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Evaluating Non-Confounded Association of an Attribute and a Class Variable Using *Partial* UniODA

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Partial UniODA is a *two-step procedure* for: (a) identifying the exact statistical model that explicitly maximizes accuracy (normed against chance) achieved for the sample by using an attribute to classify observations' actual class categories; while (b) simultaneously "controlling for" (eliminating) the effect of a confounding variable. *Step One* drops observations correctly classified using the confounder to predict class category: observations in the reduced sample *weren't* correctly predicted by the confounder. *Step Two* investigates the non-confounded relationship underlying attribute and class variable using the reduced sample.

This demonstration of the use of partial UniODA to obtain non-confounded bivariate attribute-class variable association models is illustrated using data taken from a study of the factors affecting self-rated likelihood of a discharged Emergency Department (ED) patient recommending the ED to others.[1-3] Research has reported that waiting time to see the physician—which in part is a function of case-mix and not subject to physician control—is consistently a moderate/strong predictor of patient satisfaction and recommendation ratings.[2-9] The present research objective is to assess which (and how) different aspects of *putatively controllable* physician behavior accurately predict whether or not patients report they are likely to recommend the ED to others, independently of waiting time. Thus, it is desired in this example to statistically control for waiting time and to identify factors under physician control that influence patient recommendation ratings above and beyond—that is, independently of—the effect of waiting time to see the physician.

Methods

The setting of the study was an 800-bed urban university-based level 1 Trauma center with annual census of 48,000 patients.[2] Patients were mailed a survey assessing satisfaction with care received in the ED after one week post-discharge. The survey elicited ratings of the likelihood of recommending the ED to others, and of satisfaction with aspects of administration,

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nurse, physician, laboratory, and family/friend care. A 17% return achieved over a six-month period yielded 2,109 surveys with a patient's self-rating of the likelihood that they will recommend the ED to others. This rating was assessed using a five-point Likert-type scale on which scores of 3 (*fair*, N=239) indicate *ambivalence*; and scores of 4 (*good*, N=584) reflect *likely to recommend*.

For brevity of exposition only the satisfaction ratings of aspects of care received from physicians (p1=waiting time; p2=courtesy; p3= took patient's problem seriously; p4=concern for comfort; p5=explanation of test/treatment; p6=explanation of illness/injury) were used as attributes. Satisfaction items were completed using five-point Likert-type scales: 1=*very poor* satisfaction, 2=*poor*, 3=*fair*, 4= *good* and 5= *very good* satisfaction.

Confounded Association

For the total sample of 823 patients the first analysis obtains raw bivariate relationships between the class variable (recommendation rating of 3 versus 4: called "recom" below), and patient ratings of satisfaction with waiting time (p1—the confounding variable) as well as five aspects of physician behavior (p2-p6). This analysis was accomplished by the following UniODA[1] (and MegaODA[10-13]) code:

```
OPEN recom.dat;
OUTPUT recom.out;
VARS recom p1 to p6;
CLASS recom;
ATTR p1 to p6;
MISSING all (-9);
MC ITER 10000;
GO;
```

As expected the UniODA model for p1 (waiting time, the confounding variable) was statistically significant ($p<0.0001$) and yielded a moderate level of accuracy: the effect strength for sensitivity (ESS) statistic (0=the accuracy obtained by chance; 100=perfect accuracy) indicates this model achieves 30.8% of the theoretical possible improvement in accuracy beyond what is obtained by chance for this sample and analysis—which is considered a moderate effect strength.[1] The UniODA model was: if waiting time rating≤3 (fair) then predict that recommendation=3 (ambivalent); and if waiting time rating>3 (good, very good) then predict recommendation=4 (recommend ED). Table 1 presents the confusion matrix for this model predicting patent recommendation as a function of waiting time.

Table 1: UniODA Analysis of Recommendation Rating as a Function of Waiting Time

		Predicted Recommendation	
		3	4
Actual	3	173	65
Recommendation	4	241	334

As seen, when the model predicted a recommend rating of 3 a total of 173 observations were correctly classified, and when the model predicted a recommend rating of 4 a total of 334 observations were correctly classified.

In addition, raw analysis suggested that all five measures of physician behavior were statistically significant predictors of patient recommendation rating (ps<0.0001), and all attributes generated the same UniODA model (direction and threshold values) obtained for waiting time. ESS values indicated moderate effects[1] for explanation of test/treatment (ESS= 28.1) and explanation of illness/injury (31.3), and relatively weak effects[1] for courtesy (20.3), took patient's problem seriously (24.5), and concern for comfort (22.6). These findings suggest that all five measures of physician behavior are statistically reliable predictors of patient recommendation of the ED to others.

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However, it should be noted that the effect strength of these associations involving physician behaviors is lower than was obtained for waiting time, for all except for the measure of explanation of illness/injury. Furthermore, the confounding variable—waiting time, is associated with the five measures of physician behavior. These models were obtained using the following UniODA (and MegaODA) program:

```
OPEN recom.dat;
OUTPUT recom.out;
VARS recom p1 to p6;
CLASS p1;
ATTR p2 to p6;
MISSING all (-9);
MC ITER 10000;
GO;
```

The models obtained for all five ratings of physician behavior were statistically reliable. The collinear effect for ratings of courtesy was relatively strong (p<0.0001, ESS=50.0); and was moderate for ratings of explanation of test/ treatment (p<0.0001, ESS=39.4), took patient's problem seriously (p<0.0001, ESS=38.8), explanation of test/treatment (p<0.0001, ESS= 37.0), and concern for comfort (p<0.001, ESS= 28.5). The strong association of the confounding variable to patient recommendation rating, and also to the various rated aspects of physician behavior, underscores the importance of controlling waiting time to assess the independent (partial) association of ratings of physician behavior and patient recommendations.

Non-Confounded Association

In Table 1, note that when the model based on waiting time predicted a recommend rating of 3 a total of 241 observations were misclassified, and when the model predicted a recommend rating of 4 a total of 65 observations were misclassified. These 306 "residual observations" are statistically independent of waiting time—they are the portion of the original sample that remains after statistically "controlling for" or "partialling out" (eliminating) the effect of waiting time from the sample. In the reduced sample of 306 patients (recom2.dat) the second analysis identifies the non-confounded bivariate relationships between the class variable and five attributes—patient ratings of satisfaction with five aspects of physician behavior (p2-p6). This analysis was accomplished by the following UniODA/MegaODA code:

```
OPEN recom2.dat;
OUTPUT recom.out;
VARS recom p1 to p6;
CLASS recom;
ATTR p2 to p6;
MISSING all (-9);
MC ITER 10000;
GO;
```

Non-confounded analysis revealed that there was no statistically reliable association between recommend rating and physician courtesy (p<0.46) or concern for comfort (p<0.29). However, ratings of whether the physician took the patient's problem seriously (ESS=16.7), and explanation of test/treatment (ESS=24.3), and of illness/injury (ESS=19.8) were statistically significant (p<0.00001), relatively weak predictors of patient recommendation rating, after statistically eliminating the effect of the confounding variable of waiting time from the sample data. These results also provide evidence supporting the incremental validity of physician behavior in taking patients' problems seriously and in explaining tests, treatments, illnesses, and injuries, as predictors of patient satisfaction over and above the effects of waiting time.

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Author Notes

This study involved secondary data analysis of published de-identified data and was exempt from Institutional Review Board review.

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