**APPENDIX B: Instrumental Variable Diagnostics**

For the instrumental variable estimator to be consistent, the instruments must be correlated with the endogenous treatment variable (relevance) and uncorrelated with the error term (exogeneity). We conducted diagnostic tests to examine the relevance and exogeneity of our instruments and present the results in Table B1. Diagnostic tests on our instruments provide support for the validity of the instruments used in the models. The joint significance of the excluded instruments in the first stage yielded F-statistics, ranging between 137 and 199. These statistics are greater than the critical values suggested by Stock and Yogo (2005)[[1]](#footnote-1), providing evidence that the instruments are strongly correlated with the treatment variable. In addition, we conducted Sargan-Hansen test of overidentifying restrictions, with the null hypothesis that the instruments are uncorrelated with the error term in the outcome regressions. The failure to reject the null hypothesis supports that the instruments are exogenous. The test failed to reject the null hypothesis in all condition groups at the 5% level and in all groups except Musculoskeletal and Connective Tissue (MDC 08) in the mortality model at the 10%.

Due to the ambiguous result regarding the exogeneity of instruments obtained in the mortality model in the Musculoskeletal and Connective Tissue group, we conducted sensitivity analysis of the mortality model for this group using a different set of instruments. In particular, we used the following as instruments: distance between the index ACH and the nearest LTCH and a dummy variable indicating the distance between the index ACH and the nearest LTCH is less than 0.25 miles. Using these instruments, the first-stage F-statistic of the excluded instruments is 104.91, and the Sargan-Hansen test yielded a J-statistic of 0.301 with a p-value of 0.583, providing evidence that the instruments are valid. The results of the sensitivity analysis for the Musculoskeletal and Connective Tissue category using these instruments are presented in Appendix C.

**Table B1. Instrument Diagnosticsa**

|  |  |  |
| --- | --- | --- |
| Condition Group  | F-statistic of excluded instrumentsb  | Hansen J statisticc (p-value in parentheses) |
| 365-day Mortality Model | 180-day Payment Model |
| MDC=04 Respiratory  | 137.03  | 0.168 (0.682) | 2.619 (0.106) |
| MDC=05 Circulatory  | 143.12  | 0.061(0.805) | 0.017 (0.895) |
| MDC=06 Digestive  | 199.39  | 0.842(0.359) | 0.388 (0.533) |
| MDC=08 Musculoskeletal & Connective Tissue  | 165.13  | 3.097 (0.079) | 0.099 (0.753) |
| MDC=18 Infectious & Parasitic DDs  | 179.61  | 1.179 (0.278) | 0.537 (0.464) |

Notes:

a Linear models were used in conducting diagnostic tests of instruments. Linear probability models were used for mortality, and log-transformed Medicare payment models were estimated using ordinary least squares regression.

b F-statistic associated with the F-test of excluded instruments in the first stage.

c Hansen J statistic associated with the test of overidentifying restrictions.

We also examined the relationship between the instrumental variables and several key covariates to further investigate the correlation between the instruments and factors influencing the outcome variables. Table B2 presents how age, gender, multiple organ failure, and ICU/CCU days are distributed across the instrument strata.

**Table B2. Distribution of Patient Characteristics Across Instrument Strata**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Quartiles based on “distance between index ACH and the nearest LTCH” |  | # of LTCHs in beneficiary’s HRR |
|  |  | Q1 | Q2 | Q3 | Q4 |  | 1 | 2 | 3 | 4+ |
| MDC=4 | age (mean) | 78.9 | 79.8 | 79.6 | 79.1 |  | 79.4 | 79.5 | 79.2 | 79.4 |
|  | male (%) | 42.8 | 41.8 | 42.2 | 44.2 |  | 43.4 | 42.6 | 41.9 | 41.9 |
|  | multiple organ failure (%) | 28.4 | 27.0 | 26.5 | 24.9 |  | 26.6 | 27.5 | 27.0 | 26.2 |
|  | days in ICU/CCU (mean) | 1.8 | 2.0 | 1.5 | 1.1 |  | 1.5 | 1.5 | 1.8 | 1.8 |
|  |  |  |  |  |  |  |  |  |  |  |
| MDC=5 | age (mean) | 78.6 | 79.4 | 79.9 | 79.4 |  | 79.3 | 79.4 | 79.2 | 79.4 |
|  | male (%) | 46.6 | 45.2 | 44.1 | 45.1 |  | 46.1 | 44.9 | 44.6 | 44.3 |
|  | multiple organ failure (%) | 27.4 | 27.6 | 27.9 | 26.9 |  | 26.9 | 27.5 | 28.0 | 28.2 |
|  | days in ICU/CCU (mean) | 2.4 | 2.5 | 2.3 | 1.8 |  | 2.1 | 2.2 | 2.5 | 2.4 |
|  |  |  |  |  |  |  |  |  |  |  |
| MDC=6 | age (mean) | 78.6 | 79.4 | 79.4 | 79.0 |  | 79.1 | 79.2 | 79.0 | 79.1 |
|  | male (%) | 38.2 | 37.3 | 37.3 | 38.8 |  | 38.3 | 37.9 | 37.5 | 37.2 |
|  | multiple organ failure (%) | 14.9 | 14.2 | 13.6 | 12.6 |  | 13.5 | 14.0 | 14.5 | 14.0 |
|  | days in ICU/CCU (mean) | 1.6 | 1.6 | 1.4 | 1.1 |  | 1.3 | 1.4 | 1.6 | 1.5 |
|  |  |  |  |  |  |  |  |  |  |  |
| MDC=8 | age (mean) | 77.8 | 78.3 | 78.9 | 78.6 |  | 78.4 | 78.5 | 78.4 | 78.5 |
|  | male (%) | 33.7 | 33.0 | 32.0 | 33.2 |  | 33.6 | 32.8 | 32.6 | 32.2 |
|  | multiple organ failure (%) | 6.9 | 6.9 | 7.1 | 6.4 |  | 6.5 | 6.9 | 7.3 | 7.2 |
|  | days in ICU/CCU (mean) | 0.6 | 0.6 | 0.6 | 0.4 |  | 0.5 | 0.5 | 0.7 | 0.6 |
|  |  |  |  |  |  |  |  |  |  |  |
| MDC=18 | age (mean) | 79.2 | 80.2 | 80.3 | 79.7 |  | 79.8 | 80.0 | 79.7 | 79.9 |
|  | male (%) | 44.5 | 43.7 | 43.9 | 45.4 |  | 45.1 | 44.1 | 44.0 | 43.2 |
|  | multiple organ failure (%) | 33.1 | 31.8 | 30.9 | 28.5 |  | 30.4 | 31.5 | 32.5 | 31.3 |
|  | days in ICU/CCU (mean) | 3.0 | 2.9 | 2.6 | 2.0 |  | 2.4 | 2.4 | 3.1 | 3.0 |

1. Stock, James H. and Yogo, Motohiro, (2005), Testing for Weak Instruments in Linear IV Regression. In Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg, ed. D. W. K. Andrews and J. H. Stock, p.80-108. Cambridge: Cambridge University Press. [↑](#footnote-ref-1)