**Chapter 17**

**Application to Benchmarking Clinicians: Switching Distributions**

#  [H1] Learning Objectives

# [INSERT NL]

1. Benchmark clinicians against their peers

2. Simulate the performance of clinicians on the same set of patients by switching distributions

3. Estimate outcomes for synthetic controls and improve matching of all clinicians’ cases

# [END NL]

# [H1] Key Concepts

# [INSERT BL]

* Overlap among clinicians and peers
* Distribution switch
* Event trees
* Expected outcomes
* Synthetic control

# [END BL]

# [H1] Chapter at a Glance

In this chapter, we show how data balancing, in general—and stratified covariate balancing, in particular—can be used to benchmark clinicians. Data balancing enables the analyst to compare the performance of clinicians to their peer groups as they treat the same set of patients. The comparison is done in four steps:

**[INSERT NL]**

1. The patients are described in terms of their features and comorbidities. Each combination of comorbidities is treated as a separate type of patient.
2. The patient types are used to calculate the distributions of the clinician’s and peer group’s frequency of each type. Naturally, these two groups will differ in who is taking care of sicker patients.
3. The distribution of the peer group’s patients is switched with the distribution of the clinician’s patients. In this fashion, the analyst simulates the performance of the peer group on the same clinician’s patients. The switch accomplishes the same goal as using propensity, or other types of weights, to balance the two distributions.
4. The expected outcomes are calculated for both the clinician and the peer group. The expected outcome for both the clinician and the peer group use different outcomes but the same distribution: the distribution of the patients seen by the clinician.

**[END NL]**

In reporting the outcomes of the peer group on the clinician’s patients, a problem arises when the peer group does not see a type of patient seen by the clinician. To compensate, the peer group’s outcomes for these situations are constructed using synthetic controls. These synthetic controls replace missing patient types and allow all the clinician’s patients to have at least one match to the peer group’s patients. The procedures described here can be applied easily to data in electronic health records, and this chapter presents standard query language (SQL) for doing so.

# [H1] Introduction

Clinicians often complain that benchmarking procedures are unfair. They point out that they are taking care of sicker patients than their colleagues. Since sicker patients would naturally have worse outcomes, benchmarking holds them accountable for patients’ conditions, as opposed to the quality of their care. Since no two clinicians see the same frequency of sicker patients, clinicians have good reason to be concerned. One way out is to randomly assign patients to clinicians. If patients were randomly assigned to their provider, then we can be reassured that the two groups are similar and that differences in outcome do not result from one group having sicker patients. Such randomization is almost never done, however, although exceptions exist (Cebul 1991). Patients choose their clinicians and do not want to give up their choice. This chapter discusses another approach: letting the patients select their clinicians as they wish, then using a data balancing procedure to simulate what would have happened if the peer group and the clinician had seen the same patients. Data balancing allows the analyst to focus on quality of care, independent of differences in patient conditions.

 Data balancing refers to weighting the data so that sicker patients occur at the same rate among the patients seen by both the clinician and the peer group. Data balancing was first proposed in 1983 (Rosenbaum and Rubin 1983). Since then, the approach has been repeatedly improved (Abadie and Imbens 2011; Abadie and Imbens 2006; Alemi, Elrafey, and Avramovic 2018; Hansen 2004; Hirano, Imbens, and Ridder 2003; Ho et al. 2007; Imai and Ratkovic 2014) and is in widespread use, with several tutorials describing the nuances of propensity scoring, a type of data balancing (Austin 2011). Most recently, a technique called *stratified covariate balancing* has been used (Alemi et al. 2018). In this chapter, we use stratified covariate balancing to benchmark clinicians because it does not require the statistical estimation of weights used in data balancing.

Throughout this chapter, we have replaced the terminology we used in previous chapters with terms that make sense in the context of benchmarking clinicians. *Sample* is replaced with *patient groups*. *Covariates* is replaced with *patient comorbidities*. A *stratum*, or a unique combination of covariates, is replaced with *patient types*. In the context of benchmarking, the clinician is the treatment variable. *Treatment effect* is replaced with *clinician’s quality of care*.

# [H1] Switching Probabilities

In data balancing, the types of patients seen in the peer group are weighted so that they occur at the same rate as the types seen by the clinician. The weights are derived through statistical models, usually regression. Stratified covariate balancing simplifies the calculation of the weights by deriving them analytically, without statistical modeling. To further simplify the data-balancing procedures, we bypass the estimation of weights entirely. Since weights are the means to creating equal distributions, one can discard the complex task of estimating the weight and simply switch the distribution of the peer group’s patients with the distribution of the clinician’s patients (see the box for the mathematics of how to do so). This switch in distributions sidesteps the awkward and often confusing modeling necessary to estimate the weights. It also helps the interpretation of the findings, as the switch has a physical interpretation: it simulates how the peer group would have performed if they had seen the clinician’s patients.

**[INSERT BOX]**

|  |
| --- |
| **The Math of Switching Distributions**If $P\_{i}$ is the probability of observing patients in severity group *i* and $O\_{i, Clinician} $is the average outcome for the clinician for severity group *i*, then the expected outcome for the clinician is calculated as$$O\_{Clinician}= ∑P\_{i,Clinician} O\_{i, Clinician}.$$In this formula, the summation is over the index value *i*, which indicates low-, medium-, or high-severity illness groups. The same calculation can be done for the peer clinicians with the formula $$O\_{Peer}= ∑P\_{i,Peer} O\_{i, Peer}. $$The observed peer outcome, shown as$ O\_{Peer},$ is not a reasonable benchmark. It is calculated on a different set of patients than the clinician’s patients. The simulated peer outcome, shown as$ S\_{Peer}$, adjusts for the differences in the patient populations. It is calculated by switching the peer’s probability of caring for sick patients with that of the clinician. It is calculated as$$S\_{Peer}= ∑P\_{i,Clinician} O\_{i,Peer.} $$This simulation estimates what would have happened if the peer group would have cared for the clinician’s patients. See the appendix for how to do this within electronic health records.**[END BOX]** |

Of course, the simulated values are counterfactual calculations, in the sense that these statistics report outcomes if the peer group had seen the patients of the clinician. The peer group has not really done so. We need to simulate what the situation would have been, if they had done so. If we compare the clinician’s observed outcomes to the peer group’s simulated outcomes, we are comparing the two groups on the same types of patients—apples to apples. The comparison does not blame either group for taking care of sicker patients.

 An example can demonstrate. Imagine that a clinician and his peers have had the outcomes displayed in exhibit 17.1. Is this clinician better or worse than the peer providers? To answer this question, the analyst must compare the expected outcomes for the clinician to the expected outcomes for the peer providers simulated on the same patients as the clinician. The calculation of expected outcomes has two components: probability of observing different types of patients and outcomes within different types of patients. Expected outcome is the sum of the product of these two components.

**[INSERT EXHIBIT]**

**Exhibit 17.1** Severity-Adjusted Benchmarks for Length of Stay of Clinician’s Patients

|  |  |  |
| --- | --- | --- |
| Severity of Patients | **Clinician** | **Peer Group** |
| Number of Patients | Average Length of Stay of Patients | Number of Patients | Average Length of Stay of Patients |
| Low | 20 | 3.1 | 40 | 4.1 |
| Medium | 30 | 3.4 | 40 | 3 |
| High | 70 | 5.2 | 5 | 4.5 |

**[END EXHIBIT]**

The first step is to calculate the probability of finding a patient in a different severity group. To do so, divide the number of patients in a severity group by the total number of patients seen by the clinician being evaluated. For the clinician, the probability of having a low-severity patient is 20 ÷ 120, a medium-severity patient is 30 ÷ 120, and a high-severity patient is 70 ÷ 120. This clinician mostly sees severely ill patients. Once the probabilities are calculated, the second step is to calculate the expected outcome, which in this example is expected length of stay (LOS) for the clinician, in the following manner:

**[INSERT EQUATION]**

$O\_{Clinician}= \left(\frac{20}{120}\right)×3.1 +\left(\frac{30}{120}\right)×3.4 + \left(\frac{70}{120}\right)×5.2 = 4.4 days$.

**[END EQUATION]**

To understand whether 4.4 days is too high or too low, the analyst needs to compare this clinician’s performance to that of her peer providers. But the peer providers do not see as many severely ill patients as the clinician does; the clinician sees 70 patients in the high-severity group, while the peer group sees only five. To simulate the performance of the peer providers on the patients seen by the clinician, the analyst uses the frequency of severity among the clinician’s patients to weight the outcomes of the peer providers, as seen here:

**[INSERT EQUATION]**

$$S\_{Peer}= \left(\frac{20}{130}\right)×4.1 +\left(\frac{30}{120}\right)× 3.0 + \left(\frac{70}{120}\right)×4.5 = 4.0 days.$$

**[END EQUATION]**

In this calculation, the probabilities are from the clinician’s experience with different types of patients, and the outcomes are from the peer group’s experiences with the same types of patients. The expected outcome is calculated to be four days for the peer group seeing the clinician’s patients. The clinician seems to be less efficient than the average of his peer group, when both are compared on the same set of patients. Because we equalized the frequency of low‑, medium-, and high-severity patients, the differences cannot be the result of patient severity. Of course, the analysis can be misleading if the classification of patients into various severity groups is done incorrectly. But if the classification of patients into severity groups is correct, switching of probabilities is an easy way to simulate the performance of the clinician and the peer group on the same set of patients.

#  [H1] Example with Multiple Comorbidities

In the previous section, we divided patients into broad categories of severity (low, medium, and high) and compared care provided in each category. To calculate these benchmarks, we need access to a reliable and valid measure of the severity of illness. Sometimes such a measure is not available. In these situations, an analyst must match the patients of clinicians to patients of the peer group using patient’s history of illness and comorbidities. A great deal has been written on matching, and many methods exist to match patients (Rose and Laan 2009; Rosenbaum 2007).

 An example can demonstrate the use of patient matching. Exhibit 17.2 shows 20 patients of one clinician and 24 patients of his peer providers. These patients were admitted to a hospital for myocardial infarction (MI). In each case, we have recorded two features: existence of a previous MI and presence of congestive heart failure (CHF). Obviously, a patient with a previous MI and with CHF has a worse prognosis than a patient without these features. The analyst needs to separate outcomes for patients with and without these characteristics.

**[INSERT EXHIBIT]**

**Exhibit 17.2** Patients of Clinician and Peer Group Differ
Length of Stay (LOS) History of Previous Myocardial Infarction (MI) and Congestive Heart Failure (CHF)

|  |  |
| --- | --- |
| **Cinician’s Patients** | **Peer Group’s Patients** |
| **Case** | **Previous Myocardial Infarction** | **Congestive Heart Failure** | **Length of Stay** | **Case** | **Previous Myocardial Infarction** | **Congestive Heart Failure** | **Length of Stay** |
| 1 | Yes | Yes | 6 | 1 | MI | CHF | 5 |
| 2 | Yes | No | 5 | 2 | MI | CHF | 5 |
| 3 | Yes | Yes | 6 | 3 | No MI | CHF | 4 |
| 4 | Yes | Yes | 6 | 4 | No MI | No CHF | 3 |
| 5 | Yes | Yes | 6 | 5 | No MI | CHF | 4 |
| 6 | Yes | No | 5 | 6 | No MI | CHF | 4 |
| 7 | Yes | Yes | 6 | 7 | MI | CHF | 5 |
| 8 | Yes | No | 5 | 8 | MI | CHF | 5 |
| 9 | Yes | Yes | 6 | 9 | MI | CHF | 5 |
| 10 | Yes | No | 5 | 10 | MI | CHF | 5 |
| 11 | Yes | Yes | 6 | 11 | MI | CHF | 5 |
| 12 | No | Yes | 4 | 12 | No MI | No CHF | 3 |
| 13 | No | Yes | 4 | 13 | No MI | CHF | 4 |
| 14 | No | Yes | 4 | 14 | No MI | CHF | 4 |
| 15 | Yes | Yes | 6 | 15 | No MI | CHF | 4 |
| 16 | Yes | Yes | 6 | 16 | No MI | CHF | 4 |
| 17 | Yes | Yes | 6 | 17 | No MI | CHF | 4 |
| 18 | Yes | No | 5 | 18 | No MI | No CHF | 3 |
| 19 | Yes | No | 5 | 19 | MI | No CHF | 4 |
| 20 | Yes | Yes | 6 | 20 | MI | CHF | 5 |
|  |   |   |   | 21 | MI | CHF | 5 |
|  |   |   |   | 22 | MI | CHF | 5 |
|  |   |   |   | 23 | MI | No CHF | 4 |
|  |   |   |   | 24 | No MI | CHF | 3 |

 **[END EXHIBIT]**

An event tree can organize and summarize the data in exhibit 17.2. Each feature of the patient (e.g., previous MI or CHF) can be used to create a new branch in the event tree. The branches end with the outcomes, with the LOS presented to the right of the tree. A branch on the tree shows a particular combination of patient features. The idea is to make sure that both the clinician and the peer group are matched on the same branches or same patient types.

For example, the event tree for the patients seen by the clinician and peer group are provided in exhibit 17.3. In this tree, previous MI is the first event, and CHF is the second event. The LOS is given to the right of the tree. The top branch in exhibit 17.3 is the combination of previous MI and CHF. The probability of previous MI and the conditional probability of CHF given a previous MI are given on the arcs. To make it easier to read the tree, and because in each node the probabilities add up to 1, the probabilities of negative events (such as not having CHF) are not provided. They can be easily derived.

**[INSERT EXHIBIT]**

**Exhibit 17.3** Decision Trees for the Clinician’s and Peer Group’s Practice

.85

.65

1.0

**Length of Stay**

**6**

**5**

**4**

**?**

.50

.83

.75

**Length of Stay**

**5**

**4**

**4**

**3**

*Note:* Probabilities around each node add up to 1. CHF = congestive heart failure, MI = myocardial infarction, LOS = length of stay.
 **[END EXHIBIT]**

The joint probability of events in each branch of the tree is calculated by multiplying the probabilities of each arc in the branch. So the joint probability of previous MI and CHF for the clinician is calculated as 0.85 times 0.65. The expected LOS is calculated as the sum of the product of the probability of events on the branch times the outcome associated with the branch. The expected LOS for the clinician was 5.8 days:

**[INSERT EQUATION]**

****

**[END EQUATION]**

To simulate how the same patients would have been cared for by peer clinicians, the clinician’s event tree is kept and the LOS of each patient grouping is replaced with the LOS of the patients in the peer group. This results in an expected outcome for a peer group of 4.95 days, as we can see here:

**[INSERT EQUATION]**

Expected LOS = **5** $×$ (0.65$ ×$ 0.85) + **4** $×$ ((1 − 0.65)$ × $0.85) + **4** $×$ (1.0$ × $0.25) + **3** $×$ (0) = 4.95.

**[END EQUATION]**

In this calculation, the days of hospital stay are shown in bold and the probabilities in parentheses. The probabilities come from the clinician’s tree, while the outcomes (i.e., the bold days of stay) come from the peer group’s tree. The clinician’s patients stay, on average,
5.80 − 4.95 = 0.85 days longer than they would if these same patients were treated by the peer group. Note that if we had not switched the probabilities, we could not have claimed that performance had been calculated on the basis of the same patients. Even small differences in average performance add up over a large number of patients. In our example, in 100 patients, the clinician’s patients stay 85 days longer in the hospital, which is not a minor cost.

#  [H1] Overlap of Clinician’s and Peer Group’s Patients

So far, we have compared the clinician and the peer group by finding the same patients in the two groups. In essence, we have matched the patient types across the two groups and noted the differences in outcomes. Matching patients does not always work. As the number of features increases, the number of data points that fall into each branch (each patient type) becomes smaller. Soon most branches will have no patients. Many peer providers’ patients cannot be matched feature by feature, condition by condition, to the clinician’s patients. A clinician may see patients never seen by his peer and vice versa. When the features available do not exactly match, the analyst can rely on partial matches. Obviously, as fewer features are matched, the benchmarking conclusions become less defensible. One way out of this situation is to create synthetic patients whenever an exact match does not exist. In artificial intelligence literature, the procedure for constructing synthetic controls is known as *synthetic minority oversampling technique* (Blagus and Lusa 2013).

 For example, consider the data in exhibit 17.4. For each patient managed by these providers, we have information on her hierarchical condition category (HCC) from the Centers for Medicare & Medicaid Service (CMS), as well as her diagnosis related groups (DRGs). For simplicity, we have divided the HCC scores into three groups: low, medium, and high. For the same reason, we have assumed there were only three DRGs, shown as acute myocardial infarction (AMI), congestive heart failure (CHF), and angina pectoris (AP).

Because HCC scores are always available for any patient (patients with no data are assumed to have an HCC of zero), we will start the event tree using this variable. DRGs are not always occurring for all clinicians, so these values may be null. The tree shows the probability of various HCCs and DRGs. Note that the probabilities shown for the DRGs are conditional on HCC values. The probabilities at each node add up to 1, but some values are not shown to keep the display simple. The product of the probability of HCC and conditional probability of DRG shows the joint probability of the combination of HCC and DRG. These values are also shown in exhibit 17.4 under the column named “Both HCC and DRG.”

Further suppose that the clinician and his peer have the LOS indicated in exhibit 17.4. A glimpse at the tree suggests that the clinician’s peer may be seeing patients with higher severity who thus have longer stays. The tree for the clinician and the tree for his peer group are structurally different. There are some branches in the clinician’s tree that are not in the peer group and vice versa. Given these differences, it is not possible to switch the probability events from one tree with another without first making some adjustments.

**[INSERT EXHIBIT]**

**Exhibit 17.4:** Probability and Outcomes for Dr. A and His Peer Group



*Note*: Data are not real and are for demonstration purposes. Probabilities around each node add up to 1. AMI = acute myocardial infarction, AP = angina pectoris, and CHF = congestive heart failure.

**[END EXHIBIT]**

 The clinician does not see any patients who have AMI with low HCC scores. Likewise, the peer group does not see patients with AP with high HCC scores. In most benchmarking, some patient types are missing from one or the other group. In the literature, the extent of the match in branches of the tree is referred to as *overlap* between the two trees. Perfect overlap is rare. The analyst must use data management procedures when the two trees have partial overlap. Of course, a portion of the data where the two trees do not overlap can be ignored, but doing so may throw away a lot of information, including crucial data about clinicians who see rare but severely ill patients.

#  [H1] Synthetic Controls

One solution to mismatch between peer group and clinician patients is to construct synthetic controls. Not all failure to match matters. When the clinician misses a type of patient seen by the peer group, we can ignore it. The comparison of the clinician and the peer group is done on the clinician’s patients. Therefore, patients not seen by the clinician do not affect the final conclusions. De facto, these patients will have zero chance of occurrence, and whatever the outcome, it will make no difference. For example, in exhibit 17.4 the clinician does not see patients with AMI with low HCC scores. Since we are examining the performance of both groups on the clinician’s patients, we can safely ignore the cases missing from the clinician’s practice. The missing information does not affect either the expected performance of the clinician or the simulated performance of the peer group on the clinician’s patients. Both groups are evaluated on cases seen by the clinician, and missing cases from the clinician’s practice do not matter. The situation is different when the peer group does not see a particular patient type seen by the clinician. Then, we need to construct synthetic controls to estimate the missing outcome values.

There are different ways to construct synthetic controls. One way is to use the independence among patient features. The missing case is broken into its components. The average for each component is calculated and referred to as the marginal average. Under the assumption of independence, the product of averages for two complementary components of the missing case can be used to estimate the outcome. For example, exhibit 17.5 shows the calculation for the peer group in exhibit 17.4. The peer group of the clinician is missing patients with high HCC scores and AP DRG. To estimate the LOS for these types of patients, we divide the missing case into two components: (1) high HCC and (2) AP. For each component, the marginal average is calculated. The missing outcome is estimated as the product of two marginal estimates divided by the average of all values for the peer group. See exhibit 17.5 for the calculation of marginal averages and outcomes for synthetic control. The marginal average for AP is 5.5. The marginal average for high HCC scores is 4.5. The missing outcome for the combined AP and high HCC is calculated as 4.5 × 5.5 ÷ 4 = 6.19 days.

**[INSERT EXHIBIT]**

**Exhibit 17.5:** Estimating Missing Outcomes for Peer Group

|  |  |  |
| --- | --- | --- |
| **DRG** | **HCC** | **Average** |
| **Low**  | **Med**  | **High**  |
| Angina pectoris | 6 | 5 | ? | 5.5 |
| Congestive heart failure  | 1 | 2 | 3 |   |
| Acute myocardial infarction  | 4 | 5 | 6 |   |
| Average  |   |   | 4.5 | 4 |
| *Note*: Missing length of stay is calculated as 4.5 × 5.5 ÷ 4 = 6.19. |

**[END EXHIBIT]**

Another way is to construct synthetic controls from a model of the data. First, for the peer group, a regression is done estimating outcomes as a function of the patient’s features. Suppose the regression formula for predicting the peer group’s outcomes is given as

**[INSERT EQUATION]**

$$LOS=1.88 High HCC+1.88 Medium HCC+4.12 AMI+1.13 CHF+4.51 AP. $$

**[END EQUATION]**

Then, the missing case with High HCC and AP is estimated to have an outcome of

**[INSERT EQUATION]**

$$LOS=1.88 × 1+1.88 × 0+4.12×0+1.13 × 0+4.51 × 1=6.39 days. $$

**[END EQUATION]**

With the addition of the outcome for the synthetic control, both the clinician’s and the peer group’s trees have the same structure. Since both trees have the same branches, we can now switch the probabilities and simulate the performance of the peer group on the clinician’s patients. The observed expected value for the clinician is calculated as, where probabilities are put in parentheses and the outcomes are shown in bold:

**[INSERT EQUATION]**

Clinician’s Expected LOS = **6** × (0.6 × 0.8) + **5** × (0.6 × 0.1) + **4** × (0.6 × 0.1) + **3** × (.3× .5) + **2** × (.3× .3) + **1** × (.3× .2) + **5** × (.1× .9) + **6** × (.1× .1) = 4.62.

**[END EQUATION]**

The simulated expected value for the peer group seeing the clinician’s patients is calculated as:

**[INSERT EQUATION]**

Peer’s expected LOS =

**6** × (0.6 × 0.8) + **3** × (0.6 × 0.1) + **6.2** × (0.6 × 0.1) + **5** × (0.3 × 0.5) + **2** × (0.3 × 0.3) + **5** × (0.3 × 0.2) + **1** × (0.1 × 0.9) + **6** × (0.1 × 0.1) = 4.81.

**[END EQUATION]**

Based on these calculations, we conclude that on average, and on the same set of patients, the clinician is 4.81 – 4.62 = 0.19 days more efficient than the peer group.

# [H1] Limitations

Data balancing allows us to simulate the performance of clinicians and peer groups on the same set of patients. Despite the availability of these new procedures, it is important to be cautious about benchmarking clinicians as it may lead to unintended consequences (Iezzoni 1997; Krumholz et al. 2002). Benchmarking may distort clinical goals; clinicians’ performance may improve on one dimension but inadvertently deteriorate on another. Benchmarking may lead to defensive behavior. Clinicians may put their effort in defending their existing practices as opposed to improving them. An environment needs to be created where no one is blamed, and all clinicians are encouraged to seek improvements as opposed to arguing about the results. Inadequate measure of severity may mislead the analysis. A poor severity index, one that is not predictive of the patients’ prognoses, might give a false impression of severity adjustment. Finally, too much measurement may lead to too little improvement. Sometimes analysts who conduct benchmark studies take considerable time to collect information and analyze it. In these circumstances, there may be too little time spent on discussing the results, selecting a new course of action, implementing the change, and following up to make sure that the change is an improvement. It is important to keep in mind that the goal of benchmarking is improvement. Conducting an accurate analysis is only helpful if it leads to improvement, otherwise it is a waste of time.

# [H1] Summary

This chapter described how clinicians and their peer group can be compared on the same set of comorbidities. When it comes to benchmarking performance, clinicians are concerned that they are being blamed for caring for sicker patients, who typically have worse outcomes. This tutorial describes how clinicians and their peer group can be compared on the same set of patients; thus removing concerns with differences in patient populations. First, the distribution of the clinician’s patient characteristics is measured. This distribution is the probability of observing various combinations of patient characteristics. Second, the clinician and her peer group are matched on the same patient characteristics. When there is no overlap or match, a synthetic control is organized to make sure that all patient types seen by the clinician have at least one comparable match in the peer group. Third, the probability distribution of patients of the peer group is switched with the distribution of the patients of the clinician. This switch allows the analyst to simulate what the outcome would have been if the peer group had seen the same patients as the clinician.

#  [H1] Supplemental Resources

Problem set, solutions to problems, multimedia presentations, and other related material are on the course website. The following code shows how SQL can be used to create benchmarks:

**[LIST FORMAT]**

/\*

This Code Simulates Peer Group’s Performance on Patients of the clinician

\*/

USE Benchmarking

/\*

The data used in this analysis consists of the following fields:

 Each row corresponds to one patient’s outcome of care.

 Comorbidities are in columns named DRG and HCC.

 The DRG field contains many different values.

 HCC field contains 3 different values for low, medium, and high severity.

 The column Dr indicates patients was cared for by clinician or peer group.

 Outcomes of care are in column LOS.

\*/

-- Calculate pattern of care for clinician

DECLARE @total as float

SET @total = (SELECT COUNT([ID])FROM [dbo].[clinician] WHERE Dr='Clinician')

SELECT [DRG] as DRGa

 ,[HCC] as HCCa

 ,Avg(CAST([LOS] as Float)) as LOSa

 ,COUNT([ID]) as NumA

 ,COUNT([ID])/@total as ProbA

INTO #Clinician

FROM dbo.Clinician

WHERE Dr='Clinician' -- Select the clinician

GROUP BY [DRG], [HCC]

-- Calculate pattern of care for peer group

DECLARE @totalb as float

SET @totalb = (SELECT COUNT([ID])FROM [dbo].[clinician] WHERE Dr='Peer')

SELECT [DRG] as DRGb

 ,[HCC] as HCCb

 ,Avg([LOS]) as LOSb

 ,COUNT([ID]) as Numb

 ,COUNT([ID])/@totalb as ProbB

INTO #Peer

FROM dbo.Clinician

WHERE Dr='Peer' -- Select peer group

GROUP BY [DRG], [HCC]

-- Match clinicians and peer group on common strata

SELECT CASE When HCCa IS null Then HCCb Else HCCa END as HCCa

 , CASE When DRGa IS null Then DRGb Else DRGa END DRGa

 -- Does not matter if outcomes for clinician is null

 , CASE WHEN LOSa IS NULL Then -1 Else LOSa END AS LOSa

 , CASE When NUMa IS null Then 0 Else NUMa END NUMa

 , CASE When ProbA IS null Then 0 Else ProbA END AS ProbA

 , CASE When HCCb IS null Then HCCa Else HCCb END as HCCb

 , CASE When DRGb IS null Then DRGa Else DRGb END AS DRGb

 , CASE When NUMb IS null Then 0 Else NUMb END NUMb

 , CASE When ProbB IS null Then 0 Else ProbB END AS ProbB

 , LOSb -- Null values require synthetic control calculations

INTO #Match

FROM #Clinician Full Join #Peer on DRGa=DRGb and HCCa = HCCb

-- Overlap between peer and clinician cases

SELECT Round(100.\*CAST (SUM(NUMa)

-SUM(CASE WHEN LOSb is null then NUMa else 0 end) AS float)/

CAST(SUM(NUMa) as Float),2) AS [Overlap without Synthetic controls]

FROM #Match

 -- Calculate peer group's performance, if it had clinician's patients

 SELECT NumA

 , HCCa AS HCC

 , DRGa AS DRG

 , ProbA

 , LOSa

 , ProbA AS ProbB -- Switch probabilities of peer group to clinician

 -- For missing outcomes, calculate synthetic outcomes:

 , CASE WHEN LOSb IS NULL THEN

 (SELECT AVG(LOS) FROM dbo.clinician INNER JOIN #Match ON HCC=HCCb

 WHERE Dr='Peer' and LOSb is null) \* --Average for a marginal

 (SELECT AVG(LOS) FROM dbo.clinician INNER JOIN #Match ON DRG=DRGb

 WHERE Dr='Peer' and LOSb is null) / --Average for complement marginal

 (SELECT AVG(LOS) FROM dbo.clinician -- Average for entire set

 WHERE Dr='Peer')

 ELSE LOSb END AS LOSb

 INTO #All

 FROM #Match

-- Overlap between peer and clinician cases

SELECT Round(100.\*CAST (SUM(NUMa)

-SUM(CASE WHEN LOSb is null then NUMa else 0 end) AS float)/

CAST(SUM(NUMa) as Float),2) AS [Overlap with Synthetic controls]

FROM #All

 Select Round(SUM(ProbA

 \*CASE WHEN LOSb is null then 0 else LOSa End),2) As [Clinician LOS]

 , Round(SUM(ProbB\*LOSb),2) AS [Peer LOS]

 , Round(((Cast(SUM(ProbB\*LOSb) as float)

-Cast(SUM(ProbA\*CASE WHEN LOSb is null then 0 else LOSa End) as float))\*100)

 /Cast(SUM(ProbB\*LOSb) as float),2) AS [Percent More Efficient]

 FROM #ALL

**[END LIST]**

# [H1] References

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