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**Risk factors in equine transport-related health problems: a survey of the Australian equine industry.**

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29 **Background:** Transportation can affect equine health and is a potential source of economic loss  
30 to the industry.

31 **Objectives:** To identify journey (duration, vehicle, commercial/non-commercial) and horse (sex,  
32 age, breed, use, amateur or professional status) characteristics associated with development of  
33 transport-related health problems.

34 **Study design:** Cross-sectional online survey.

35 **Methods:** An online survey was conducted targeting amateur and professional participants in the  
36 Australian equine industry; eligible respondents organised horse movements at least monthly.  
37 They provided details of the last case of a transport-related health problem that had affected their  
38 horse(s). Associations between type of health problem, journey and horse characteristics were  
39 examined with multivariable multinomial regression analysis.

40 **Results:** Based on 214 responses, health problems were classified as injuries, muscular  
41 problems, heat stroke, gastrointestinal and respiratory problems, or death/euthanasia. Respiratory  
42 problems were reported most frequently (33.7%) followed by gastrointestinal problems (23.8%)  
43 and traumatic injuries (16.3%). The type of health problem was associated with journey-duration  
44 ( $P < 0.001$ ) and horse breed ( $P = 0.001$ ). Injuries were more likely to occur on short journeys,  
45 while more severe illnesses (gastrointestinal and respiratory problems or death/euthanasia) were  
46 more likely to occur on long journeys. Using Standardbreds as the reference group,  
47 Thoroughbreds, Arabians and Warmbloods were more likely to experience a severe illness than  
48 injury.

49 **Main limitation:** Self-selected participation in the study and self-reported nature of transport-  
50 related problems.

51 **Conclusion:** Horses undertaking journeys longer than 24 hours were at greater risk of developing  
52 severe disease or dying. Further studies are needed on long-haul transportation effects to  
53 safeguard the welfare of horses moved over long distances.

## 55 **Introduction**

56 Transportation is an integral part of many horse related activities, with horses being moved  
57 frequently [1] and for a wide range of reasons [2]. Horses transported frequently may become  
58 habituated to travel [3]. However, for other horses, the challenges associated with transport, such  
59 as confinement, noise and vibration [4] may trigger fear [5]. The physical and mental stressors

60 associated with transportation can result in adverse effects on the horses' health [6]. Fear may  
61 also trigger behaviours that put horses at risk of injury [7], ranging from small abrasions to  
62 catastrophic fractures [8]. The stress associated with transport, and the way in which horses are  
63 managed during transport [9-11], can contribute also to the development of potentially fatal  
64 infections of the respiratory [12] or gastrointestinal systems [13].

65 Transport's effects on physiological [14], behavioural [15], endocrine [16], reproductive [17],  
66 muscular [18], gastric [19], inflammatory [20] and respiratory parameters [9] have been  
67 described in many observational studies. In contrast, few epidemiological studies have been  
68 conducted. The incidence of and risk factors for health problems has been reported in horses  
69 being transported for slaughter [21-23]. The only epidemiological study on risk factors for the  
70 development of transport-related health problems during long haul transportation of horses for  
71 other purposes identified journey duration (more than 20 hours) and season (spring) as risk  
72 factors. However, the study reported only 47 cases [24]. Consequently, the relationship between  
73 journey and horse characteristics, and the risk of developing disease remains poorly defined. We  
74 collected data with an online questionnaire and examined associations between transport related  
75 health problems and journey and horse characteristics across a number of Australian equine  
76 industry sectors.

## 77

## 78 **Material and methods**

### 79 Study design and data collection

80 The study was a cross-sectional online survey conducted in Australia from June to September  
81 2015. Detail of the design and distribution of the cross sectional survey and the description of the  
82 demographic characteristics of the study population have been reported previously [25]. Briefly,  
83 the survey was digitised using SurveyMonkey<sup>a</sup>. The target population was people involved in  
84 any equine industry sector who had organised or participated in the movement of horses  
85 (commercially or non-commercially) at least monthly over the past two years. The respondents  
86 classified themselves as either professionals (people who were involved for financial reward,  
87 such as trainers, stud/farm managers) or amateurs (people involved as a hobby, such as riders,  
88 owners). An invitation letter and the link to the survey  
89 (<https://www.surveymonkey.com/r/SM9F9SJ>) were provided to several Australian horse sport

90 associations and were published on their websites. The link was also promoted through several  
91 horse magazines, relevant Facebook pages and online horse forums.

92 The questionnaire was divided into four parts: respondent details; management strategies pre-,  
93 during and post-transport; transport-related behavioural and health problems identified during  
94 and after transportation in the past two years; details of the most recent case including horse sex,  
95 age, breed, the use of the horse, the vehicle in which the horse was transported, the journey  
96 duration, and whether the horse was moved by a commercial or non-commercial carrier. The  
97 results for the first three parts are presented elsewhere [25]. The data collected within the first  
98 and fourth part of the questionnaire (Supplementary Item 1) are presented in the current report.

#### 99 Risk factors and outcome

100 Horse-level predictive variables were sex (mare/filly, gelding, stallion/colt), age (8-24 months, 2-  
101 5 years, 6-10 years, >10 years), breed (Arabian, Quarter horse, Standardbred, Thoroughbred,  
102 Warmblood, use (breeding, recreational non-competitive activities, Standardbred racing,  
103 Thoroughbred racing, endurance, equestrian competitive sport), and amateur or professional  
104 status.

105 Journey-level predictive variables were categorised according to the type of vehicle used (truck,  
106 horse trailer) and operator (commercial versus non-commercial transporter). The journey  
107 duration was categorised as: short (less than 8 hours), intermediate (8-24 hours) and long (more  
108 than 24 hours). These cut-offs were chosen on the basis of the European and Australian Code of  
109 Animal Transportation, in which the maximum journey durations without watering are of 8 and  
110 24 hours respectively [26; 27]. In Australia a rest stop of 12 hours is recommended after 12 and  
111 compulsory after 24 hours of journey [26]. Thus all reported multiday trips in this dataset  
112 included mandatory rest stops.

113 To categorise outcome, there was an open question in which the respondents reported a  
114 description of the signs and their veterinarians' diagnosis of any transport-related health problem  
115 that affected the horse. Based on the respondent's description, health problems were classified  
116 into six categories (injuries, muscular problems, heat stroke, gastrointestinal problems,  
117 respiratory problems, death/euthanasia) by an experienced equine veterinarian (B.P.; Table 1).

#### 118 Data analysis

119 Initial descriptive analysis was undertaken using statulator<sup>beta</sup>  
120 (<http://statulator.com/descriptive.html>). Associations between the predictive variables were  
121 explored using Contingency tables and  $\chi^2$  tests using GenStat<sup>®</sup> Version 14<sup>b</sup>.  
122 A multivariable multinomial regression analysis was constructed using SPSS Version 22<sup>c</sup> with  
123 health problem category as outcome with injuries as the reference level for comparisons. Vehicle  
124 and operator were excluded as they were found to be collinear with journey duration. Horse age,  
125 breed, sex, use, amateur or professional status and journey-duration were considered for  
126 inclusion in the final multinomial model. A stepwise backward elimination was then conducted  
127 to remove the least significant variable one at a time until all variables within the model had P  
128 value < 0.05. The data met with all assumptions for multinomial regression including that of IIA.  
129 The findings are presented as odds ratio (OR), confidence interval (95% CI) and P value for each  
130 predictive variable value.

131

## 132 **Results**

### 133 Population

134 Of the 797 responses to the survey, 214 included details of a transport-related health problem and  
135 these 214 records make up the database. The distribution of the data (including missing values)  
136 is reported in Supplementary Item 2.

137 The frequency of the health outcomes according to the predictive variables is shown in  
138 Supplementary Item 3. Ten horses died during transit: 8 were humanely destroyed due to  
139 fractures (5 limb, 1 pelvis, and 2 neck), and 2 were found dead. A further 15 horses were  
140 humanely destroyed within one week after the journey due to colic (5 cases), colitis (5 cases),  
141 and pneumonia (5 cases). Additionally, 7 deaths occurred within 24 hours after arrival, of which  
142 5 underwent post mortem examination, one was diagnosed with water intoxication; no cause of  
143 death was identified in the other four cases.

### 144 Journey variables

145 Journey duration was associated with vehicle (Pearson chi-square: 71.51, df = 2; P<0.001) and  
146 transport by a commercial company (Pearson chi-square: 78.74, df = 2; P<0.001). Companies  
147 transported fewer horses on short journeys and more horses on long journeys. The number of  
148 horses moved by horse trailer was larger for short journeys, and smaller for long journeys  
149 (Supplementary Item 4).

## 150 Factors associated with Health Outcomes

151 The final multivariate multinomial model for risk factors associated with health problems  
152 included journey-duration ( $\chi^2$ : 88.153, df:10,  $P < 0.001$ ) and breed ( $\chi^2$ : 46.087, df:20,  $P = 0.001$ ).  
153 None of the other predictive variables considered for inclusion reached significance. Figure 1  
154 shows the distribution of the different transport-related illness according to the journey duration  
155 category. Using injuries as reference, death/euthanasia (odds ratio, OR: 101.6, 95% confidence  
156 interval (CI):10.2-1010.5,  $P < 0.001$ ), gastrointestinal (OR:14.2, CI:1.5-133.8,  $P = 0.02$ ) and  
157 respiratory (OR:113.9; CI:12.2-1060.7,  $P < 0.001$ ) problems were more likely to occur on long  
158 journeys than on short journeys. Respiratory problems were also more likely (OR: 15.7, CI:4.3-  
159 56.7,  $P < 0.001$ ) to occur on intermediate journeys than on short journeys. Using the injury group  
160 as the reference, muscular problems were more likely to occur on an intermediate journey than  
161 on a short one (OR:5.8, CI:1.1-29.5,  $P = 0.03$ ). There was no significant difference among the  
162 journey-duration categories comparing injuries versus heat stroke (Supplementary Item 5).  
163 Using injuries as reference group, gastrointestinal problems were more likely to occur in  
164 Arabians (OR: 95.8, CI: 4.6-1990.3,  $P = 0.003$ ) and Warmbloods (OR: 43.0, CI: 3.8-485.9,  $P =$   
165 0.002) compared with Standardbreds. Respiratory problems were more likely to occur in  
166 Arabians (OR: 20.8, CI: 1.2-345.2,  $P = 0.034$ ), Warmbloods (OR: 18.5, CI: 2.5-136.89,  $P =$   
167 0.004), and Thoroughbreds (OR: 7.4, CI: 1.2-45.7,  $P = 0.031$ ) compared with Standardbreds.  
168 Death/euthanasia was more likely to occur in Thoroughbreds than in Standardbreds (OR; 7.5, CI:  
169 1.0-56.0,  $P = 0.048$ ) (Supplementary Item 5).

## 170 **Discussion**

171 This is the first study to investigate whether journey and horse characteristics were associated  
172 with transport-related health problems across a diverse range of Australian horses used for  
173 various activities undertaking different journeys. Journey duration and breed were identified as  
174 risk factors for the development of transport-related health problems, while horse sex, age, use  
175 and amateur or professional status were not predictors. The main finding of this study was the  
176 association between journey-duration and the nature of transport-related health problems,  
177 confirming that journeys longer than 24 hours pose the greatest risk of horses having serious  
178 health outcomes [24; 28]. The association between health problem category and breed should be  
179 considered preliminary, and warrants future research using a larger dataset.

180 The observation that shorter trips are associated with a higher risk of injury is in agreement with  
181 previous reports. In an epidemiological study conducted in Australia, injuries occurred more  
182 often at the beginning of a 3.5 day journey and that they were often related to behavioural  
183 problems [24]. Previous studies have also identified that behavioural problems and movement of  
184 the horse within the vehicle are greatest during the first hour of transportation, and that horses  
185 become habituated after 5 hours of transport [14; 17; 29; 30]. The higher risk of injuries during  
186 short trips is likely to be associated with behavioural problems and lack of habituation.

187 In this study muscular problems were reported to occur more often during non-commercial  
188 transport of non-racing horses, and the risk of muscular problem was greater for intermediate  
189 journeys compared with short journeys. The reasons for this cannot be ascertained from the  
190 available data, although it could be speculated that limitations in driver ability and in horse  
191 fitness could have contributed. In an electromyographic study on the effects of transportation on  
192 muscle, horses transported by less experienced drivers required more muscular effort to maintain  
193 balance compared with horses transported by expert drivers [18]. In another study it was found  
194 that the effort required to maintain balance during a 300 km journey had the same impact on  
195 muscles as a 1,500 metres canter, and caused a comparable increase in serum muscle enzyme  
196 activities [31]. The effects of journey-duration on muscular problems warrant future research.

197 Respiratory diseases were the most commonly identified problem in this study, a finding that  
198 agrees with previous studies [32; 33]. In our study the likelihood of respiratory problems was  
199 approximately 15 times greater on intermediate journeys and approximately 100 times greater on  
200 long journeys than on short journeys. The relationship between duration of transport and  
201 incidence of respiratory disease has been previously reported [6; 12; 34; 35] and our data  
202 confirm it. This relationship may relate to the head position of the transported horses, vehicle  
203 ventilation or air quality. If horses are restrained in a way that prevents them lowering their  
204 head, mucociliary clearance will be adversely affected [9]. Ventilation may be inadequate in  
205 many types of vehicles [36] resulting in an accumulation of dust, bacteria and noxious gases in  
206 the vehicle as journey length increases [11]. The ongoing high incidence of respiratory diseases  
207 suggest that more research is needed to identify how ventilation systems can be improved and  
208 how any periods of enforced head elevation can be shortened.

209 In agreement with our previous study [24], the risk of gastrointestinal and respiratory disorders  
210 and death/euthanasia was greater than the risk of injury for journeys longer than 24 hours. In



211 livestock the association between adverse outcomes and journey duration is influenced by the  
212 physiological and clinical state of the animal before and during journey, the management of  
213 feeding and watering, the opportunities animals have to rest and the thermal environment rather  
214 than journey length per se [28]. These factors may also be important in determining whether  
215 horses experience adverse outcomes as a result of transport. However, the reasons why some  
216 horses develop fatal diseases during and after a multi-day journey, while others remain healthy  
217 under the same conditions are unknown. Protracted transport stress may compromise the immune  
218 system and lead to psychological and physical exhaustion and death [35]. The use of  
219 immunostimulants before shipping has been found to be useful in reducing the incidence of  
220 transport-related pneumonia in horses transported for more than 24 hours [37]. Thus, the higher  
221 risk of severe diseases in horses transported for longer than 24 hours might be related to  
222 immunosuppression, and the relationship between long journeys and the immune system requires  
223 further investigation.

224 Compared with Standardbreds, Thoroughbred, Arabian and Warmblood horses were more likely  
225 to develop gastrointestinal and respiratory diseases than to be injured during transportation.  
226 Thoroughbreds were found at higher risk of transport pleuropneumonia in a previous study [12].  
227 Arabians have been found at higher risk of colic compared with other breeds [38]. There might  
228 therefore be a breed-predisposition for developing a particular type of transport-related diseases.  
229 However, our data should be considered preliminary and a larger data set would be required to  
230 determine the actual effects of breed on different types of transport related illnesses.

231 This study has a number of limitations that must be considered in interpreting the results. The  
232 problems of bias associated with self-selected participation in the study could not be addressed,  
233 nor could the possibility of response bias in the answers provided. It was not possible to check  
234 the diagnoses reported, nor was there any standardisation of the processes by which the  
235 diagnoses were made. The target population was not estimated and it was not possible to  
236 calculate a response rate, a common problem with online surveys [39]. Notwithstanding these  
237 limitations, this is the first study which analysed 214 cases with a novel approach and our  
238 findings may be important in helping reduce the negative impact of transportation on horse  
239 health.

240

241 **Conclusions**

242 There is an association between transport-related health problems and journey-duration and the  
243 likelihood of developing a more severe illness (i.e. respiratory and gastrointestinal problem or  
244 death/euthanasia) was higher on journeys over 24 hours than on journeys of less than 8 hours,  
245 suggesting the need to decrease the maximum journey time in Australia. This study also  
246 highlights the need for further research into the effects of long haul transport on the respiratory,  
247 gastrointestinal and immune systems to assist in proposing improved management practices for  
248 safeguarding horse welfare during travel, particularly over long distances.

249

#### 250 **Authors' declaration of interests**

251 No competing interests have been declared.

252

253

#### 254 **Ethical animal research**

255 The ethical aspects of this study have been approved by the Human Research Ethics Committee  
256 of the University of Sydney [2015/308].

257

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268 SurveyMonkey program.

269

#### 270 **Authorship**

271 B. Padalino, E. Hall, S. Raidal, P. Knight, P. Celi, L. Jeffcott, and G. Muscatello conceived and  
272 designed the survey; B. Padalino and E. Hall analysed the data, B. Padalino wrote the paper; E.  
273 Hall, S. Raidal, P. Knight, L. Jeffcott, and G. Muscatello edited the paper.

274

275

276 **Manufacturers' addresses**

277 <sup>a</sup>SurveyMonkey Inc., California, USA. ([www.surveymonkey.com](http://www.surveymonkey.com))

278 <sup>b</sup>VSNi International, Hemel Hempstead, Hertfordshire, UK.

279 <sup>c</sup>IBM SPSS

280 **Supplementary Information**

281

282 **Supplementary Item 1:** Questionnaire.

283 **Supplementary Item 2:** Data distribution.

284 **Supplementary Item 3:** Health outcomes.

285 **Supplementary Item 4:** Associations between journey variables.

286 **Supplementary Item 5:** Associations between health outcomes and horse and journey variables.

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433 **Table 1:** Categorisation of health problems observed in transported horses.

<b>Health problem category</b>	<b>Definition</b>
Injuries	Laceration, abrasion, contusion, swelling.
Muscular problems	Typing up, sore muscle, stiffness.
Heat stroke	Rectal temperature >38.5°C, sweating, lethargy.
Gastrointestinal problems	Oesophageal obstruction, gastric ulceration, diarrhoea, colic, enterocolitis.
Respiratory problems	Nasal discharge, coughing, inflammation/infection of the upper or lower respiratory tract, and pneumonia.
Death	Horses found dead or humanely destroyed.

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