Appendix 3 (as supplied by the authors): Details about the latent class model used to measure the probability that an urgent (unplanned) readmission was avoidable

The latent class model

Latent class analysis (LCA) is a statistical method that can be used to assign individuals into different "latent classes" based on a set of observed categorical variables. The latent variable (in our case, "avoidable" readmission status) cannot be observed directly; instead, it is measured indirectly by using multiple observed variables (in our case, "avoidability" ratings by multiple physicians).

Suppose there are K raters, each with two possible ratings: 1=Positive and 2=Negative. This results in 2^K different response patterns of positive and negative ratings $(\boldsymbol{Y})$. Each response pattern is associated with a particular probability $P(\boldsymbol{Y}=\boldsymbol{y})$. Let L represent the dichotomous latent variable (in our case, true avoidable readmission status). Let γ_1 and γ_2 represent the prevalences of the two latent classes given by L. Let the conditional probabilities of positive and negative ratings given membership in latent class c, be given by $\rho_{1|c}$ and $\rho_{2|c}$, respectively. Note that, if latent class 1 represents truly avoidable readmissions, then $\rho_{1|1}$ may be interpreted as the sensitivity and $\rho_{2|2}$ as the specificity of classification by each rater. Allowing sensitivities and specificities to vary among the raters, we let $\rho_{k,r|c}$ represent the conditional classification probabilities for a rater. The latent class model may then be written as:

$$P(\boldsymbol{Y}=\boldsymbol{y})=\sum_{c=1}^{2}\gamma_c\prod_{k=1}^{K}\prod_{r=1}^{2}\rho_{k,r|c}$$

Given the observed proportions of cases that receive each rating pattern, the Expectation-Maximization (EM) algorithm may be used to estimate the parameters γ and ρ. These parameters can then easily be used to calculate the posterior probability of membership in a particular latent class for any case, given its pattern of ratings. Using Bayes' theorem, we have the posterior probability:

$$P(L=c\,|\,\boldsymbol{Y}=\boldsymbol{y})=\frac{\gamma_c\prod_{k=1}^{K}\prod_{r=1}^{2}\rho_{k,r|c}}{\sum_{c=1}^{2}\gamma_c\prod_{k=1}^{K}\prod_{r=1}^{2}\rho_{k,r|c}}$$

Appendix to: van Walraven C, Jennings A, Taljaard M, et al. Incidence of potentially avoidable hospital readmissions and their relation to all-cause urgent readmissions. *CMAJ* 2011. DOI:10.1503/cmaj.110400.

Model fit

Measures suggested by Nagin[1] indicated that the fit of our latent class model was excellent: the average posterior probability of assignment for patients classified with avoidable readmission (which measures the certainty of patient classification) was 0.94 and greatly exceeded the rule-of-thumb threshold of 0.7; and the odds of correct classification for patients classified with avoidable readmission (which measures the ratio of correct classification with the model vs. by random chance) was 69.1, indicating that patients were almost 70 times more likely to be correctly classified as having an avoidable readmission with the model than by chance.

Operating characteristics of reviewing physicians

This table presents each reviewer's sensitivity and specificity for identifiying avoidable readmissions.

Reviewer	Sensitivity	Specificity	Reviewer	Sensitivity	Specificity
1	0.905	0.713	**19**	0.495	0.742
2	0.903	0.806	**20**	0.493	0.885
3	0.898	0.969	**21**	0.492	0.914
4	0.885	0.938	**22**	0.490	0.942
5	0.834	0.826	**23**	0.490	0.999
6	0.822	0.828	**24**	0.454	0.851
7	0.756	0.838	**25**	0.412	0.886
8	0.739	0.856	**26**	0.411	0.914
9	0.736	0.899	**27**	0.360	0.884
10	0.698	0.999	**28**	0.251	0.686
11	0.677	0.792	**29**	0.247	0.914
12	0.675	0.934	**30**	0.245	0.999
13	0.674	0.963	**31**	0.231	0.997
14	0.656	0.913	**32**	0.164	0.971
15	0.655	0.913	**33**	0.083	0.943
16	0.575	0.856	**34**	0.082	1.000
17	0.545	0.852	**35**	0.045	1.000
18	0.497	0.714			

Reference

1. Nagin DS. *Group-based modeling of development*. Cambridge (MA): Harvard University Press; 2005.