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A Modified Bayesian Network model of a scenario study for risk management related to shark-human interactions

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Introduction

In our recently published article "A scenario study of the acceptability to ocean users of more and less invasive management after shark-human interactions" [1], Bayesian Network (BN) [2][3] was chosen as the principal analysis tool for identifying patterns from a study of 1769 valid responses from a survey which was open to all Australian residents aged 18 or over. The study was aimed to (1) Improve understanding of community attitudes in NSW to shark management options, and (2) Improve understanding of contextual influences on attitudes to shark bite mitigation approaches and how authorities should respond following an interaction. A modified BN model (26 nodes, 54 links) was proposed (implemented in Netica version 6.09 [4]) in this poster to improve the prediction performance of those four variables of risk management policy/strategy in the original BN model (26 nodes, 44 links) (implemented in Netica version 6.05 [1,5])

Description of the variables in the BN model

The full factorial combination of the five scenario variables creates 48 different shark-human interaction scenarios

- Human Use at location with two possible options: Imagine this happened today at a Patrolled Beach (P) or an Unpatrolled Beach (U).
- Recency of bite at location with two possible options: R = Recent such as where there have been two shark bites this year; T = Ten years since previous shark bite.
- Severity of harm with three possible outcomes: B = Bumped; I = Injured; K = Killed (by a Great White shark).
- Time of Day with two possible options: S = just after Sunrise; M = just after Midday.
- User Activity or Activity of victim with two possible options: U = victim Surfing at the time of the incident; W = victim Swimming close to share at the time of the incident.

The four options of support for shark management categories/strategies

- Support Education = Education and research (risk avoidance/responsibility)
- Support Noninvasive = Non-Invasive (monitoring and alerts)
- Support Invasive = Invasive (in-water shark nets, SMART drumlines)
- Support Pop Reduction = Population Reduction (culling, drumlines)

Respondents' personal factors

- Gender; Age; and Frequency of beach use.

Respondents' use of the beach or ocean

- There are 13 variables of this class which include any activities of: Boat Fishing, Swimming, Ocean Swimming, Surfing, Board, Beach Rock-fishing, Surf Life Saving, Tourism, Conservation, Body surfing, Land Based, Snorkel Scuba, Spear fishing.

Model development and modification

Determination of model structure

In the original model (Figure 1), without including the five scenario definition variables (namely **Human Use**, **Recency**, **Severity**, **Time of Day**, and **User Activity**), the **Scenario** node is designated as the target variable for determining the model structure via Netica TAN algorithm. Then, the five scenario definition variables were manually added into the model by linking to the target node.

In the modified model (Figure 2), upon the original model structure, ten extra links were further manually added to directly associate the **Gender**, **Age**, and **Frequency of beach use** nodes with the four shark management strategies nodes.

Estimation of model parameters

Netica EM algorithm was employed for parameter estimation based on the survey study data.

Improvement of model performance

At the cost of substantive increase in number of model parameters (7200 conditional probabilities estimated for the original model versus 19872 for the modified model), the modified model was able to achieve lower error rate results in predicting the outcomes of the four focus strategy variables (Table 1). Since the modified model counted for both the direct and indirect effects of the predictor variables on the response variables, the changes of the proportions of support for each of the four possible risk management strategies were more sensitive to the changes in the predictor variable such as Scenario, Age, Gender, or Frequency of Beach Visit (Table 2).

Table 1: Prediction Error Rate (%)

	Support Education	Support Noninvasive	Support Invasive	Support Pop Reduction
Original Model	2.32	7.46	8.93	6.11
Modified Model	1.41	6.50	6.56	2.21

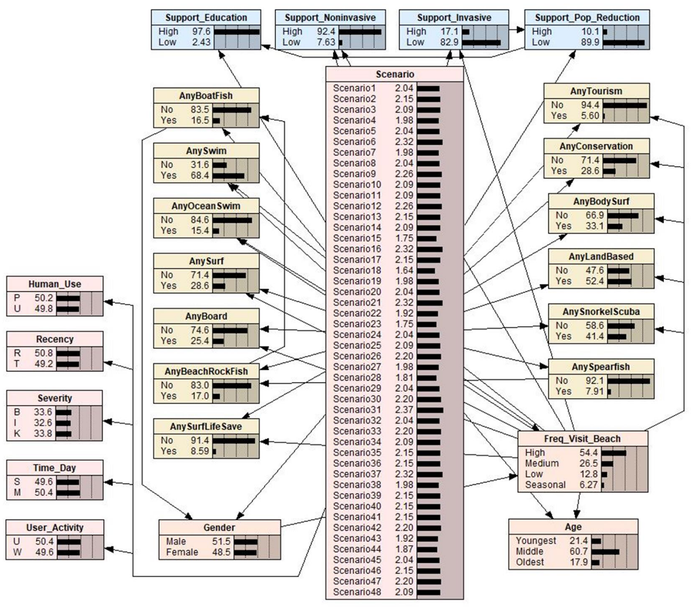

Figure 1: the original BN model: baseline condition

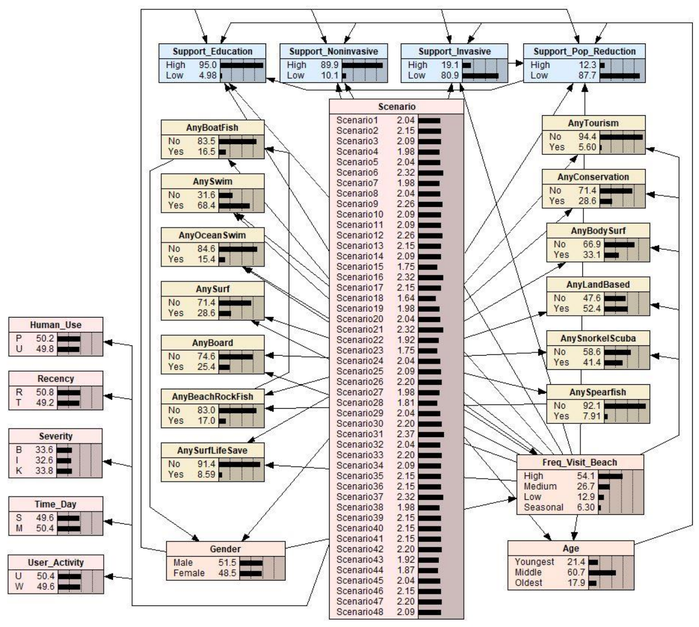

Figure 2: the modified BN model: baseline condition

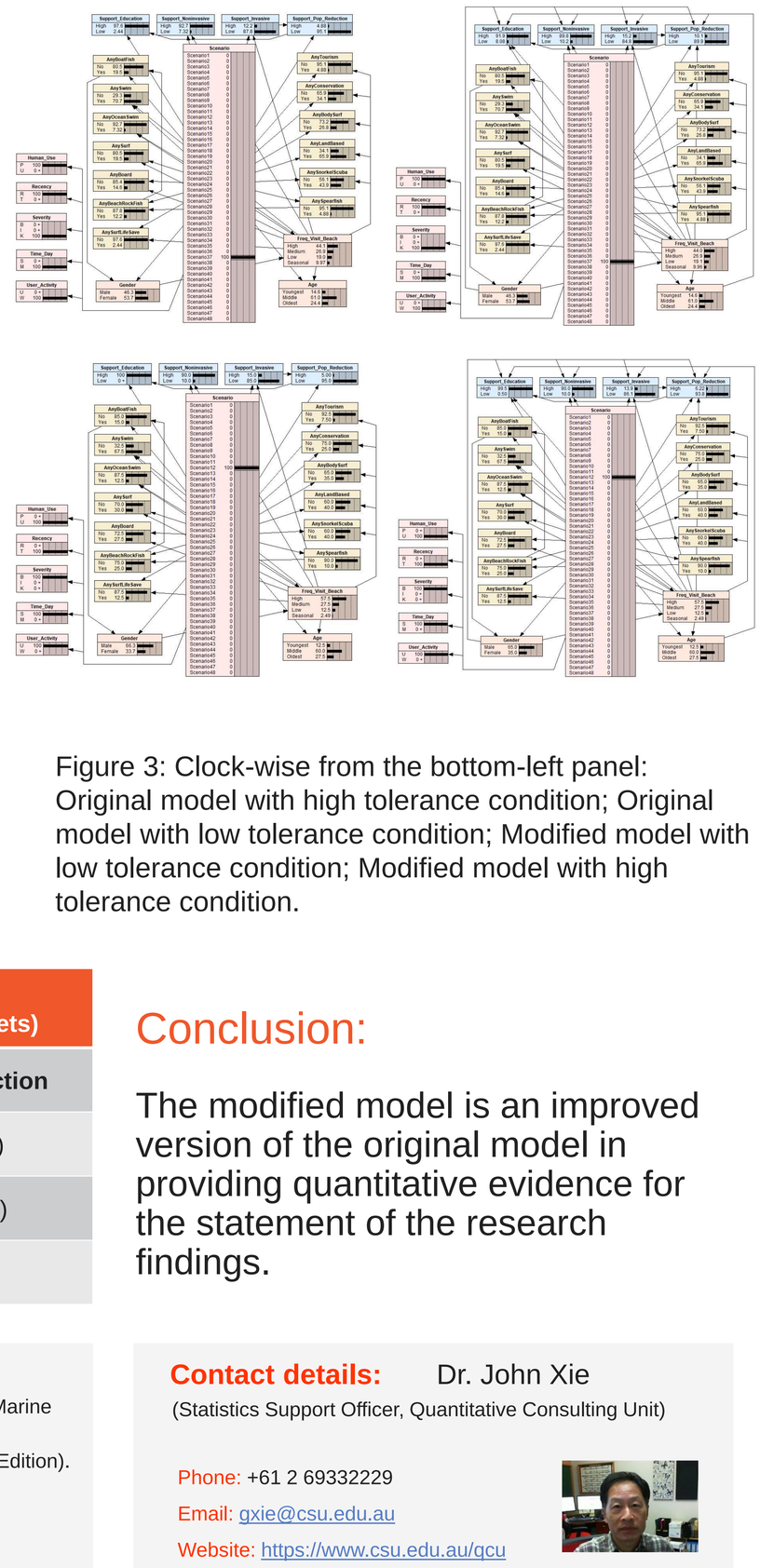

Figure 3: Clock-wise from the bottom-left panel: Original model with high tolerance condition; Original model with low tolerance condition; Modified model with low tolerance condition; Modified model with high tolerance condition.

Table 2 (refer to data analysis results presented in Figures 1- 3):
Preferences for shark management in high/low tolerance scenarios and baseline: original versus modified model (in brackets)

Condition	Education & research	Non-invasive	Invasive	Population reduction
Baseline	97.6% (95.0%)	92.4% (89.9%)	17.1% (19.1%)	10.1% (12.3%)
Low Tolerance	97.6% (91.9%)	92.7% (89.8%)	12.2% (15.2%)	4.88% (10.1%)
High Tolerance	100% (99.5%)	90.0% (90.0%)	15.0% (13.9%)	5% (6.22%)

Conclusion:

The modified model is an improved version of the original model in providing quantitative evidence for the statement of the research findings.

References

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