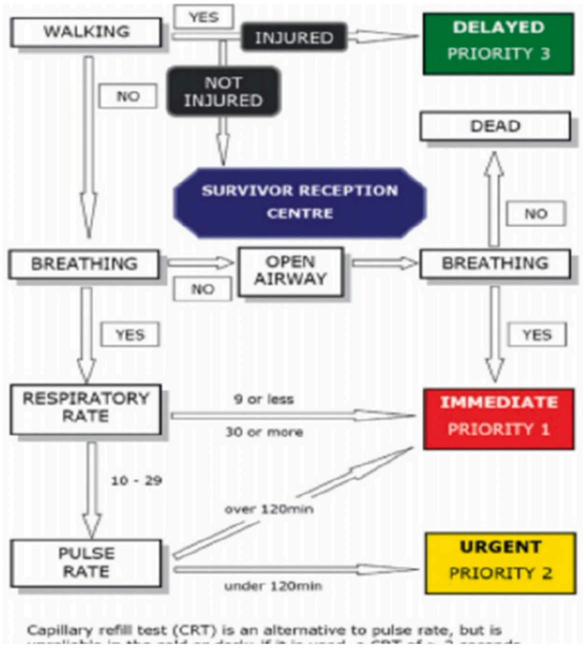

Fig. 4. Sieve triage system [29].

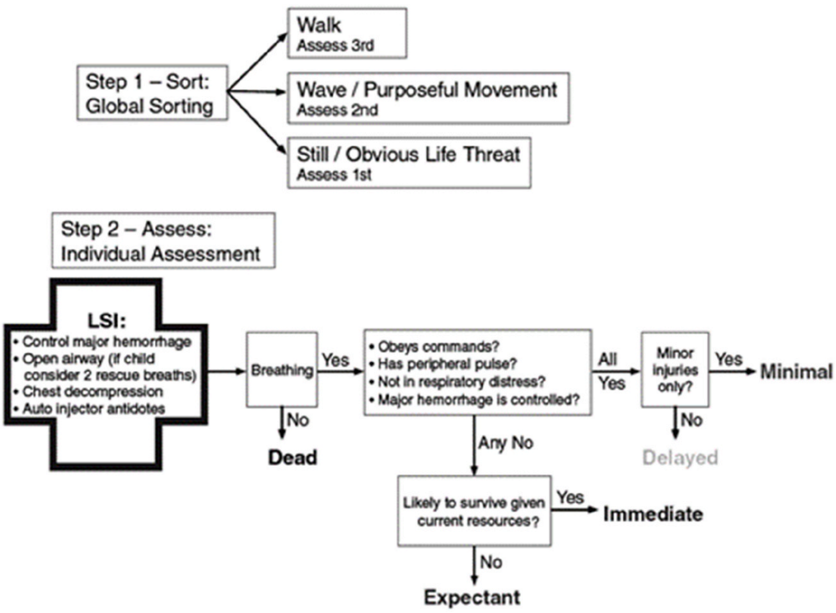

Fig. 5. SALT triage system [30].

protocol, based on the following arguments:

1) It is the most recent system, developed based on experience with the previous systems, literature and expert opinion [30,39];
2) Its accuracy is at least as good as the other systems if not better [26,31,36];
3) It has introduced a global sorting step prior to individual assessment of victims, speeding up the process of managing individuals when in large groups, similar to individual animals in herds.

3.2. Protocol development with consultation of experts

The steps and physiological criteria included in the initial draft of the animal field triage protocol after completion of the expert consultation, are summarized in Table 4. In comparison to the human SALT triage system, an extra step was added, prior to the steps of

Table 2
Overview literature study of the accuracy of the primary triage algorithms.

Triage system	Study	Method	Accuracy
START	Garner et al., 2001 [28]	Retrospective review	85% accuracy
	Schenker et al., 2006 [34]	Disaster drill evaluation	70% accuracy
	Kahn et al., 2009 [27]	Retrospective review	44,6% accuracy 53,3% over-triage 2% under-triage
	Bhalla et al., 2015 [26]	Retrospective review	55% accuracy 12% over-triage 33% under-triage
	McKee et al., 2020 [33]	Prospective, observational study	36% accuracy 7% over-triage 57% under-triage
SIEVE	Garner et al., 2001 [28]	Retrospective review	45% accuracy
	Cuttance et al., 2017 [35]	Comparison accuracy of simulated triage between educational review or no educational review	47–90% accuracy 16% over-triage 37% under-triage
	McKee et al., 2020 [33]	Prospective, observational study	37% accuracy 6% over-triage 58% under-triage
SALT	Cone et al., 2009 [36]	Disaster drill evaluation	78,8% accuracy 13,5% over-triage 3,8% under-triage
	Lerner et al., 2010 [31]	Simulated mass-casualty incidents	83% accuracy 6% over-triage 10% under-triage
	Cone et al., 2011 [37]	Virtual reality simulation	70% accuracy 6,8% over-triage 23,2 under-triage
	Bhalla et al., 2015 [26]	Retrospective review	65% accuracy 5% over-triage 30% under-triage
	McKee et al., 2020 [33]	Prospective, observational Study	52% accuracy 22% over-triage 26% under-triage
Comparison accuracy among triage algorithms	Garner et al., 2001	Retrospective review	START: 85% SIEVE: 45–90%
	Bhalla et al., 2015	Retrospective review	START: 55% SALT: 65%
	McKee et al., 2020	Prospective, observational study	START: 36% SIEVE: 37% SALT: 52%

Table 3
Comparison of the physiological criteria of the START, Sieve and SALT triage methods.

Model	Priority of physiological assessment criteria			
START	Ability to walk	Respiration	Pulse/capillary refill	Obeying commands
Sieve	Ability to walk	Respiration	Pulse/capillary refill	–
SALT	Ability to walk	Respiration	Pulse	Obeying commands

triaging as described in de MUCC for mass casualty triage [32]. This 'Step 0' concerns the safety of the first responder on-site and human and animal safety off-site (biosecurity risks). Step 0 emphasizes the importance for the first responder's situational awareness and safety, which have the highest priority when working in a potentially hazardous environment. Not only should first responders in a disaster situation assess whether their actions can be performed safely, they should also take into account that animals in distress can

Table 4
Modifications SALT triage system to create draft animal field triage protocol.

SALT triage human	Draft veterinary field triage protocol
–	Step 0: Safety and biosecurity
Step 1: Global sorting	
Walking, wave or purposeful movement	Walking uninjured
Step 2: individual assessment	
Breathing	Breathing
Obeys or makes purposeful movements on command	Not responsive to stimuli and/or severe neurological abnormalities
Peripheral pulse	Not included
Respiratory distress	Respiratory distress
Major hemorrhage	Severe hemorrhage
Minor injuries	Severe wounds/lameness
Likely to survive given current resources	Animals without prognosis of permanent disability and pain or with long-term impairment of welfare
Step 3: Lifesaving interventions	
Control major hemorrhage	Provide first aid, sedation, pain relief or euthanasia if safe and possible giving the circumstances/resources
Open airway	
Chest decompression	
Autoinjector antidotes	

react unexpectedly, creating unforeseen dangerous situations [15]. Basic hygiene and zoonotic disease prevention measures should also be considered during triage, including any biosecurity breaches as a result of animal evacuation [15]. As a disaster situation can evolve and rapidly deteriorate, a designated safety officer [6] could monitor and assess any changes and inform any first responders on-site on whether Step 0 needs to be reconsidered.

In 'Step 1', the global sorting of victims is performed, in preparation of prioritizing them for individual assessment. In the SALT triage protocol for humans, global sorting is made using simple voice commands acted upon by the victims to divide them into three categories. However, animals may not understand and respond to simple voice commands under stressful conditions. It was therefore suggested to segregate apparently uninjured animals that are able to walk from those that remain stationary. The idea was these animals that can move by themselves may be evacuated or secured immediately without initial individual assessment (to be done at a later time) and thus reduce the group of animals that require immediate individual triage assessment in Step 2.

For 'Step 2', the actual triage of individual victims, the suggestion was made that in addition to the SALT algorithm and the opinions of the three experts, the recently developed MARCH PAWS sequence (acronym for: Massive hemorrhage, Airway, Respiration, Circulation, Hypothermia/Head injury, Pain, Antibiotics, Wounds, Splints) was to be followed [40]. This particular sequence is a proven useful tool applied in tactical combat casualty care (TCCC) for accurately treating injuries. The MARCH PAWS sequence treats injuries in order of their immediate threat to life, setting priorities for lifesaving interventions. However, it was decided not to let *massive hemorrhage* be the first assessment criterium because saving animals in the field with a major hemorrhage is considered very difficult in contrast to humans.

Similar to the SALT algorithm, it was suggested to start the individual triage in animals with the assessment of breathing, because it is possible to make a first assessment at a distance to the animal. Assessment of 'breathing' is followed in humans by assessment of 'obeys or makes purposeful movement on command'. Ability to respond to commands is a method to determine whether there may be neurological damage. As 'obeying of commands' is not possible to evaluate in animals, a more observable description: 'not responsive to stimuli and/or severe neurological abnormalities' was used in the draft animal field triage protocol. After 'obeys commands', in humans peripheral pulse is assessed. It has been decided to leave out 'Pulse' in the animal protocol because (wild) animals are likely to be more difficult to quickly approach safely in order to assess their peripheral pulse in a disaster situation. The subsequent physiological variables in human triage are 'respiratory distress' and 'major hemorrhage'. These variables were kept unchanged in the animal protocol except for a textual adjustment from 'major hemorrhage' to 'severe hemorrhage' because major hemorrhage is probably not possible to stop in (wild) animals during a mass casualty incident. The step of the SALT protocol assessing the likelihood of survival of the human patient given current resources, was adapted for animals by considering their prognosis of permanent disability and pain or with long-term impairment of welfare'. Unlike in humans, euthanasia in the field is an option for animals that are likely to have impaired welfare. The last factor in Step 2 of the SALT triage is 'minor injuries'. This was changed in the animal triage to 'severe wounds/lameness'. The underlying thought was that animals that do not have severe wounds or severe lameness are not in direct need of first aid and can be seen by a veterinarian at a later point in time.

At the end of Steps 1 and 2, in the human SALT triage algorithm, a clear segregation into five categories (dead, expectant, immediate (care), delayed (care) or minimal (care)) is achieved. However, in the draft animal field triage protocol, cases were divided into three categories (dead/expectant, immediate/urgent or delayed) as described in 2009 by Wingfield et al. [15]. At the time, it was considered that the expectant would rapidly be euthanized and thus join the category of the dead, while the delayed or minimal cases could be grouped because both would receive care at a later stage or after being secured elsewhere.

The third and final step of the SALT protocol is lifesaving interventions. In the SALT triage, four specific interventions are stated (Table 4). For animal triage, these four specific actions might not be possible due to safety conditions or available resources. The description 'provide first aid, sedation, pain relief or euthanasia, if possible' was chosen instead.

Collectively, this led to the draft animal field triage protocol as presented in the flowchart (Fig. 6), submitted for review and comments by the SMEs using the Delphi study.

3.3. Delphi study

3.3.1. Round 1

Table 5 describes the variables of the first survey and the results. The first questionnaire consisted of eighteen statement questions (Appendix A) from which nine reached agreement (≥80% consensus) among the SMEs (rows highlighted in blue in Table 5). Comments and suggestions received from the SMEs for all the questions were reviewed and used to refine the second version of the protocol. Clear consensus was reached on the importance of safety as Step 0 of the triage protocol (Q2) and on the added value of an animal field triage protocol (Q19). The physiological variables 'breathing' (Q7), 'not responsive to stimuli and/or severe neurological abnormalities' (Q8), 'respiratory distress' (Q9) and 'severe hemorrhage' (Q10) also reached consensus. This also applied to questions six, twelve and thirteen.

The comments made by the SMEs on five of the nine statement questions that reached consensus led to seven precision questions in Round 2 (Table 5). In addition, eight of the original nine statements that did not reach agreement were rephrased or clarified with a description to minimize differences in interpretation in the second survey, leading to ten questions in round 2 of the Delphi study (Table 5). No follow-up was done on one statement question that did not reach consensus, being the one regarding AVA recommendations on burns (Round 1, Q15). Indeed, based on the SMEs' comments received ('high degree of species difference and specificity

Table 5
Questions round 1. Questions where consensus was reached are highlighted in blue.

Variable	Consensus (≥80%)	%
Q1. Definition of triage	No	55 (>agree) 20 (>neutral) 25 (>disagree)
Q2. Safety as step 0 of the protocol	Yes	100 (>agree)
Q3. Global sorting and evacuation of walking animals that are not injured	No	75 (>agree) 15 (>neutral) 10 (>disagree)
Q4/5. Three triage categories (black; orange; green)	No	60 (>agree) 30 (>neutral) 10 (>disagree)
Q6. Marking of assessed animals	Yes	80 (>agree)
Q7. Not breathing as predictive value for the black category	Yes	85 (>agree)
Q8. Not responsive to stimuli and/or severe neurological abnormalities as predictive values for the black category	Yes	90 (>agree)
Q9. Respiratory distress as predictive value for the orange category	Yes	90 (>agree)
Q10. Severe haemorrhage as predictive value for the orange category	Yes	95 (>agree)
Q11. Severe wounds/lameness as predictive value for the orange category	No	70 (>agree) 15 (>neutral) 15 (>disagree)
Q12. Interventions should be done under veterinary supervision	Yes	80 (>agree)
Q13. Euthanasia in de field on animals with prognosis of permanent disability and pain or with long-term impairment of welfare	Yes	90 (>agree)
Q14. All animals in the disaster should be seen by a veterinarian	No	70 (>agree) 25 (>neutral) 5 (>disagree)
Q15. AVA recommendations on burns should be included in the protocol	No	60 (>agree) 25 (>neutral) 15 (>disagree)
Q16. Protocol is executable on livestock, horses, and wildlife	No	65 (>agree) 20 (>neutral) 15 (>disagree)
Q17. No distinctions are made between animals in step 1 and 2	No	45 (>agree) 25 (>neutral) 30 (>disagree)
Q18. Flowchart is understandable for emergency workers	No	70 (>agree) 20 (>neutral) 10 (>disagree)
Q19. The existence of a animal field triage protocol has added value in mass casualty incidents. Do you agree with this statement?	Yes	95 (>agree)

of the recommendations'), it was decided not to include this specific burn injury assessment in the second version of the animal field triage protocol.

Specific adjustments to statements included a new, more inclusive description of the definition for triage (Q1). Furthermore, in Step 1, global sorting, the description was modified to make it more inclusive for animals that are autonomously mobile but do not walk (Q2). An additional triage category was added to allow for a better distinction between urgent first-aid cases and animals for which direct care can be slightly delayed (Q3). Triage categories were given a number for priority of treatment, to clarify which triage category needs to be addressed for care first (Q4). To make the observation of breathing more concrete, a minimal observation time was included (Q5), and an extra factor (absence of corneal reflex) was added to assess if an animal falls in the black category 'dead' (Q7). The description 'not responsive to stimuli and/or severe neurological abnormalities' was refined based on the veterinary modified Glasgow Coma Scale, which is used to determine different levels of consciousness in animals (Q6) [14,41]. Finally, some

Table 6
Questions round 2. Questions where consensus was reached are highlighted in blue.

Variable	Consensus (≥80%)	%
Q1. Definition of triage	Yes	88.89 (>agree)
Q2. Global sorting and evacuation of animals that do not have obvious major injuries and are autonomously mobile	Yes	88.89 (>agree)
Q3. Four triage categories (black; red; yellow; green)	Yes	100 (>agree)
Q4. Prioritization of categories (red, black, yellow, green)	No	66.67 (>agree) 22.22 (>neutral) 11.11 (>disagree)
Q5. Observation time breathing ≥ 20 seconds	No	72.22 (>agree) 5.56 (>neutral) 22.22 (>disagree)
Q6. Adjustment 'not responsive to stimuli and/or severe neurological abnormalities' to 'unresponsive to repeated noxious stimuli'	Yes	94.45 (>agree)
Q7. Corneal reflex as final test for the black category	Yes	94.45 (>agree)
Q8. Description for respiratory distress	Yes	88.89 (>agree)
Q9. Description for severe haemorrhage	Yes	83.34 (>agree)
Q10. Severe wounds/fractures as predictive value for yellow category	No	61.11 (>agree) 22.22 (>neutral) 16.67 (disagree)
Q11. No distinctions are made between animals in step 1 and 2	Removed from analysis	
Q12. Euthanasia in the field on animals with poor long-term welfare or in need of sustained veterinary care if this can't be provided	Yes	94.45 (>agree)
Q13. Euthanasia in the field on food producing animals that are not suitable for human consumption anymore	No	66.67 (>agree) 5.56 (>neutral) 27.78 (disagree)
Q14. All animals in the disaster area should be seen by a veterinarian	No	77.78 (>agree) 16.67 (>neutral) 5.56 (>disagree)
Q15. Protocol is executable on livestock, horses	Yes	100 (>agree)
Q16. Protocol is executable on wildlife	No	61.11 (>agree) 16.67 (>neutral) 22.22 (>disagree)
Q17. The protocol can be performed by first responders without a veterinary background	No	44.44 (>agree) 16.67 (>neutral) 38.89 (>disagree)
Q18. The protocol can be performed by first responders without a veterinary background that received a short briefing	No	72.22 (>agree) 11.11 (>neutral) 16.67 (>disagree)
Q19. Flowchart is understandable for emergency workers	Yes	83.34 (>agree)

clarifying descriptions were added for 'respiratory distress' (Q8) 'and severe hemorrhage' (Q9). The description for the criterium severe wounds/lameness (Q10) was amended to make it more predictive for the yellow category and suitable for different animal species.

3.3.2. Round 2

Table 6 describes the variables of the second survey and the results. The second questionnaire consisted of nineteen statement questions (Appendix C) from which ten reached consensus (highlighted in blue in Table 6). Based on comments received from the SMEs it was decided to remove question eleven from the analysis due to the lack of clarity of the question.

Statement questions that reached consensus in round two (Q6, Q9 and Q12) were the adjustments or clarifications in its descriptions, based on comments placed in the first round. The adjustments of the prioritization of the categories (Q4), observation time for breathing (Q5) and the addition of euthanizing food producing animals unfit for human consumption (Q13) did not reach agreement among the SMEs.

From the descriptive physiological variables in the questions, only 'severe wounds/fractures' as predictive value for yellow category (Q10) did not reach consensus. The question whether all animals present in the disaster area should be seen by a veterinarian (Q14) also did not reach agreement in the second round, as well as the question if the protocol is executable on wildlife (Q16). Questions seventeen and eighteen, regarding whether first responders without a veterinary background and with or without additional training could perform triage in the field, also failed to reach agreement among the SMEs.

Five variables on which there was no consensus in the first round, reached agreement in the second round. An overview of these variables is provided in Table 7. After consulting a native English speaker, the definition of triage from the first round as 'a method that is used to efficiently allocate resources when the number of patients exceeds the capacity of the available resources', was rephrased into 'a method that is used for prioritizing patients according to urgency, in order to allocate (limited) manpower and resources efficiently'. This second definition reached consensus among the experts.

In Step 1, Global sorting, the modified description from animals that are 'walking' to 'autonomously mobile' to make it more inclusive for different animal species led to agreement among the SMEs. Four categories instead of three for animal triage reached consensus in the second round. In the first round the question whether the protocol is executable on wildlife and livestock including horses did not reach consensus. In the second round, separate questions were asked about executability on livestock (including horses) (Q15) and wildlife (Q16). The statement that the protocol is executable on livestock and horses reached consensus in the second round.

The flowchart was not visible for all panel members in the first round. As a result, in the first round the outcome of the question on the flowchart being understandable for emergency workers (round 1, Q18) may not have been reliable. The question was asked again in the second round (round 2: Q19), after ensuring that all participants could access the flowchart. In the second round the question reached consensus.

The animal field triage protocol was revised based on the results of the first and second round of the Delphi study. All statements the SMEs agreed on were included in the protocol. In addition, several statements (Second round Q4, Q10, Q14) that did not reach agreement among the SMEs were included in the protocol despite the absence of consensus. This was done because the authors believe these statements have added value for animal welfare. For the prioritization of categories (Q4), no adjustments were made in priority order. Based on existing understanding of color-coding in triage, the red category (immediate/urgent care/Priority 1), should always be treated first. However, it was the authors' opinion that animals that are considered beyond saving and about to die need to be euthanized as soon as possible to limit further impairment of animal welfare. Therefore, it was considered justified to make the black category (beyond saving) Priority 2 after the red category (Priority 1), but before animals with Priority 3 (delayed care). In the statement in Q10, a small amendment was made by changing 'severe wounds/fractures' to 'severe wounds/severe fractures'. Although it may be a good description for this particular purpose, it should not be considered a clear indicator for a good or bad prognosis.

Finally, the statement that all animals should be seen by a veterinarian if required (Q14) was included, although consensus by the experts did not reach the 80% threshold, albeit very close (78% agree/17% neutral). Some injuries may remain unnoticed at first glance during global sorting, but may cause deterioration of health at a later stage. Animals from the minor category should be monitored and receive veterinary examination and treatment if necessary. The newly created version of the animal field triage protocol, taking into account the results from the Delphi study is presented in Fig. 7.

3.4. Validation survey with first responders

The results of the nineteen surveys completed by the first responders (Appendix F) were split based on professional background (firefighters (FF-#10)/other (O-#9)) to determine if a possible background bias existed on how the animal field triage protocol is understood and applied using the Animal Triage Training Game (ATTG) whilst playing the barn fire scenario.

Questions one, two, thirteen and fourteen were open questions about the background and experience of the first responders

Table 7
Changes in consensus between rounds 1 and 2.

Variable	Consensus (≥80%)	Round 1%	Round 2%
Definition triage	Changed to Yes	55 (>agree)	88.89 (>agree)
Global sorting and evacuation of animals	Changed to yes	75 (>agree)	88.89 (>agree)
Number of categories	Changed to Yes	60 (>agree)	100 (>agree)
Protocol is executable on livestock and horses	Changed to Yes	65 (>agree)	100 (>agree)
Flowchart is understandable for emergency workers	Changed to Yes	70 (>agree)	83.34 (>agree)

(Table 1). Question three, four, ten and twelve were multiple choice questions and questions five to nine and eleven used the same five-point Likert scale as used for the Delphi surveys with the SMEs. As several of the multiple choice questions would relate to the personal experiences of each first responder described under Q2, respective answers might be influenced as a result of it. Because of the small number of veterinarians participating in the validation survey, Q12 was not considered for further analysis.

All responders, either combined or per group did not agree to the question that additional advice on specific disasters should be included in the protocol (Q11, FF 70%/O 33,33%). Neither groups reached consensus on the question whether the application of the triage protocol would have helped in the situation they described in Q2 (Q3, FF 70%/O 77,77%).

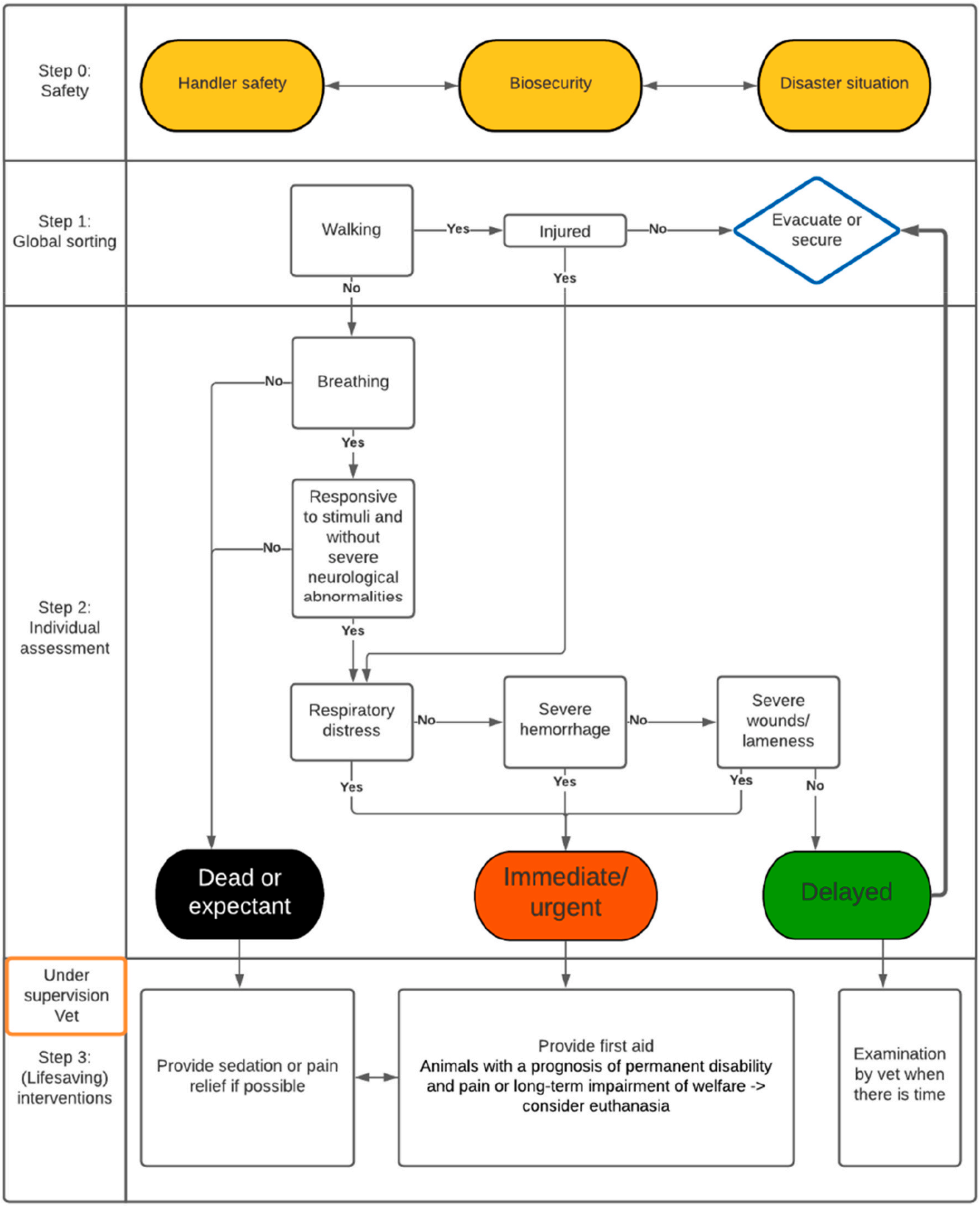

Fig. 6. First draft animal field triage protocol, not validated.

Different personal experiences created a distinction between FF and O responders on the usefulness of four triage categories (Q4, FF 70%/O, 88,88%)), with only O responders reaching consensus, which is in line with the consensus reached by the SMEs on question three of their second survey (Q3, 100%).

In Q7, on whether the distribution of cases within four triage categories was intuitive and feasible, consensus was again not reached by the FF and O combined. However, similar to the response to Q4, consensus was reached by the O responders alone (Q7, FF 60%, O, 88,88%), underlining again how existing personal experiences and different backgrounds can influence the usefulness of four triage categories.

All responders, either combined or per group, considered the flowchart and protocol easy to read, understand and perform (Q5, FF

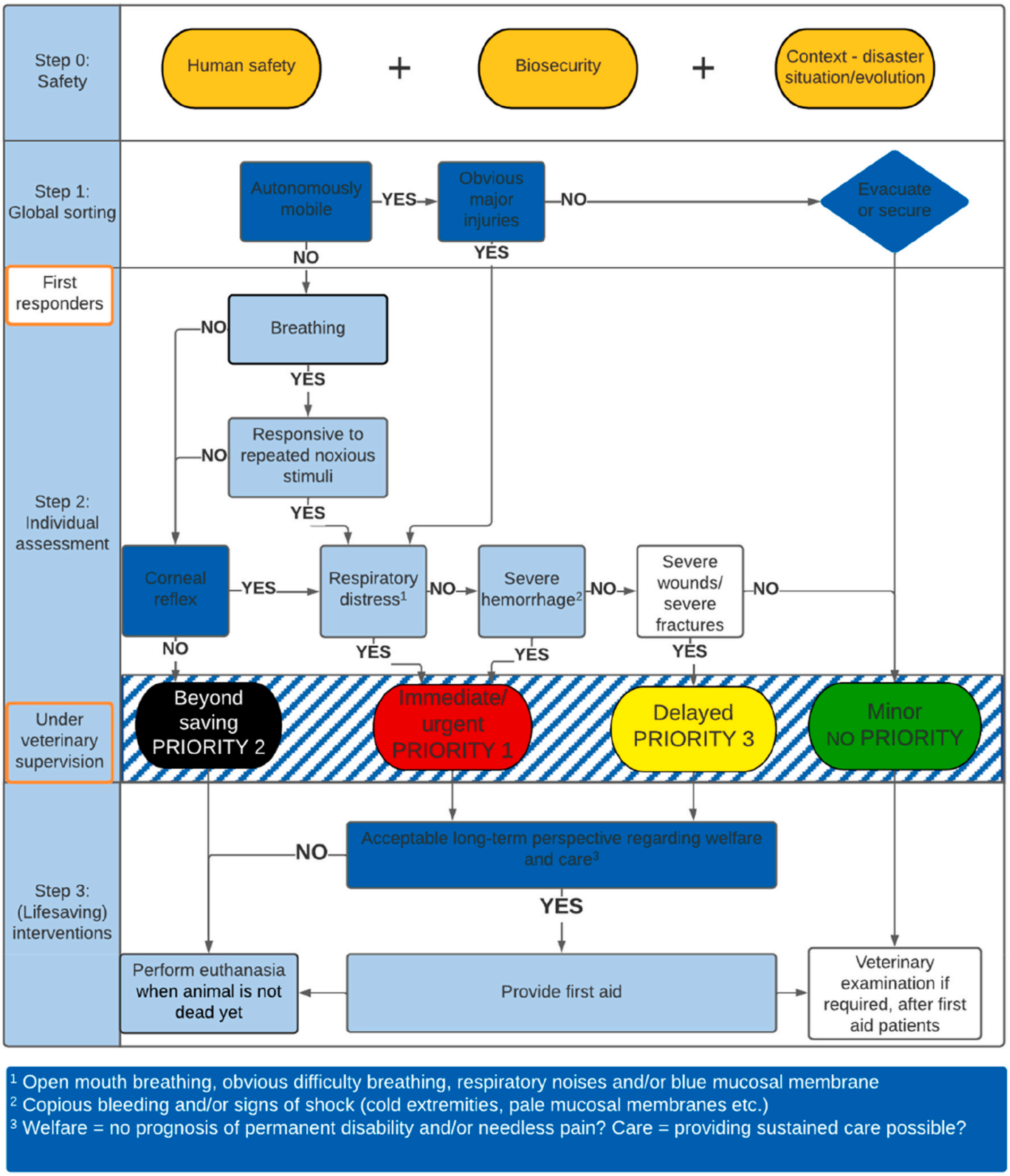

Fig. 7. Second draft of the animal field triage protocol for livestock and horses, based on the Delphi study. Elements that reached consensus in the first round are highlighted in light blue, elements that reached consensus in the second round are highlighted in dark blue. Partial consensus (consensus reached on the categories, but not on the priority of care) is shaded. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

90%/O 88,88%) (Q6, FF 90%/O 88,88%).

In addition, all responders, either combined or per group, would likely use this triage protocol in the field themselves or recommend it to their colleagues (Q10, FF 100%/O 100%), and they also confirmed the triage protocol to be of use in the situation they described

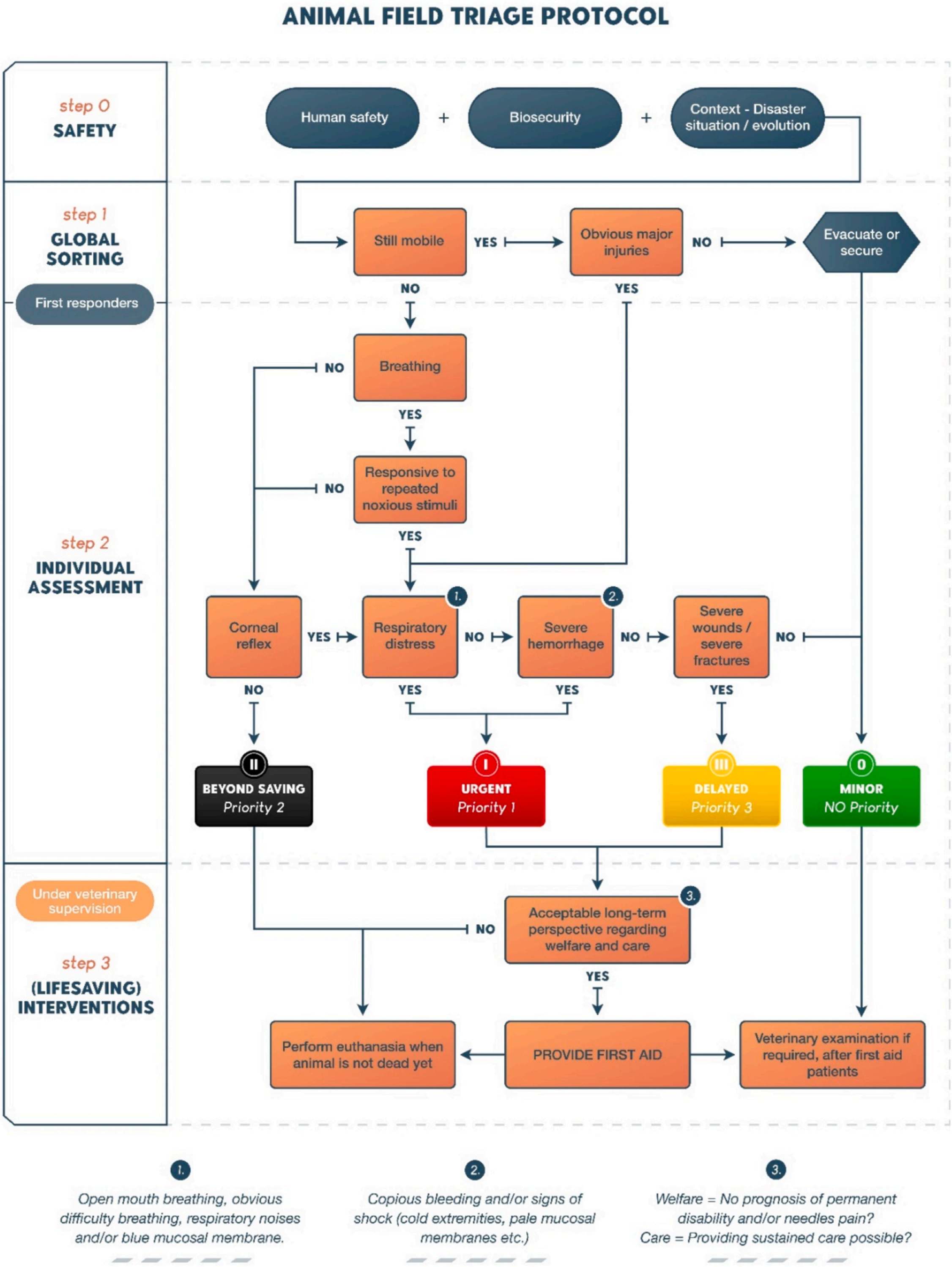

Fig. 8. Final version of the animal field triage protocol for livestock and horses.

themselves in Q2 (Q9, FF 100%/O 88,88%).

Lastly, all responders, either combined or per group, reached consensus on whether the triage protocol is executable on livestock and horses (Q8, FF 90%/O 100%), which is in line with the consensus reached by the SMEs on question fifteen of their second survey (Q15, 100%).

3.5. Final version of the animal field triage protocol

Taking into account the results of the first and the second round of the Delphi study with the SMEs, the validation survey with the first responders and the authors' opinions on those questions that did not reach consensus, the final version of the animal field triage protocol was created (Fig. 8).

4. Discussion

The main research question addressed in this study was to determine whether it is possible to develop an animal field triage protocol for livestock (excluding poultry), horses and wildlife caught in natural disasters or major incidents resulting in mass casualty situations, based on a validated human triage system. The results of this Delphi study indicate that a modified version of the human triage algorithm SALT appears to be well-suited for livestock and horses and has added value in mass casualty situations. The SMEs reached a 100% consensus on both suitability of the protocol on livestock and horses and its contribution to emergency response in animals. Around two-thirds of the first responders included in the validation study recommended the use of the protocol in mass casualty situations (and one-third indicating 'maybe') with no-one recommending against its use. A clear majority support on all practical aspects of the triage protocol was given by the first responders. Together, both SMEs and first responders provided ample support on both suitability and usability of this novel animal field triage protocol for livestock and horses in natural disasters (see Fig. 8).

The SALT system (Fig. 5), which was retained as the most suitable model for the animal field triage protocol after reviewing the literature on human triage systems, assesses multiple physiological criteria to assign victims into one of five categories. Nearly all these criteria were adopted in de initial version of the triage protocol. Four of the five proposed physiological criteria for the distribution of animals into the triage categories reached consensus among the SMEs. These four were 'breathing', 'not responsive to repeated noxious stimuli', 'respiratory distress' and 'severe hemorrhage'. The exception was 'severe wounds/fractures' as a predictive value for the yellow category (61,11% agreement). Although the last did not reach consensus, the authors believed that if amended to "severe wound/severe fractures", it is a good description for this purpose, although it may not be a clear indicator for a good or bad prognosis.

In the initial version of the animal field triage protocol, cases were distributed among only three triage categories (dead or expectant, immediate/urgent, delayed), as described by Wingfield et al., in 2009 [15]. However, this was modified into four categories following the first Delphi round, to ensure that, among those in need of direct care, distinction was made between urgent first-aid cases and animals requiring less urgent care (100% consensus). While there was consensus on the four categories (black – beyond saving, red – immediate/urgent, yellow – delayed, green – minor) there was no consensus on category priority for care (66,67% agreement). Although no clear arguments where provided by the SMEs, it was assumed that this absence of consensus was based on the Priority 2 for animals triaged into the black category. However, palliative care (sedation/pain management) for animals under these conditions is not considered a practical or feasible option requiring monitoring and specific drugs that could also be applied to animals with a more acceptable long-term perspective regarding welfare and care. Therefore, with injured animals categorized as Priority 1 already taken care of, it is the authors' opinion that animals that are beyond saving need to be euthanized rapidly to limit continuing impairment of animal welfare. This opinion would justify the subsequent decision to maintain the existing prioritization of animals that are beyond saving over animals in the newly introduced yellow category with a delayed priority in the final animal field triage protocol.

The SALT system, as used in human triage, starts with global assessment of victims. In this study, we have added Step 0: Safety, prior to global assessment. A paramount consideration when working with animals is to create and maintain a safe personal working environment, which is also applicable to the animals involved. Studies on work-related injuries among veterinarians in Australia and the US show that more than half of the veterinarians reported a significant animal-related injury during their career [42–44]. Situational awareness related to safety needs to be constant, as during (veterinary) interventions on injured animals, the probability of a fight or flight response in the animal may increase and such situations can be dangerous for any personnel close to the animal [45]. Animal handling risks (trauma, zoonoses etc.) and risks associated with capture and injectable anaesthetics, especially for wildlife, should be considered and evaluated [46,47]. Finally, biosecurity risks for evacuee receiving areas should also be considered prior to evacuation.

Another distinction between the human SALT system and the animal adaptation developed as part of this study, is the separation of individual assessment and lifesaving interventions. In the original SALT protocol, lifesaving interventions are part of Step 2: individual assessment. For the animal field triage protocol the choice was made to segregate lifesaving interventions and present it as a separate step (Step 3: interventions), to be completed by on-site veterinarians. Which (lifesaving) interventions are possible in the field would strongly depend on the available resources and skillset of the first responders. Most traditional first responders who are the first to arrive on scene (firefighters, police officers, first aiders) have no or little training in animal health care [48]. The flowchart of Step 2 provides guidance for objective initial assessment of injured animals by such first responders and separation into categories according to urgency and level of care required. Veterinary trained personnel can then address the animals in order of category priority and determine in Step 3 which interventions can be done, while also considering the long-term perspective of an injured animal. The statement that Step 3 should be done under veterinary supervision did reach consensus among the experts (80% agreement).

It is interesting to note that the statements in Q17 and Q18 of the second Delphi round, regarding whether first responders without a veterinary background can carry out Step 2 (individual assessment) of the protocol, without (Q17) or with (Q18) a short briefing on the protocol, failed to reach consensus among the SMEs (Q17 44,45% agreement/Q18 72,22%). However, for Q18, if the conservative response from two SMEs, 'neither agree nor disagree' (11,11%) would be included, consensus is reached. Such an outcome is more likely given the clear consensus of the SMEs on Q19 (83,34%), in which the SMEs were asked whether the flow chart of the animal field triage protocol is easy to read and understandable for emergency workers.

However, the results from the validation study (Appendix F) given by first responders, show a somewhat different opinion provided by both fire fighters (FF) and non-fire fighters (O). For Q5 and Q6, on easy reading, understanding and performing the triage protocol, both groups reached consensus. Both groups would recommend it to their colleagues (Q10) and both groups reached consensus on whether the protocol could be executed on livestock and horses (Q8) and also on a specific situation based their own experiences (Q9). These results from the validation study indicate that those professionals with extensive first responder experience, which is different from being an experienced veterinarian, tend to be more positive and comfortable in applying this new animal field triage protocol and that it can remain generic and therefore applicable in various disaster situations (Q11). Provided of course that a sound and practical protocol is made available to them.

Overall, these results support the relevance to develop a training environment, to perform animal field triage based on the developed protocol for both first responders and veterinarians. Such training would assist in the implementation of the protocol which is quite complex without minimal veterinary training. Assessment of neurological abnormalities, corneal reflex or shock under stressful conditions for the first responder and limited time available to complete an individual animal triage might indeed require specific training.

According to studies on human triage, training prior to performing triage significantly improves accuracy percentages [49] regardless of experience or previous training [50]. Skills and accuracy in human triage were retained for a period of four to six months after training [49,51] which implies the importance of repeated training for both first responders and veterinarians. Short refresher training was found to be effective to increase triage accuracy percentages, as well as providing an aide de mémoire, for example a flowchart or phone app, for use during the performance of triage [35,52].

Both the SMEs and first responders reached consensus on executability of the protocol on livestock and horses, although the SMEs could not reach consensus on whether it is also executable in wildlife (61,11% agreement). This result therefore clearly differs from the original research question to develop a generic veterinary triage protocol applicable to multiple species in addition to livestock and horses. This outcome can be explained by the fact that wildlife is too broad a group, including mammalian, avian, reptile and many other species, which cannot be covered on a single generic protocol. Because of the major differences between species and species-specific approaches on injury assessment, adapted triage protocols per identified animal group are advisable.

Knowledge of these animals is necessary to be able to handle them correctly, assess physiological criteria and make educated decisions about acceptable long-term perspectives [53,54]. In addition, wild animals can react very different to human presence and handling in comparison to domestic animals [55]. Stress development plays a major role in handling and treating wildlife. Human presence tends to initially increase stress hormone levels in wildlife before acclimatization of the animals. Handling and transport of wild animals is associated with significant increases in stress hormone (cortisol) levels [56]. Animal losses have been reported during veterinary examination of wild animals due to acute stress [57]. Also capture myopathy, due to overexertion and capture-related muscle injury are contributing factors that complicate wildlife triage. Capture myopathy is associated with stress of handling and transport and can cause death in wild animals [15,58]. In addition, other capture-related muscle damage that remains undetected can cause a long-term negative effect in wildlife after their subsequent release [59]. A good plan, expertise, and appropriate resources for capturing and handling wildlife are necessary to prevent these injuries and impairment of animal welfare [58].

To the best of the authors' knowledge, no peer-reviewed article has ever been published on an animal field triage protocol. Therefore, this study has the limitation that it cannot rely on previous scientific literature and should therefore be considered a proof of principle. This triage protocol was designed and confirmed by means of a modified Delphi study. Delphi studies have been used in human medicine and triage to reach consensus on topics where there is lack of empirical evidence or on topics that involve a high degree of subjectivity [17–19,60].

As a result of this study design, a selection bias in this panel of SMEs used for both Delphi surveys could not be avoided due to the fact that the SMEs invited have known expertise in animal disaster management, veterinary trauma medicine or wildlife and were accessible via personal contacts and network or their academic visibility on the subject. Furthermore, 'expert' is a subjective term and depends on the context of the assumed expertise and level of knowledge. Because our SMEs consisted of both national and international livestock and wildlife experts from specific areas, it may be possible that their country of origin (Australia, Canada, Europe, United States), background, professional training or cultural beliefs have had an influence on whether consensus was reached or not on certain statements. To minimize bias, the composition of the SME panel was not disclosed among SMEs and the results of both Delphi rounds were presented to them anonymized.

The panel of first responders participating in the validation survey also came from a wide variety of professional and national backgrounds, but all with hands-on experience in handling animals in various emergency situations, such as barn fires, flooding, transport accidents, technical large animal rescue, disaster management and training. Their response was based on their professional expertise in the context of applying the triage protocol in the different scenarios of the training game (ATTG). The results from their responses support the consensus achieved by the SMEs in the Delphi studies. However, due to the limited number (19) of first responders actually replying to the validation survey, we will have to learn from future case reports exactly how beneficial the application of the animal field triage protocol will be in mass casualty situations involving animals.

5. Conclusion

Triage, defined as 'a method that is used for prioritizing patients according to urgency, in order to allocate (limited) manpower and resources efficiently', has not been described for animals caught in disaster events in the field. In this research, a new model for an animal field triage protocol was developed based on the widely used and fairly accurate human SALT-triage system, as a proof of principle.

Consensus was reached for the animal field triage protocol on nearly all physiological variables applied for individual health state assessment. Based on the consensus reached by both panels of SMEs and first responders involved in the protocol development and subsequent validation, an acceptable level of certainty is reached to state that this novel animal field triage protocol is executable on livestock and horses and has added practical value in mass casualty incidents and natural disasters involving and affecting animals.

Future feedback from first responders on the real-life application of this novel protocol will confirm the authors' initial conclusions or indicate how the protocol should be amended to reach its intended goal. In addition, further research is recommended for a specific triage protocol for wildlife caught in natural disasters. Subsequent new versions of the triage protocol could then be further validated and trained in newly developed scenarios included in the Animal Triage Training Game.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

CRediT authorship contribution statement

Anne M. Dubbink: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jolianne M. Rijks:** Writing – review & editing, Writing – original draft, Conceptualization. **Derek H. van Dongen:** Visualization, Software. **Joris J. Wijnker:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:Anne Dubbink reports a relationship with ADE-Foudation that includes: board membership. Derek van Dongen reports a relationship with ADE-Foundation that includes: board membership. Joris Wijnker reports a relationship with ADE-Foundation that includes: board membership.

Data availability

Data will be made available on request.

Acknowledgements

The completion of the two parts of this study could not have been possible without the expertise and assistance of all the experts and first responders involved. They were instrumental by providing their knowledge and comments which led to the completion of animal field triage protocol. In addition, We would also like to acknowledge the entire design team of Mindgame [61], who were able understand and visualize our concepts and build a great training game.

Appendix A–F. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2024.104384.

References

[1] Dieren in nood door hoog water: 'Redden is bijna niet te doen', RTL Nieuws Web site (2021). https://www.rtlnieuws.nl/editienl/artikel/5242207/wilde-dieren-grazers-nood-waterramp-limburg-evacuatie. (Accessed 7 December 2021). Updated.
[2] C.H. Lee, Disaster and mass casualty triage, AMA Journal of Ethics 12 (6) (2010) 466–470.
[3] J.L. Jenkins, M.L. McCarthy, L.M. Sauer, et al., Mass-casualty triage: time for an evidence-based approach, Prehospital Disaster Med. 23 (1) (2008) 3–8.
[4] R. Campbell, T. Knowles, The Economic Impacts of Losing Livestock in a Disaster, a Report for the World Society for the Protection of Animals (WSPA), 2011 prepared by economists at large. Melbourne, Australia.
[5] J. Sawyer, G. Huertas, Animal Management and Welfare in Natural Disasters, Routledge, 2018.
[6] S.E. Heath, Animal Management in Disasters, Mosby Inc., 1999.
[7] R. Chadwin, Evacuation of pets during disasters: a public health intervention to increase resilience, Am. J. Publ. Health 107 (9) (2017) 1413–1417.
[8] M.J. Hall, A. Ng, R.J. Ursano, H. Holloway, C. Fullerton, J. Casper, Psychological impact of the animal-human bond in disaster preparedness and response, J. Psychiatr. Pract. 10 (6) (2004) 368–374.
[9] K. Thompson, Facing disasters together: how keeping animals safe benefits humans before, during and after natural disasters, OIE Revue scientifique et technique-office international des epizooties (Special Issue on 'The Contribution of Animals to Human Welfare') 37 (1) (2018) 223–230.
[10] S. Glassey, N. Liebergreen, M. Rodriguez Ferrere, M. King, It was one of the worst days of my life: companion animal owners' experiences of the edgecumbe 2017 flood in aotearoa New Zealand, Int. J. Disaster Risk Reduc. 96 (2023) 103923, https://doi.org/10.1016/j.ijdrr.2023.103923.

[11] World Organisation for Animal Health, Guidelines on Disaster Management and Risk Reduction in Relation to Animal Health and Welfare and Veterinary Public Health, 2016.
[12] J. Bazyar, M. Farrokhi, H. Khankeh, Triage systems in mass casualty incidents and disasters: a review study with a worldwide approach 7 (3) (2019) 482.
[13] L.J. Ruys, M. Gunning, E. Teske, J.H. Robben, N.E. Sigrist, Evaluation of a veterinary triage list modified from a human five-point triage system in 485 dogs and cats 22 (3) (2012) 303–312.
[14] K. Ash, G.M. Hayes, R. Goggs, J.P. Sumner, Performance evaluation and validation of the animal trauma triage score and modified glasgow coma scale with suggested category adjustment in dogs: a VetCOT registry study 28 (3) (2018) 192–200.
[15] W.E. Wingfield, S.B. Palmer, Veterinary Disaster Response, John Wiley & Sons, 2009.
[16] World Health Organization, Updated Guideline: Paediatric Emergency Triage, Assessment and Treatment: Care of Critically-Ill Children, 2016.
[17] J.M. Culley, J.A. Effken, Development and validation of a mass casualty conceptual model 42 (1) (2010) 66–75.
[18] E.B. Lerner, C.H. McKee, C.E. Cady, et al., A consensus-based gold standard for the evaluation of mass casualty triage systems 19 (2) (2015) 267–271.
[19] L. Thompson, M. Hill, F. Lecky, G. Shaw, Defining major trauma: A delphi study 29 (1) (2021) 1–20.
[20] M. Fry, G. Burr, Using the delphi technique to design a self-reporting triage survey tool, Accid. Emerg. Nurs. 9 (4) (2001) 235–241.
[21] A.J. Mackway-Jones, K.C. Mackway-Jones, An expert delphi study to derive a tool for mental health triage in emergency departments 37 (12) (2020) 738–743.
[22] S. Edwards, L. Swamy, M. Cosimini, B. Watsjold, T.M. Chan, Educator's blueprint: a how-to guide for creating analog serious games for learning in medical education, 7(6), https://search.proquest.com/docview/2897484749, 2023.
[23] ADE-foundation. https://ade-foundation.com/#/. (Accessed 24 May 2023).
[24] D.P. Thangavelu, A.J.Q. Tan, R. Cant, W.L. Chua, S.Y. Liaw, Digital serious games in developing nursing clinical competence: A systematic review and meta-analysis 113 (2022) 105357, https://doi.org/10.1016/j.nedt.2022.105357, 10.1016/j.nedt.2022.105357.
[25] S. Gürer, E. Surer, M. Erkayaoğlu, MINING-VIRTUAL: A comprehensive virtual reality-based serious game for occupational health and safety training in underground mines 166 (2023) 106226, https://doi.org/10.1016/j.ssci.2023.106226, 10.1016/j.ssci.2023.106226.
[26] M.C. Bhalla, J. Frey, C. Rider, M. Nord, M. Hegerhorst, Simple triage algorithm and rapid treatment and sort, assess, lifesaving, interventions, treatment, and transportation mass casualty triage methods for sensitivity, specificity, and predictive values, Am. J. Emerg. Med. 33 (11) (2015) 1687–1691.
[27] C.A. Kahn, C.H. Schultz, K.T. Miller, C.L. Anderson, Does START triage work? an outcomes assessment after a disaster, Ann. Emerg. Med. 54 (3) (2009) 424–430. e1.
[28] A. Garner, A. Lee, K. Harrison, C.H. Schultz, Comparative analysis of multiple-casualty incident triage algorithms, Ann. Emerg. Med. 38 (5) (2001) 541–548.
[29] W. Smith, Triage in mass casualty situations 30 (11) (2012) 413–415.
[30] E.B. Lerner, R.B. Schwartz, P.L. Coule, et al., Mass casualty triage: an evaluation of the data and development of a proposed national guideline 2 (S1) (2008) S25–S34.
[31] E.B. Lerner, R.B. Schwartz, P.L. Coule, R.G. Pirrallo, Use of SALT triage in a simulated mass-casualty incident 14 (1) (2010) 21–25.
[32] A.T. Society, N.A. of County, C.H. Officials, et al., Model uniform core criteria for mass casualty triage 5 (2) (2011) 125–128.
[33] C.H. McKee, R.W. Heffernan, B.D. Willenbring, et al., Comparing the accuracy of mass casualty triage systems when used in an adult population 24 (4) (2020) 515–524.
[34] J.D. Schenker, S. Goldstein, J. Braun, et al., Triage accuracy at a multiple casualty incident disaster drill: the emergency medical service, fire department of new york city experience 27 (5) (2006) 570–575.
[35] G. Cuttance, K. Dansie, T. Rayner, Paramedic application of a triage sieve: a paper-based exercise, Prehosp.Disaster Med 32 (1) (2017) 3–13.
[36] D.C. Cone, J. Serra, K. Burns, D.S. MacMillan, L. Kurland, C. Van Gelder, Pilot test of the SALT mass casualty triage system 13 (4) (2009) 536–540.
[37] D.C. Cone, J. Serra, L. Kurland, Comparison of the SALT and smart triage systems using a virtual reality simulator with paramedic students 18 (6) (2011) 314–321.
[38] L. Thompson, M. Hill, C. Davies, G. Shaw, M.D. Kiernan, Identifying pre-hospital factors associated with outcome for major trauma patients in a regional trauma network: an exploratory study 25 (1) (2017) 1–8.
[39] S.M. Sasser, R.C. Hunt, M. Faul, et al., Guidelines for field triage of injured patients: recommendations of the national expert panel on field triage 61 (1) (2011. . 2012) 1–20.
[40] Defence Health Agency, Tactical Trauma Assessment Skill Instructions, 2020.
[41] S.R. Platt, N.J. Olby, BSAVA Manual of Canine and Feline Neurology, British Small Animal Veterinary Association, 2014.
[42] L. Fritschi, L. Day, A. Shirangi, I. Robertson, M. Lucas, A. Vizard, Injury in australian veterinarians 56 (3) (2006) 199–203.
[43] D.J. Hill, R.L. Langley, W.M. Morrow, Occupational Injuries and Illnesses Reported by Zoo Veterinarians in the united states, 1998, pp. 371–385.
[44] J. Landercasper, T.H. Cogbill, P.J. Strutt, B.O. Landercasper, Trauma and the veterinarian, J. Trauma 28 (8) (1988) 1255–1259.
[45] P.D. McGreevy, C. Henshall, M.J. Starling, A.N. McLean, R.A. Boakes, The importance of safety signals in animal handling and training 9 (6) (2014) 382–387.
[46] S. Smith, Principles of capture, handling and transportation, in: BSAVA Manual of Wildlife Casualties, BSAVA Library, 2016, pp. 17–26.
[47] N. Caulkett, T. Shury, Human Safety during Wildlife Capture, 2014, pp. 181–187.
[48] Jr JL. Gilpen, H. Carabin, J.L. Regens, Jr RW. Burden, Agriculture emergencies: a primer for first responders 7 (2) (2009) 187–198.
[49] A. Nilsson, K. Åslund, M. Lampi, H. Nilsson, C. Jonson, Improved and sustained triage skills in firemen after a short training intervention 23 (1) (2015) 1–6.
[50] C.M. Brosinski, A.J. Riddell, S. Valdez, Improving triage accuracy: a staff development approach 31 (3) (2017) 145–148.
[51] M.R. Deluhery, E.B. Lerner, R.G. Pirrallo, R.B. Schwartz, Paramedic accuracy using SALT triage after a brief initial training 15 (4) (2011) 526–532.
[52] H.L. Tam, S.F. Chung, C.K. Lou, A review of triage accuracy and future direction 18 (1) (2018) 1–7.
[53] E. Mullineaux, Veterinary treatment and rehabilitation of indigenous wildlife, J. Small Anim. Pract. 55 (6) (2014) 293–300.
[54] E.A. Miller, Minimum Standards for Wildlife Rehabilitation, 2012.
[55] L. Stocker, Practical Wildlife Care, John Wiley & Sons, 2013.
[56] M.R. Baker, K.S. Gobush, C.H. Vynne, Review of factors influencing stress hormones in fish and wildlife 21 (5) (2013) 309–318.
[57] C.P. Teixeira, C.S. De Azevedo, M. Mendl, C.F. Cipreste, R.J. Young, Revisiting translocation and reintroduction programmes: the importance of considering stress, Anim. Behav. 73 (1) (2007) 1–13.
[58] D. Breed, L.C. Meyer, J.C. Steyl, A. Goddard, R. Burroughs, T.A. Kohn, Conserving wildlife in a changing world: understanding capture myopathy—a malignant outcome of stress during capture and translocation 7 (1) (2019) coz027.
[59] M. Cattet, J. Boulanger, G. Stenhouse, R.A. Powell, M.J. Reynolds-Hogland, An evaluation of long-term capture effects in ursids: implications for wildlife welfare and research, J. Mammal. 89 (4) (2008) 973–990.
[60] L.B. Mokkink, C.B. Terwee, D.L. Knol, et al., Protocol of the COSMIN study: COnsensus-based standards for the selection of health measurement INstruments 6 (1) (2006) 1–7.
[61] Mindgame. https://mindgame.eu/en/home-en/. (Accessed 24 May 2023).