

## Appendix

Appendix Table 1. Variation in hospital characteristics between the included group and excluded group.

| Hospital characteristics     | The included group, | The excluded group, | <i>P value</i> |
|------------------------------|---------------------|---------------------|----------------|
|                              | n (%)               | n (%)               |                |
| <b>Hospitals, n</b>          | 466                 | 216                 |                |
| <b>Geographic region</b>     |                     |                     | 0.2032         |
| east                         | 240(51.50)          | 97(44.91)           |                |
| west                         | 127(27.25)          | 72(33.33)           |                |
| mid                          | 99(21.24)           | 47(21.76)           |                |
| <b>Ownership</b>             |                     |                     | 0.8126         |
| Public                       | 446(95.71)          | 203(95.31)          |                |
| Private                      | 20(4.29)            | 10(4.69)            |                |
| <b>Hospital level</b>        |                     |                     | 0.5408         |
| secondary                    | 17(3.65)            | 10(4.63)            |                |
| tertiary                     | 449(96.35)          | 206(95.37)          |                |
| <b>University Affiliated</b> |                     |                     | 0.3137         |
| yes                          | 127(27.25)          | 51(23.61)           |                |
| no                           | 339(72.75)          | 165(76.39)          |                |
| <b>Nurse-to-bed ratio</b>    |                     |                     | 0.0703         |
| ~0.4                         | 13(2.79)            | 7(3.24)             |                |
| 0.4~0.6                      | 136(29.18)          | 60(27.78)           |                |

|  |                     |                     |        |
|--|---------------------|---------------------|--------|
| 0.6~0.8  | 195(41.85)          | 110(50.93)          |        |
| 0.8~   | 122(26.18)          | 39(18.06)           |        |
| <b>Health technician-to-bed ratio</b>                        |                     |                     | 0.1295 |
| ~1.03  | 90(19.31)           | 44(20.37)           |        |
| 1.03~1.50  | 235(50.43)          | 125(57.87)          |        |
| 1.50~2.0   | 115(24.68)          | 37(17.13)           |        |
| 2.0~   | 26(5.58)            | 10(4.63)            |        |
| <b>Annual outpatient volume,<br/>median (IQR), per 10000</b> | 87.77(55.55,140.64) | 71.35(45.77,156.63) | 0.2561 |

\* IQR: Interquartile Range.

Appendix Table 2. Variation in patient characteristics between the included group and excluded group.

| Patient characteristics      | The included group, | The excluded group, | Standardized |
|------------------------------|---------------------|---------------------|--------------|
|                              | n (%)               | n (%)               | difference   |
| <b>Patients, n</b>           | 183,334             | 13,164              |              |
| <b>Age</b>                   |                     |                     |              |
| <55                          | 34,774(18.97)       | 3,450(26.21)        | -0.17        |
| 55~65                        | 42,342(23.10)       | 2,822(21.44)        | 0.04         |
| 65~75                        | 63,729(34.76)       | 4,176(31.72)        | 0.06         |
| >75                          | 42,489(23.18)       | 2,716(20.63)        | 0.06         |
| <b>Primary payer status</b>  |                     |                     |              |
| socialized medicine          | 7,663(4.18)         | 730(5.55)           | -0.06        |
| basic medical insurance      | 145,627(79.43)      | 9,736(73.96)        | 0.13         |
| other insurance types        | 13,089(7.14)        | 1,012(7.69)         | -0.02        |
| self-paying                  | 16,955(9.25)        | 1,610(12.23)        | -0.10        |
| <b>Patterns of admission</b> |                     |                     |              |
| emergency                    | 60,701(33.11)       | 5,059(38.43)        | -0.11        |
| outpatient                   | 122,633(66.89)      | 8,029(60.99)        | 0.12         |
| <b>Ejection fraction</b>     |                     |                     |              |
| CHFrEF                       | 32,700(17.84)       | 2,048(15.56)        | 0.06         |
| CHFpEF                       | 48,058(26.21)       | 2,746(20.86)        | 0.13         |
| CHFmrEF                      | 19,274(10.51)       | 1,193(9.06)         | 0.05         |

|                                   |               |              |       |
|-----------------------------------|---------------|--------------|-------|
| Unrecorded                        | 83,302(45.44) | 7,177(54.52) | -0.18 |
| <b>NYHA classification</b>        |               |              |       |
| Grade I                           | 389(0.21)     | 30(0.23)     | 0.00  |
| Grade II                          | 5,651(3.08)   | 218(1.66)    | 0.09  |
| Grade III                         | 59,402(32.40) | 4,009(30.45) | 0.04  |
| Grade IV                          | 43,173(23.55) | 2,838(21.56) | 0.05  |
| Unrecorded                        | 74,719(40.76) | 6,069(46.10) | -0.11 |
| <b>Coexisting diseases</b>        |               |              |       |
| diabetes mellitus                 | 17,337(9.46)  | 791(6.01)    | 0.13  |
| myocardial infarction             | 16,540(9.02)  | 865(6.57)    | 0.09  |
| pneumonia                         | 12,282(6.70)  | 551(4.19)    | 0.11  |
| coronary heart disease            | 12,202(6.66)  | 544(4.13)    | 0.11  |
| renal failure                     | 7,526(4.11)   | 337(2.56)    | 0.09  |
| COPD                              | 9,166(5.00)   | 399(3.03)    | 0.10  |
| arrhythmia                        | 10,679(5.82)  | 383(2.91)    | 0.14  |
| hematological disease             | 17,211(9.39)  | 705(5.36)    | 0.15  |
| cerebrovascular disease           | 7,412(4.04)   | 256(1.94)    | 0.12  |
| rheumatic valvular heart diseases | 6,510(3.55)   | 242(1.84)    | 0.11  |
| congestive heart failure          | 34,004(18.55) | 1,979(15.03) | 0.09  |
| <b>Year</b>                       |               |              |       |
| 2011                              | 17,080(9.32)  | 1,565(11.89) | -0.08 |
| 2012                              | 27,723(15.12) | 2,265(17.21) | -0.06 |

|                                   |                  |                  |       |
|-----------------------------------|------------------|------------------|-------|
| 2013                              | 34,890(19.03)    | 2,894(21.98)     | -0.07 |
| 2014                              | 30,269(16.51)    | 2,161(16.42)     | 0.00  |
| 2015                              | 27,749(15.14)    | 2,051(15.58)     | -0.01 |
| 2016                              | 30,502(16.64)    | 1,560(11.85)     | 0.14  |
| 2017                              | 15,121(8.25)     | 668(5.07)        | 0.13  |
| <b>In-hospital mortality</b>      | 1,923(1.05)      | 199(1.51)        | -0.04 |
| <b>Treatment outcome</b>          |                  |                  |       |
| unimproved                        | 56,695(30.92)    | 4,705(35.74)     | -0.10 |
| improved                          | 126,639(69.08)   | 8,459(64.26)     | 0.10  |
| <b>Medical costs, median, RMB</b> | 13633.67±1640.93 | 13958.90±2222.65 | -0.17 |
| <b>LOS, median, day</b>           | 10.87±7.08       | 9.56±7.35        | 0.18  |

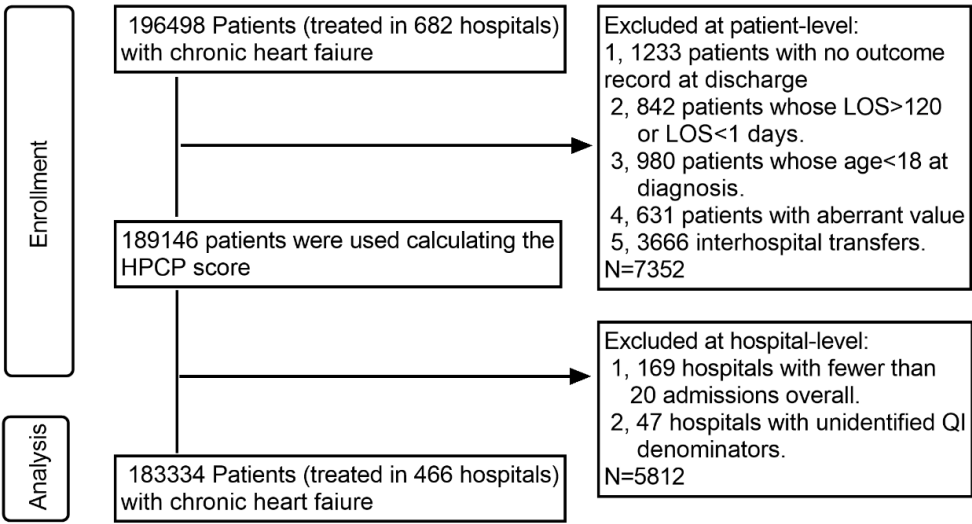
\* Abbreviations: CHF<sub>r</sub>EF: Congestive heart failure with reduced ejection fraction, CHF<sub>p</sub>EF: Congestive heart failure with preserved ejection fraction, CHF<sub>mr</sub>EF: Congestive heart failure with mid-range ejection fraction, COPD: chronic obstructive pulmonary disease, LOS, length of stay. Differences of patient characteristics between included and excluded patients were expressed using standardized differences. All percentages are based on non-missing values.

Appendix Table 3. Hospital Characteristics by Hospital Performance Quartile

| Hospital characteristics     | Overall | Lowest<br>quality | Quartile<br>2 | Quartile<br>3 | Highest<br>quality | <i>P value</i> |
|------------------------------|---------|-------------------|---------------|---------------|--------------------|----------------|
| <b>Hospitals, n</b>          | 466     | 117               | 116           | 117           | 116                |                |
| <b>Geographic region</b>     |         |                   |               |               |                    | 0.5143         |
| east                         | 51.5    | 50.43             | 51.72         | 52.99         | 50.86              |                |
| west                         | 27.25   | 23.08             | 25.86         | 27.35         | 32.76              |                |
| mid                          | 21.24   | 26.5              | 22.41         | 19.66         | 16.38              |                |
| <b>Ownership</b>             |         |                   |               |               |                    | 0.3081*        |
| Government                   | 95.71   | 97.44             | 94.83         | 97.44         | 93.1               |                |
| Private                      | 4.29    | 2.56              | 5.17          | 2.56          | 6.90               |                |
| <b>Hospital level</b>        |         |                   |               |               |                    | 0.5507*        |
| secondary                    | 3.65    | 1.71              | 4.31          | 5.13          | 3.45               |                |
| tertiary                     | 95.71   | 98.29             | 95.69         | 94.87         | 96.55              |                |
| <b>University Affiliated</b> |         |                   |               |               |                    | 0.1982         |
| yes                          | 27.25   | 29.91             | 25.86         | 32.48         | 20.69              |                |
| no                           | 72.75   | 70.09             | 74.14         | 67.52         | 79.31              |                |
| <b>Nurse-to-bed ratio</b>    |         |                   |               |               |                    | 0.3893         |
| ~0.4                         | 2.79    | 4.27              | 2.59          | 3.42          | 0.86               |                |
| 0.4~0.6                      | 29.18   | 29.91             | 33.62         | 23.08         | 30.17              |                |
| 0.6~0.8                      | 41.85   | 42.74             | 37.93         | 45.30         | 41.38              |                |
| 0.8~                         | 26.18   | 23.08             | 25.86         | 28.21         | 27.59              |                |

|                                 |       |       |       |       |       |        |
|---------------------------------|-------|-------|-------|-------|-------|--------|
| <b>Health technician-to-bed</b> |       |       |       |       |       |        |
| <b>ratio</b>                    |       |       |       |       |       | 0.4202 |
| ~1.03                           | 19.31 | 23.08 | 20.69 | 14.53 | 18.97 |        |
| 1.03~1.50                       | 50.43 | 51.28 | 50.86 | 50.43 | 49.14 |        |
| 1.50~2.0                        | 24.68 | 21.37 | 24.14 | 26.50 | 25.86 |        |
| 2.0~                            | 5.58  | 4.27  | 4.31  | 7.69  | 6.90  |        |
| <b>Annual outpatient</b>        |       |       |       |       |       |        |
| <b>volume, median, per</b>      | 87.77 | 97.00 | 89.58 | 91.48 | 74.79 | 0.0632 |
| <b>10000</b>                    |       |       |       |       |       |        |

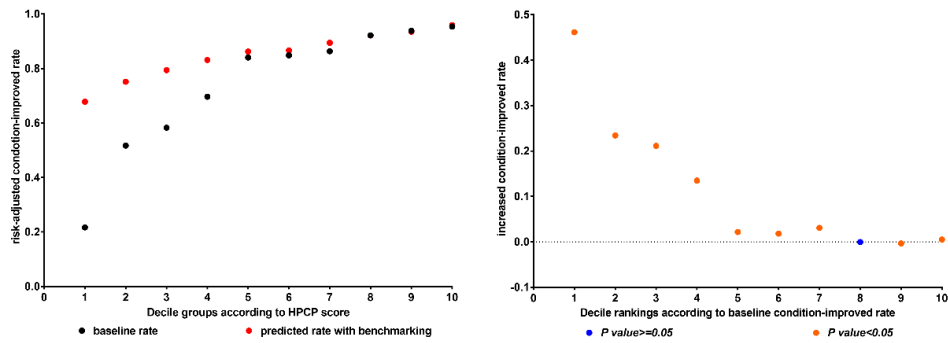
\* Fisher exact tests were used. Hospitals are divided into quartiles based on hospital ranks sorted by hospital process composite performance scores. The first quartile was regarded as the lowest quality group and the fourth quartile was regarded as the highest quality group.



Appendix Figure 1. Study flow diagram of the chronic heart failure patient population.

Abbreviations: LOS, length of stay; HPCP, hospital process composite performance; QI, quality indicator.





Appendix Figure 2. Risk-adjusted condition improved rate and predicted quality improvement of the best-performing decile group (hospitals in the last 10% ranking orders of hospital process composite performance scores).