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Response to Reviewer Comments

Andrew Auerbach, MD, MPH
Editor in Chief, Journal of Hospital Medicine

Elizabeth Goldman MD
Associate Editor, Journal of Hospital Medicine

Dear Drs. Auerbach and Goldman:

Attached is our revised manuscript, “Association of the position of a hospital acquired condition diagnosis code with changes in Medicare Severity Diagnosis-Related Group assignment.” We appreciate the comments and suggestions from you, the editorial team and the reviewer(s) about the statistical methods. We have performed sensitivity analyses to address these comments and have incorporated these findings into the manuscript. The reviewer comments are indicated with [R] and our responses are indicated with [AU].

[R] Please perform, and report back, results from sensitivity analyses adjusting for the total number of comorbidities as well as adjusting for individual comorbidities as defined by Elixhauser (SAS code for these variables is publicly available). We remain concerned that the position of the code may be as important (or less so) than the total comorbidity burden.

[AU] We used the Elixhauser method of identifying comorbid conditions and created 30 additional variables, which included 29 individual comorbid conditions and total number of comorbid conditions (i.e., the sum of individual conditions). Reviewer Table 1 reports the prevalence of each conditions stratified by MS-DRG change. We ran two additional binary logistic regression models and compared their predictive accuracy with the predictive accuracy of our original model that included the number of diagnosis codes (Reviewer Table 2). The correlation between number of diagnosis codes and number of comorbid conditions was strong (ρ = 0.57). The predictive accuracy of the model with the number of comorbid conditions was not statistically different from the model with the number of diagnosis codes. The predictive accuracy for the model with the individual comorbid conditions that were associated with MS-DRG change in Reviewer Table 1 (p < 0.05) was significantly higher, although the magnitude of difference was small (AUC = 0.936 versus AUC = 0.943). The odds ratios for the HAC position were very similar (Reviewer Table 2). We have incorporated the results of this sensitivity analysis into our results.

[R] Thank you for clarifying your methods. Given that you observed site-level variation in coding practices, clustering at the hospital level and performing sensitivity analyses seem necessary to test the robustness of your findings. Please repeat your analyses using hierarchical models as the primary analytic approach.

[AU] We re-ran the logistic regression model as a hierarchical model. Reviewr Table 3 compares our original model with the hierarchical model (with number of diagnosis codes as an independent variable). The odds ratios for HAC position are not attenuated with the inclusion of hospital as a random effect, suggesting that our primary results are not driven by site-level variation in coding practices. We have incorporated the results of this sensitivity analysis into our results.

I hope that you find the revised manuscript suitable for publication in *Journal of Hospital Medicine*.

Sincerely,

Tricia Johnson, PhD

Associate Professor and Health Economist

Reviewer Table 1. Prevalence of Comorbid Conditions

| Variable | MS-DRG Changen (%) or M ± SDN = 980 | No MS-DRG Changen (%) or M ± SDN = 6,047 | p-value |
| --- | --- | --- | --- |
| Total number of comorbid conditions | 3.2 ± 1.9 | 3.9 ± 2.1 | <0.001 |
| Congestive heart failure | 91 (9.3) | 975 (16.1) | <0.001 |
| Valvular disease | 51 (5.2) | 384 (6.4) | 0.167 |
| Pulmonary circulation disorders | 385 (39.3) | 1,099 (18.7) | <0.001 |
| Peripheral vascular disease | 76 (7.8) | 590 (9.8) | 0.047 |
| Hypertension | 540 (55.1) | 3,3138 (51.9) | 0.062 |
| Paralysis | 52 (5.3) | 535 (8.9) | <0.001 |
| Other neurological disorders | 92 (9.4) | 780 (12.9) | 0.002 |
| Chronic pulmonary disease | 165 (16.8) | 1,106 (18.3) | 0.273 |
| Diabetes without complications | 170 (17.4) | 1,147 (19.0) | 0.228 |
| Diabetes with complications | 61 (6.2) | 489 (8.1)( | 0.044 |
| Hypothyroidism | 122 (12.5) | 653 (10.8) | 0.126 |
| Renal failure | 84 (8.6) | 1,223 (20.2) | <0.001 |
| Liver disease | 16 (1.6) | 355 (5.9) | <0.001 |
| Chronic peptic ulcer disease | 1 (0.1) | 5 (0.1) | 0.847 |
| HIV and AIDS | 0 (0) | 38 (0.6) | 0.013 |
| Lymphoma | 12 (1.2) | 120 (2.0) | 0.104 |
| Metastatic cancer | 78 (8.0) | 377 (6.2) | 0.042 |
| Solid tumor without mestastatis | 31 (3.2) | 199 (3.3) | 0.835 |
| Rheumatoid arthritis/collagen vascular diseases | 36 (3.7) | 151 (2.5) | 0.034 |
| Coagulation deficiency | 69 (7.0) | 1,252 (20.7) | <0.001 |
| Obesity | 95 (9.7) | 532 (8.8) | 0.361 |
| Weight loss | 72 (7.4) | 1,314 (21.7) | <0.001 |
| Fluid and electrolyte disorders | 305 (31.1) | 3,460 (57.1) | <0.001 |
| Blood loss anemia | 22 (2.2) | 181 (3.0) | 0.195 |
| Deficiency anemias | 247 (25.2) | 1,892 (31.3) | <0.001 |
| Alcohol abuse | 31 (3.2) | 337 (5.6) | 0.002 |
| Drug abuse | 29 (3.0) | 228 (3.8) | 0.209 |
| Psychoses | 34 (3.5) | 298 (4.9) | 0.046 |
| Depression | 135 (13.8) | 724 (12.0) | 0.110 |

Correlation between total number of diagnosis codes and total number of cormorbid conditions: ρ = 0.57, p < 0.001

Reviewer Table 2. Comparison of Binary Logistic Regression Models with Different Specifications of Disease Burden

|  | Model with number of diagnosis codes | Model with number of comorbid conditions | Model with individual comorbid conditions |
| --- | --- | --- | --- |
| Intercept | Odds Ratio | p-value | Odds Ratio | p-value | Odds Ratio | p-value |
| HAC ICD-9 Diagnosis code in 2nd position | 40.52 | <0.001 | 45.14 | <0.001 | 32.88 | <0.001 |
| HAC ICD-9 Diagnosis code in 3rd position | 1.82 | 0.009 | 2.04 | 0.002 | 1.64 | 0.033 |
| HAC ICD-9 Diagnosis code in 4th position | 1.72 | 0.032 | 1.89 | 0.012 | 1.72 | 0.033 |
| HAC ICD-9 diagnosis code in 5th position | 1.15 | 0.662 | 1.21 | 0.535 | 1.10 | 0.755 |
| Number of ICD-9 diagnosis codes per patient | 0.97 | 0.004 |  |  |  |  |
| Number of comorbid conditions |  |  | 1.02 | 0.436 |  |  |
| Congestive heart failure |  |  |  |  | 1.07 | 0.675 |
| Pulmonary circulatory disorders |  |  |  |  | 2.35 | <0.001 |
| Peripheral vascular disease |  |  |  |  | 1.26 | 0.215 |
| Paralysis |  |  |  |  | 0.74 | 0.133 |
| Other neurological disorders |  |  |  |  | 0.97 | 0.853 |
| Diabetes with complications |  |  |  |  | 1.55 | 0.043 |
| Renal failure |  |  |  |  | 0.74 | 0.080 |
| Liver disease |  |  |  |  | 0.76 | 0.420 |
| Metastatic cancer |  |  |  |  | 1.08 | 0.688 |
| Rheumatoid arthritis/collagen vascular diseases |  |  |  |  | 1.93 | 0.019 |
| Coagulation deficiency |  |  |  |  | 0.98 | 0.913 |
| Weight loss |  |  |  |  | 1.52 | 0.020 |
| Fluid and electrolyte disorders |  |  |  |  | 1.01 | 0.904 |
| Deficiency anemias |  |  |  |  | 1.07 | 0.549 |
| Alcohol abuse |  |  |  |  | 1.13 | 0.651 |
| Psychoses |  |  |  |  | 0.67 | 0.100 |
| Area under the ROC curve | 0.936 |  | 0.936 | 0.682\* | 0.943 | <0.001\* |

The reference category for includes extreme severity of illness and HAC ICD-9 code in the 6th position or higher. The model controls for patient age, sex, race/ethnicity, primary payer, hospital HAC rate, severity of illness, and total number of discharges per hospital.

\*Compared to the model with the number of diagnosis codes.

Reviewer Table 3. Comparison of Models With and Without Hospital Effects

|  | Model without hospital | Model with hospital(hierarchical model) |
| --- | --- | --- |
| Intercept | Odds Ratio | p-value | Odds Ratio | p-value |
| Minor severity of illness | 6.80 | <0.001 | 6.66 | <0.001 |
| Moderate severity of illness | 5.52 | <0.001 | 5.43 | <0.001 |
| Major severity of illness | 8.02 | <0.001 | 8.10 | <0.001 |
| Number of ICD-9 diagnosis codes per patient | 0.97 | 0.004 | 1.03 | 0.001 |
| HAC ICD-9 Diagnosis code in 2nd position | 40.52 | <0.001 | 48.57 | <0.001 |
| HAC ICD-9 Diagnosis code in 3rd position | 1.82 | 0.009 | 1.94 | 0.003 |
| HAC ICD-9 Diagnosis code in 4th position | 1.72 | 0.032 | 1.94 | 0.010 |
| HAC ICD-9 diagnosis code in 5th position | 1.15 | 0.662 | 1.30 | 0.403 |
| Hospital, coefficient |  |  | 0.211 |  |
| Hospital, standard error of coefficient |  |  | 0.073 |  |
| Area under the ROC curve | 0.936 |  | 0.945 |  |