

Emergency Severity Index (Version 3) Score Predicts Hospital Admission

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Hospital admission status, Emergency Severity Index (ESI) Version 3 triage score, and binary indicators of whether lab work or radiological examinations were completed in the Emergency Department (ED), were available for 160,471 patients seen over a three-year period in the ED of a leading community teaching hospital in Toronto. Hierarchical CTA conducted for these data yielded ESS=63.8, a relatively strong effect. The model correctly classified 80.2% of the admitted patients, and 83.6% of the patients who weren't admitted. The model was correct 60.1% of the time that it predicted that a patient would be admitted, and correct 93.2% of the time that it predicted that a patient wouldn't be admitted.

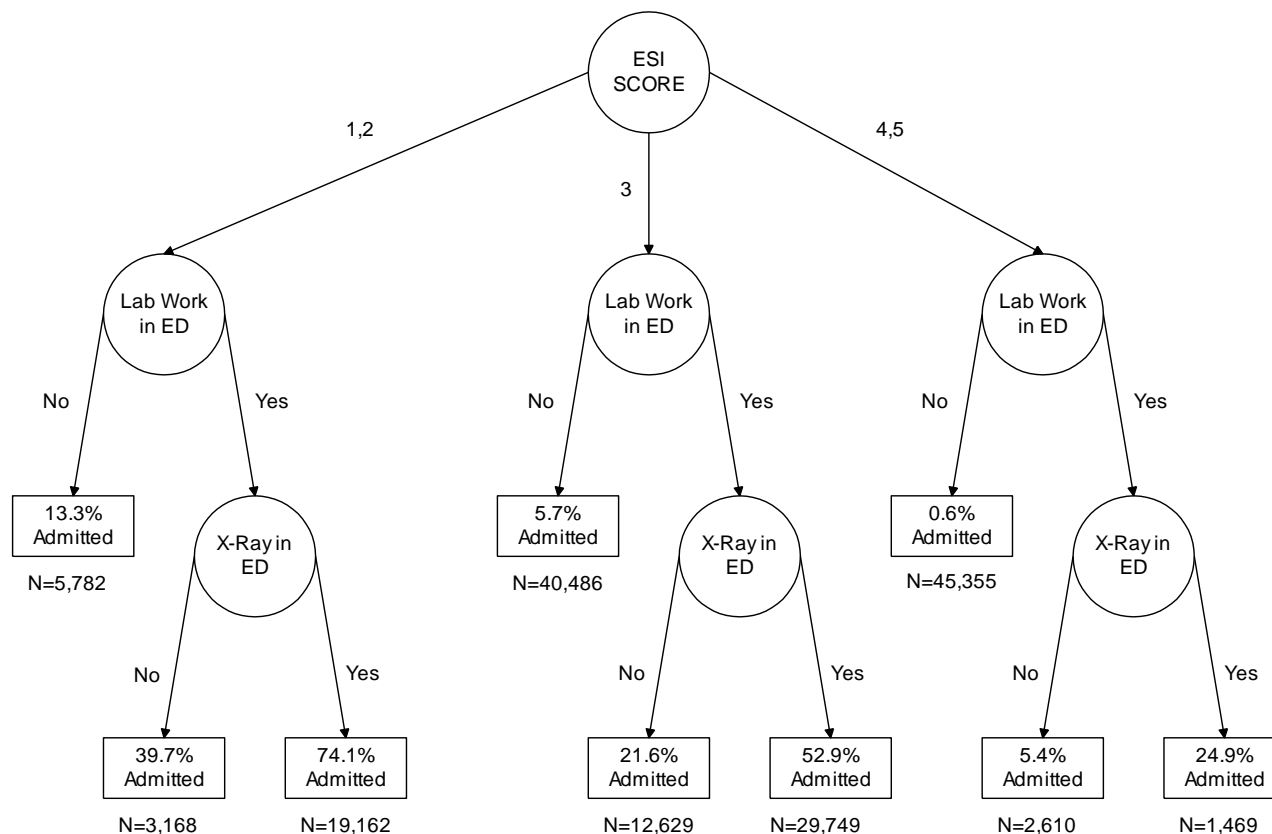
Figure 1 illustrates the hierarchically-optimal CTA model developed¹ using these data². As seen, ESI score stratified the sample into three groups: ESI scores of 1 or 2 were associated with highest likelihood of admission; scores of 3 were associated with intermediate likelihood of admission; and scores of 4 or 5 were associated with the lowest likelihood of admission. For each of these three strata, a binary indicator of whether laboratory work was completed in the ED was the initial attribute, followed by a binary indicator of whether radiological work was completed in the ED.

If no laboratory work was completed in the ED then the likelihood of admission is 2.3 times greater for patients with ESI scores of 1 or 2 versus scores of 3; 10.4 times greater for patients with ESI scores of 3 versus scores of 4 or 5; and 24.2 times greater for patients with ESI scores of 1 or 2 versus scores of 4 or 5.

If lab work was completed in the ED, but no radiological work was completed, then the likelihood of admission is 3.0 times greater (versus patients with no lab work) for patients with ESI scores of 1 or 2; 3.8 times greater for patients with ESI scores of 3; and 9.8 times greater for patients with ESI scores of 4 or 5. Also, the likelihood of admission is 1.8 times greater for patients with ESI scores of 1 or 2 versus 3; 4.0 times greater for patients with ESI scores of 3 versus scores of 4 or 5; and 7.4 times greater for patients with ESI scores of 1 or 2 versus scores of 4 or 5.

Finally, if radiological work was also completed in the ED, likelihood of admission is 1.9 times greater (versus patients with no radiological work) for patients with ESI scores of 1 or 2; 2.4 times greater for patients with ESI scores of 3; and 4.6 times greater for patients with ESI scores of 4 or 5. And, the likelihood of

Figure 1: Hierarchical CTA Model for Hospital Admission (all $p < 0.0001$)



admission is 1.4 times greater for patients with ESI scores of 1 or 2 versus scores of 3; 2.1 times greater for patients with ESI scores of 3 versus scores of 4 or 5; and 3.0 times greater for patients with ESI scores of 1 or 2 versus 4 or 5.

The CTA model was used to construct the staging table for hospital admission: in Table 1 a missing entry (dashes) indicates that the attribute is not included in the attribute profile (i.e., branch and endpoint of the tree model); N is the number of patients with the indicated attribute profile (the denominator in the corresponding endpoint); p_{Admit} is the empirical probability of hospital admission for the indicated attribute profile; and Odds is p_{Admit} expressed as approximate odds of hospital admission. As seen, the CTA model provides $0.74/0.0055=134$ -fold stratification in likelihood of patient hospital admission.

Table 1: Admission Model Staging Table

Stage	ESI	Labs	X-Ray	N	p_{Admit}	Odds
1	4,5	No	---	45,355	0.0055	1:170
2	4,5	Yes	No	2,610	0.054	1:17
3	3	No	---	40,486	0.057	1:17
4	1,2	No	---	5,782	0.13	2:13
5	3	Yes	No	12,629	0.22	2:7
6	4,5	Yes	Yes	1,469	0.25	1:3
7	1,2	Yes	No	3,168	0.40	2:3
8	3	Yes	Yes	29,749	0.53	8:7
9	1,2	Yes	Yes	19,162	0.74	3:1

For the three ESI strata identified by the CTA model the *absolute magnitude* of the difference between patients with no lab work, versus patients with lab and radiological work completed in the ED, is greater for *lower* ESI scores. For ESI scores of 1 and 2 the absolute difference is 74.1%-13.3% or 60.8%. For scores of 3 the absolute difference is 47.2%, and for scores of 4 or 5 absolute difference is 24.3%.

In contrast, the *relative magnitude* of the difference between patients with no lab work, versus patients with lab and radiological work completed in the ED, is greater for *higher* ESI scores. For ESI scores of 1 and 2 the relative difference is 74.1%/13.3% or 5.6. For ESI scores of 3 the relative difference is 9.3, and for scores of 4 or 5 the relative difference is 41.5.

References

¹Soltysik RC, Yarnold PR (2010). Automated CTA software: Fundamental concepts and control commands. *Optimal Data Analysis, 1*, 144-160.

²The study was designed and data collected by our friend and colleague, Dr. David R. Eitel (deceased), an emergency medicine physician with a background in OR/MS—a strong proponent of optimal methodologies. One of the developers of the ESI, he was excited about this project. This research report represents only a portion of the Results section of the article that Dr. Eitel would have produced, but in his absence, we decided that we should deliver what we can. Dave will be missed, as our colleague, and as our friend.

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