A LENS MODEL APPROACH FOR DISCRIMINATING VENOMOUS SNAKEBITES IN TAIWAN

Chih-Hsiang Hsu
Department of Industrial Engineering & Management, Yuan Ze University
135 Yuan-Tung Road, Chungli, Taoyuan, Taiwan 32003
Ableman0522@gmail.com

Ray F. Lin
Department of Industrial Engineering & Management, Yuan Ze University
135 Yuan-Tung Road, Chungli, Taoyuan, Taiwan 32003
Juifeng@satum.yzu.edu.tw

Rachel Pang
Department of Industrial Engineering & Management, Yuan Ze University
135 Yuan-Tung Road, Chungli, Taoyuan, Taiwan 32003
Achhiu99@gmail.com

ABSTRACT

Because of complicated exhibiting signs and clinical symptoms, physicians in Taiwan have difficulty making quick and correct judgments determining venomous snakebites. To help decision making of snakebites, this study aimed at developing lens models by using the statistical data of 282 snakebite cases reported by Hung (2002) . The occurrence percentages of the nine common exhibiting signs and clinical symptoms of seven individual snakebite categories were utilized to randomly generate 3500 simulated cases for model training and 700 cases for model testing. The developed lens models effectively predicted the snakebites of Daboia russellii siamensis (100%) and Bungarus multicinctus (98%), and fairly predicted the snakebites of Deinagkistrodon (69%), but poorly predicted the rest (below 27%). This study demonstrated the potential of lens model apprach for helping discriminating snakebites in Taiwan. To enhance model performance, empirical data with additional exhibiting signs and clinical symptoms should be collected.

KEYWORDS

Decision Making, Lens Model, Venomous Snakes, Snakebite, Physician Judgment

1. INTRODUCTION

Because Taiwan is located at the juncture of the tropical and subtropical regions, the weather is warm and humid. This climate thrives a variety of snake species. According to Chen (2010), every year approximately 3 to 5 hundred people were bitten by poisonous snakes. The six common poisonous snakes in Taiwan are Bungarus multicinctus (BM), Cobra, Trimeresurus mucrosquamatus (TM), Trimeresurus stejnegeri (TS), Deinagkistrodon (DK) and Daboia russellii siamensis (DRS). When the victims are sent to the emergency department for treatment, physicians have difficulty discriminating snakebites if the patient cannot bring the snake and cannot identify the snake from snake photos. To make judgment of snakebites, physicians utilize available cues, such as exhibiting signs and clinical symptoms. However, poisonous snakebites in Taiwan result in a variety of signs and symptoms. Even experienced physicians had difficulties memorizing all the clinical manifestations of viper poisoning, not to mention new physicians. Hence, the front line clinicians must depend on a strong back-end system to make correct judgments if possible.

2. LITERATURE REVIEW

2.1. VENOMOUS SNAKES IN TAIWAN

In Taiwan, there are approximately 59 species of snakes, in which poisonous snakes account for 23 species (14 kinds of land-based venomous snakes and 9 kinds of sea snakes). Among all the poisonous species, as reported in Jie (2009), Bungarus multicinctus (Figure-1a), Cobra (Figure-1b), Trimeresurus mucrosquamatus (Figure-1c), Trimeresurus stejnegeri (Figure-1d), Deinagkistrodon (Figure-1e), and Daboia russellii siamensis (Figure-1f) are the six most common venomous snakes. According to venom reactions, the six snake species are also classified into hemorrhagic vipers, neurological vipers and mixed vipers. The detail of these three vipers reported by (Chen, 2010) are summarized in the following sections.

Figure 1 – Six most common venomous snakes in Taiwan (source: Jie, 2009)

2.1.1. Hemorrhagic Vipers

Hemorrhagic snakes refer to Trimeresurus mucrosquamatus, Trimeresurus stejnegeri and Deinagkistrodon. Trimeresurus mucrosquamatus lives in an altitude around 1000 meters in Taiwan. They mainly inhabit the land reclamations by the brooks and the forests. Trimeresurus stejnegeri distributes in low altitudes below 1500 meters in Taiwan. Deinagkistrodon, common in the southern and eastern parts of Taiwan, inhabits in broadleaf forests, bamboo forests, and valleys with less interference.

Hemorrhagic snakebites could result in a variety of exhibiting signs and clinical symptoms, including swelling, bruises, bleeding wounds, pains, cellulitis, tissue necrosis, circulation disorders, drop in blood pressure, shock, gastrointestinal bleeding, extension of blood coagulation, hematuria, hemoptysis, rhabdomyolysis, impairment of kidney function, and acute renal failure. These diverse signs and symptoms make difficulties discriminating snakebites, especially between Trimeresuurus Mucrosquamatus and Trimeresurus Stejnegeri. The clinical symptoms of these two species are very similar and the available information of differential diagnosis is limited.

2.1.2. Neurological Vipers

Neurological snakes include Bungarus multicinctus and Cobras. Bungarus multicinctus distributes all over Taiwan, Kinmen, and Matsu. Further, Bungarus multicinctus likes forests, bamboo forests and swampy areas at a low altitude of 1000 meters. Cobras distributes below an altitude of 1000 meters, but Cobras is uncommon in northern. Clinical symptoms of neurological vipers are muscle paralysis, eyelid paralysis, respiratory muscle paralysis, speech and swallowing difficulties. However, after bitten by neurological snakes, there are no exhibiting signs, no pain, and no swelling.

2.1.3. Mixed Poisonous Vipers

Daboia russellii siamensis is the only common venomous snake species classified in the category of mixed poisonous snakes. Compared to hemorrhagic snakes and neurological snakes, mixed poisonous snakes could be discriminated more effectively. Bitten by Daboia russellii siamensis would lead to serious coagulation abnormalities. Physicians can discriminate the snakebites based on this clinical symptom.

2.2. SNAKEBITDIAGNOSIS DIFFICULTY

Discriminating snakebites is difficult for the physicians in Taiwan. In most domestic hospitals, physicians diagnose poisoning cases directly based on informed signs and symptoms by patients. Although physicians could obtain more persuaded information by sending the specimen for inspection, the inspection takes times and patients would miss the proper time for treatment. While making judgment based on exhibiting signs and clinical symptoms, as mentioned previously, signs and symptoms are complicated and occur across snake species. It is difficulty for physicians to memorize all combinations of signs and symptoms caused by individual venomous snake. Even though physicians can memorize the combinations, snakebites of certain venomous snakes do not always result in same signs and symptoms; the occurrence of signs and symptoms vary according to patient characteristics. Hence, the snakebites diagnosis is so difficult even experienced physicians cannot always make quick and correct judgments. The development of a decision-making system should help physicians discriminate snakebites.

2.3. LENS MODEL BACKGROUND

The framework of lens model was developed by the Brunswik (1952) who study human behavior of judgment (Guo, 2003). As mentioned in Bisantz et al. (2000), Brunswik's lens model with its extensions (Bmnswik, 1955; Cooksey, 1996; Kenneth R. Hammond et al., 1975) apply linear models to describe judgment behavior. Human's judgment and the actual outcomes are described as linear combinations of environmental cues (i.e., available information in the environment). Because the model can capture both the relationships of judgment strategy and the environmental structure to environmental cues, the comparison of the relationships can utilized to understand the policies of individual judgment, to measure the quality of judgment, and to explain the reasons for differences in judgment and actual results.

As shown in Figure-2, the three basic elements of the lens model are the cues (x_1, x_2, …, x_n) available in the environment, actual outcomes (Y_e), and the decisions (Y_s). Two linear regression models are built to represent two linear relationships, in which one is between cues and the actual outcomes (Y_e) and human's linear predictions of the outcomes (Y_t), and other one is between the cues and the human decisions (Y_s) and generates the linear predictions (Y_f) of the human decisions. The obtained four sets of Y values can be further used to obtain five correlation indices. Each of index can be used to evaluate certain aspect of a decision maker's judgment performance (see Tucker, 1964 for more details).

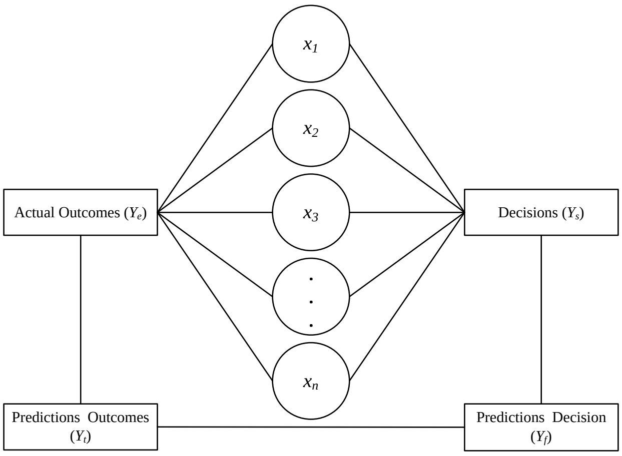

Figure 2 – Lens model

2.4. APPLICATIONS OF LENS MODEL

Lens model and its extensions have been widely applied to a variety of domains, such as dynamic judgment tasks (Bisantz et al., 1997; Bisantz et al., 2000), social policy making (Brehmer, 1986; Dalgleish, 1988; Kenneth R Hammond, 1996; Kenneth R. Hammond and Stewart, 1975; Rohrbaugh, 1988), control of the reservoir (Jha et al., 2001), children's reading achievement judge (Cooksey et al., 1985), weather forecasting (Stewart et al., 1992), educational judgments(Cooksey et al., 1986), and decision of purchasing goods (Tapp, 1984).

Lens model has been also applied widely to the field of clinical. For example, Hirsh et al. (2011) used lens model to assess how medical staff use patients characterization and facial expression to make pain judgment. Speroff et al. (1989) used a number of cues and clinical data to build a lens model that conferred the experience relationship between clinical data and physiological measures of hemodynamic status. Furthermore, Werner et al. (1983) analyzed 30 psychologists and psychiatrists' judgment of psychiatric patients' imminent dangerousness. These applications show the effectiveness of lens model for predicting and helping human judgment.

2.6. RESEARCH OBJECTIVE

The main purpose of this study was to utilize lens model approach to establish a decision support model for helping discriminating six common venomous snakebites in Taiwan. Lens model has been approved that it can effectively predict human decision-making. Hence, our goal was to analyze exhibiting signs and clinical symptoms caused by the domestic venomous snakebites and to confer the weights of the influential cues to establish lens models of snakebites screening.

3. METHOD

3.1. DATA GENERATION

The statistic data, the occurrence percentages of the nine common signs and symptoms of seven individual snakebite categories, reported by Hung (2002) was utilized. To note, in addition to the six common venomous snakes in Taiwan, a category, "undefined", was added for the snakebite cases that could not be defined. Hung (2002) reported 282 snakebite cases collected in Taichung veterans general hospital from 1993 to 2000. As shown in Table-1, when bitten by the six common venomous snakes, nine common signs and symptoms are fang marks, swelling, blood stasis, blister or blister with blood, muscle weakness, respiratory failure, subcutaneous bleeding, dizziness or headache, and local necrosis. The occurrence percentages of the sign and symptom of seven individual snakebite categories are listed in the table.

To build lens models, the occurrence percentages were used to randomly generate 600 simulated cases for each snakebite category. Each snakebite case had specific signs and symptoms randomly determined according to the occurrence percentages of certain snakebite category. Hence, there were totally 4200 simulated snakebite cases, in which 3500 cases were used for model training and 700 cases were used for model testing.

3.2. CUE WEIGHT CALCULATION

The 3500 simulated snakebite cases were first utilized to determine the influential cues of each snakebite category by regression analysis. In the process of model development, all the 3500 cases were used for training individual models. However, for certain snakebite model, only the cases of that snakebite cases were set as the signal, and the remanding cases of other snakebites were set as noise. If there was no significant effect of cues (i.e., signs and symptoms), the cues were assigned a cue weight value at zero for that snakebite category (see Table-2). For example, while building the lens model of Bungarus Multinctus, the signs or symptoms that had significant effects on judgment were swelling ($p<0.05$), muscle weakness ($p<0.05$) and respiratory failure ($p<0.05$) after regression analysis. The remaining cues, including fang marks, blood stasis, blister or blister with blood, subcutaneous bleeding, dizziness or headache, and local necrosis, were not significant and thus were assigned a weight value at zero.

Once influential cues were determined, the next step was to compute the weight value of ω^2, which represents the extent to which the clue affects the judgment. According to Equation-1, the high value of ω^2 means the high influence of that cue in making judgment. The cues in the formula represent the exhibiting signs and clinical symptoms of snakebites.

$$\omega^2 = (SS_{cue} - (N-1)MSE)/(SSTO + MSE) \quad (1)$$

where, SS_{cue} is a cue sum of square, SSTO is sum of square Total, MSE is mean of square error, and N is cue number.

Table 1 – Occurrence percentages of the nine common signs and symptoms for seven individual snakebite categories in Taiwan

Occurrence(%)	Cobra	BM	TM	TS	DK	DRS	Undefined
Fang marks	72	64	76	86.5	100	100	67
Swelling	63	12	76	86.5	100	100	37
Blood stasis	14	4	34	16	75	100	12
Blister or blister with blood	15		11	3	50		8
Muscle weakness		96					
Respiratory failure		96					
Subcutaneous bleeding			16				
Dizziness or headache	24			24			
Local necrosis	26.2						

3.3 MODEL TESTING

After lens models of seven snakebite categories were established with influential cues and relative weights, the remanding 700 simulated cases were then utilized to test model performance. To discriminate each snakebite case, the occurrences of signs and symptoms of that case were first simultaneously assigned to all the seven lens models. Each model would obtain a final score that representing the extent to which the judged case related to the certain snakebite category. The final decision of the judged snakebite cases would make for the model that obtained the highest final score. After discriminating 700 simulated cases, the correct rates of seven types of snakebites were calculated.

4. RESULTS

4.1. DEVELOPED LENS MODELS

The influential cues with cues weights of seven snakebite lens models are shown in Table-2. As shown in the table, not all signs or symptoms were important for all the snakebite categories. For those cues that were not important, as mentioned previously, the cue weights were assigned a value at zero. For instance, Figure-3 shows the lens model of Bungarus multicinctus. The influential cues of this snakebite category were swelling, muscle weakness, and respiratory failure. To note, the uninfluential cues (marked in gray shade) of Bungarus multicinctus do not mean these cues would not occur after bitten. Instead, the occurrence of these cues does not help discriminating snakebites. For example, although fang marks is a common signs after bitten by Bungarus multicinctus, it is not an influential cue for helping discriminating.

4.2. MODEL PERFORMANCE

Figure-4 shows the correct rates for discriminating the seven snakebite categories. As shown in the figure, the models effectively predicted the snakebites of Daboia russellii siamensis (100%) and Bungarus multicinctus (98%), and fairly predicted the snakebite of Deinagkistrodon (69%). However, for the remaining snakebites, the models had poor predictions. The correct rates of Trimeresurus Stejnegeri, Cobra, undefined snakebites, and Trimeresurus mucrosquamatus were 27%, 20%, 16%, and 8%, respectively.

Table 2 – Obtained cue weights of lens models for seven snakebite categories

Sings & Symptoms	Cobra	BM	TM	TS	DK	DRS	Undefined
Fang marks	3.07	0	0.44	3.11	11.77	10.58	6.29
Swelling	-0.29	25.44	0	15.79	17.54	15.73	18.92
Blood stasis	10.51	0.00	0.06	43.38	20.11	55.73	5.67
Blister or blister with blood	0	0.00	0	8.65	48.76	15.73	-0.79
Muscle weakness	17.10	73.23	16.77	0	0	0	49.07
Respiratory failure	0	1.33	0	0	0	0	0.18
Subcutaneous bleeding	1.78	0	72.80	2.77	0.69	1.37	2.39
Dizziness or headache	18.15	0	7.45	26.29	0.96	0.86	11.73
Local necrosis	49.68	0	2.49	0.00	0.18	0.00	6.55

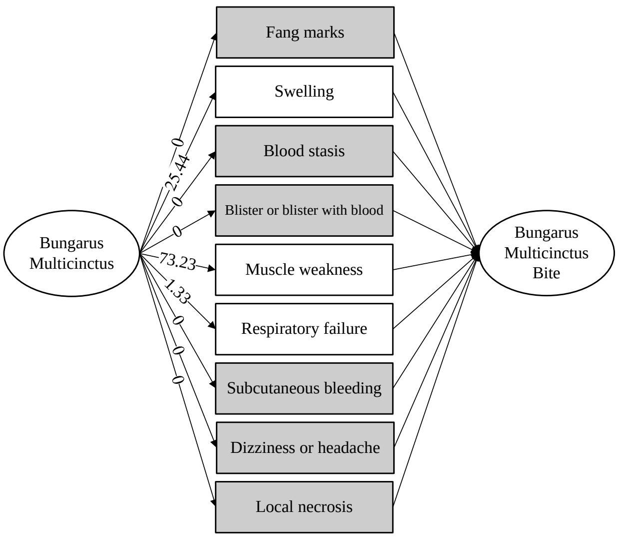

Figure 3 – Lens model of Bungarus multicinctus

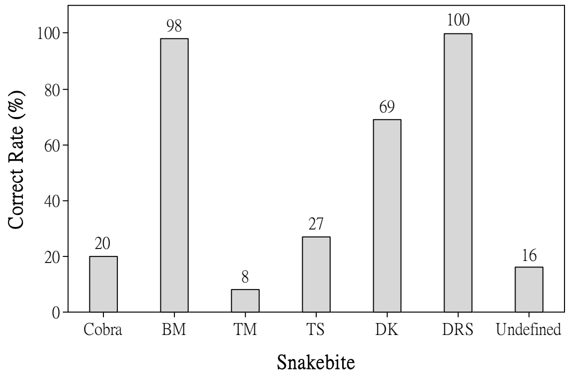

Figure 4 – Models performance of discriminating snakebites

5. DISCUSSION AND CONCLUSIONS

This study utilized lens model approach to establish seven lens models, in which six models referred to the six common venomous snakes in Taiwan and one model referred to the snakebites that could not be defined in the data reported by Hung (2002). When simulated data were utilized to develop models, this study showed the potential application of lens model approach to build a decision support system for helping discriminating venomous snakebites in Taiwan.

Our developed lens models effectively predicted the snakebites of Daboia russellii siamensis and Bungarus multicinctus. The two types of snakebites had respective influential cues that effectively help discrimination. As shown in Table-2, blood stasis is a signature cue for the snakebite by Daboia russellii siamensis, whereas muscle weakness is a signature cue for Bungarus multicinctus. The models fairly predicted the snakebites of Deinagkistrodon. When bitten by Deinagkistrodon, several signs and symptoms could occur, decreasing the correct rate of judgment. However, the models predicted poorly of the remaining snakebite categories. Because the snakebites of Cobra, Trimeresurus stejnegeri, and Trimeresurus mucrosquamatus result in similar exhibiting signs and clinical symptoms, the developed models had difficulty making correct judgements.

To enhance the model prediction, empirical data with sufficient signs and symptoms should be collected. The analysed data utilized in this study were generated based on the occurrence percentages statistically reported in the literature. However, the simulated data may not be able to represent real snakebite cases. For example, in our way to generate the simulated snakebite cases, we assumed the occurrences among signs and symptoms were independent. However, this assumption could be incorrect. The occurrence of a sign may have certain degree relate to the occurrence of another symptom. Furthermore, the nine exhibiting signs and clinical symptoms utilized in this study were limited to the data reported by Hung (2002). Although these signs and symptoms occur the most frequently, other signs and symptoms that did not reported by Hung (2002) may play critical roles for discriminating snakebites. Therefore, empirical snakebite profiles with completed signs and symptoms should enhance the model comprehension.

Future research should develop high-performance model for clinical testing. The validated model should help physicians make decisions of discriminating snakebites and perform correct serum treatment. The developed models could develop a program in a website format or as a mobile APP. While diagnosing, physicians can input patient exhibiting signs and clinical symptoms into the program, and the model could immediately provide suggestions for helping decision-making, increasing survival rates.

7. ACKNOWLEDGEMENT

The authors would like to thank the Taiwan National Science Council (NSC 101-2221-E-155-006) for funding the paper submission and presentation.

REFERENCES

Bisantz, A. M., Gay, P., Phipps, D. A., Walker, N., Kirlik, A.and Fisk, A. D.,“Specifying training needs in dynamic judgment tasks using a lens model approach”, Institute of Electrical and Electronics Engineers,Vol. 2,No., 1997, pp 1849-1854

Bisantz, A. M., Kirlik, A., Gay, P., Phipps, D. A., Walker, N.and Fisk, A. D.,“Modeling and analysis of a dynamic judgment task using a lens model approach”, Institute of Electrical and Electronics Engineers,Vol. 30,No. 6, 2000, pp 605-615

Bmnswik, E.,“Representative design and probabilistic theory in a functional psychology”, Psychological Review,Vol. 62,No. 3, 1955, pp 193-217

Brehmer, B.,“Social judgment theory and the analysis of interpersonal conflict”, Psychological Bulletin,Vol. 83, 1986, pp 985-1003

Brunswik, E. “The conceptual framework of psychology”, (Vol. 1), University of Chicago Press Chicago, 1952

Chen, Y. J.,“Common treatment advances of snake bites in Taiwan”, Taipei Veterans General Hospital school news,Vol. 155,No., 2010, pp 15-28

Cooksey, R. W. “Judgment analysis: Theory, methods, and applications”, Academic Press San Diego, CA, US, 1996, pp 407

Cooksey, R. W. and Freebody, P.,“Cue subset contributions in the hierarchical multivariate lens model: Judgments of children's reading achievement”, Organizational Behavior and Human Decision Processes,Vol. 39,No. 1, 1985, pp 115-132

Cooksey, R. W., Freebody, P.and Davidson, G. R.,“Teacher's prediction of children's early reading achievement ”, American Educational Research Journal,Vol. 23, 1986, pp 41-64

Dalgleish, L. I.,“Decision making in child abuse cases: Application of social judgment theory and signal detection theory”, Human Judgment: The SJT View, B. Brehmer and C. R. B. Joyce, Eds. Amsterdam, The Netherlands: North-Holland, 1988, pp 317-360

Guo, J. M. “Policy capturing on budget management performance judgment－an application study of lens model”. ROC National Defense University. 2003

Hammond, K. R. “Human Judgment and Social Policy”, New York: Oxford Univ. Press, 1996

Hammond, K. R. and Stewart, T. R. “Social Judgment Theory”, New York: Academic Press, 1975

Hirsh, A. T., Callander, S. B.and Robinson, M. E.,“Patient demographic characteristics and facial expressions influence nurses' assessment of mood in the context of pain: A virtual human and lens model investigation”, International Journal of Nursing Studies,Vol. 48,No. 11, 2011, pp 1330-1338

Hung, Z. D. “Studies on the diagnosis, treatment and toxic meachanism of Taiwan venomous snakebites”. National Taiwan University. 2002

Jha, P. and Bisantz, A. M. (2001). Modeling fault diagnosis in a dynamic process control task using a multivariate lens model. Paper presented at the Proceedings of the Human Factors and Ergonomics Society Annual Meeting.

Jie, A. (2009). Six most common venomous snakes in Taiwan

Rohrbaugh, J.,“Cognitive conflict tasks and small group processes”, Human Judgment: The SJT View, B. Brehmer and C. R. B. Joyce, Eds. Amsterdam, The Netherlands: North-Holland, 1988, pp 199-226

Speroff, T., Connors, A. F.and Dawson, N. V.,“Lens model analysis of hemodynamic status in the critically III”, Med Decis Making,Vol. 9,No. 4, 1989, pp 243-252

Stewart, T. R., Heideman, K. F., Moninger, W. R.and Reagan-Cirincione, P.,“Effects of improvedinformation on the components of skill in weatherforecasting”, Organizational Behavior and Human Decision Processes,Vol. 53, 1992, pp 107-134

Tapp, S. R.,“Brunswik's lens model: A review and extension to consumer research”, Advances in Consumer Research,Vol. 11, 1984, pp 103-108

Tucker, L. R.,“A suggested alternative formulation in the developments by Hursch, Hammond, and Hursch, and by Hammond, Hursch, and Todd”, Psychological Review,Vol. 71,No. 6, 1964, pp 528-530

Werner, P. D., Rose, T. L.and Yesavage, J. A.,“Reliability, accuracy, and decision-making strategy in clinical predictions of imminent dangerousness”, Journal of Consulting and Clinical Psychology,Vol. 51,No. 6, 1983, pp 815-825