

PROBABILISTIC DCS MODELS USING HIERARCHICAL OUTCOME SEVERITY

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INTRODUCTION

- ❖ USN dive data are graded as no-DCS, marginal DCS, and DCS [1].
- ❖ DCS can be mild (type I or type A) or serious (type II or type B – Table 1) but current probabilistic models do not differentiate risks according to severity.
- ❖ USN diving guidelines call for a maximum acceptable risk of mild and serious DCS of $P_m=0.02$ and $P_s=0.001$, respectively [2].
- ❖ We developed hierarchical probability models for estimating mild and serious DCS risk.

METHODS

- ❖ We developed a hierarchical DCS framework that allowed a single DCS model to give binomial (no-DCS, DCS), trinomial (no-DCS, mild DCS, serious DCS) or tetranomial (no-DCS, marginal DCS, mild DCS, serious DCS) risk predictions.
- ❖ We derived reconstructed multinomial likelihoods that allowed for the rigorous testing of our nested hierarchical severity framework.
- ❖ The LE1 model [3] was fitted with our binomial, trinomial, and tetranomial definitions to type I,II and type A,B gradings of mild and serious DCS (Table 1) of the BIG292 data set [1].

RESULTS

- ❖ The multinomial models were successful in simultaneously predicting the probabilities of mild and serious DCS (Fig. 1).
- ❖ Reconstructed likelihood tests revealed that the trinomial I,II and A,B models were a highly significant improvement over the binomial model ($p<0.0001$).

Manifestation	Occurrences	Type I,II	Type A,B
Serious neurological	18	38 Type II	20 Type B
Cardiopulmonary	2		
Mild neurological	18		
Pain	150	152 Type I	170 Type A
Skin	1		
Constitutional	1		
Total	190	190	190

Table 1. BIG292 DCS severity categories [1].

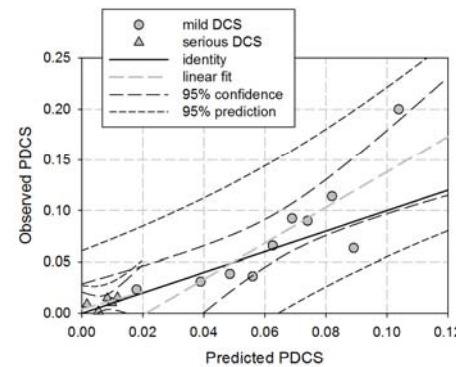


Figure 1. Observed vs. predicted mild and serious DCS from the trinomial A,B model.

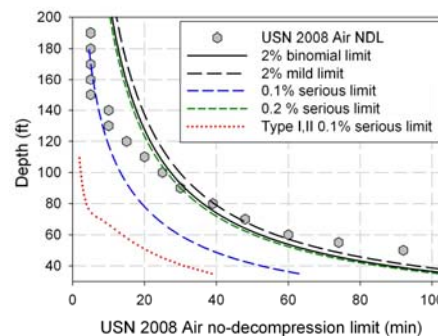


Figure 2. Trinomial model predictions of USN 2008 air no-decompression limits.

- ❖ Reconstructed likelihood tests revealed that the tetranomial I,II and A,B models were a highly significant improvement over the binomial model ($p<0.0001$).
- ❖ The 4-state tetranomial models gave a *worse* fit to the data than the 3-state trinomial models.
- ❖ The type I,II trinomial $P_s=0.001$ air no-decompression limit places an unreasonable restriction on dive operations (Fig. 2, red dotted line).
- ❖ The type A,B models were operationally inconsistent with the USN $P_s=0.001$ limit (Fig. 2, blue dashed line).
- ❖ Redefining the P_s limit from 0.001 to 0.002 for type A,B severity corrects the operational inconsistency (Fig. 2, green dashed line).

DISCUSSION

- ❖ Recommendation 1: Consider the trinomial model for predictions of mild and serious DCS as it is a highly significant improvement over the binomial model ($p<0.0001$).
- ❖ Recommendation 2: Consider adopting type A,B severity definitions and accept operationally consistent $P_m=0.02$ and $P_s=0.002$ limits.
or
Retain type I,II severity definitions accept operationally consistent $P_m=0.02$ and $P_s=0.005$ limits.

REFERENCES

1. Temple. NMRC 99-02. 1999.
2. Van Liew. UHM 32:187. 2000.
3. Thalmann. UHM 24. 1997.