Bayesian Inference for Hospital Quality in a Selection Model: Appendices

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July, 2002

Appendix A1: Construction of prior distributions

This appendix describes in detail the construction of the prior distributions used in the selection model. The notation in this appendix is the same as in the paper.

A1.1 Prior distributions for α (selection model)

There are five coefficients in the vector α in the hospital multinomial choice model (2) corresponding to the five covariates: distance from patient *i*'s home to hospital *j*, the square of this distance, and the product of distance with age, disease stage, and income respectively. The priors for the five coefficients are independent, each Gaussian with mean zero and a specified standard deviation.

To construct these standard deviations, we took a random subsample of 1,000 patients and constructed the covariate vectors $\mathbf{z}_{ij}$ $(i=1,\ldots,1000; j=1,\ldots,114)$ of the multinomial choice model. For each of the five covariates we found a value of the coefficient such that if all other coefficients are zero then the joint probability that the patient goes to one of the 27 hospitals farthest away is 0.003. We verified that these values resulted in the probabilities of the patient going to the nearest hospital being between 0.1 and 0.2. These resulted in coefficient values of -6, -12, -4, -5 and -35 for the respective covariates (ordered as in Table 4, bottom panel).

The prior standard deviations are therefore set to 6, 12, 4, 5 and 35, respectively. Since the mean of all distributions is zero, the prior is centered about independence of hospital choice from the covariates. But it is sufficiently inclusive that it renders reasonable what we regard as *a priori* reasonable effects of the covariates on hospital choices.

A1.2 Prior distribution for δ (selection model)

We begin with the probit equation (2) of the hospital choice model before differencing,

$$\tilde{\mathbf{c}}_i^* = \tilde{\mathbf{Z}}_i \alpha + \tilde{\eta}_i; \quad \tilde{\eta}_i \sim N\left(\mathbf{0}, \mathbf{I}_J\right) \tag{A1.1}$$

Express the correlation between $\tilde{\eta}_i$ and the shock ε_i to the mortality equation (1) by means of the linear projection

$$\varepsilon_i = \sum_{j=1}^{J} \tilde{\delta}_i \tilde{\eta}_{ij} + \tilde{\zeta}_i; \quad \tilde{\zeta}_i \sim N\left(0,1\right). \tag{A1.2}$$

This equation corresponds to (5) in the paper; we return to this correspondence below.

Suppose that in the system (A1.1)-(A1.2) our prior distribution for $\tilde{\delta}$ is

$$\tilde{\delta} \sim N\left(0, \underline{h}_{\tilde{\delta}}^{-1} \mathbf{I}_J\right) \tag{A1.3}$$

In (A1.3) the priors are independent and exchangeable across hospitals. The corresponding correlation between ε_i and $\tilde{\eta}_i$ is $\tilde{\rho}_j = \tilde{\delta}_j \Big/ \left(\tilde{\delta}'\tilde{\delta} + 1\right)^{1/2}$. Since the distribution in (A1.3) is symmetric about zero, the prior correlation between the parameters $\tilde{\rho}_j$ and $\tilde{\rho}_k$ is zero.

As explained between (2) and (3) in the paper, normalizing $\tilde{c}_J^* = 0$ leads to

$$\mathbf{c}_i^* = \mathbf{Z}_i \alpha + \eta_i, \quad \eta_i \sim N\left(\mathbf{0}, \Sigma\right), \quad \Sigma = \mathbf{I}_{J-1} + \mathbf{e}_{J-1}\mathbf{e}_{J-1}'$$

which is (3) in the paper. Express the linear projection of ε_i on η_i as

$$\varepsilon_i = \sum_{j=1}^{J-1} \delta_j^* \eta_{ij} + \zeta_i^*. \tag{A1.4}$$

The asterisks in this equation reflects the fact that $\text{var}\left(\zeta_i^*\right) \neq 1$ whereas $\text{var}\left(\zeta_i\right) = 1$ in (5). The next step is to derive $\delta^* = \left(\delta_1^*, \ldots, \delta_{J-1}^*\right)'$ and $\text{var}\left(\zeta_i^*\right)$.

From (A1.4), and then from (A1.1)-(A1.2),

$$\delta^* = \left[\text{var}\left(\eta_i\right)\right]^{-1} \text{cov}\left(\eta_i, \varepsilon_i\right) = \left[\text{var}\left(\eta_i\right)\right]^{-1} \text{cov}\left(\tilde{\eta}_{(-J)} - \mathbf{e}_{J-1}\tilde{\eta}_J, \varepsilon_i\right) = \Sigma^{-1}\left(\tilde{\delta}_{(-J)} - \mathbf{e}_{J-1}\tilde{\delta}_J\right). \tag{A1.5}$$

(In this expression, the subscript "J" denotes the last element of the $J \times 1$ vector, and the subscript "$\left(-J\right)$" denotes the first $J-1$ elements of the $J \times 1$ vector.) Since the prior distribution of $\tilde{\delta}$ is (A1.3), the prior distribution of δ^* is also normal, with mean zero and variance

$$\mathrm{var}\left(\delta^*\right) = \Sigma^{-1}\,\mathrm{var}\left(\tilde{\delta}_{(-J)} - \mathbf{e}_{J-1}\tilde{\delta}_J\right)\Sigma^{-1}.$$

Since

$$\mathrm{var}\left(\tilde{\delta}_{(-J)} - \mathbf{e}_{J-1}\tilde{\delta}_J\right) = \left[\mathbf{I}_{J-1} \;\; -\mathbf{e}_{J-1}\right]\underline{h}_{\tilde{\delta}}^{-1}\mathbf{I}_J\begin{bmatrix}\mathbf{I}_{J-1}\\ -\mathbf{e}'_{J-1}\end{bmatrix} = \underline{h}_{\tilde{\delta}}^{-1}\left(\mathbf{I}_{J-1} + \mathbf{e}_{J-1}\mathbf{e}'_{J-1}\right) = \underline{h}_{\tilde{\delta}}^{-1}\Sigma,$$

$$\mathrm{var}\left(\delta^*\right) = \underline{h}_{\tilde{\delta}}^{-1}\Sigma^{-1} = \underline{h}_{\tilde{\delta}}\left(\mathbf{I}_{J-1} - J^{-1}\mathbf{e}_{J-1}\mathbf{e}'_{J-1}\right). \qquad \text{(A1.6)}$$

Because $\mathrm{var}\left(\zeta_i^*\right) \neq 1$ whereas $\mathrm{var}\left(\zeta_i\right) = 1$ in (5), δ^* differs from δ by a scale factor. The prior for δ will have mean zero and variance proportional to (A1.6). To obtain the factor of proportionality, scale δ^* by $\left[\mathrm{var}\left(\zeta_i^*\right)\right]^{-1}$ to obtain $\mathrm{var}\left(\delta\right)$. By the usual population regression formulas, $\mathrm{var}\left(\zeta_i^*\right) = \mathrm{var}\left(\varepsilon_i\right) - \delta^{*\prime}\Sigma\delta^*$. From (A1.5),

$$\begin{aligned}
\delta^{*\prime}\Sigma\delta^* &= \tilde{\delta}'\begin{bmatrix}\mathbf{I}_{J-1}\\ -\mathbf{e}'_{J-1}\end{bmatrix}\Sigma^{-1}\left[\mathbf{I}_{J-1} \quad -\mathbf{e}_{J-1}\right]\tilde{\delta}\\
&= \tilde{\delta}'\begin{bmatrix}\mathbf{I}_{J-1}\\ -\mathbf{e}'_{J-1}\end{bmatrix}\left[\mathbf{I}_{J-1} - J^{-1}\mathbf{e}_{J-1}\mathbf{e}'_{J-1}\right]\left[\mathbf{I}_{J-1} \quad -\mathbf{e}_{J-1}\right]\tilde{\delta} \qquad \text{(A1.7)}\\
&= \tilde{\delta}'\begin{bmatrix}\mathbf{I}_{J-1} - J^{-1}\mathbf{e}_{J-1}\mathbf{e}'_{J-1} & -J^{-1}\mathbf{e}_{J-1}\\ -J^{-1}\mathbf{e}'_{J-1} & 1 - J^{-1}\end{bmatrix}\tilde{\delta} = \tilde{\delta}'\left(\mathbf{I}_J - J^{-1}\mathbf{e}_J\mathbf{e}'_J\right)\tilde{\delta} = \tilde{\delta}\Sigma^{-1}\tilde{\delta}.
\end{aligned}$$

Hence from (A1.2) and (A1.7),

$$\mathrm{var}\left(\zeta_i^*\right) = \tilde{\delta}'\tilde{\delta} + 1 - \tilde{\delta}'\left(\mathbf{I}_J - J^{-1}\mathbf{e}_J\mathbf{e}'_J\right)\tilde{\delta} = J^{-1}\left(\mathbf{e}'_J\tilde{\delta}\right)^2 + 1 = J^{-1}\left(\sum\nolimits_{j=1}^{J}\tilde{\delta}_j\right)^2 + 1. \qquad \text{(A1.8)}$$

Thus $\tilde{\delta} \sim N\left(\mathbf{0}, \underline{h}_{\tilde{\delta}}^{-1}\mathbf{I}_T\right)$ implies the prior expectation $\underline{h}_{\tilde{\delta}}^{-1} + 1$ for $\mathrm{var}\left(\zeta_i^*\right)$. This leads to the appropriate normalization for (A1.6),

$$\mathrm{var}\left(\delta\right) = \left(\frac{\underline{h}_{\tilde{\delta}}^{-1}}{\underline{h}_{\tilde{\delta}}^{-1} + 1}\right)\Sigma^{-1} = \left(1 + \underline{h}_{\tilde{\delta}}\right)^{-1}\Sigma^{-1}.$$

Since $\mathrm{var}\left(\zeta_i^*\right)$ involves $\tilde{\delta}$, the implied distribution for $\tilde{\delta}$ under the normalization $\mathrm{var}\left(\zeta_i\right) = 1$ of (5) is not Gaussian. We therefore conjecture a Gaussian prior distribution for δ, and then examine whether it is in fact similar to the non-Gaussian prior implied by (A1.3) and (5). From (A1.3) and (A1.8), the prior expectation of $\mathrm{var}\left(\zeta_i^*\right)$ is $1 + \underline{h}_{\tilde{\delta}}^{-1}$. Our conjectured Gaussian distribution for δ is therefore

$$\delta \sim N\left(0,\sigma_{\delta}^2\Sigma^{-1}\right), \text{ with } \sigma_{\delta}^2 = \left(1+\underline{h}_{\tilde{\delta}}\right)^{-1}. \tag{A1.9}$$

A series of numerical experiments showed that the non-Gaussian prior implied by (A1.3) and (A1.5), and the Gaussian prior (A1.9), give essentially identical moments for the correlations $\tilde{\rho}_j$ and ρ_j, for the same values of $\underline{h}_{\delta}$. Table A1 shows the relationships between $\underline{h}_{\delta}$ and some moments of $\tilde{\rho}_j$ and ρ_j. (In Table A1, $\tilde{R}^2 = \tilde{\delta}'\tilde{\delta}\big/\left(\tilde{\delta}'\tilde{\delta}+1\right)$, the fraction of variance in the mortality shock explained by the hospital choice probits in (A1.2); $R^2 = \delta'\delta\big/\left(\delta'\delta+1\right)$, the fraction of variance in the mortality shock explained by the hospital choice probits in (5).)

Observe that as the standard deviation in the elements of $\tilde{\delta}$, $\underline{h}_{\delta}^{-1/2}$, increases, R^2 and $\tilde{R}^2$ increase; that this must happen is obvious from (A1.2) and (5). But the correlations ρ_j and $\tilde{\rho}_j$ do not increase significantly beyond $\underline{h}_{\delta}^{-1/2} = .08$. This is due to the large number of hospitals, and the symmetry of the prior in δ. For the work reported in this paper, we chose $\underline{h}_{\delta}^{-1/2} = 0.2$, or equivalently, $\sigma_{\delta} = 0.196$.

A1.3 Prior distributions for $\boldsymbol{\beta}$

The variance component structure in the prior for β described in the text can be used to simplify the coding of the algorithm detailed in Appendix A2. Let **W** be a $J\times\left(J+9\right)$ matrix of hospital characteristics. Let the first column of **W** be entirely units, columns 2 through 5 dichotomous variables for the four ownership categories, and columns 6 through 9 dichotomous variables for the four size categories. Redefine β to be the $\left(J+9\right)\times 1$ vector of corresponding coefficients. The priors for the components of this vector are mutually independent, with $\beta_1 \sim N\left(0,3^2\right)$. The hierarchical prior distribution for $\beta_2,\ldots,\beta_{J+9}$ is

$$\underline{s}_p^2/\tau_p^2 \sim \chi^2\left(\underline{\nu}_p\right),\quad \beta_j \sim N\left(0,\tau_p^2\right)\ \left(j=2,3,4,5\right);$$
$$\underline{s}_s^2/\tau_s^2 \sim \chi^2\left(\underline{\nu}_s\right),\quad \beta_j \sim N\left(0,\tau_s^2\right)\ \left(j=6,7,8,9\right);$$
$$\underline{s}_u^2/\tau_u^2 \sim \chi^2\left(\underline{\nu}_u\right),\quad \beta_j \sim N\left(0,\tau_u^2\right)\ \left(j=10,\ldots,J+9\right).$$

In the prior distribution used in the paper, $\underline{s}_p^2 = \underline{s}_s^2 = \underline{s}_u^2 = 1.25$ for the conventional probit model with $\sigma = 1$. As discussed in Section 2.2, the variances in the selection model are scaled by

$\left[\sigma_\delta^2(J-1)+1\right]=5.35$, so that $\underline{s}_p^2=\underline{s}_s^2=\underline{s}_u^2=6.68$. For both models $\underline{\nu}_p=\underline{\nu}_s=\underline{\nu}_u=5$. It is readily verified that the prior distribution of $\mathbf{W}\beta$ is the same as the prior distribution of β described in the text. The elements of the $(J+9)\times 1$ vector β have proper prior distributions, and the posterior distribution of $\mathbf{W}\beta$ is exactly the same as that of β described in the text.

A1.3 Prior distributions for γ

The demographic covariates x_i are of two types: dichotomous variables, and two continuous variables (income and its square). The coefficients γ_i of the dichotomous variables are independent in the prior, all with standard deviation 0.5 in the conventional probit model with $\sigma=1$. The coefficients on income and its square (call them γ_1 and γ_2) are derived from the independent priors

$$\gamma_1\overline{y}+\gamma_2\overline{y}^2\sim N\left(0,0.25^2\right),$$
$$\gamma_1\left(2\overline{y}\right)^2+\gamma_2\left(2\overline{y}\right)^2\sim N\left(0,0.25^2\right).$$

Substituting for average income $\overline{y}$, scaling y by 10^{-5} and y^2 by 10^{-9} (as was done in variable construction) yields prior variances of 3.603 and 0.1437 for γ_1 and γ_2, respectively, and a prior covariance of –0.7026. As discussed in Section 2.2, these coefficients are scaled by $\left[\sigma_\delta^2(J-1)+1\right]^{1/2}=2.31$ for the selection model relative to these values.

Appendix A2: Details of distributions and computations

This appendix describes in detail the prior and data distributions used in the selection model, and the probit model. The notation in this appendix is the same as in the paper.

A2.1 Notation

The notation in this appendix is the same as in the paper. We collect all the definitions here for reference, and introduce some additional useful notation.

Indexing:

$i=1,\ldots,n$ Patients in sample

$j = 1, \ldots, J$	Hospitals in Los Angeles County, California

Observed variables:

m_i	Mortality indicator, 1 if patient dies, else 0
$\mathbf{c}_i : J \times 1$	Hospital choice indicator, $c_{ij} = 1$ if *i* chooses *j*, else 0
$\mathbf{x}_i : k \times 1$	Individual characteristics affecting mortality
$\mathbf{Z}_i : (J-1) \times q$	Individual characteristics affecting hospital choice
$\mathbf{W} : J \times (J+9)$	Matrix of hospital characteristics
$\mathbf{u}_i' \equiv (\mathbf{c}_i'\mathbf{W}, \mathbf{x}_i')$	

Latent variables

m_i^*	Mortality probit
$\mathbf{c}_i^* : (J-1) \times 1$	Hospital choice probit

Miscellaneous:

$\chi_S(z)$	Indicator function, $\chi_S(z) = 1$ if $z \in S$, else 0
$\mathbf{e}_n : n \times 1$	$\mathbf{e}_n' = (1, \ldots, 1)$

A2.2 Model

The model for the latent variables and observables is:

$$\mathbf{c}_i^* = \mathbf{Z}_i \alpha + \eta_i, \quad c_{iJ}^* \equiv 0$$

$$c_{ij} = \prod\nolimits_{\ell=1}^{J} \chi_{[0,\infty)}\left(c_{ij}^* - c_{i\ell}^*\right)$$

$$m_i^* = \mathbf{c}_i'\mathbf{W}\beta + \mathbf{x}_i'\gamma + \eta_i'\delta + \zeta_i$$

$$m_i = \chi_{[0,\infty)}\left(m_i^*\right)$$

$$\begin{pmatrix} \eta_i \\ \zeta_i \end{pmatrix} \overset{IID}{\sim} \mathrm{N}\left(\mathbf{0}, \begin{bmatrix} \Sigma & \mathbf{0} \\ \mathbf{0}' & 1 \end{bmatrix}\right); \; \Sigma = \mathbf{I}_{J-1} + \mathbf{e}_{(J-1)}\mathbf{e}_{(J-1)}'$$

$$\tau \equiv \left(\tau_p^2, \tau_s^2, \tau_u^2\right)', \; \lambda' \equiv (\beta', \gamma'), \; \nu' \equiv (\lambda', \delta')$$

A2.3 Prior distribution

As motivated in the text the prior distribution consists of three, independent components: $\underline{s}_j^2/\tau_j^2 \sim \chi^2(\underline{\nu}_j)\,(j = p,s,u)$ and $\lambda|\tau \sim \mathrm{N}\left(\underline{\lambda}, \underline{\mathbf{H}}_\lambda(\tau)^{-1}\right)$; $\delta \sim \mathrm{N}\left(\underline{\delta}, \underline{\mathbf{H}}_\delta^{-1}\right)$; $\alpha \sim \mathrm{N}\left(\underline{\alpha}, \underline{\mathbf{H}}_\alpha^{-1}\right)$. Hence the prior density is

$$\begin{aligned}
\mathrm{p}(\lambda,\delta,\alpha,\tau) = \prod\nolimits_{j=p,s,u} &\left\{\left[2^{\underline{\nu}_j/2}\Gamma\left(\underline{\nu}_j/2\right)\right]^{-1}\left(\underline{s}_j^2\right)^{\underline{\nu}_j/2}\left(\tau_j^2\right)^{-(\underline{\nu}_j+2)/2}\exp\left(-\underline{s}_j^2/2\tau_j^2\right)\right\} \\
&\cdot(2\pi)^{-(r+k+J+q-1)/2}\left|\underline{\mathbf{H}}_\lambda(\tau)\right|^{1/2}\left|\underline{\mathbf{H}}_\delta\right|^{1/2}\left|\underline{\mathbf{H}}_\alpha\right|^{1/2} \qquad \text{(A2.1)} \\
&\cdot\exp\left\{-.5\left[(\lambda-\underline{\lambda})'\,\underline{\mathbf{H}}_\lambda(\tau)(\lambda-\underline{\lambda})+(\delta-\underline{\delta})'\,\underline{\mathbf{H}}_\delta(\delta-\underline{\delta})+(\alpha-\underline{\alpha})'\,\underline{\mathbf{H}}_\alpha(\alpha-\underline{\alpha})\right]\right\}.
\end{aligned}$$

A2.4 Distribution of observables and latent variables

To derive the joint density of the observable data and latent variables for individual *I*, let $\Phi_i \equiv \{\mathbf{Z}_i, \mathbf{W}, \alpha, \lambda, \delta, \Sigma\}$. Then

$$\begin{aligned}
\mathrm{p}\left(\mathbf{c}_i^*, \mathbf{c}_i, \mathbf{m}_i^*, \mathbf{m}_i|\Phi_i\right) &= \mathrm{p}\left(\mathbf{c}_i^*|\Phi_i\right)\mathrm{p}\left(\mathbf{c}_i|\mathbf{c}_i^*,\Phi_i\right)\mathrm{p}\left(m_i^*|\mathbf{c}_i,\mathbf{c}_i^*,\Phi_i\right)\mathrm{p}\left(m_i|m_i^*,\mathbf{c}_i\mathbf{c}_i^*,\Phi_i\right) \\
&= \mathrm{p}\left(\mathbf{c}_i^*|\mathbf{Z}_i,\alpha,\Sigma\right)\mathrm{p}\left(\mathbf{c}_i|\mathbf{c}_i^*\right)\mathrm{p}\left(m_i^*|\mathbf{c}_i,\mathbf{c}_i^*,\mathbf{Z}_i,\mathbf{W},\alpha,\lambda,\delta,\Sigma\right)\mathrm{p}\left(m_i|m_i^*\right)
\end{aligned}$$

$$\begin{aligned}
&= (2\pi)^{-J/2}|\Sigma|^{-1/2}\exp\left[-.5\left(\mathbf{c}_i^*-\mathbf{Z}_i\alpha\right)'\Sigma^{-1}\left(\mathbf{c}_i^*-\mathbf{Z}_i\alpha\right)\right]\cdot\left[\sum\nolimits_{j=1}^J c_{ij}\prod\nolimits_{\ell=1}^J \chi_{[0,\infty)}\left(c_{ij}^*-c_{i\ell}^*\right)\right] \\
&\quad\cdot\exp\left\{-.5\left[m_i^*-\mathbf{u}_i'\lambda-\left(\mathbf{c}_i^*-\mathbf{Z}_i\alpha\right)'\delta\right]^2\right\}\cdot\left[m_i\chi_{[0,\infty)}\left(m_i^*\right)+(1-m_i)\,\chi_{(-\infty,0)}\left(m_i^*\right)\right]. \qquad \text{(A2.2)}
\end{aligned}$$

Since individuals are independent, the joint distribution of observables and latent variables for all individuals is the product of this expression over $i = 1,\ldots,n$.

A2.5 Gibbs sampling algorithm

The posterior density is proportional to the product of the prior density (A2.1) and the distribution of observables and latent variables (A2.2) over $i = 1,\ldots,n$, taking the observables as fixed and the unobserved latent variables and parameters as the arguments of the posterior density. In a Gibbs sampling algorithm (Gelfand and Smith, 1990; Geweke, 1997) the unobservables are grouped and successive drawings are made for each group. Given weak regularity conditions, the unique stationary distribution of these repeated drawings is the posterior distribution. In the algorithm described here there are $2n+2$ groups: $\mathbf{c}_i^* \left(i=1,\ldots,n\right)$, $m_i^* \left(i=1,\ldots,n\right)$, α, and ν. In each case the conditional distribution may be determined by examining the kernel of the posterior density in the vector being drawn.

The latent vectors $\mathbf{c}_i^* \left(i=1,\ldots,n\right)$ are conditionally independent, with $\mathbf{c}_i^* \sim \mathrm{N}\left(\overline{\mathbf{c}}_i, \overline{\mathbf{H}}_i^{-1}\right)$ where

$$\overline{\mathbf{H}}_i = \Sigma^{-1} + \delta\delta', \; \overline{\mathbf{c}}_i = \overline{\mathbf{H}}_i^{-1}\left[\Sigma^{-1}\mathbf{Z}_i\alpha + \delta\left(m_i^* - \mathbf{u}_i'\lambda + \delta'\mathbf{Z}_i\alpha\right)\right],$$

and subject to $c_{ij}^* - c_{i\ell}^* \geq 0$ where $j : c_{ij} = 1$. While the elements of $\mathbf{c}_i^*$ can be drawn in succession using the generic algorithm in Geweke (1991), the fixed structure of Σ permits a more efficient procedure. Specifically, it can be shown that conditional on all the other parameters and latent variables, the *j*'th element of $\mathbf{c}_i^*$, denoted c_{ij}^*, is

$$c_{ij}^* \sim \mathrm{N}\left\{\overline{c}_{ij} + \left(1 - J^{-1} + \delta_j^2\right)^{-1}\left[\sum\nolimits_{\ell \neq j}\left(J^{-1} - \delta_j\delta_\ell\right)\left(c_{i\ell}^* - \overline{c}_{i\ell}\right)\right], \quad \left(1 - J^{-1} + \delta_j^2\right)^{-1}\right\},$$

truncated to the interval $\left(0,\infty\right) \cap \left(\max_{\ell \neq j} c_{i\ell}^*, \infty\right)$ if *j* is the observed choice; truncated to the interval $\left(-\infty, c_{ik}^*\right)$ if $k \left(\neq j, J\right)$ is the observed choice; and to $\left(-\infty, 0\right)$ if $k = J$ is the observed choice.

The latent vectors $m_i^* \left(i=1,\ldots,n\right)$ are conditionally independent, with $m_i^* \sim \mathrm{N}\left[\mathbf{u}_i'\lambda + \delta'\left(c_i^* - \mathbf{Z}_i\alpha\right), 1\right]$ subject to $\left(2m_i - 1\right)m_i^* \geq 0$.

The conditional distribution of α is $\alpha \sim \mathrm{N}\left(\overline{\alpha}, \overline{\mathbf{H}}_\alpha^{-1}\right)$ where

$$\overline{\mathbf{H}}_\alpha = \underline{\mathbf{H}}_\alpha + \sum\nolimits_{i=1}^n \mathbf{Z}_i'\left(\Sigma^{-1} + \delta\delta'\right)\mathbf{Z}_i$$

$$\overline{\alpha} = \underline{\mathbf{H}}_\alpha^{-1}\left\{\underline{\mathbf{H}}_\alpha \underline{\alpha} + \sum\nolimits_{i=1}^n \mathbf{Z}_i'\left[\Sigma^{-1}\mathbf{c}_i^* + \delta\left(\delta'\mathbf{c}_i^* - m_i^* + \mathbf{u}_i'\lambda\right)\right]\right\}.$$

Let $\nu' = \left(\lambda', \delta'\right)$. The conditional distribution of ν is $\nu \sim \mathrm{N}\left(\overline{\nu}, \overline{\mathbf{H}}_\nu\left(\tau\right)^{-1}\right)$ where

$$\overline{\mathbf{H}}_\nu\left(\tau\right) = \begin{bmatrix} \underline{\mathbf{H}}_\lambda\left(\tau\right) & \mathbf{0} \\ \mathbf{0} & \underline{\mathbf{H}}_\delta \end{bmatrix} + \sum\nolimits_{i=1}^n \begin{bmatrix} \mathbf{u}_i \\ \mathbf{c}_i^* - \mathbf{Z}_i\alpha \end{bmatrix}\begin{bmatrix} \mathbf{u}_i' & \left(\mathbf{c}_i^* - \mathbf{Z}_i\alpha\right)' \end{bmatrix},$$

$$\overline{\nu} = \overline{\mathbf{H}}_\nu^{-1}\left[\underline{\mathbf{H}}_\nu \underline{\nu} + \sum\nolimits_{i=1}^n \begin{pmatrix} \mathbf{u}_i \\ \mathbf{c}_i^* - \mathbf{Z}_i\alpha \end{pmatrix} m_i^*\right].$$

Finally,

$$\bar{s}_j^2 / \tau_j^2 \sim \chi^2(\bar{\nu}_j)\,(j = p, s, u)$$

where $\bar{s}_p^2 = \underline{s}_p^2 + \sum_{j=2}^{5} \beta_j^2, \bar{\nu}_p = \underline{\nu}_p + 4$, $\bar{s}_s^2 = \underline{s}_s^2 + \sum_{j=6}^{9} \beta_j^2, \bar{\nu}_s = \underline{\nu}_s + 4$, $\bar{s}_u^2 = \underline{s}_u^2 + \sum_{j=10}^{J+9} \beta_j^2$, and $\bar{\nu}_u = \underline{\nu}_u + J$.

The conditions set forth by Roberts and Smith (1994) for the posterior distribution to be the unique stationary distribution for a Gibbs sampling algorithm, described as Gibbs sampler convergence condition 2 in Geweke (1997) are satisfied. The key technical condition is that the support of the posterior distribution in latent variables and parameters is connected and upper semicontinuous.

A2.6 Computation time

Using an IBM 332Mhz 604e processor and ESSL matrix computation routines, the computational time per iteration was approximately 6 minutes. This processor is comparable to a Pentium III 600. We then used an IBM SP supercomputer with Silver nodes, each of which has the 604e processor as its base, in order to compute each iteration in parallel. Two steps were very parallelizable: the c_{ij}^* can be computed in parallel for each individual, and the matrix multiplications necessary to compute the conditional posterior of α can also be broken up by individual. We were able to reduce the computation time close to proportionally to the number of processors that we used. For instance, the algorithm took 100 seconds per iteration with 4 processors, 60 seconds per iteration with 8 processors and 33 seconds per iteration with 20 processors. Thus, computation time for 20,000 iterations with 20 processors is roughly 8 days.

Appendix A3: Accuracy of the MCMC approximation to posterior moments

Collect the parameter vectors in the single vector $\theta' = (\alpha', \beta', \gamma', \delta')$ and the data in the single vector **y**. A posterior moment can then be expressed $\mathrm{E}[\mathrm{g}(\theta)|\mathbf{y}]$ for the appropriate function of interest g. The Gibbs sampling algorithm produces serially correlated draws $\theta^{(1)}, \ldots, \theta^{(M)}$ from the posterior distribution. Hence $\mathrm{g}(\theta^{(1)}), \ldots, \mathrm{g}(\theta^{(M)})$ is a sequence of draws from the posterior distribution of $\mathrm{g}(\theta)$. The numerical approximation of $\bar{g} = \mathrm{E}[\mathrm{g}(\theta)|\mathbf{y}]$ is

$\overline{g}_M = M^{-1}\sum_{m=1}^{M} g\left(\theta^{(m)}\right)$. Standard methods for serially correlated time series (Geweke (1999), Section 3.7) then produce a consistent (in *M*) approximation of $\tilde{\sigma}^2 = \lim_{M\to\infty} M\, E\left(\overline{g}^{(M)} - \overline{g}\right)^2$. [Expectation in the latter expression is with respect to the Markov chain that defines the Gibbs sampling algorithm.]

The efficiency of any Markov chain Monte Carlo (MCMC) algorithm can be evaluated by comparing $\tilde{\sigma}^2$ with the posterior variance of $g(\theta)$, $\sigma^2 = E\left\{\left[g(\theta) - \overline{g}\right]^2 |\mathbf{y}\right\}$. If the algorithm produced iid draws from the posterior distribution, then $\tilde{\sigma}^2 = \sigma^2$. More generally, the relative numerical efficiency of any MCMC algorithm for the function of interest $g(\theta)$ is $RNE = \sigma^2 / \tilde{\sigma}^2$. Numerical approximations of $\overline{g}$ based on *M* iterations of the algorithm will have the same accuracy as $RNE \cdot M$ iterations from a hypothetical algorithm that made iid drawings directly from the posterior distribution. The ratio of the standard error of approximation $\left(\tilde{\sigma}^2/M\right)^{1/2}$, to the posterior standard deviation σ, is $\left(RNE \cdot M\right)^{1/2}$. For any given posterior distribution and MCMC algorithm, RNE will be different for different functions of interest.

The results reported in the paper are based on 20,000 iterations of the Gibbs sampler. Visual inspection of parameter draws shows that convergence to the invariant (i.e., posterior) distribution occurs within the first 1,000 iterations, which are discarded. Of the remaining 19,000, every tenth iteration is used to compute posterior moments. (This reduces the size of the posterior files. Because of the serial correlation in functions of interest over iterations, little information is lost.)

The values of NSE and RNE corresponding to the moments reported in Table 4 are provided in Table A2. (RNE is computed from the 1900 retained iterations.) The Gibbs sampling algorithm for the probit model exhibits no serial correlation, and consequently numerical standard errors are all about $1/\sqrt{1900} \approx 1/44$ of the posterior standard deviation. The degree of serial correlation in the Gibbs sampling algorithm for the selection model varies, depending on the moments. Serial correlation is modest for the demographic and severity coefficients in the mortality probit equation, with all but one RNE greater than 0.2. For the group quality probits and the coefficients in the multinomial probit hospital selection model serial correlation is greater, with RNEs between 0.004 and 0.014. Observe that if RNE is 0.01, with

1900 iterations the variance in the posterior moments due to simulation is 1/19 that of the posterior variance itself: stated less formally, simulation noise inflates the posterior standard deviation by $(20/19)^{1/2} - 1 = 2.6\%$.

Table A3 provides similar information about the numerical accuracy of approximations in the Gibbs sampling algorithm for the quality probits q_j (selection model) and q_j^* (probit model) and for ρ_j, the correlation between the mortality probit equation shock and the shocks to the hospital choice multinomial probit model. The RNEs for q_j^* in the probit model are centered about 1.0, as was the case for all moments of this model in Table A2. The RNEs of the quality probits q_j in the selection model are comparable to those of the group quality probits and α vector in Table A2, while for the correlations ρ_j they are somewhat lower.

Appendix A4: Rankings of hospitals

Table A4 provides rankings for hospitals based on quadratic and absolute value loss functions, using the posterior density from the selection model. Table A5 provides pairwise comparisons: for hospitals at equally spaced quartiles of the posterior quality distribution, the table indicates the posterior probability that the hospital has lower quality than each of the other hospitals in the set. The choice of loss function does not have a large effect on the orderings of relative quality. The majority of hospitals have probability of at least 0.05 of being in any of three quartiles of the distribution. Roughly 10% of hospitals appear to be either better or worse than average, with posterior probability of at least 95%. Fairly confident pairwise rankings can be made for the ends of the distribution but not for the majority of hospitals.

Tables A6 and A7 provide the same figures as Tables A4 and A5 respectively, using the posterior density from the probit model. The two sets of tables indicate substantially different orders of rankings, but similar magnitudes of coefficients. In both models, there are 42 hospitals that have quality probit exceeding 0.1 in absolute value. However, the probit model exhibits somewhat more confidence about the rankings. There are only 9 hospitals (as opposed to 21 for the selection model) for which the probability of placement is at least .10 in each quartile, and about 25% of hospitals appear to be either better or worse than average, with posterior probability of at least 95%. The greater confidence in rankings can be ascribed to the restriction of no correlation between shocks to hospital choice and mortality in the probit model.

Appendix A5: Results with alternative prior distributions

Section 4.4 of the paper describes three alternative priors chosen to study their impact on the results. To recapitulate, variant A effectively eliminates the instruments, by scaling the prior standard deviations of the coefficient vector α in the multinomial hospital assignment model by the factor 10^{-6}. This leaves only the functional form to identify the hospital-specific parameters in the mortality equation. Variant B scales the prior standard deviations of α in the original selection model downward by a factor of 5. It does the same for the hospital coefficients β in the mortality probit equation, by taking $1.25 \times \frac{1}{5} \times \frac{1}{5} \times \left[\sigma_\delta^2 (J-1)+1\right] / \tau_j^2 \sim \chi^2(5)$ rather than $1.25\left[\sigma_\delta^2 (J-1)+1\right] / \tau_j^2 \sim \chi^2(5)$. Variant C is like Variant B except that prior standard deviations are increased by a factor of 5 relative to the base model. Variants B and C are simply reasonable alternatives to the base prior used in the paper.

Tables 3 and 4 in the paper are reproduced for each of these variants in this appendix: for variant A in Tables A8 and A9, for variant B in Tables A10 and A11, and for variant C in Tables A12 and A13. Turning first to the variants on Table 3 (i.e. Tables A8, A10, A12), note that there is almost no sensitivity of the covariate coefficients in the mortality equation to the three alternative priors. Given that (1) the priors for these coefficients are the same in all three variants, (2) these priors are independent of the priors for all the other parameters in the model, and (3) that hospital choice and unobserved disease severity are orthogonal to the covariates in the sample, the posterior distribution of the covariate coefficients in the mortality equation would be the same under all three priors. Conditions (1) and (2) are met here; (3) cannot be verified, but it is reasonable as an approximation and is the leading interpretation of the insensitivity of mortality covariate coefficients to priors for hospital quality and the hospital choice multinomial probit model. The posterior distribution of the coefficient vector α in this model is little affected by the alternative priors B and C, while of course under variant A these coefficients are much smaller.

As one would expect, there is substantially more variation in the group hospital quality probits q_j, across the alternative priors. Table A14 provides the correlation coefficients between the posterior means of the individual hospital quality probits across the 114 hospitals. The correlations between the base selection model and prior variants B and C are both 0.80, whereas correlation between the base model and prior variant A is 0.34. These comparisons support the conclusion of the paper (in Section 4.4) that reasonable variations in the prior distribution produce distinct but small effects on the posterior moments of interest, while eliminating the instruments from the selection model produces a substantially larger effect.

This relationship between the alternative priors and the base model is also evident in the posterior probability comparisons of orderings in group quality probits: see the variants on Table 4 in Tables A9, A11 and A13. For the hospital size and ownership group quality probits, the results are clear: the tighter (B) and looser (C) priors produce results close to the base model. By contrast elimination of instruments (prior variant A) produces results entirely dissimilar from the base model.

Table A1

Relationship between $\underline{h}_{\delta}^{-1/2}$ and severity correlations

$\underline{h}_{\delta}^{-1/2}$	.01	.08	.20	.50	.80
$E\left(\left\|\tilde{\rho}_j\right\|\right)$	.008	.048	.067	.067	.067
$s.d.\left(\left\|\tilde{\rho}_j\right\|\right)$	.010	.050	.060	.061	.061
$corr\left(\left\|\tilde{\rho}_i\right\|,\left\|\tilde{\rho}_j\right\|\right)$	.001	.005	.005	.005	.005
$\tilde{R}^2$	.001	.060	.271	.683	.838
$s.d.\left(\tilde{R}^2\right)$	.0005	.025	.088	.104	.070
$E\left(\left\|\rho_j\right\|\right)$	.008	.067	.067	.067	.067
$s.d.\left(\left\|\rho_j\right\|\right)$	.006	.051	.051	.051	.051
$corr\left(\left\|\rho_i\right\|,\left\|\rho_j\right\|\right)$	.223	.233	.233	.233	.233
R^2	.011	.421	.819	.966	.986
$s.d.\left(R^2\right)$	.0015	.032	.020	.005	.002

Table A2

Posterior numerical standard errors and relative numerical efficiencies

	Coefficient	Selection model	
		$\gamma/(\delta\Sigma\delta+1)^{1/2}$	
Demographic covariates	Age 70-74	-0.009 (.024)	[.0005, 1.040]
	Age 75-79	0.065 (.023)	[.0011, 0.220]
	Age 80-84	0.184 (.023)	[.0010, 0.296]
	Age > 84	0.369 (.022)	[.0001, 0.269]
	Female	-0.087 (.013)	[.0006, 0.258]
	Black	-0.020 (.028)	[.0021, 0.099]
	Hispanic	-0.122 (.022)	[.0011, 0.210]
	Native	0.152 (.133)	[.0039, 0.622]
	Asian	-0.091 (.030)	[.0010, 0.466]
	Income	0.222 (.021)	[.0068, 0.490]
	Income^2	-0.028 (.024)	[.0008, 0.478]
Disease severity covariates		$\gamma/(\delta\Sigma\delta+1)^{1/2}$	
	Emergency admit	0.180 (.015)	[.0006, 0.327]
	Disease stages 1.3-2.3	0.089 (.028)	[.0009, 0.502]
	Disease stages 3.1-3.6	0.493 (.023)	[.0004, 1.849]
	Disease stage 3.7	0.635 (.019)	[.0008, 0.292]
	Disease stage 3.8	1.396 (.038)	[.0010, 0.704]
Hospital group quality probits and severity correlations		q_G	ρ_G
	150 beds or less	0.018 (0.021) [0.0053, 0.008]	0.001 (0.008) [0.0025, 0.006]
	151 to 200 beds	-0.069 (0.032) [0.0065, 0.012]	-0.017 (0.003) [0.0032, 0.007]
	201 to 300 beds	-0.023 (0.027) [0.0052, 0.014]	-0.010 (0.011) [0.0024, 0.010]
	Over 300 beds	0.039 (0.020) [0.0040, 0.013]	0.022 (0.008) [0.0022, 0.006]
	Private, not for profit	0.006 (0.018) [0.0041, 0.011]	0.003 (0.008) [0.0020, 0.008]
	Private, for profit	0.007 (0.015) [0.0039, 0.008]	0.008 (0.006) [0.002, 0.007]
	Private Teaching	0.019 (0.041) [0.0121, 0.006]	0.006 (0.014) [0.0045, 0.005]
	Public	-0.071 (0.089) [0.0319, 0.004]	-0.017 (0.029) [0.0113, 0.003]
Variance of quality		$\tau^2/(\delta\Sigma\delta+1)$	
	Size	0.020 (0.144)	[0.0057, 0.334]
	Ownership	0.020 (0.135)	[0.0042, 0.537]
	Individual Hospital	0.037 (0.006)	[0.0005, 0.099]
Hospital choice covariates		α	
	Distance	-13.65 (0.15)	[0.022, 0.024]
	Distance ^{2}	12.43 (0.09)	[0.015, 0.015]
	Distance $\times$ Age	-0.453 (0.025)	[0.0057, 0.010]
	Distance $\times$ Severity	-0.311 (0.034)	[0.0066, 0.014]
	$10^{-5} \times$ Distance $\times$ Income	-0.974 (0.257)	[0.0256, 0.053]

Notation and definitions are exactly as in Table 3 of the paper. The first two numbers in each entry indicate the posterior mean and standard deviation, respectively. The pair of numbers in brackets, separated by a comma, indicate the numerical standard error (NSE) and relative numerical efficiency (RNE) for the Gibbs sampling approximation of the corresponding posterior mean.

Table A2 (continued)

Posterior means and standard deviations

	Coefficient	Probit model	
		γ	
Demographic covariates	Age 70-74	-0.008 (0.025)	[0.0005, 1.354]
	Age 75-79	0.068 (0.024)	[0.0004, 1.842]
	Age 80-84	0.187 (0.024)	[0.0005, 1.317]
	Age > 84	0.374 (0.022)	[0.0003, 3.669]
	Female	-0.087 (0.013)	[0.0003, 1.339]
	Black	-0.025 (0.028)	[0.0006, 1.356]
	Hispanic	-0.126 (0.023)	[0.0006, 0.712]
	Native	0.168 (0.134)	[0.0028, 1.168]
	Asian	-0.091 (0.031)	[0.0004, 3.106]
	Income	0.253 (0.201)	[0.0032, 2.074]
	Income^2	-0.033 (0.024)	[0.0004, 1.549]
Disease severity covariates		γ	
	Emergency admit	0.181 (0.016)	[0.0003, 1.889]
	Disease stages 1.3-2.3	0.089 (0.028)	[0.0007, 0.940]
	Disease stages 3.1-3.6	0.496 (0.023)	[0.0005, 1.015]
	Disease stage 3.7	0.640 (0.018)	[0.0004, 1.061]
	Disease stage 3.8	1.412 (0.037)	[0.0008, 1.239]
ty prob its and		q_G^*	
	150 beds or less	0.007 (0.012)	[0.0002, 1.252]
	151 to 200 beds	-0.034 (0.018)	[0.0006, 0.422]
	201 to 300 beds	-0.003 (0.013)	[0.0003, 1.418]
	Over 300 beds	0.004 (0.012)	[0.0001, 3.594]
	Private, not for profit	-0.001 (0.009)	[0.0001, 2.454]
	Private, for profit	-0.008 (0.009)	[0.0002, 1.057]
	Private Teaching	0.021 (0.024)	[0.0005, 1.013]
	Public	-0.167 (0.042)	[0.0009, 1.077]
Variance of quality		τ^2	
	Size	0.209 (0.155)	[0.0028, 1.601]
	Ownership	0.208 (0.155)	[0.0039, 0.841]
	Individual Hospital	0.030 (0.005)	[0.0001, 1.353]

Notation and definitions are exactly as in Table 3 of the paper. The pair of numbers in brackets, separated by a comma, indicate the numerical standard error (NSE) and relative numerical efficiency (RNE) for the Gibbs sampling approximation of the corresponding posterior mean.

Table A3

Some relative numerical efficiencies of the algorithm for hospital-specific parameters

Parameter name	q_j	ρ_j	q_j^*
Average efficiency	.0201	.0084	1.62
Lowest	.0039	.0036	0.27
Third quartile	.0074	.0051	0.91
Median	.0103	.0064	1.23
First quartile	.0215	.0095	2.02
Highest	.1687	.0723	4.86
Number of parameters	114	113	114

Posterior moments are computed using every 10th draw of the Gibbs sampling algorithm. Relative numerical efficiency is the ratio of the estimated variance of numerical approximation errors using every 10th draw, to the estimated posterior variance.

Table A4

Posterior distribution of hospital quality probits, selection model

	Hospital name	q_j	Rank		Quartile probabilities			
		Mean	Mean	Median				
1	MONTEREY PARK HOSPITAL	0.338	6.7	3	0.959	0.037	0.004	0
2	ST. JOHNS HOSPITAL AND HEALTH	0.294	7.9	5	0.964	0.034	0.003	0
3	TERRACE PLAZA MEDICAL CENTER	0.258	13.2	8	0.88	0.096	0.02	0.004
4	SAN DIMAS COMMUNITY HOSPITAL	0.231	15.4	11	0.839	0.138	0.022	0.001
5	QUEEN OF ANGELS/HOLLYWOOD PRES	0.194	18.9	12	0.769	0.197	0.034	0
6	DANIEL FREEMAN MARINA HOSPITAL	0.181	22.9	15	0.691	0.223	0.077	0.009
7	EAST LOS ANGELES DOCTORS HOSPI	0.173	24.2	16	0.685	0.206	0.089	0.019
8	COMMUNITY HOSPITAL OF HUNTINGT	0.183	25.4	15	0.687	0.17	0.097	0.046
9	WOODRUFF COMMUNITY HOSPITAL	0.165	26.1	19	0.646	0.235	0.099	0.02
10	LOS ANGELES COMMUNITY HOSPITAL	0.159	27.3	19	0.633	0.229	0.106	0.032
11	LINDA VISTA COMMUNITY HOSPITAL	0.165	27.4	19	0.632	0.221	0.113	0.034
12	KAISER FOUNDATION HOSPITAL - L	0.15	27.7	22	0.608	0.272	0.107	0.012
13	AMI TARZANA REGIONAL MEDICAL C	0.14	28.4	21	0.597	0.277	0.102	0.024
14	MISSION HOSPITAL	0.146	28.8	22	0.609	0.248	0.112	0.031
15	BELLFLOWER DOCTORS HOSPITAL	0.141	30.2	25	0.555	0.295	0.126	0.024
16	CEDARS SINAI MEDICAL CENTER	0.115	30.4	29	0.486	0.456	0.058	0
17	NU MED REGIONAL MED CENTER WES	0.118	31	27	0.536	0.344	0.108	0.012
18	DOCTORS HOSPITAL OF LAKEWOOD -	0.14	31.7	22	0.574	0.222	0.154	0.051
19	WHITE MEMORIAL MEDICAL CENTER	0.118	32.6	26	0.548	0.293	0.116	0.044
20	PRESBYTERIAN INTERCOMMUNITY HO	0.111	34.3	24	0.565	0.206	0.174	0.055
21	CIGNA HOSPITAL OF LOS ANGELES	0.114	34.5	28	0.502	0.3	0.152	0.047
22	ST. MARY MEDICAL CENTER	0.101	34.8	30	0.457	0.385	0.139	0.018
23	ST. VINCENT MEDICAL CENTER	0.089	36.1	34	0.384	0.481	0.13	0.005
24	ANTELOPE VALLEY HOSPITAL MEDIC	0.092	36.1	32	0.425	0.414	0.151	0.011
25	GREATER EL MONTE COMMUNITY HOS	0.083	38.1	36	0.373	0.444	0.173	0.009
26	SANTA MARTA HOSPITAL	0.081	39.1	35	0.402	0.388	0.161	0.049
27	LOS ANGELES CO. USC MEDICAL CE	0.078	39.8	36	0.376	0.395	0.193	0.037
28	SHERMAN OAKS COMMUNITY HOSPITA	0.076	40	38	0.363	0.408	0.195	0.033
29	GLENDALE MEMORIAL HOSPITAL & H	0.074	40.9	40	0.299	0.476	0.206	0.018
30	ST. JOSEPH MEDICAL CENTER	0.068	41.4	37	0.373	0.374	0.217	0.036
31	SOUTH BAY HOSPITAL	0.075	41.6	37	0.385	0.337	0.197	0.081
32	PACIFIC ALLIANCE MEDICAL CENTE	0.071	41.8	38	0.377	0.343	0.211	0.069
33	WESTSIDE HOSPITAL	0.072	42.1	40	0.362	0.358	0.217	0.063
34	COVINA VALLEY COMMUNITY HOSPIT	0.069	42.6	38	0.379	0.335	0.207	0.079
35	LITTLE COMPANY OF MARY HOSPITA	0.061	42.7	39	0.307	0.434	0.224	0.035
36	MOTION PICTURE & TELEVISION HO	0.073	43.5	37	0.414	0.258	0.192	0.135
37	KAISER FOUNDATION HOSPITAL - P	0.059	43.9	41	0.309	0.397	0.241	0.053
38	HENRY MAYO NEWHALL MEMORIAL HO	0.047	45.8	45	0.182	0.565	0.243	0.011
39	KAISER FOUNDATION HOSPITAL - B	0.053	46.1	45	0.316	0.333	0.274	0.078
40	GLENDALE ADVENTIST MED CENTER	0.046	46.3	44	0.299	0.368	0.285	0.047
41	SANTA MONICA HOSPITAL MEDICAL	0.048	46.3	44	0.286	0.367	0.295	0.052
42	UCLA MEDICAL CENTER	0.047	46.5	42	0.281	0.412	0.217	0.091
43	HOLLYWOOD COMMUNITY HOSPITAL	0.044	48.4	44	0.317	0.301	0.233	0.149
44	ALHAMBRA COMMUNITY HOSPITAL	0.041	48.9	48	0.26	0.353	0.301	0.086
45	HUMANA HOSPITAL WEST HILLS	0.033	49.5	48	0.207	0.419	0.312	0.062
46	VALLEY PRESBYTERIAN HOSPITAL	0.037	49.8	49	0.227	0.373	0.328	0.072
47	CENTINELA HOSPITAL MEDICAL CEN	0.034	49.8	48	0.259	0.345	0.298	0.097
48	BEVERLY HILLS MEDICAL CENTER	0.035	50.6	49	0.29	0.298	0.263	0.149
49	HAWTHORNE HOSPITAL	0.027	51.7	50	0.241	0.342	0.293	0.124
50	KAISER FOUNDATION HOSPITAL - H	0.033	52	53	0.314	0.223	0.282	0.182
51	SAN PEDRO PENINSULA HOSPITAL	0.027	52	53	0.222	0.329	0.364	0.085
52	LONG BEACH DOCTORS HOSPITAL	0.016	53.8	53	0.236	0.309	0.302	0.153
53	METHODIST HOSPITAL OF SOUTHERN	0.014	53.9	51	0.181	0.396	0.314	0.109
54	SAN FERNANDO COMMUNITY HOSPITA	0.011	55.1	56	0.243	0.279	0.291	0.187
55	INTER COMMUNITY MEDICAL CENTER	0.009	55.7	55	0.115	0.42	0.379	0.086
56	BAY HARBOR HOSPITAL	0.002	57	57	0.074	0.433	0.419	0.074
57	PICO RIVERA COMMUNITY HOSPITAL	-0.003	58.2	59	0.201	0.284	0.301	0.215
58	CHARTER SUBURBAN HOSPITAL	-0.008	59	59	0.162	0.329	0.311	0.198
59	MONROVIA COMMUNITY HOSPITAL	-0.016	59.8	58	0.225	0.267	0.234	0.273
60	BROTMAN MEDICAL CENTER	-0.009	60.4	62	0.13	0.311	0.383	0.177

61	CENTURY CITY HOSPITAL	-0.015	60.8	61	0.127	0.323	0.363	0.188
62	MEMORIAL MEDICAL CENTER OF LON	-0.014	61	63	0.144	0.303	0.352	0.202
63	AMI GLENDORA COMMUNITY HOSPITA	-0.019	61	61	0.164	0.301	0.288	0.246
64	LANCASTER COMMUNITY HOSPITAL	-0.018	61.9	62	0.062	0.377	0.407	0.154
65	BELLWOOD GENERAL HOSPITAL	-0.02	62	63	0.147	0.286	0.339	0.228
66	RIO HONDO MEMORIAL HOSPITAL	-0.023	62.1	62	0.088	0.348	0.388	0.175
67	NORTHRIDGE HOSPITAL MEDICAL CE	-0.02	62.1	62	0.059	0.362	0.435	0.144
68	QUEEN OF THE VALLEY HOSPITAL -	-0.022	62.6	64	0.074	0.322	0.453	0.152
69	PACIFICA HOSPITAL OF THE VALLE	-0.022	62.9	65	0.132	0.271	0.371	0.226
70	CHARTER COMMUNITY HOSPITAL	-0.03	64.1	65	0.094	0.311	0.375	0.22
71	LOS ANGELES DOCTORS HOSPITAL	-0.035	64.7	67	0.149	0.259	0.302	0.291
72	MIDWAY HOSPITAL MEDICAL CENTER	-0.034	65.6	70	0.098	0.272	0.392	0.238
73	COMMUNITY HOSPITAL OF GARDENA	-0.043	66.7	70	0.124	0.244	0.328	0.304
74	HOLY CROSS MEDICAL CENTER	-0.045	68.3	71	0.047	0.271	0.445	0.237
75	BEVERLY HOSPITAL	-0.047	68.5	73	0.105	0.218	0.361	0.316
76	ROBERT F. KENNEDY MEDICAL CENT	-0.054	68.8	71	0.088	0.259	0.335	0.317
77	TEMPLE COMMUNITY HOSPITAL	-0.055	69.2	72	0.084	0.263	0.335	0.319
78	MEDICAL CENTER OF LA MIRADA	-0.056	69.2	73	0.117	0.217	0.323	0.343
79	PALMDALE HOSPITAL MEDICAL CENT	-0.049	69.3	71	0.033	0.262	0.465	0.24
80	HUNTINGTON MEMORIAL HOSPITAL	-0.051	70	71	0.013	0.265	0.486	0.236
81	NORWALK COMMUNITY HOSPITAL	-0.062	71.4	74	0.056	0.235	0.388	0.321
82	ST. LUKE MEDICAL CENTER	-0.066	71.5	74	0.054	0.254	0.357	0.335
83	LOS ANGELES CO. OLIVE VIEW MED	-0.082	74.2	79	0.081	0.197	0.319	0.403
84	TORRANCE MEMORIAL HOSPITAL MED	-0.073	74.4	77	0.024	0.223	0.398	0.355
85	DANIEL FREEMAN MEMORIAL HOSPIT	-0.078	74.5	78	0.053	0.221	0.328	0.398
86	GARFIELD MEDICAL CENTER	-0.086	74.6	76	0.046	0.224	0.358	0.372
87	ST. FRANCIS MEDICAL CENTER	-0.078	75.2	78	0.023	0.213	0.391	0.373
88	ENCINO HOSPITAL	-0.086	75.5	80	0.058	0.194	0.326	0.422
89	THE HOSPITAL OF THE GOOD SAMAR	-0.085	76.3	77	0.017	0.202	0.399	0.383
90	DOWNEY COMMUNITY HOSPITAL	-0.083	76.8	79	0.016	0.185	0.417	0.382
91	KAISER FOUNDATION HOSPITAL - W	-0.095	77	81	0.047	0.195	0.328	0.431
92	POMONA VALLEY HOSPITAL MEDICAL	-0.085	77.6	81	0.009	0.173	0.413	0.405
93	WHITTIER HOSPITAL MEDICAL CENT	-0.106	78.2	84	0.073	0.166	0.285	0.477
94	GRANADA HILLS COMMUNITY HOSPIT	-0.094	78.3	83	0.027	0.181	0.349	0.442
95	PIONEER HOSPITAL	-0.096	79.1	85	0.043	0.141	0.346	0.471
96	PANORAMA COMMUNITY HOSPITAL	-0.114	81.3	87	0.041	0.147	0.302	0.51
97	LOS ANGELES CO. MARTIN L. KING	-0.151	82.4	88	0.05	0.161	0.279	0.51
98	LONG BEACH COMMUNITY HOSPITAL	-0.122	83.6	88	0.014	0.121	0.33	0.535
99	SAN GABRIEL VALLEY MEDICAL CEN	-0.125	83.8	87	0.006	0.124	0.367	0.504
100	BURBANK COMMUNITY HOSPITAL	-0.127	84.5	92	0.035	0.111	0.262	0.592
101	CALIFORNIA MEDICAL CENTER - LO	-0.142	86.1	94	0.018	0.13	0.26	0.592
102	SANTA TERESITA HOSPITAL	-0.141	86.7	91	0.009	0.092	0.327	0.572
103	WASHINGTON MEDICAL CENTER	-0.137	87	92	0.008	0.088	0.315	0.589
104	DOMINGUEZ MEDICAL CENTER	-0.179	91.3	98	0.018	0.079	0.212	0.691
105	VALLEY HOSPITAL MEDICAL CENTER	-0.159	91.8	96	0.001	0.044	0.254	0.702
106	MEDICAL CENTER OF NORTH HOLLYW	-0.165	92.9	97	0	0.032	0.253	0.716
107	VERDUGO HILLS HOSPITAL	-0.169	94.1	98	0.001	0.025	0.213	0.761
108	FOOTHILL PRESBYTERIAN HOSPITAL	-0.169	94.3	97	0.001	0.019	0.221	0.759
109	CANOGA PARK HOSPITAL	-0.213	96.4	103	0.005	0.05	0.165	0.779
110	COAST PLAZA MEDICAL CENTER	-0.213	97.9	104	0.002	0.032	0.154	0.812
111	MEMORIAL HOSPITAL OF GARDENA	-0.277	102.1	108	0	0.016	0.113	0.871
112	LOS ANGELES CO. HARBOR/UCLA ME	-0.275	103.5	108	0	0.01	0.094	0.896
113	KAISER FOUNDATION HOSPITAL - W	-0.282	105	108	0	0.002	0.061	0.938
114	PACIFIC HOSPITAL OF LONG BEACH	-0.333	108.8	112	0	0.002	0.023	0.975

Table A5

Comparison of selected hospital quality probits, selection model

Posterior probability that hospital with rank in row ranks below hospital with rank in column

	1	15	29	43	57	71	85	99
15	0.886	1						
29	0.91	0.638	1					
43	0.938	0.682	0.568	1				
57	0.972	0.775	0.658	0.604	1			
71	0.977	0.822	0.724	0.648	0.559	1		
85	0.999	0.911	0.8	0.713	0.655	0.580	1	
99	0.992	0.947	0.888	0.822	0.751	0.677	0.634	1
114	1	0.998	1	0.985	0.969	0.957	0.968	0.887

Identity of hospital by rank

Rank	Hospital Name
1	Monterey Park Hospital
15	Bellflower Doctors Hospital
29	Glendale Memorial Hospital & Health Center
43	Hollywood Community Hospital
57	Pico Rivera Community Hospital
71	Los Angeles Doctors Hospital
85	Daniel Freeman Memorial Hospital
99	San Gabriel Valley Medical Center
114	Pacific Hospital of Long Beach

Table A6

Posterior distribution of hospital quality probits, probit model

	Hospital name	q_j^*	Rank		Quartile probabilities			
		Mean	Mean	Median				
1	SANTA MARTA HOSPITAL	0.331	3.1	2	0.998	0.002	0	0
2	ST. JOHNS HOSPITAL AND HEALTH	0.227	7.5	6	0.995	0.005	0	0
3	LINDA VISTA COMMUNITY HOSPITAL	0.24	12.4	6	0.868	0.098	0.029	0.005
4	MONTEREY PARK HOSPITAL	0.187	13.9	10	0.883	0.106	0.011	0
5	WOODRUFF COMMUNITY HOSPITAL	0.199	15.7	9	0.827	0.129	0.038	0.006
6	COMMUNITY HOSPITAL OF HUNTINGT	0.194	16.6	9	0.812	0.142	0.041	0.006
7	QUEEN OF ANGELS/HOLLYWOOD PRES	0.145	17.6	16	0.896	0.104	0	0
8	TERRACE PLAZA MEDICAL CENTER	0.174	19.1	12	0.763	0.173	0.058	0.006
9	SAN DIMAS COMMUNITY HOSPITAL	0.155	19.5	14	0.768	0.198	0.03	0.003
10	WHITE MEMORIAL MEDICAL CENTER	0.141	19.7	17	0.794	0.194	0.012	0
11	HENRY MAYO NEWHALL MEMORIAL HO	0.135	20.9	18	0.763	0.217	0.019	0.001
12	BELLFLOWER DOCTORS HOSPITAL	0.149	21.7	15	0.709	0.228	0.057	0.005
13	SAN PEDRO PENINSULA HOSPITAL	0.123	23.6	21	0.698	0.274	0.028	0
14	SOUTH BAY HOSPITAL	0.135	24.1	17	0.677	0.239	0.075	0.008
15	MOTION PICTURE & TELEVISION HO	0.152	25.2	14	0.663	0.196	0.102	0.039
16	CHARTER SUBURBAN HOSPITAL	0.113	26.4	23	0.618	0.326	0.053	0.003
17	DANIEL FREEMAN MARINA HOSPITAL	0.116	26.5	22	0.617	0.318	0.06	0.005
18	BEVERLY HOSPITAL	0.098	28.5	27	0.549	0.417	0.034	0
19	CEDARS SINAI MEDICAL CENTER	0.09	29.4	28	0.502	0.488	0.011	0
20	INTER COMMUNITY MEDICAL CENTER	0.088	31.5	29	0.486	0.442	0.071	0.001
21	LOS ANGELES CO. USC MEDICAL CE	0.086	32.2	30	0.46	0.464	0.075	0.002
22	COVINA VALLEY COMMUNITY HOSPIT	0.096	32.4	27	0.519	0.321	0.134	0.026
23	LOS ANGELES COMMUNITY HOSPITAL	0.102	33	26	0.544	0.267	0.135	0.053
24	HUMANA HOSPITAL WEST HILLS	0.084	33.6	31	0.464	0.399	0.129	0.008
25	ST. MARY MEDICAL CENTER	0.081	33.6	31	0.455	0.435	0.102	0.008
26	MISSION HOSPITAL	0.101	33.7	27	0.527	0.265	0.152	0.056
27	AMI TARZANA REGIONAL MEDICAL C	0.081	34	32	0.435	0.442	0.115	0.008
28	HOLLYWOOD COMMUNITY HOSPITAL	0.088	34.3	29	0.492	0.332	0.146	0.03
29	GLENDALE MEMORIAL HOSPITAL & H	0.073	34.4	34	0.337	0.627	0.036	0
30	HAWTHORNE HOSPITAL	0.09	34.8	29	0.486	0.31	0.163	0.041
31	UCLA MEDICAL CENTER	0.074	35.6	33	0.396	0.472	0.129	0.003
32	CENTURY CITY HOSPITAL	0.072	37.1	33	0.422	0.384	0.167	0.027
33	SANTA MONICA HOSPITAL MEDICAL	0.062	38	37	0.287	0.606	0.105	0.001
34	KAISER FOUNDATION HOSPITAL - P	0.065	38	36	0.347	0.487	0.157	0.009
35	KAISER FOUNDATION HOSPITAL - L	0.061	38.4	37	0.299	0.577	0.123	0.002
36	PACIFIC ALLIANCE MEDICAL CENTE	0.065	38.4	36	0.38	0.429	0.17	0.021
37	GREATER EL MONTE COMMUNITY HOS	0.062	38.9	37	0.344	0.465	0.182	0.009
38	CIGNA HOSPITAL OF LOS ANGELES	0.065	40	36	0.394	0.352	0.199	0.055
39	PRESBYTERIAN INTERCOMMUNITY HO	0.051	41.7	41	0.242	0.567	0.188	0.003
40	ALHAMBRA COMMUNITY HOSPITAL	0.052	42.3	40	0.307	0.439	0.22	0.033
41	BELLWOOD GENERAL HOSPITAL	0.046	44.6	42	0.308	0.39	0.237	0.065
42	NORTHRIDGE HOSPITAL MEDICAL CE	0.041	44.8	44	0.2	0.549	0.239	0.012
43	SAN FERNANDO COMMUNITY HOSPITA	0.05	45.1	41	0.365	0.291	0.232	0.113
44	LANCASTER COMMUNITY HOSPITAL	0.033	47.3	47	0.207	0.472	0.286	0.035
45	ST. LUKE MEDICAL CENTER	0.031	47.9	47	0.203	0.46	0.303	0.034
46	WHITTIER HOSPITAL MEDICAL CENT	0.033	48	46	0.247	0.407	0.267	0.079
47	EAST LOS ANGELES DOCTORS HOSPI	0.031	48.2	48	0.232	0.415	0.296	0.057
48	BEVERLY HILLS MEDICAL CENTER	0.037	48.5	46	0.331	0.282	0.235	0.153
49	GRANADA HILLS COMMUNITY HOSPIT	0.027	49.2	49	0.204	0.427	0.316	0.052
50	LITTLE COMPANY OF MARY HOSPITA	0.02	50.9	51	0.127	0.504	0.341	0.029
51	BROTMAN MEDICAL CENTER	0.019	51.2	51	0.104	0.537	0.336	0.023
52	NORWALK COMMUNITY HOSPITAL	0.017	52.6	52	0.207	0.365	0.311	0.117
53	ST. JOSEPH MEDICAL CENTER	0.012	53.2	53	0.036	0.597	0.359	0.008
54	ST. VINCENT MEDICAL CENTER	0.012	53.3	53	0.11	0.474	0.365	0.051
55	ANTELOPE VALLEY HOSPITAL MEDIC	0.01	54.3	54	0.119	0.447	0.358	0.075
56	KAISER FOUNDATION HOSPITAL - H	0.007	55.1	55	0.106	0.44	0.387	0.067
57	THE HOSPITAL OF THE GOOD SAMAR	0.005	55.6	56	0.048	0.499	0.428	0.025
58	TORRANCE MEMORIAL HOSPITAL MED	0.004	55.9	56	0.071	0.455	0.421	0.053
59	MEMORIAL MEDICAL CENTER OF LON	-0.002	57.7	58	0.051	0.443	0.454	0.052
60	LOS ANGELES CO. MARTIN L. KING	-0.003	58	58	0.126	0.367	0.374	0.134

61	KAISER FOUNDATION HOSPITAL - B	-0.005	58.5	59	0.067	0.398	0.449	0.085
62	LOS ANGELES DOCTORS HOSPITAL	-0.006	58.9	61	0.234	0.242	0.267	0.257
63	ROBERT F. KENNEDY MEDICAL CENT	-0.009	59.9	61	0.074	0.367	0.469	0.09
64	DOCTORS HOSPITAL OF LAKEWOOD -	-0.009	60	60	0.043	0.399	0.484	0.074
65	LONG BEACH DOCTORS HOSPITAL	-0.013	60.8	61	0.144	0.314	0.326	0.216
66	SAN GABRIEL VALLEY MEDICAL CEN	-0.018	62.6	63	0.009	0.354	0.587	0.049
67	NU MED REGIONAL MED CENTER WES	-0.023	63.9	65	0.051	0.325	0.467	0.157
68	AMI GLENDORA COMMUNITY HOSPITA	-0.029	64.9	67	0.116	0.283	0.349	0.253
69	LOS ANGELES CO. OLIVE VIEW MED	-0.03	65.1	66	0.123	0.283	0.308	0.286
70	HOLY CROSS MEDICAL CENTER	-0.039	68.9	70	0.022	0.244	0.545	0.189
71	ENCINO HOSPITAL	-0.041	69	70	0.052	0.255	0.433	0.261
72	GLENDALE ADVENTIST MED CENTER	-0.038	69.2	70	0	0.183	0.736	0.081
73	SHERMAN OAKS COMMUNITY HOSPITA	-0.045	69.8	73	0.075	0.23	0.406	0.289
74	BURBANK COMMUNITY HOSPITAL	-0.046	70.1	72	0.059	0.243	0.414	0.285
75	KAISER FOUNDATION HOSPITAL - W	-0.046	70.3	72	0.048	0.242	0.433	0.277
76	CENTINELA HOSPITAL MEDICAL CEN	-0.045	70.6	73	0.032	0.228	0.488	0.251
77	VALLEY PRESBYTERIAN HOSPITAL	-0.044	70.8	72	0.006	0.216	0.602	0.176
78	PICO RIVERA COMMUNITY HOSPITAL	-0.056	71.1	76	0.123	0.215	0.276	0.387
79	WESTSIDE HOSPITAL	-0.053	72.4	74	0.031	0.209	0.473	0.287
80	GARFIELD MEDICAL CENTER	-0.049	72.5	74	0.002	0.164	0.669	0.165
81	METHODIST HOSPITAL OF SOUTHERN	-0.054	73.9	75	0.001	0.135	0.676	0.188
82	MONROVIA COMMUNITY HOSPITAL	-0.061	74.1	77	0.046	0.202	0.394	0.358
83	COMMUNITY HOSPITAL OF GARDENA	-0.071	75.1	81	0.092	0.184	0.292	0.432
84	PALMDALE HOSPITAL MEDICAL CENT	-0.07	76.7	79	0.025	0.168	0.418	0.388
85	WASHINGTON MEDICAL CENTER	-0.076	78.7	82	0.016	0.158	0.422	0.405
86	SANTA TERESITA HOSPITAL	-0.086	82.5	84	0.002	0.077	0.473	0.447
87	PACIFIC HOSPITAL OF LONG BEACH	-0.088	82.6	85	0.004	0.087	0.455	0.454
88	HUNTINGTON MEMORIAL HOSPITAL	-0.088	83.9	85	0.001	0.023	0.518	0.458
89	TEMPLE COMMUNITY HOSPITAL	-0.103	84.4	89	0.024	0.11	0.32	0.546
90	MEDICAL CENTER OF LA MIRADA	-0.109	84.6	91	0.026	0.115	0.297	0.562
91	FOOTHILL PRESBYTERIAN HOSPITAL	-0.095	84.7	87	0.002	0.069	0.416	0.513
92	DOWNEY COMMUNITY HOSPITAL	-0.094	85.2	87	0.001	0.033	0.457	0.51
93	MEDICAL CENTER OF NORTH HOLLYW	-0.095	85.2	87	0	0.049	0.429	0.522
94	VALLEY HOSPITAL MEDICAL CENTER	-0.103	86.3	89	0.004	0.066	0.362	0.568
95	BAY HARBOR HOSPITAL	-0.104	87.5	89	0	0.025	0.389	0.586
96	MIDWAY HOSPITAL MEDICAL CENTER	-0.105	88.3	90	0	0.005	0.383	0.612
97	PANORAMA COMMUNITY HOSPITAL	-0.121	89	94	0.009	0.067	0.298	0.626
98	QUEEN OF THE VALLEY HOSPITAL -	-0.109	89	91	0	0.019	0.359	0.622
99	PACIFICA HOSPITAL OF THE VALLE	-0.124	90.1	95	0.003	0.062	0.285	0.651
100	CHARTER COMMUNITY HOSPITAL	-0.121	91	94	0	0.027	0.302	0.672
101	POMONA VALLEY HOSPITAL MEDICAL	-0.12	91.8	94	0	0.007	0.268	0.724
102	DANIEL FREEMAN MEMORIAL HOSPIT	-0.127	93.1	95	0	0.007	0.241	0.752
103	LONG BEACH COMMUNITY HOSPITAL	-0.13	93.3	96	0	0.015	0.232	0.753
104	VERDUGO HILLS HOSPITAL	-0.134	94	96	0	0.012	0.221	0.768
105	COAST PLAZA MEDICAL CENTER	-0.161	95.5	102	0.005	0.044	0.201	0.75
106	RIO HONDO MEMORIAL HOSPITAL	-0.167	98.7	103	0.001	0.017	0.136	0.847
107	DOMINGUEZ MEDICAL CENTER	-0.206	100.6	107	0.004	0.031	0.126	0.839
108	PIONEER HOSPITAL	-0.183	101.3	105	0	0.009	0.1	0.891
109	KAISER FOUNDATION HOSPITAL - W	-0.18	102	105	0	0.002	0.076	0.922
110	MEMORIAL HOSPITAL OF GARDENA	-0.204	104.2	107	0	0.004	0.06	0.936
111	LOS ANGELES CO. HARBOR/UCLA ME	-0.213	105.2	108	0	0.002	0.045	0.954
112	ST. FRANCIS MEDICAL CENTER	-0.197	105.2	107	0	0	0.011	0.989
113	CANOGA PARK HOSPITAL	-0.276	106.8	112	0.001	0.016	0.058	0.926
114	CALIFORNIA MEDICAL CENTER - LO	-0.315	112.5	113	0	0	0	1

Table A7

Comparison of selected hospital quality probits, probit model

Posterior probability that hospital with rank in row ranks below hospital with rank in column

	1	15	29	43	57	71	85	99
15	0.87	1						
29	0.995	0.708	1					
43	0.975	0.724	0.574	1				
57	1	0.843	0.864	0.636	1			
71	0.999	0.885	0.899	0.728	0.681	1		
85	1	0.927	0.959	0.807	0.805	0.619	1	
99	1	0.96	0.986	0.894	0.915	0.782	0.673	1
114	1	0.999	1	0.996	1	0.997	0.991	0.974

Identity of hospital by rank

Rank	Hospital Name
1	Santa Marta Hospital
15	Motion Picture & Television Hospital
29	Glendale Memorial Hospital & Health Center
43	San Fernando Community Hospital
57	The Hospital of the Good Samaritan
71	Encino Hospital
85	Washington Medical Center
99	Pacifica Hospital of the Valley
114	California Medical Center - Los Angeles

Table A8

Posterior means and standard deviations

Selection model, prior variant A: instruments eliminated

	Coefficient	Selection model			
		$\gamma/(\delta\Sigma\delta+1)^{1/2}$			
Demographic covariates	Age 70-74	-0.006	(0.025)		
	Age 75-79	0.068	(0.024)		
	Age 80-84	0.186	(0.024)		
	Age > 84	0.368	(0.022)		
	Female	-0.086	(0.012)		
	Black	-0.031	(0.027)		
	Hispanic	-0.11	(0.023)		
	Native	0.171	(0.13)		
	Asian	-0.085	(0.031)		
	Income	0.256	(0.197)		
	Income^2	-0.029	(0.023)		
Disease severity covariates		$\gamma/(\delta\Sigma\delta+1)^{1/2}$			
	Emergency admit	0.173	(0.015)		
	Disease stages 1.3-2.3	0.088	(0.028)		
	Disease stages 3.1-3.6	0.487	(0.022)		
	Disease stage 3.7	0.630	(0.018)		
	Disease stage 3.8	1.387	(0.036)		
Hospital group quality probits and severity correlations		q_G		ρ_G	
	150 beds or less	0.006	(0.025)	-0.0002	(0.041)
	151 to 200 beds	-0.005	(0.072)	0.009	(0.052)
	201 to 300 beds	0.033	(0.037)	0.012	(0.040)
	Over 300 beds	-0.020	(0.031)	-0.006	(0.048)
	Private, not for profit	0.024	(0.031)	0.009	(0.047)
	Private, for profit	-0.047	(0.038)	-0.012	(0.034)
	Private Teaching	-0.006	(0.13)	-0.006	(0.046)
	Public	0.038	(0.19)	0.017	(0.066)
Variance of quality		$\tau^2/(\delta\Sigma\delta+1)$			
	Size	0.24	(0.18)		
	Ownership	0.25	(0.18)		
	Individual Hospital	0.046	(0.009)		
Hospital choice covariates		α			
	Distance	-1.39×10^{-6}	(6.12×10^{-6})		
	Distance ^{2}	-3.40×10^{-6}	(1.17×10^{-6})		
	Distance $\times$ Age	-2.33×10^{-6}	(3.98×10^{-6})		
	Distance $\times$ Severity	-1.65×10^{-6}	(4.91×10^{-6})		
	$10^{-5}\times$ Distance $\times$ Income	-1.58×10^{-6}	(1.39×10^{-6})		

Notation and definitions are exactly as for Table 3 of the paper.

Table A9

Posterior probability comparisons of group hospital quality probits
Selection model, prior variant A: instruments eliminated

	A. Hospitals grouped by size			
	≤ 150 beds	151-200 beds	201-300 beds	> 300 beds
≤ 150 beds	-- 0.10 (--)	34% 0.099 (0.013)	75% 0.105 (0.009)	31% 0.096 (0.007)
151-200 beds	66% 0.103 (0.012)	-- 0.10 (--)	74% 0.108 (0.017)	51% 0.098 (0.013)
201-300 beds	25% 0.096 (0.009)	26% 0.095 (0.018)	-- 0.10 (--)	13% 0.092 (0.008)
> 300 beds	69% 0.105 (0.008)	49% 0.103 (0.014)	87% 0.110 (0.010)	-- 0.10 (--)
	B. Hospitals grouped by ownership classification			
	Private not-for-profit	Private for-profit	Private teaching	Public
Private not-for-profit	-- 0.10 (--)	15% 0.089 (0.011)	47% 0.096 (0.020)	56% 0.107 (0.034)
Private for-profit	85% 0.114 (0.012)	-- 0.10 (--)	57% 0.110 (0.027)	67% 0.120 (0.035)
Private teaching	53% 0.107 (0.022)	43% 0.096 (0.025)	-- 0.10 (--)	50% 0.117 (0.053)
Public	44% 0.102 (0.036)	33% 0.090 (0.030)	50% 0.101 (0.049)	-- 0.10 (--)

Notation and definitions are exactly as for Table 4 of the paper. The first number in each cell is the posterior probability that the group quality probit q_G in the column category exceeds q_G in the row category, and the second number is the posterior mean probability of mortality in the row category given a 10% probability of mortality in the column category, with the posterior standard deviation of this statistic in parentheses.

Table A10

Posterior means and standard deviations

Selection model, prior variant B: tighter prior on α and β

	Coefficient	Selection model			
		$\gamma/(\delta'\Sigma\delta+1)^{1/2}$			
Demographic covariates	Age 70-74	-0.008	(0.024)		
	Age 75-79	0.066	(0.025)		
	Age 80-84	0.185	(0.025)		
	Age > 84	0.370	(0.023)		
	Female	-0.087	(0.013)		
	Black	-0.008	(0.026)		
	Hispanic	-0.13	(0.022)		
	Native	0.177	(0.13)		
	Asian	-0.089	(0.031)		
	Income	0.262	(0.198)		
	Income^2	-0.033	(0.024)		
Disease severity covariates		$\gamma/(\delta'\Sigma\delta+1)^{1/2}$			
	Emergency admit	0.183	(0.016)		
	Disease stages 1.3-2.3	0.091	(0.028)		
	Disease stages 3.1-3.6	0.492	(0.023)		
	Disease stage 3.7	0.633	(0.018)		
	Disease stage 3.8	1.402	(0.038)		
Hospital group quality probits and severity correlations		q_G		ρ_G	
	150 beds or less	-0.001	(0.019)	-0.009	(0.021)
	151 to 200 beds	-0.062	(0.029)	-0.013	(0.025)
	201 to 300 beds	0.013	(0.025)	0.004	(0.019)
	Over 300 beds	0.025	(0.021)	0.014	(0.017)
	Private, not for profit	0.007	(0.019)	0.002	(0.016)
	Private, for profit	0.003	(0.018)	0.007	(0.024)
	Private Teaching	0.033	(0.045)	0.012	(0.026)
	Public	-0.068	(0.069)	-0.020	(0.023)
Variance of quality		$\tau^2/(\delta\Sigma\delta+1)$			
	Size	0.011	(0.008)		
	Ownership	0.012	(0.009)		
	Individual Hospital	0.008	(0.0023)		
Hospital choice covariates		α			
	Distance	-13.47	(0.141)		
	Distance ^{2}	12.35	(0.073)		
	Distance $\times$ Age	-0.46	(0.025)		
	Distance $\times$ Severity	-0.36	(0.040)		
	$10^{-5}\times$ Distance $\times$ Income	-0.979	(0.232)		

Notation and definitions are exactly as for Table 3 of the paper.

Table A11

Posterior probability comparisons of group hospital quality probits
Selection model, prior variant B: tighter prior on α and β

	A. Hospitals grouped by size			
	≤ 150 beds	151-200 beds	201-300 beds	> 300 beds
≤ 150 beds	-- 0.10 (--)	2% 0.090 (0.005)	68% 0.103 (0.007)	76% 0.104 (0.006)
151-200 beds	98% 0.111 (0.006)	-- 0.10 (--)	94% 0.114 (0.009)	98% 0.112 (0.008)
201-300 beds	32% 0.098 (0.007)	6% 0.088 (0.008)	-- 0.10 (--)	66% 0.102 (0.005)
> 300 beds	23% 0.096 (0.006)	2% 0.086 (0.007)	34% 0.098 (0.005)	-- 0.10 (--)
	B. Hospitals grouped by ownership classification			
	Private not-for-profit	Private for-profit	Private teaching	Public
Private not-for-profit	-- 0.10 (--)	44% 0.100 (0.006)	70% 0.105 (0.009)	12% 0.088 (0.011)
Private for-profit	56% 0.101 (0.006)	-- 0.10 (--)	70% 0.106 (0.009)	20% 0.088 (0.013)
Private teaching	30% 0.096 (0.009)	30% 0.095 (0.008)	-- 0.10 (--)	11% 0.084 (0.017)
Public	87% 0.114 (0.014)	81% 0.114 (0.015)	89% 0.120 (0.015)	-- 0.10 (--)

Notation and definitions are exactly as for Table 4 of the paper. The first number in each cell is the posterior probability that the group quality probit q_G in the column category exceeds q_G in the row category, and the second number is the posterior mean probability of mortality in the row category given a 10% probability of mortality in the column category, with the posterior standard deviation of this statistic in parentheses.

Table A12

Posterior means and standard deviations

Selection model, prior variant C: looser prior on α and β

	Coefficient	Selection model			
		$\gamma/(\delta'\Sigma\delta+1)^{1/2}$			
Demographic covariates	Age 70-74	-0.007	(0.023)		
	Age 75-79	0.068	(0.023)		
	Age 80-84	0.187	(0.024)		
	Age > 84	0.370	(0.023)		
	Female	-0.088	(0.014)		
	Black	-0.023	(0.028)		
	Hispanic	-0.12	(0.024)		
	Native	0.140	(0.12)		
	Asian	-0.091	(0.029)		
	Income	0.211	(0.194)		
	Income^2	-0.024	(0.023)		
Disease severity covariates		$\gamma/(\delta'\Sigma\delta+1)^{1/2}$			
	Emergency admit	0.179	(0.016)		
	Disease stages 1.3-2.3	0.088	(0.028)		
	Disease stages 3.1-3.6	0.490	(0.022)		
	Disease stage 3.7	0.634	(0.018)		
	Disease stage 3.8	1.388	(0.038)		
Hospital group quality probits and severity correlations		q_G		ρ_G	
	150 beds or less	0.009	(0.019)	-0.003	(0.029)
	151 to 200 beds	-0.028	(0.029)	0.003	(0.031)
	201 to 300 beds	-0.021	(0.020)	-0.006	(0.029)
	Over 300 beds	0.013	(0.024)	0.011	(0.031)
	Private, not for profit	-0.001	(0.012)	0.002	(0.028)
	Private, for profit	-0.003	(0.020)	0.005	(0.028)
	Private Teaching	0.023	(0.071)	0.010	(0.048)
	Public	-0.098	(0.058)	-0.025	(0.028)
Variance of quality		$\tau^2/(\delta'\Sigma\delta+1)$			
	Size	3.95	(2.53)		
	Ownership	3.99	(2.41)		
	Individual Hospital	0.28	(0.044)		
Hospital choice covariates		α			
	Distance	-13.67	(0.122)		
	Distance ^{2}	12.43	(0.073)		
	Distance $\times$ Age	-0.45	(0.021)		
	Distance $\times$ Severity	-0.31	(0.035)		
	10^{-5} $\times$ Distance $\times$ Income	-0.875	(0.216)		

Notation and definitions are exactly as for Table 3 of the paper.

Table A13

Posterior probability comparisons of group hospital quality probits
Selection model, prior variant C: looser prior on α and β

	A. Hospitals grouped by size			
	≤ 150 beds	151-200 beds	201-300 beds	> 300 beds
≤ 150 beds	-- 0.10 (--)	9% 0.094 (0.005)	13% 0.095 (0.004)	50% 0.101 (0.007)
151-200 beds	91% 0.107 (0.006)	-- 0.10 (--)	59% 0.102 (0.005)	77% 0.108 (0.008)
201-300 beds	87% 0.106 (0.005)	41% 0.099 (0.005)	-- 0.10 (--)	81% 0.106 (0.007)
> 300 beds	50% 0.100 (0.007)	23% 0.094 (0.008)	19% 0.095 (0.006)	-- 0.10 (--)
	B. Hospitals grouped by ownership classification			
	Private not-for-profit	Private for-profit	Private teaching	Public
Private not-for-profit	-- 0.10 (--)	50% 0.100 (0.004)	65% 0.105 (0.013)	4% 0.084 (0.009)
Private for-profit	50% 0.100 (0.004)	-- 0.10 (--)	63% 0.106 (0.015)	5% 0.085 (0.010)
Private teaching	35% 0.097 (0.013)	37% 0.097 (0.014)	-- 0.10 (--)	11% 0.082 (0.014)
Public	96% 0.119 (0.011)	95% 0.119 (0.012)	89% 0.124 (0.020)	-- 0.10 (--)

Notation and definitions are exactly as for Table 4 of the paper. The first number in each cell is the posterior probability that the group quality probit q_G in the column category exceeds q_G in the row category, and the second number is the posterior mean probability of mortality in the row category given a 10% probability of mortality in the column category, with the posterior standard deviation of this statistic in parentheses.

Table A14

Correlation between posterior means of hospital quality probits, alternative selection models

	Prior variant A	Prior variant B	Prior variant C
Base model	.34	.80	.80
Prior variant A	--	.16	.47
Prior variant B	--	--	.66

Table entry indicates correlations between row and column models.

References (beyond those in the paper)

Geweke, J., 1991, "Efficient Simulation from the Multivariate Normal and Student-*t* Distributions Subject to Linear Constraints," in E. M. Keramidas (ed.), *Computing Science and Statistics: Proceedings of the 23rd Symposium on the Interface*, 571-578. Fairfax, VA: Interface Foundation of North America.

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