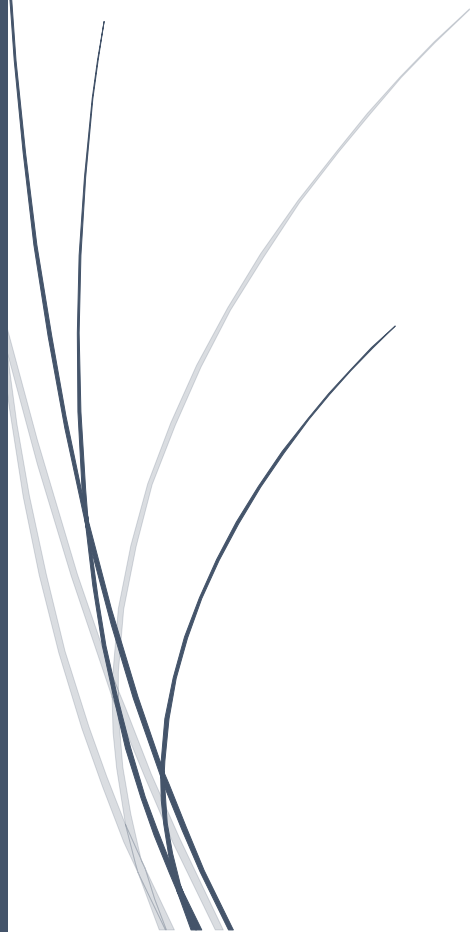




IMMC 2018

# The Best Hospital

End User Hospital Ranking Model  
106358613



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## Summary

Medical issues are often enormously stressful, and it is difficult for patients to know how to proceed. Because of this, it is vital that patients are fully equipped to make the best possible choices about their treatment. Today, information is often accessible through online reviews, star ratings and ranking websites, however this information can be biased, inaccurate, or not tailored directly to a patient's needs.

The goal of our model was to produce a system whereby the best hospital can be chosen, for a given, specified patient. The factors that influence the quality of care a patient receives in hospital are incredibly broad and are usually specific to certain diseases and other criteria. By taking many different factors into account we were able to produce a far more accurate and personalised model, whereby a patient can choose the hospital which will best cater to their needs.

Our initial model (Question 1) is based entirely on hospital specific mortality rates. To make this model as specific and accurate as possible our model encompasses both evitable mortality rates and mortality rates specific to medical issues. This allows the patient to take hospital specialisations into account, as well as eliminating the error related to evitable vs inevitable death rates. The model described in this report normalises both the specific mortality and evitable mortality data, and these scores are then averaged to produce an overall hospital score.

The second task was to create a model that includes multiple factors in addition to mortality, and hence will be far more supportive in assisting patient choices. To achieve this, quantitative measures of the quality of a hospital were separated into factors that affected the process of treatment and factors that affected the outcome. Outcome factors measure if a patient receives the best possible outcome from their treatment and include specific mortality rate, HSMR, rates of infection, the likelihood of serious complications and readmission rates, as these are the factors that affect the outcome. The process factors relate to how well a patient is cared for, and how comfortable their stay in hospital was. This factors in waiting times, patient score (from survey), cost of treatment and travel time. In most cases, where recovery is the most likely option, we chose to assume that the outcome of treatment is the dominant factor, as this is what will affect the patients remaining life. The exception to this however, is when a patient has been diagnosed with a terminal illness. In this case, process carries greater weight as this is what effects the patients remaining quality of life.

The strength of our model is the ability to correlate a score to a hospital based upon the patient's personal specifications including life expectancy and diagnosis. This allows a more accurate analysis of hospitals specific to the patient's requirements as the best hospital will not be the same for all users.

## Introduction

It is inevitable that everyone will need to seek health care at some point in their lives. To maintain the best possible quality of life, it is crucial that this health care be the best possible for every patient. In emergency cases time is crucial, and patients will need to seek medical attention at the nearest hospital. However, for any medical condition that does not require immediate treatment, the correct choice of hospital will ensure that the optimum outcome is achieved.

There are currently no hospital ranking systems that allow hospitals to be ranked based on a specific patient, only on the general population. Hence, this model aims to choose the hospital which best facilitates the needs of a specific patient, taking the patient's primary diagnosis, age and life expectancy into account to produce a more applicable rating for each hospital.

We will examine two scenarios, the semi-urgent scenario requiring one of four or five local hospitals and the less urgent scenario deciding from one of around fifty hospitals. We will also consider the problem of ranking all hospitals by their treatment for a specific patient.

## Assumptions

1. The required data is available for the relevant hospitals
  - We assume that all relevant data is available and accurate. It is impossible to create a model with adequate accuracy and effectiveness without adequate data. We acknowledge, however, that in many real-world situations some data may be unavailable, and the model is designed to compensate for this scenario.
2. Patients want the best possible result and care
  - Our model only applies to patients who are after the best possible medical care, with the result of the best possible quality and length of life. Patients seeking procedures such as legal euthanasia will not be considered in our model.
3. Maximum patient satisfaction is desired
  - While we acknowledge the perfect patient experience is not always possible, we can assume that patients would want to undergo their treatment with few negative side effects. This is affected by factors such as waiting time, facilities and staff experience.
4. Always able to travel
  - We assume that patients can access all the hospitals being analysed. Patients who require oxygen/specialised equipment, or whose condition is dangerously contagious may not be able to travel in community transport and may not be able to be transported to the best hospital specified by our model.
5. Minimise travel

- While our model assumes that patients are willing to travel for treatment, it is reasonable to assume that less travel is preferable. Travel takes up time, costs money and may be uncomfortable for someone with a serious medical condition who may in pain or have symptoms that make some forms of travel impossible. Shorter travel times also make it easier for family and visitors to access which makes the process easier.
6. Minimal cost of treatment
    - We assume that whilst patients would wish to minimise unnecessary expenses, patients are able and willing to pay for what is deemed the most effective treatment for their condition. That is, the patient will not sacrifice their treatment for the sake of being abstemious. Any patient who did not have the required funding would not necessarily be able to go to the hospital of their choice. In this case patients should just veto hospitals based on their cost.
  7. Patients will choose their hospital based only on the hospitals merit, not on that of individual doctors/health care professionals.
    - Some patients may wish to choose their hospital based on the doctor by whom they wish to be treated. In this case, their hospital choice will not be based on the hospitals merit but the preferences of their medical practitioner.

## Model Based on Mortality

### Mortality as a Variable

The simplest measure of a hospital's quality is the rate of deaths occurring within the hospital. In general, the lower the proportion of deaths, the more efficiently and safely the systems are working. There are however, significant issues with the use of this statistic. Firstly, hospitals have different focuses. For example, large emergency departments who frequently deal with car crash injuries would have significantly more deaths than a small community hospital dealing only with simple treatments such as broken arms. Therefore, this is not necessarily an indicator of how effective the overall treatment would be.

The deaths that occur at any hospital can be split into two categories; evitable and inevitable. An evitable death is one that could have been prevented given adequate treatment. This, however, is incredibly difficult to measure.

### Hospital Standardised Mortality Ratio

As stated above, the important factor in determining the quality of a hospital in terms of mortality is the ratio of evitable deaths to total deaths. This is the purpose of the Hospital Standardised Mortality Ratio (HSMR), which is an internationally recognised value, widely used in the United Kingdom and United States<sup>1</sup>. The HSMR compares a hospital's mortality rate with the national average rate, considering aspects such as age, gender and patient condition. This gives the best indication of what proportion of deaths would have been evitable and allows for a direct comparison between hospital's mortality rates. This is an

already accepted model and will be used as a part of our model as this data is not accessible to most users however the HSMR value is usually available.

The HSMR for a given hospital is calculated as follows, where observed deaths is the number of deaths within the hospital and expected deaths is calculated using the national average and the number of people in the hospital, considering patient age, gender and diagnosis:

$$HSMR = \frac{\text{Observed Deaths}}{\text{Expected Deaths}} * 100$$

This means an HSMR of 100 would be the average hospital, with an ideal HSMR of 0 as this would indicate no deaths have occurred within the hospital.

The HSMR is used widely in the United Kingdom and United States, so should be a statistic that is available to most patients when deciding upon a hospital.

### Specific Mortality

While the HSMR is a far more accurate measure of the quality of a hospital than general mortality, it is not a perfect indicator of a patient's chance of death. HSMR indicates the overall quality of a hospital, however some hospitals may be more effective at treating some conditions than others. All illnesses have different mortality rates and will have different mortality rates at each hospital depending on the quality of treatment. Comparing the mortality rates of a patient's specific illness at various hospitals will give a better idea of how each hospital will perform at treating that specific patient. This data exists for many common illnesses such as pneumonia, cancer, heart attack, heart failure etc. However, for more obscure illnesses, the total hospital mortality rate could be substituted instead.

### Mortality Model

We believe that to find the most accurate measure of hospital quality from its mortality rate, you must factor in both the hospital's HSMR and the mortality rate at the hospital specific to the patient's issue. From a patient's perspective, the mortality rate for the specific disease matters as that is an indicator of how likely they are to survive; however, this doesn't consider any previous user data such as age so HSMR is a better indicator of actual hospital safety. In our model, we gave both factors equal weighting as both factors measure different qualities of equal importance, the overall hospital quality and the hospital quality at treating the specific issue.

For these two values to be combined, we have adjusted them onto comparable scales. HSMR is a score greater than 0 averaging 100 where 0 is the ideal score. The specific mortality rate is a percentage between 0 and 100 where 0 is the ideal value. Hence, for these values to be combined, they must be normalized to a similar scale.

We chose to normalise the values to a scale where 0 is the worst hospital in the data set and 100 is the "ideal" hospital, i.e. a HSMR or mortality rate of 0. A hospital's normalized score

will represent the proportion of the way a hospital is from the worst hospital to an ideal hospital.

The normalization formula can be seen below where  $V_i$  is hospital  $i$ 's value for category  $V$ . We will refer to  $V'_i$  as the normalization of  $V_i$ .

$$V'_i = \frac{V_i - Worst\ V}{Ideal\ V - Worst\ V} * 100$$

As an example, to find the normalised HSMR score for a hospital:

$$Normalised\ HSMR = \frac{HSMR - Worst\ HSMR}{0 - Worst\ HSMR} * 100$$

The normalised scores for HSMR and specific mortality rate are then averaged to provide an overall score between 0 and 100, which is then ranked such that the highest score is the “best” hospital for the specified patient. This normalization is better than other options, such as standardization, as it provides an easy to understand score between 0 and 100, indicating the proportion of the way the score is from the worst hospital to an ideal hospital. A score of 0 for the worst hospital is fair as if it is not much worse than the best score, all scores will be relatively close to 0 and will have little impact, however if the worst hospital is a lot worse than the other hospitals the 0 weighs this into the overall result. This also means that values with more spread will have more impact on the overall result than a value with little spread.

### Examples

The HSMR and Specific Mortality Rate Model was trialled on two test cases: 5 hospitals and 50 hospitals. Each of these cases was tested with our two example patients. Patient 1, a teenage girl with a broken ankle and Patient 2, an elderly man terminally ill with cancer.

These two cases test the limits of mortality examples as Patient 1 would be expected to have very low mortality rate and patient 2 has a 100% mortality rate as they are terminally ill (i.e. an inevitable death). This meant the ordering was primarily based off the HSMR data for each of the hospitals, as there was not much spread in the mortality rate data. The results for the two tests with 5 hospitals can be seen below, with the complete data and normalised scores in **Appendix A**.

### Raw Data Patient 1:

Hospital Name	HSMR	Specific Mortality Rate (%)
HUNTINGTON MEMORIAL HOSPITAL	81	0.3
SAN GABRIEL VALLEY MEDICAL CENTER	109	0.2
MONTEREY PARK HOSPITAL	122	0.4
ALHAMBRA HOSPITAL MEDICAL CENTER	81	0.2
GARFIELD MEDICAL CENTER	99.0	0.2
		0.25

## Raw Data Patient 2:

Hospital Name	HSMR	Specific Mortality Rate (%)
HUNTINGTON MEMORIAL HOSPITAL	81	100.0
SAN GABRIEL VALLEY MEDICAL CENTER	109	100.0
MONTEREY PARK HOSPITAL	122	100.0
ALHAMBRA HOSPITAL MEDICAL CENTER	81	100.0
GARFIELD MEDICAL CENTER	99.0	100.0

## Overall Scores Patient 1:

Hospital Name	Overall Score	Rank
ALHAMBRA HOSPITAL MEDICAL CENTER	47.9	1
GARFIELD MEDICAL CENTER	33.3	2
HUNTINGTON MEMORIAL HOSPITAL	29.2	3
SAN GABRIEL VALLEY MEDICAL CENTER	29.2	4
MONTEREY PARK HOSPITAL	0.0	5

## Overall Scores Patient 2:

Hospital Name	Overall Score	Rank
HUNTINGTON MEMORIAL HOSPITAL	16.8	1
ALHAMBRA HOSPITAL MEDICAL CENTER	16.8	1
GARFIELD MEDICAL CENTER	9.4	3
SAN GABRIEL VALLEY MEDICAL CENTER	5.3	4
MONTEREY PARK HOSPITAL	0.0	5

The model effectively ranks by HSMR in these examples as the specific mortality rates were at the two extremes.

The mortality model was also tested on the case of 50 hospitals and again the HSMR was the primary factor affecting the result due to little spread in the specific mortality rates.

These two examples also serve to demonstrate how the model works to show the best hospital depending on different patient's needs, since the model produced different rankings given two different scenarios. If only the general mortality rate was used to rank these hospitals these different results could not have been produced.

## Analysis

The mortality model successfully ranks hospitals based on their HSMR and specific mortality rate data to determine a score for each hospital. It provides a simple, user-friendly ranking of each hospital a score between 0 and 100 for each, where 100 is an idealistic "perfect" hospital and 0 is the hospital with a combination of all the worst statistics.



The major weakness of this simple model is that it does not incorporate any factors other than mortality. For example, outcomes such as infections or complications are not considered. In addition, the patient experience evaluated through measures such as patient satisfaction and well-being are not considered.

The use of mortality rate and HSMR data has limitations both are probabilistic. Given some hospital and condition, there is a certain probability of any given patient dying. For small data sets, the sample may not be a true reflection of the real mortality rate. This is because the mortality rate usually relies on very small data sets, especially in smaller hospitals. This means the mortality rate is unlikely to be a very good representation of the actual chance of death.

## General Model

### Introduction

As stated earlier, to provide a more comprehensive model, more factors than just the mortality rate of the patients must be included. Many other factors must be considered to provide the best hospital with the best overall experience for the patient. These factors can be divided into two categories: those related to the process and those related to the outcome. Whilst outcome includes mortality, it will also consider outcomes such as the risk of infection, serious complications and readmission rates. These are also included since when someone is to be admitted to hospital, mortality is not always the only concerning outcome. For example, surgical treatment for a broken ankle has a low risk of death however the risk of infection may be quite high. For many, death is not even a threat surgery is relatively minor.

There are also factors other than outcomes that affect the patient's experience. The process that the patients go through is also extremely important for them. For many, going to hospital is a frightening and anxious experience. Therefore, the care that they receive is of utmost importance and is a strong factor in deciding on a hospital. Process factors considers the patient's entire experience, including waiting times, travel times, patient score and cost of treatment.

### Choosing Factors

The factors we chose were based off several criteria. Firstly, we wanted to measure as many different aspects of each hospital as possible, to gain the most accurate picture of the quality of each. The statistics used to measure these variables however, had to be of reasonable accuracy and be of a form which is comparable. It is essential that they can have a quantitative measure applied, as qualitative measures cannot be applied to a mathematical model. We also aimed to choose statistics which would be readily available to any individual who wished to use our model to choose a hospital.

## Outcome Factors:

### Specific Mortality

As described earlier, the specific mortality refers to the mortality rate at the given hospital for the specific disease the patient has. It should be as specific as possible given the data available for the most accurate results. This is the best measure of the chance of death for the patient as the chance of death depends on the disease, so a hospital wide mortality rate has little to do with the chance of death of an individual. Also, different hospitals have different specialities, so the specific mortality of a patient with cancer at a cancer specific hospital would be expected to be lower than at a general hospital.

The specific mortality rate is a percentage of people who have died in that hospital given the specific disease or issue, between 0 and 100, where 0% is no deaths in the hospital from that condition and hence the ideal case.

### HSMR

The Hospital Standardised Mortality Ratio (HSMR) is an internationally recognised score that rates hospitals by comparing them to the average hospital mortality rate as described earlier. This gives an approximation of how many evitable deaths there were compared to the national average. The HSMR is hence a score greater than 0, where 0 is the ideal score due to no deaths, and 100 being the average hospital.

### Serious Complications

The serious complications rate is the percentage of all hospital patients that experience a serious complication from their surgery. This provides an indication of the quality of a hospital is and the skills of the surgeons and nurses as most complications are due to medical staff errors, such as a misdiagnosis causing mistake.

The ideal score would be 0% as that would mean no serious complications in the hospital.

### Infection Rate

The infection rate is the percentage of all hospital patients that get an infection during their stay at the hospital. This gives an indicator of the cleanliness and safety of the practices at the hospital since the most common cause of infection in hospital is through transmitted pathogens on equipment that has not been adequately cleaned.<sup>ii</sup>

The ideal score would be 0% as this would mean no infections in the hospital.

### Readmission Rate

Readmission rate is the percentage of hospital patients that must undertake unplanned return to hospital after a specific procedure. This rate gives an indication on the quality and efficiency of the specific treatment provided. This can be directly linked to the ability of the surgeons and the care taken by the nurses. It is important because it reflects the breadth and depth of care that a patient receives. However, it must be considered that readmissions are not always due to surgical error and can be due to uncontrollable factors in a patient's personal recovery.

The ideal readmission rate of hospitals would be 0% as that would mean that no patients have been readmitted.

### Process Factors:

#### Patient score

Patient score is the best indicator of patient satisfaction with regards to the treatment received, the hospital facilities and the overall communication skills of the medical staff. This is important because patient satisfaction is the best indicator of how tolerable the process is which is a crucial component in a patient's choice of hospital.

The patient score is a score given between 0 and 100 and is obtained by surveying hospital patients and asking them to rate their hospital experience on a scale of 0 to 10. the ideal patient score for a hospital is 100%.

#### Waiting times

Factoring into account the waiting time of a hospital is important because the patient's condition may deteriorate before treatment, leaving them uncomfortable, and in extreme cases reducing the effectiveness of the treatment. Waiting itself can be very distressing and may significantly affect a patient's life so reducing the waiting time before treatment is important to a patient's well-being.

The waiting time is given as the median numbers of days before treatment is delivered. The ideal case would be 0 days before treatment.

#### Cost of treatment

The cost of treatment is determined by the cost of the specified treatment the patient must undergo. It gives an indicator for the value of the treatment, which means the quality of the treatment for the given price. This data is important because if two hospitals offer the same or very similar quality of treatment, the patient would clearly prefer to choose the lowest costing hospital, because they save more money. However, if the quality of the treatment varies significantly, the patient will not sacrifice quality for cost.

The cost of the specified treatment is a monetary value given in USD and the ideal price for the specified treatment is \$0.

#### Travel times

Travel times is imperative in the calculations for the best hospital. A patient would prefer to stay near family and spend less time travelling. Furthermore, travel costs money and thus as we are trying to minimise spending, we must try to minimise travel times.

Travelling time is calculated by using the quickest and most efficient means of transportation. It is given as the amount of time in minutes required to travel to and from the hospital from the patient's location. The ideal travel time is 0 minutes. The worst-case scenario is a minimum of 120 minutes to minimise the weightings of short travel times that are relatively similar, as shown in the table below.

	Travel Time (min)	Normalized score	Adjusted Normalized score
Hospital 1	5	37.5	95.8
Hospital 2	1	87.5	99.2
Hospital 3	4	50.0	96.7
Hospital 4	8	0	93.3
Hospital 5	3	62.5	97.5

Before the worst-case scenario was adjusted, the score for the worst case and best-case scenario differed by 87.5, however, this was deemed as unfair because a 7-minute difference is negligibly small. The difference after the normalised score was adjusted was just 5.9. Hence, this is a better representation of the small difference in time.

### Normalization

For two sets of data to be compared, they must be on similar scales. However, the input data for each variable in a hospital is usually on entirely different scales. For example, the rate of infection is a percentage while wait for surgery is time in days. Hence, for these values to be compared and weighted against each other, they must be normalized to a similar scale.

Hence, for each category of data for each hospital, a normalized score was determined. We normalized to a scale where 0 was the worst hospital in the data set and 100 was the “ideal” hospital as this means that a normalized score will represent the proportion of the way a hospital is from the worst hospital to an ideal hospital.

The normalization formula can be seen below where  $V_i$  is hospital  $i$ 's value for category  $V$ .

$$V'_i = \frac{V_i - Worst\ V}{Ideal\ V - Worst\ V} * 100$$

### Weighting

After the normalized scores are found, the scores then need to be combined into a single score for each category of outcome and process.

Each score is given a weighting, as explained below. The scores are then combined using a weighted average as this allocates each score a certain importance.

Given the set of  $n$  scores  $S\{ \}$  and the set of  $n$  corresponding weightings  $W\{ \}$  which add up to 100%, the weighted average can be found using the formula:

$$Weighted\ Average = \sum_{i=1}^n S_i W_i$$

Which gives an aggregate score taking each individual score with a specific weighting or importance.

## Weighting Determination

### Outcome

For the outcome category, it was decided that each score should be weighted based on how large the corresponding value is. For example, if the mortality rate is 50% and the infection rate is only 10%, the mortality rate should be weighted significantly more heavily whereas if mortality rate is 1% and infection rate is 20%, the infection rate should be weighted more heavily as it is more likely to occur and hence more concerning from the patient's point of view.

However, if all the scores are the same, then mortality rate is still more important than infection rate so there must be an initial weighting as well as a weighting based on average value size.

The five scores that form the outcome category are the HSMR, specific mortality, infection rate, serious complications rate and readmission rate.

The initial weightings with justifications can be seen in the table below:

Score	Symbol	Initial Weighting	Justification
HSMR	<i>H</i>	25%	Mortality is the most important value out of the outcomes as death is a worse outcome than an infection or complication. Mortality was then given a value of 50% split across HSMR and specific mortality.
Specific Mortality	<i>M</i>	25%	
Infection Rate	<i>I</i>	15%	An infection is a reasonably minor inconvenience relative to the other outcomes however it still gives an indicator of the cleanliness of the hospital so was weighted slightly less than serious complications so is initially weighted at 15%.
Serious Complication Rate	<i>C</i>	20%	Serious complications are a more major inconvenience relative to the infection rate so is initially weighted at 20%.
Readmission Rate	<i>R</i>	15%	Readmission is a similar level of inconvenience as infection rate so is initially weighted the same at 15%.

Given the set of 5 average scores from the raw data  $V\{ \}$  and the set of initial weightings  $I\{ \}$  for each score, the correct score weighting can be determined by:

$$\text{Weighting for } V_x = \frac{I_x V_x}{\sum_{i=1}^n I_i V_i}$$

However, the scale for HSMR is not comparable to the other values, so this formula cannot be used directly. It was hence decided that the weighting for both HSMR and the specific mortality would be based off the data for specific mortality as that is the data that is most relevant to the patient in terms of their own individual chance of death.

Hence the formula used to find the weighting for score  $V$  and its initial weighting  $W$  is

$$\text{Weighting for } V = \frac{W\bar{V}}{50\% * \bar{M} + 15\% * \bar{I} + 20\% * \bar{C} + 15\% * \bar{R}}$$

Where the weighting for HSMR is calculated as equal to the weighting for specific mortality.

For example, if the average specific mortality is 10%, the average infection rate is 20%, the average complication rate is 5% and the average readmission rate is 15%, the weighting for HSMR can be found by:

$$\begin{aligned} \text{HSMR Weighting} &= \frac{\text{Specific Mortality Rating}}{25\% * 10\%} \\ &= \frac{10\%}{50\% * 10\% + 15\% * 20\% + 20\% * 5\% + 15\% * 15\%} \\ &= \frac{2.5\%}{5\% + 3\% + 1\% + 2.25\%} \\ &= 22\% \end{aligned}$$

#### Process

The weightings for process are simpler as no matter what each value is, their importance remains roughly constant.

The weightings were then just determined to be as follows:

Score	Weighting	Justification
Patient Score	45%	Patient score incorporates all elements of the process and thus is weighted the highest. Unfortunately, patient score does not consider factors for a specific diagnosis such as travel time or cost for the specific patient. Therefore, other factors must be weighed in to better determine how good the process is, so the patient score is weighed at 45%.
Waiting Times	25%	Waiting time is weighted less because patients are generally willing to wait to receive better treatment.

		The time still matters however as it affects patient well-being so wasting time is weighed at 25%
Cost	15%	Most patients would not be willing to sacrifice the quality of treatment for the price, so the cost is weighed at only 15%. Hospitals can also be vetoed based on their cost if it is higher than the patients budget. Cost is weighted less than weighting time as cost will not directly affect the patient's well-being if they can afford it whereas weighting time can be distressing and lead to worse illness.
Overall Travel Time	15%	Travel time is regarded as less important than the other factors in process because if the patient has time to research different hospitals, it is assumed that treatment is not particularly urgent. Hence travel time is only weighed at 15%.

#### Outcome vs. Process

After the weighted averages for the Outcome and Process are calculated, we then need to determine how to weight outcome against process to give an overall score for each hospital. It was decided that this weighting should be determined based on the proportion of the patient's remaining life that is to be spent in hospital. For example, for a child with a broken bone, the outcome is significantly more important than the process, however for an elderly adult with a terminal illness, process will matter a lot more than the outcome.

The proportion of a patient's life can be determined by

$$\frac{\text{Average time spent in hospital given disease}}{\text{Average life expectancy given disease}}$$

The simplistic model would be that this then gives the weighting of the process, as the lower the proportion of life spent in hospital, the less important the process. However, process is still important for a short stay and outcome is still important for a long stay, so it was decided the minimum weighting for outcome would be 20%. We believe this to be optimal for the patient as if you are spending the rest of your life in hospital, the outcome is pretty much already known so happiness of the patient is the most important factor. The minimum weighting for process would be 30% as if your spending a short period of time in hospital, the process still matters to one's wellbeing more than the outcome does to a terminally ill patient and is also still an indicator of how reliable the hospital is.

Hence the range for the process score is 30% to 80% so we just need to normalise the proportion of life to this range. This can be accomplished through the following formula where  $P$  is the average proportion of the patient's life to be spent in hospital:

$$\text{Weighting of Process} = 30\% + P * 50\%$$



For a patient expecting to spend an almost negligible percentage of their life in hospital (e.g. a minor surgery, setting a broken limb) their percentage of life in hospital will be close to 0%, and hence their weightings will be approximately 70% outcome and 30% process. We believe this to be the ideal weighting for the average patient, as outcome should be far more important than process, although process should still be considered as the patient will still care about the process and the process is also an indicator of the success rate. A patient will have outcome and process weighted equally if the patient spends 40% of the remainder of their life in hospital, which we believe to be correct as during that time they will care more about the process but afterwards the outcome will be more important for longer.



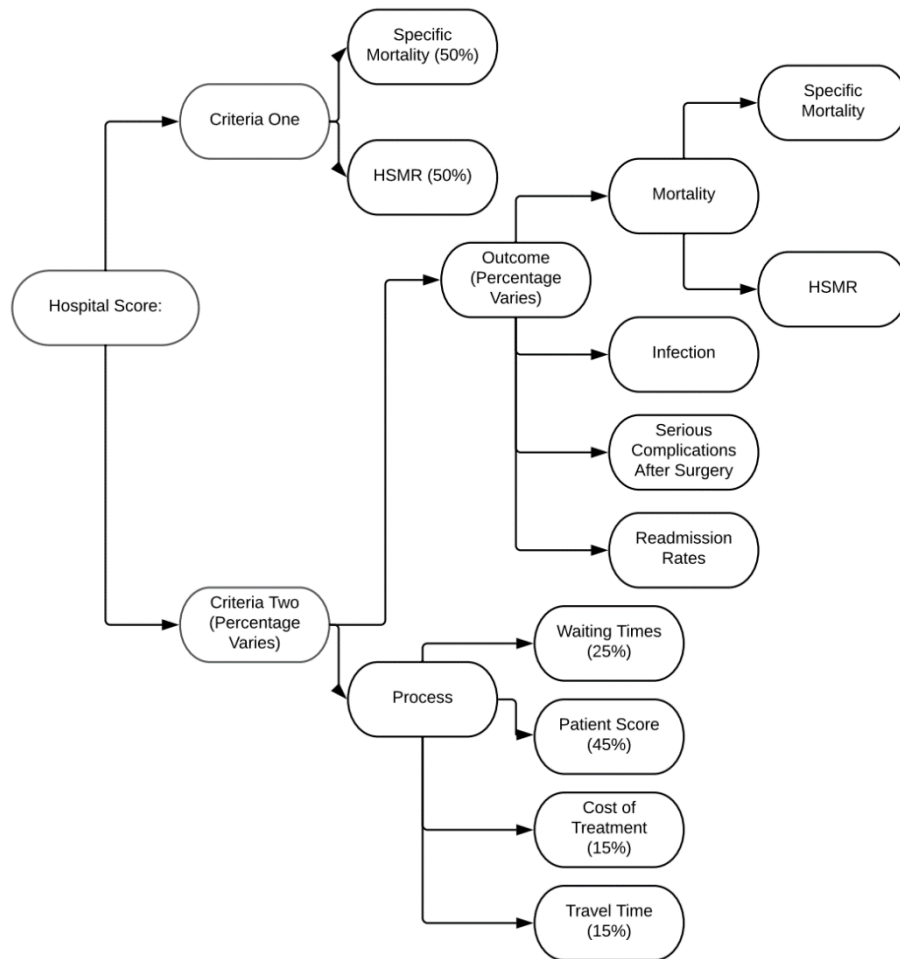


Figure 1: Flow chart diagram showing combinations of data to form overall hospital score using the two models

### Dealing with Missing Data

Not all data will always be accessible to the user. For example, certain hospitals might not record or publish statistics such as HSMR or average waiting times. In this case, the user should take the average of all hospitals for that specific value, as setting it to a notional 0 would be unfair on the hospital, as small hospitals don't necessarily get HSMR score. Hence average is the fairest estimation we can achieve as it allows the hospital to be ranked on the other criteria instead. In the case where no data for a certain measure can be found across all hospitals, the normalized values for that measure can just be set to 0 as this will affect all hospitals equally and will also reduce the corresponding categories score, balancing out the impact of the missing category by weighing the other categories more.

### Meaning of Hospital Scores

Each hospital comes out with an overall score between 0 and 100, where 100 would be an "ideal" hospital and 0 would be a hospital that had the worst data in every field. This means that they can be compared by just comparing their scores, where the highest score is the "best" hospital for the given patient.

## Examples

Our general model was tested on two cases: 5 hospitals and 50 hospitals. Each of these cases was tested with our two patients. Patient 1 who is a teenage girl with a severely broken ankle and Patient 2 who is an elderly man terminally ill with cancer.

The results for the two tests with 5 hospitals can be seen below, with the complete data in **Appendix B**.

### Overall Scores Patient 1:

Hospital Name	Outcome	Process	Overall	Rank
SAN GABRIEL VALLEY MEDICAL CENTER	17.4	16.3	17.1	1
ALHAMBRA HOSPITAL MEDICAL CENTER	15.5	17.1	16.0	2
HUNTINGTON MEMORIAL HOSPITAL	9.5	27.1	14.8	3
GARFIELD MEDICAL CENTER	11.7	11.4	11.6	4
MONTEREY PARK HOSPITAL	1.8	15.7	5.9	5

### Overall Scores Patient 2:

Hospital Name	Outcome	Process	Overall	Rank
HUNTINGTON MEMORIAL HOSPITAL	16.1	27.1	24.9	1
ALHAMBRA HOSPITAL MEDICAL CENTER	16.5	17.1	17.0	2
SAN GABRIEL VALLEY MEDICAL CENTER	5.0	16.3	14.1	3
MONTEREY PARK HOSPITAL	0.1	15.7	12.6	4
GARFIELD MEDICAL CENTER	8.5	11.4	10.8	5

The model appears to be effective, as San Gabriel Valley had the best outcome scores which is most heavily weighted for Patient 1 whereas Huntington had the best process scores which is more heavily weighted for Patient 2. This is great as it shows that our model is customised to the patients needs, unlike alternative hospital ranking systems.

The model was then tested on 50 hospitals for each of the two patients as seen in **Appendix C**. The hospital ranking for Patient 1 was heavily weighted towards the outcome category. This is because their treatment did not require a lengthy stay in hospital, and the broken ankle had no effect on her life expectancy. Hence, the ratio of time in hospital to life expectancy was significantly small. The older patient's ranking was largely weighted towards process, as their complication required them to stay in hospital for a large proportion of their remaining lives and would most likely lead to death. Consequently, the comfort and enjoyment of their stay is more important than the outcome.

The model was also tested on all 4800 American hospitals that provide the required data to provide an overall ranking for the two patients. Mayo Clinic Hospital was the #1 ranked hospital for the child, which is consistent with other ranking systems which also rank hospitals primarily on outcome which is the most important factor for patients with short hospital stays.<sup>iii</sup>

For the terminally ill patient however, process is more important in our view, so Bigfork Valley Hospital was the #1 ranked hospital whereas Mayo Clinic Hospital dropped down to #3. This is an advantage of our ranking method against current ranking systems. Those have no ability to conform to the patient's own needs. Bigfork Valley is the better option for a terminally ill patient as it has very high patient satisfaction and well-being scores. Although it's outcomes may not be as good, that is less important for a patient who may be terminally ill.

### Analysis

While we believe this model to be better than existing models, there are still several weaknesses to be considered. One such weakness is that the model cannot consider variables that do not have definite/accurate data, or only have qualitative measures. The model must produce a ranking system, and hence scores which can be used to determine the quality of hospitals. This means that many important factors have had to be disregarded in the building of this model.

A major factor that is not accounted for is personal recommendation, or expert opinion. This is entirely subjective, and based on one, or possibly a small group of people's opinions. This also cannot be measured in any kind of consistent qualitative measure. However, depending on the circumstance the expert opinion of a GP or surgeon may be the best indicator of hospitals, since they will know the hospital, the patient and the staff far more intimately. We suggest that a patient should consider doctor advice as well as the results given by our model when making their final decision. In most circumstances however, our model will still be more appropriate as a large data set is a much more reliable indicator than one off opinion.

Another qualitative factor which is not accounted for in our model is the personal preferences a patient has when choosing a hospital. These preferences are influenced by a variety of different aspects with regards to the belief and background of the patient, which includes religion and culture. For example, a patient who is Catholic may prefer a Catholic hospital over a general hospital, regardless of the quality of either hospital. Culture is another personal preference that patients may consider when choosing a hospital. This is because many different cultures have their own way of treating specific conditions. For example, a Chinese patient might prefer acupuncture over the physiotherapist with regards to a sports related injury.

The strength of our model is the ability to correlate a standardized score to a hospital using the patient's personal needs and specifications. This score is easy to compare because the parameters and data used to calculate the score are quantitative. It also considers the variable change of a patient's life expectancy due to that illness as well as the time the patient is required to stay in hospital for that illness.

Our model works well when there is specific data available for the patient's disease and sufficient data to provide meaningful results. This works well for common illnesses such as pneumonia or a heart attack, however more obscure diseases will be hard to rank using this model as specific data may not be available.

Further work is needed in ensuring the required data is available to patients and providing more specific data for various categories. The model could also be more specialized to a patient by allowing the patient to determine themselves how important they find each category such as waiting times or cost. With more data we could also allow a patient to decide between more specific factors such as room cleanliness or quietness, which could make a patient's experience more pleasant.

## Memo

### *Step 1: Researching*

The first step to finding the best hospital for your treatment is to find the necessary information. Depending on your country this data will normally be accessible through a government organisation/agency, however if the data is not available you should use the mean of the existing data instead. The categories of data that need to be found can be found in table 1.

### Finding the mean

The mean represents the average value of the data you have collected and will be used later to rank your selected hospitals. It can be found by adding the values in each row, and then dividing by the number of values.

### *Step 2: Normalising Values*

$$\text{Normalised Value} = \frac{\text{Value} - \text{Worst Value}}{\text{Ideal Value} - \text{Worst Value}} \times 100$$

Now that you have found your data, we now need to convert it to a form that it can be easily compared to other values. This is done using a process called normalisation, and it is done using the above formula. Normalisation requires you to know certain pieces of information, about the variable, specifically, the *Worst Value* and the *Ideal Value*. The *Worst Value* is the value out of the data you have collected that represents the worst hospital (e.g. Highest mortality rate, lowest patient score), while the *Ideal Value* is the value that would be given to a perfect hospital (e.g. a mortality rate of 0%, or a patient score of 100%). Your normalised scores can be placed into the Normalised Score column of table 1.

### *Step 3: Determine Outcome Weightings*

The variables you researched have been divided into two categories; outcome and process. In the case of the outcome variables, some values will be more important than others depending on the magnitude of the value. To account for this, we need to adjust the weighting of each value. Table 1 contains all the formulas (not including the *Base*) you need to do this (note, this only applies to the outcome variables, not process). Finding the base requires knowing the mean of each variable, which can be done using the method described in step 1.

$$\text{Base} = 0.5 \times \text{Average Specific Mortality} + 0.15 \times \text{Average Infection Rate} + 0.2 \times \text{Average Complication Rate} + 0.15 \times \text{Average Readmission Rate}$$

### *Step 4: Outcome and Process scores*

The next step is to develop separate outcome and process scores for each hospital. To do this, the Weighting score (column 5) and the Normalised Score (column 3) for each variable must be multiplied and put in the Final Score column. The final process and outcome scores are the sums of each of the variable scores.

### *Step 5: Outcome and Process Weighting*

Depending on your condition, the importance of outcome vs process will vary. To find the weightings, you must find the expected percentage of your life you expect to spend in hospital. This can be found using the below formula.

$$\% \text{ life in hospital} = \frac{\text{Expected time in hospital (years)}}{\text{Life Expectancy given your disease (years)}}$$

Note:

- To find expected time in hospital in years, divide the number of days you expect to spend in hospital by 365
- The average life expectancy for an Australian female is 84.6 years, and 80.4 for an Australian male. Life expectancies vary across countries and genders, so find the value most applicable value to you.
- If your condition may potentially be terminal, your life expectancy may differ from those shown above.

Once you know your percentage life, you can find the appropriate weightings from the table below.

% life in hospital	<1	<10	<20	<30	<40	<50	<60	<70	<80	<90	<100
<b>Outcome Weighting:</b>	0.7	0.65	0.6	0.55	0.5	0.45	0.4	0.35	0.3	0.25	0.2
<b>Process Weighting:</b>	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8

### Step 6: Final Hospital Score

You can now find your final hospital score, by multiplying your total Outcome by the outcome weighting, and the total Process by the process weighting. This will give a score out of 100. The best hospital for your condition will be the hospital with the highest final score.

Table 1: This table can be copied for each hospital to be compared						
Variables:	Data:	Ideal Value	Normalised Score:	Weighting (formulas):	Weighting:	Final Score:
<b>Specific Mortality:</b>		0		$\frac{0.25 \times \text{Average Specific Mortality}}{\text{Base}}$		
<b>HSMR:</b>		0		$\frac{0.25 \times \text{Average Specific Mortality}}{\text{Base}}$		
<b>Infection:</b>		0		$\frac{0.15 \times \text{Average Infection Rate}}{\text{Base}}$		
<b>Serious Complications:</b>		0		$\frac{0.2 \times \text{Average Serious Complications}}{\text{Base}}$		
<b>Readmission rates:</b>		0		$\frac{0.15 \times \text{Average Readmission Rate}}{\text{Base}}$		
<b>Total (Outcome):</b>						
<b>Waiting times:</b>		0			0.25	
<b>Patient score:</b>		100			0.45	
<b>Cost of treatment:</b>		0			0.15	
<b>Travel time:</b>		0			0.15	
<b>Total (Process):</b>						
<b>Overall Hospital score:</b>						

## Appendix A

## Mortality Model 5 Hospital Tests

Patient 1

**Raw Data:**

Hospital Name	HSMR	Specific Mortality Rate (%)
HUNTINGTON MEMORIAL HOSPITAL	81	0.3
SAN GABRIEL VALLEY MEDICAL CENTER	109	0.2
MONTEREY PARK HOSPITAL	122	0.4
ALHAMBRA HOSPITAL MEDICAL CENTER	81	0.2
GARFIELD MEDICAL CENTER	99.0	0.2
		0.25

**Normalised Scores:**

Hospital Name	HSMR	Specific Mortality Rate
HUNTINGTON MEMORIAL HOSPITAL	33.6	25
SAN GABRIEL VALLEY MEDICAL CENTER	10.7	50
MONTEREY PARK HOSPITAL	0.0	0
ALHAMBRA HOSPITAL MEDICAL CENTER	33.6	62.5
GARFIELD MEDICAL CENTER	18.9	50

**Overall Scores:**

Hospital Name	Overall Score	Rank
HUNTINGTON MEMORIAL HOSPITAL	29.3	4
SAN GABRIEL VALLEY MEDICAL CENTER	30.3	3
MONTEREY PARK HOSPITAL	0.0	5
ALHAMBRA HOSPITAL MEDICAL CENTER	48.1	1
GARFIELD MEDICAL CENTER	34.4	2

Patient 2

**Raw Data:**

Hospital Name	HSMR	Specific Mortality Rate (%)
HUNTINGTON MEMORIAL HOSPITAL	81	100.0
SAN GABRIEL VALLEY MEDICAL CENTER	109	100.0
MONTEREY PARK HOSPITAL	122	100.0
ALHAMBRA HOSPITAL MEDICAL CENTER	81	100.0
GARFIELD MEDICAL CENTER	99.0	100.0

**Normalised Scores:**

Hospital Name	HSMR	Specific Mortality Rate
HUNTINGTON MEMORIAL HOSPITAL	33.6	0
SAN GABRIEL VALLEY MEDICAL CENTER	10.7	0
MONTEREY PARK HOSPITAL	0.0	0
ALHAMBRA HOSPITAL MEDICAL CENTER	33.6	0
GARFIELD MEDICAL CENTER	18.9	0

**Overall Scores:**

Hospital Name	Overall Score	Rank
HUNTINGTON MEMORIAL HOSPITAL	16.8	1
SAN GABRIEL VALLEY MEDICAL CENTER	5.3	4
MONTEREY PARK HOSPITAL	0.0	5
ALHAMBRA HOSPITAL MEDICAL CENTER	16.8	1
GARFIELD MEDICAL CENTER	9.4	3



## Appendix B

## General Model 5 Hospital Tests

Patient 1

## Outcome Raw Data:

Hospital Name	HSMR	Specific Mortality Rate (%)	Serious Complications (%)	Infection Rate (%)	Readmission Rate %
HUNTINGTON MEMORIAL HOSPITAL	81	0.3	4.2	4.3	15.3
SAN GABRIEL VALLEY MEDICAL CENTER	109	0.2	3.1	2.5	16.0
MONTEREY PARK HOSPITAL	122	0.4	3.8	5.1	16.9
ALHAMBRA HOSPITAL MEDICAL CENTER	81	0.2	2.8	4.6	15.2
GARFIELD MEDICAL CENTER	99.0	0.2	3.7	4.5	15.1
Average:	98.4	0.25	3.52	4.1926	15.7

## Outcome Normalised Scores:

Hospital Name	HSMR	Specific Mortality Rate	Serious Complications	Infection Rate	Readmission Rate
HUNTINGTON MEMORIAL HOSPITAL	33.6	25	0.0	16.1	9.5
SAN GABRIEL VALLEY MEDICAL CENTER	10.7	50	26.2	50.2	5.3
MONTEREY PARK HOSPITAL	0.0	0	9.5	0.0	0.0
ALHAMBRA HOSPITAL MEDICAL CENTER	33.6	62.5	33.3	9.4	10.1
GARFIELD MEDICAL CENTER	18.9	50	11.9	11.3	10.7

## Process Raw Data:

Hospital Name	Waiting Time (Days)	Patient Score		Cost (\$)	Travel Time (Min)
		(%)			
HUNTINGTON MEMORIAL HOSPITAL	35	92		\$20,699	9
SAN GABRIEL VALLEY MEDICAL CENTER	25	88		\$19,470	17
MONTEREY PARK HOSPITAL	19	88		\$19,889	26
ALHAMBRA HOSPITAL MEDICAL CENTER	19	87		\$18,951	18
GARFIELD MEDICAL CENTER	24	87		\$19,167	22
Average:	24.2	88.4		19635.28	18.4

## Process Normalised Scores:

Hospital Name	Waiting Time	Patient Score	Cost	Travel Time
HUNTINGTON MEMORIAL HOSPITAL	0.0	38.5	0.0	65.4
SAN GABRIEL VALLEY MEDICAL CENTER	27.2	7.7	5.9	34.6
MONTEREY PARK HOSPITAL	46.5	7.7	3.9	0.0
ALHAMBRA HOSPITAL MEDICAL CENTER	44.8	0.0	8.4	30.8

GARFIELD MEDICAL CENTER

31.8

0.0

7.4

15.4

**Outcome Weightings:**

HSMR	Specific Mortality	Serious Complications	Infection Rate	Readmission Rate
2%	2%	18%	16%	62%

**Process Weightings:**

Waiting Time	Patient Score	Cost	Travel Time
25%	45%	15%	15%

**User Details:**

Life Expectancy (Years)	Time to be spent in hospital (Years):	Process Weighting	Outcome Weighting
65	0.01	30%	70%

**Overall Scores:**

Hospital Name	Outcome	Process	Overall	Rank
HUNTINGTON MEMORIAL HOSPITAL	9.5	27.1	14.8	3
SAN GABRIEL VALLEY MEDICAL CENTER	17.4	16.3	17.1	1
MONTEREY PARK HOSPITAL	1.8	15.7	5.9	5
ALHAMBRA HOSPITAL MEDICAL CENTER	15.5	17.1	16.0	2
GARFIELD MEDICAL CENTER	11.8	11.4	11.7	4

Patient 2

**Outcome Raw Data:**

Hospital Name	HSMR	Specific Mortality Rate (%)	Serious Complications (%)	Infection Rate (%)	Readmission Rate %
HUNTINGTON MEMORIAL HOSPITAL	81	100.0	4.2	4.3	15.3
SAN GABRIEL VALLEY MEDICAL CENTER	109	100.0	3.1	2.5	16.0
MONTEREY PARK HOSPITAL	122	100.0	3.8	5.1	16.9
ALHAMBRA HOSPITAL MEDICAL CENTER	81	100.0	2.8	4.6	15.2
GARFIELD MEDICAL CENTER	99.0	100.0	3.7	4.5	15.1
Average:	98.4	100	3.52	4.1926	15.7

**Outcome Normalised Scores:**

Hospital Name	HSMR	Specific Mortality Rate	Serious Complications	Infection Rate	Readmission Rate
HUNTINGTON MEMORIAL HOSPITAL	33.6	0	0.0	16.1	9.5
SAN GABRIEL VALLEY MEDICAL CENTER	10.7	0	26.2	50.2	5.3
MONTEREY PARK HOSPITAL	0.0	0	9.5	0.0	0.0
ALHAMBRA HOSPITAL MEDICAL CENTER	33.6	0	33.3	9.4	10.1
GARFIELD MEDICAL CENTER	18.9	0	11.9	11.3	10.7

**Process Raw Data:**

Hospital Name	Waiting Time (Days)	Patient Score		Cost (\$)	Travel Time (Min)
		(%)			
HUNTINGTON MEMORIAL HOSPITAL	35	92		\$20,699	9
SAN GABRIEL VALLEY MEDICAL CENTER	25	88		\$19,470	17
MONTEREY PARK HOSPITAL	19	88		\$19,889	26
ALHAMBRA HOSPITAL MEDICAL CENTER	19	87		\$18,951	18
GARFIELD MEDICAL CENTER	24	87		\$19,167	22
Average:	24.2	88.4		19635.28	18.4

**Process Normalised Scores:**

Hospital Name	Waiting Time	Patient Score	Cost	Travel Time
HUNTINGTON MEMORIAL HOSPITAL	0.0	38.5	0.0	65.4
SAN GABRIEL VALLEY MEDICAL CENTER	27.2	7.7	5.9	34.6
MONTEREY PARK HOSPITAL	46.5	7.7	3.9	0.0
ALHAMBRA HOSPITAL MEDICAL CENTER	44.8	0.0	8.4	30.8
GARFIELD MEDICAL CENTER	31.8	0.0	7.4	15.4

**Outcome Weightings:**

HSMR	Specific Mortality	Serious Complications	Infection Rate	Readmission Rate
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47%

47%

1%

1%

4%

### Process Weightings:

Waiting Time	Patient Score	Cost	Travel Time
25%	45%	15%	15%

### User Details:

Life Expectancy (Years)	Time to be spent in hospital (Years):	Process Weighting	Outcome Weighting
65	0.01	30%	70%

### Overall Scores:

Hospital Name	Outcome	Process	Overall	Rank
HUNTINGTON MEMORIAL HOSPITAL	16.3	27.1	24.9	1
SAN GABRIEL VALLEY MEDICAL CENTER	6.1	16.3	14.3	3
MONTEREY PARK HOSPITAL	0.1	15.7	12.6	4
ALHAMBRA HOSPITAL MEDICAL CENTER	16.6	17.1	17.0	2
GARFIELD MEDICAL CENTER	9.5	11.4	11.0	5

## Appendix C

## General Model 50 Hospital Tests

Patient 1

## Outcome Raw Data:

Hospital Name	HSMR	Specific Mortality Rate (%)	Serious Complications (%)	Infection Rate (%)	Readmission Rate %
ST ROSE HOSPITAL	152	0.49	4.30	3.42	152
ST JOSEPH HOSPITAL	96	0.66	1.98	7.29	96
MILLS-PENINSULA MEDICAL CENTER	63	0.29	5.20	3.85	63
CALIFORNIA PACIFIC MEDICAL CTR-DAVIES					
CAMPUS HOSP	118	0.58	4.97	5.43	118
QUEEN OF THE VALLEY MEDICAL CENTER	97	0.35	4.77	8.89	97
ST HELENA HOSPITAL	139	0.49	3.35	5.72	139
SUTTER AMADOR HOSPITAL	112	0.54	4.22	1.57	112
MERCY GENERAL HOSPITAL	84	0.52	4.32	3.61	84
PACIFIC ALLIANCE MEDICAL CENTER	120	0.53	3.89	4.69	120
RIVERSIDE COMMUNITY HOSPITAL	121	0.43	4.59	6.37	121
PARADISE VALLEY HOSPITAL	115	0.58	3.95	2.37	115
UC SAN DIEGO HEALTH HILLCREST - HILLCREST MED CTR	111	0.44	4.09	6.17	111
GROSSMONT HOSPITAL	126	0.53	3.30	5.36	126
MAD RIVER COMMUNITY HOSPITAL	134	0.66	4.68	4.02	134
OROVILLE HOSPITAL	109	0.45	5.00	3.39	109
BAKERSFIELD MEMORIAL HOSPITAL	89	0.55	3.34	6.03	89
SANTA CLARA VALLEY MEDICAL CENTER	83	0.50	3.42	5.87	83
ENLOE MEDICAL CENTER	76	0.50	3.26	3.67	76
LAC/OLIVE VIEW-UCLA MEDICAL CENTER	82	0.47	4.02	5.30	82
ST ELIZABETH COMMUNITY HOSPITAL	123	0.61	4.60	5.09	123
ALTA BATES SUMMIT MEDICAL CENTER	63	0.44	4.66	5.30	63
EL CENTRO REGIONAL MEDICAL CENTER	66	0.42	4.93	6.55	66
CALIFORNIA PACIFIC MEDICAL CTR-PACIFIC					
CAMPUS HOSP	95	0.46	4.20	5.08	95
SAN GORGONIO MEMORIAL HOSPITAL	100	0.41	3.69	5.84	100
CALIFORNIA PACIFIC MEDICAL CTR - ST. LUKE'S CAMPUS	104	0.42	4.64	4.81	104
ANTELOPE VALLEY HOSPITAL	111	0.51	3.61	4.72	111
KAWEAH DELTA MEDICAL CENTER	106	0.30	5.56	5.80	106
GLENDALE MEM HOSPITAL & HLTH CENTER	88	0.50	4.03	4.64	88
COMMUNITY REGIONAL MEDICAL CENTER	119	0.42	4.83	7.74	119
HOLLYWOOD PRESBYTERIAN MEDICAL CENTER	80	0.50	4.08	7.45	80
OAK VALLEY HOSPITAL DISTRICT	136	0.52	4.10	3.65	136
ST JOSEPH HOSPITAL	104	0.54	3.63	5.41	104
KAISER FOUNDATION HOSPITAL-SANTA CLARA	95	0.60	4.72	4.98	95
KAISER FOUNDATION HOSPITAL AND REHAB CENTER	120	0.56	4.40	4.61	120
KAISER FOUNDATION HOSPITAL - OAKLAND/RICHMOND	120	0.41	4.29	5.41	120
SCRIPPS MERCY HOSPITAL	114	0.36	3.69	4.87	114
PROVIDENCE LITTLE CO OF MARY MED CTR					
SAN PEDRO	103	0.46	4.57	4.37	103
ST JOHNS REGIONAL MEDICAL CENTER	132	0.41	3.33	3.02	132
ST JOSEPH'S MEDICAL CENTER OF STOCKTON	96	0.58	2.94	3.11	96
COMMUNITY HOSPITAL OF SAN BERNARDINO	81	0.41	4.32	2.49	81
SONOMA VALLEY HOSPITAL	92	0.51	5.14	6.16	92
COMMUNITY HOSPITAL OF HUNTINGTON PARK	96	0.46	4.36	4.41	96
SAINT AGNES MEDICAL CENTER	72	0.62	3.54	4.79	72
SAN ANTONIO REGIONAL HOSPITAL	115	0.33	4.57	5.11	115
SHARP MEMORIAL HOSPITAL	112	0.49	4.72	5.40	112
SUTTER SOLANO MEDICAL CENTER	78	0.41	3.49	4.72	78
PARKVIEW COMMUNITY HOSPITAL MEDICAL CENTER	131	0.38	3.73	9.52	131

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WHITE MEMORIAL MEDICAL CENTER	71	0.46	1.96	3.31	71
SAINT FRANCIS MEDICAL CENTER	95	0.63	2.77	4.04	95
MARIAN REGIONAL MEDICAL CENTER	113	0.61	4.27	2.94	113
Average:	103	0.32	4.08	4.97	103

## Outcome Normalised Data:

Hospital Name	HSMR	Specific Mortality Rate	Serious Complications	Infection Rate	Readmission Rate
ST ROSE HOSPITAL	0.0	26.2	22.8	64.1	0.0
ST JOSEPH HOSPITAL	36.6	0.2	64.4	23.5	36.6
MILLS-PENINSULA MEDICAL CENTER	58.6	56.0	6.6	59.5	58.6
CALIFORNIA PACIFIC MEDICAL CTR- DAVIES CAMPUS HOSP	22.6	12.0	10.7	42.9	22.6
QUEEN OF THE VALLEY MEDICAL CENTER	36.0	47.5	14.2	6.6	36.0
ST HELENA HOSPITAL	8.6	25.2	39.8	39.9	8.6
SUTTER AMADOR HOSPITAL	26.3	18.4	24.1	83.5	26.3
MERCY GENERAL HOSPITAL	44.6	22.0	22.4	62.0	44.6
PACIFIC ALLIANCE MEDICAL CENTER	21.1	19.8	30.1	50.8	21.1
RIVERSIDE COMMUNITY HOSPITAL	20.5	35.1	17.5	33.0	20.5
PARADISE VALLEY HOSPITAL	24.6	12.6	29.1	75.1	24.6
UC SAN DIEGO HEALTH HILLCREST - HILLCREST MED CTR	27.3	32.7	26.5	35.2	27.3
GROSSMONT HOSPITAL	17.0	19.3	40.7	43.7	17.0
MAD RIVER COMMUNITY HOSPITAL	12.2	0.0	16.0	57.8	12.2
OROVILLE HOSPITAL	28.2	31.2	10.1	64.4	28.2
BAKERSFIELD MEMORIAL HOSPITAL	41.7	16.8	40.0	36.6	41.7
SANTA CLARA VALLEY MEDICAL CENTER	45.6	24.4	38.5	38.3	45.6
ENLOE MEDICAL CENTER	50.0	23.7	41.4	61.5	50.0
LAC/OLIVE VIEW-UCLA MEDICAL CENTER	46.4	28.4	27.8	44.3	46.4
ST ELIZABETH COMMUNITY HOSPITAL	19.3	8.1	17.4	46.5	19.3
ALTA BATES SUMMIT MEDICAL CENTER	58.5	33.3	16.3	44.3	58.5
EL CENTRO REGIONAL MEDICAL CENTER	56.8	35.8	11.3	31.2	56.8
CALIFORNIA PACIFIC MEDICAL CTR- PACIFIC CAMPUS HOSP	37.7	31.0	24.5	46.6	37.7
SAN GORGONIO MEMORIAL HOSPITAL	34.4	38.6	33.7	38.6	34.4
CALIFORNIA PACIFIC MEDICAL CTR - ST. LUKE'S CAMPUS	31.5	36.7	16.7	49.5	31.5
ANTELOPE VALLEY HOSPITAL	27.2	23.4	35.1	50.4	27.2
KAWEAH DELTA MEDICAL CENTER	30.2	54.9	0.0	39.0	30.2
GLENDALE MEM HOSPITAL & HLTH CENTER	42.0	24.8	27.5	51.3	42.0
COMMUNITY REGIONAL MEDICAL CENTER	21.7	35.9	13.2	18.6	21.7
HOLLYWOOD PRESBYTERIAN MEDICAL CENTER	47.7	24.0	26.8	21.7	47.7
OAK VALLEY HOSPITAL DISTRICT	10.8	21.8	26.4	61.7	10.8
ST JOSEPH HOSPITAL	31.6	17.9	34.7	43.2	31.6
KAISER FOUNDATION HOSPITAL-SANTA CLARA	37.5	9.5	15.2	47.7	37.5
KAISER FOUNDATION HOSPITAL AND REHAB CENTER	21.1	15.8	21.0	51.5	21.1
KAISER FOUNDATION HOSPITAL - OAKLAND/RICHMOND	21.0	37.9	22.9	43.1	21.0
SCRIPPS MERCY HOSPITAL	25.1	45.1	33.6	48.9	25.1
PROVIDENCE LITTLE CO OF MARY MED CTR SAN PEDRO	32.6	29.9	17.8	54.1	32.6
ST JOHNS REGIONAL MEDICAL CENTER	13.2	38.2	40.1	68.2	13.2
ST JOSEPH'S MEDICAL CENTER OF STOCKTON	36.6	11.7	47.2	67.3	36.6
COMMUNITY HOSPITAL OF SAN BERNARDINO	46.9	38.7	22.4	73.9	46.9
SONOMA VALLEY HOSPITAL	39.5	23.1	7.5	35.3	39.5
COMMUNITY HOSPITAL OF HUNTINGTON PARK	36.6	31.1	21.7	53.6	36.6
SAINT AGNES MEDICAL CENTER	52.8	6.1	36.3	49.7	52.8
SAN ANTONIO REGIONAL HOSPITAL	24.2	49.5	17.9	46.3	24.2
SHARP MEMORIAL HOSPITAL	26.3	25.8	15.2	43.3	26.3

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SUTTER SOLANO MEDICAL CENTER	49.0	38.7	37.2	50.4	49.0
PARKVIEW COMMUNITY HOSPITAL MEDICAL CENTER	13.9	42.0	32.9	0.0	13.9
WHITE MEMORIAL MEDICAL CENTER	53.6	31.1	64.8	65.2	53.6
SAINT FRANCIS MEDICAL CENTER	37.4	5.1	50.3	57.5	37.4
MARIAN REGIONAL MEDICAL CENTER	25.6	7.5	23.2	69.1	25.6



## Process Raw Data:

Hospital Name	Waiting Time (Days)	Patient Score (%)	Cost (\$)	Travel Time (Min)
ST ROSE HOSPITAL	17	29	86	\$22,262
ST JOSEPH HOSPITAL	14.5	39.6	86	\$17,360
MILLS-PENINSULA MEDICAL CENTER	13.6	24.6	93	\$18,209
CALIFORNIA PACIFIC MEDICAL CTR-DAVIES CAMPUS HOSP	14.5	27.3	87	\$19,348
QUEEN OF THE VALLEY MEDICAL CENTER	14.4	30.5	88	\$17,834
ST HELENA HOSPITAL	15.2	23.6	88	\$19,527
SUTTER AMADOR HOSPITAL	15.9	31.8	89	\$19,466
MERCY GENERAL HOSPITAL	15.4	33.6	90	\$20,040
PACIFIC ALLIANCE MEDICAL CENTER	15.2	25.1	86	\$20,431
RIVERSIDE COMMUNITY HOSPITAL	16.6	43.2	85	\$21,101
PARADISE VALLEY HOSPITAL	15.5	31.6	86	\$22,282
UC SAN DIEGO HEALTH HILLCREST - HILLCREST MED CTR	15.7	53.4	89	\$19,713
GROSSMONT HOSPITAL	16.1	43	89	\$19,174
MAD RIVER COMMUNITY HOSPITAL	14.7	29	88	\$18,954
OROVILLE HOSPITAL	19.2	30.8	82	\$19,019
BAKERSFIELD MEMORIAL HOSPITAL	16.2	52.5	88	\$19,086
SANTA CLARA VALLEY MEDICAL CENTER	15	39.8	86	\$19,474
ENLOE MEDICAL CENTER	15.6	30.2	92	\$18,846
LAC/OLIVE VIEW-UCLA MEDICAL CENTER	14.7	62.7	90	\$18,732
ST ELIZABETH COMMUNITY HOSPITAL	14.6	29.4	88	\$17,869
ALTA BATES SUMMIT MEDICAL CENTER	13.9	33.2	89	\$20,310
EL CENTRO REGIONAL MEDICAL CENTER	14.9	49.5	84	\$19,048
CALIFORNIA PACIFIC MEDICAL CTR-PACIFIC CAMPUS HOSP	15.3	33.9	87	\$18,041
SAN GORGONIO MEMORIAL HOSPITAL	15.1	41.6	84	\$18,440
CALIFORNIA PACIFIC MEDICAL CTR - ST. LUKE'S CAMPUS	14.8	29.6	85	\$18,878
ANTELOPE VALLEY HOSPITAL	16.2	50.7	82	\$20,004
KAWEAH DELTA MEDICAL CENTER	15.3	43.7	89	\$18,759
GLENDALE MEM HOSPITAL & HLTH CENTER	15.9	27.9	87	\$22,127
COMMUNITY REGIONAL MEDICAL CENTER	16.7	105.9	89	\$19,775
HOLLYWOOD PRESBYTERIAN MEDICAL CENTER	17.1	36.5	82	\$22,351
OAK VALLEY HOSPITAL DISTRICT	15.1	28.8	86	\$19,155
ST JOSEPH HOSPITAL	14.8	34.9	93	\$21,230
KAISER FOUNDATION HOSPITAL-SANTA CLARA	15.3	26	89	\$19,742
KAISER FOUNDATION HOSPITAL AND REHAB CENTER	15.1	34.3	91	\$19,742
KAISER FOUNDATION HOSPITAL - OAKLAND/RICHMOND	15.1	38.5	89	\$19,742
SCRIPPS MERCY HOSPITAL	15.3	36	89	\$18,644
PROVIDENCE LITTLE CO OF MARY MED CTR SAN PEDRO	14.1	35.9	89	\$18,383
ST JOHNS REGIONAL MEDICAL CENTER	15.2	29.3	89	\$19,742
ST JOSEPH'S MEDICAL CENTER OF STOCKTON	15	47.2	86	\$21,067
COMMUNITY HOSPITAL OF SAN BERNARDINO	16.1	29.4	90	\$20,517
SONOMA VALLEY HOSPITAL	14.7	31.9	87	\$22,067
COMMUNITY HOSPITAL OF HUNTINGTON PARK	17.1	48.8	86	\$20,700
SAINT AGNES MEDICAL CENTER	16.1	52	86	\$20,596
SAN ANTONIO REGIONAL HOSPITAL	15.5	31.2	89	\$19,899
SHARP MEMORIAL HOSPITAL	15	37.6	84	\$20,959
SUTTER SOLANO MEDICAL CENTER	15.2	47.4	87	\$19,078
PARKVIEW COMMUNITY HOSPITAL MEDICAL CENTER	17.1	47.4	89	\$21,396
WHITE MEMORIAL MEDICAL CENTER	15.8	23.6	93	\$19,609
SAINT FRANCIS MEDICAL CENTER	15.6	35.4	85	\$20,673
MARIAN REGIONAL MEDICAL CENTER	14.6	35	81	\$21,640
Average:	15.45	37.88	87.44	19820.79

## Process Normalized Data:

Hospital Name	Waiting Time (Days)	Patient Score (%)	Cost (\$)	Travel Time (Min)
ST ROSE HOSPITAL	11.5	72.6	26.3	0.4
ST JOSEPH HOSPITAL	24.5	62.6	26.3	22.3
MILLS-PENINSULA MEDICAL CENTER	29.2	76.8	63.2	18.5
CALIFORNIA PACIFIC MEDICAL CTR-DAVIES CAMPUS HOSP	24.5	74.2	31.6	13.4
QUEEN OF THE VALLEY MEDICAL CENTER	25.0	71.2	36.8	20.2
ST HELENA HOSPITAL	20.8	77.7	36.8	12.6
SUTTER AMADOR HOSPITAL	17.2	70.0	42.1	12.9
MERCY GENERAL HOSPITAL	19.8	68.3	47.4	10.3
PACIFIC ALLIANCE MEDICAL CENTER	20.8	76.3	26.3	8.6
RIVERSIDE COMMUNITY HOSPITAL	13.5	59.2	21.1	5.6
PARADISE VALLEY HOSPITAL	19.3	70.2	26.3	0.3
UC SAN DIEGO HEALTH HILLCREST - HILLCREST MED CTR	18.2	49.6	42.1	11.8
GROSSMONT HOSPITAL	16.1	59.4	42.1	14.2
MAD RIVER COMMUNITY HOSPITAL	23.4	72.6	36.8	15.2
OROVILLE HOSPITAL	0.0	70.9	5.3	14.9
BAKERSFIELD MEMORIAL HOSPITAL	15.6	50.4	36.8	14.6
SANTA CLARA VALLEY MEDICAL CENTER	21.9	62.4	26.3	12.9
ENLOE MEDICAL CENTER	18.8	71.5	57.9	15.7
LAC/OLIVE VIEW-UCLA MEDICAL CENTER	23.4	40.8	47.4	16.2
ST ELIZABETH COMMUNITY HOSPITAL	24.0	72.2	36.8	20.1
ALTA BATES SUMMIT MEDICAL CENTER	27.6	68.6	42.1	9.1
EL CENTRO REGIONAL MEDICAL CENTER	22.4	53.3	15.8	14.8
CALIFORNIA PACIFIC MEDICAL CTR-PACIFIC CAMPUS HOSP	20.3	68.0	31.6	19.3
SAN GORGONIO MEMORIAL HOSPITAL	21.4	60.7	15.8	17.5
CALIFORNIA PACIFIC MEDICAL CTR - ST. LUKE'S CAMPUS	22.9	72.0	21.1	15.5
ANTELOPE VALLEY HOSPITAL	15.6	52.1	5.3	10.5
KAWEAH DELTA MEDICAL CENTER	20.3	58.7	42.1	16.1
GLENDALE MEM HOSPITAL & HLTH CENTER	17.2	73.7	31.6	1.0
COMMUNITY REGIONAL MEDICAL CENTER	13.0	0.0	42.1	11.5
HOLLYWOOD PRESBYTERIAN MEDICAL CENTER	10.9	65.5	5.3	0.0
OAK VALLEY HOSPITAL DISTRICT	21.4	72.8	26.3	14.3
ST JOSEPH HOSPITAL	22.9	67.0	63.2	5.0
KAISER FOUNDATION HOSPITAL-SANTA CLARA	20.3	75.4	42.1	11.7
KAISER FOUNDATION HOSPITAL AND REHAB CENTER	21.4	67.6	52.6	11.7
KAISER FOUNDATION HOSPITAL - OAKLAND/RICHMOND	21.4	63.6	42.1	11.7
SCRIPPS MERCY HOSPITAL	20.3	66.0	42.1	16.6
PROVIDENCE LITTLE CO OF MARY MED CTR SAN PEDRO	26.6	66.1	42.1	17.8
ST JOHNS REGIONAL MEDICAL CENTER	20.8	72.3	42.1	11.7
ST JOSEPH'S MEDICAL CENTER OF STOCKTON	21.9	55.4	26.3	5.7
COMMUNITY HOSPITAL OF SAN BERNARDINO	16.1	72.2	47.4	8.2
SONOMA VALLEY HOSPITAL	23.4	69.9	31.6	1.3
COMMUNITY HOSPITAL OF HUNTINGTON PARK	10.9	53.9	26.3	7.4
SAINT AGNES MEDICAL CENTER	16.1	50.9	26.3	7.9
SAN ANTONIO REGIONAL HOSPITAL	19.3	70.5	42.1	11.0
SHARP MEMORIAL HOSPITAL	21.9	64.5	15.8	6.2
SUTTER SOLANO MEDICAL CENTER	20.8	55.2	31.6	14.6
PARKVIEW COMMUNITY HOSPITAL MEDICAL CENTER	10.9	55.2	42.1	4.3
WHITE MEMORIAL MEDICAL CENTER	17.7	77.7	63.2	12.3
SAINT FRANCIS MEDICAL CENTER	18.8	66.6	21.1	7.5
MARIAN REGIONAL MEDICAL CENTER	24.0	66.9	0.0	3.2

**Outcome Weightings:**

HSMR	Specific Mortality	Serious Complications	Infection Rate	Readmission Rate
2%	2%	20%	18%	57%

**Process Weightings:**

Waiting Time (Days)	Patient Score (%)	Cost (\$)	Travel Time (Min)
25%	45%	15%	15%

**User Details:**

Life Expectancy	Time to be spent in hospital (Years):	Process Weighting	Outcome Weighting
65	0.01	30%	70%

**Overall Scores:**

Hospital Name	Outcome	Process	Overall	Rank
ST ROSE HOSPITAL	23.5	33.1	26.4	43
ST JOSEPH HOSPITAL	32.1	40.7	34.7	8
MILLS-PENINSULA MEDICAL CENTER	31.3	63.4	40.9	2
CALIFORNIA PACIFIC MEDICAL CTR-DAVIES CAMPUS HOSP	24.8	35.2	27.9	39
QUEEN OF THE VALLEY MEDICAL CENTER	20.1	47.7	28.4	38
ST HELENA HOSPITAL	28.0	45.1	33.2	12
SUTTER AMADOR HOSPITAL	31.0	41.3	34.1	9
MERCY GENERAL HOSPITAL	28.6	42.0	32.6	14
PACIFIC ALLIANCE MEDICAL CENTER	28.2	32.7	29.6	30
RIVERSIDE COMMUNITY HOSPITAL	18.5	27.1	21.1	47
PARADISE VALLEY HOSPITAL	31.5	33.7	32.2	19
UC SAN DIEGO HEALTH HILLCREST - HILLCREST MED CTR	23.5	45.5	30.1	27
GROSSMONT HOSPITAL	26.3	45.5	32.0	20
MAD RIVER COMMUNITY HOSPITAL	27.6	47.1	33.4	11
OROVILLE HOSPITAL	15.1	31.5	20.0	48
BAKERSFIELD MEMORIAL HOSPITAL	25.0	39.4	29.3	31
SANTA CLARA VALLEY MEDICAL CENTER	28.8	30.4	29.3	32
ENLOE MEDICAL CENTER	31.9	60.0	40.3	3
LAC/OLIVE VIEW-UCLA MEDICAL CENTER	28.7	34.6	30.5	25
ST ELIZABETH COMMUNITY HOSPITAL	26.4	38.4	30.0	29
ALTA BATES SUMMIT MEDICAL CENTER	29.1	40.8	32.6	15
EL CENTRO REGIONAL MEDICAL CENTER	22.7	31.3	25.3	45
CALIFORNIA PACIFIC MEDICAL CTR-PACIFIC CAMPUS HOSP	26.6	38.0	30.0	28
SAN GORGONIO MEMORIAL HOSPITAL	27.6	31.1	28.7	36
CALIFORNIA PACIFIC MEDICAL CTR - ST. LUKE'S CAMPUS	27.0	33.2	28.9	34
ANTELOPE VALLEY HOSPITAL	26.4	31.3	27.9	40
KAWEAH DELTA MEDICAL CENTER	20.5	40.2	26.4	42
GLENDALE MEM HOSPITAL & HLTH CENTER	26.2	43.4	31.4	23
COMMUNITY REGIONAL MEDICAL CENTER	14.7	25.5	17.9	50
HOLLYWOOD PRESBYTERIAN MEDICAL CENTER	17.1	20.8	18.2	49
OAK VALLEY HOSPITAL DISTRICT	29.6	38.7	32.3	17
ST JOSEPH HOSPITAL	29.1	51.5	35.8	6
KAISER FOUNDATION HOSPITAL-SANTA CLARA	24.5	39.7	29.0	33
KAISER FOUNDATION HOSPITAL AND REHAB CENTER	26.7	49.6	33.6	10
KAISER FOUNDATION HOSPITAL - OAKLAND/RICHMOND	26.0	42.8	31.0	24
SCRIPPS MERCY HOSPITAL	28.9	41.0	32.5	16

PROVIDENCE LITTLE CO OF MARY MED CTR SAN PEDRO	30.1	46.8	35.1	7
ST JOHNS REGIONAL MEDICAL CENTER	33.7	43.6	36.6	4
ST JOSEPH'S MEDICAL CENTER OF STOCKTON	35.5	37.5	36.1	5
COMMUNITY HOSPITAL OF SAN BERNARDINO	29.1	42.5	33.1	13
SONOMA VALLEY HOSPITAL	22.7	42.0	28.5	37
COMMUNITY HOSPITAL OF HUNTINGTON PARK	21.9	40.5	27.5	41
SAINT AGNES MEDICAL CENTER	26.9	38.5	30.4	26
SAN ANTONIO REGIONAL HOSPITAL	24.7	38.2	28.7	35
SHARP MEMORIAL HOSPITAL	24.6	30.2	26.3	44
SUTTER SOLANO MEDICAL CENTER	30.5	36.4	32.3	18
PARKVIEW COMMUNITY HOSPITAL MEDICAL CENTER	14.0	38.2	21.3	46
WHITE MEMORIAL MEDICAL CENTER	37.0	58.3	43.3	1
SAINT FRANCIS MEDICAL CENTER	32.4	30.1	31.7	21
MARIAN REGIONAL MEDICAL CENTER	31.8	30.4	31.4	22

Patient 2

Outcome Raw Data:

Hospital Name	HSMR	Specific Mortality Rate (%)	Serious Complications (%)	Infection Rate (%)	Readmission Rate %
ST ROSE HOSPITAL	152	100	4.30	3.42	17
ST JOSEPH HOSPITAL	96	100	1.98	7.29	14.5
MILLS-PENINSULA MEDICAL CENTER	63	100	5.20	3.85	13.6
CALIFORNIA PACIFIC MEDICAL CTR-DAVIES					
CAMPUS HOSP	118	100	4.97	5.43	14.5
QUEEN OF THE VALLEY MEDICAL CENTER	97	100	4.77	8.89	14.4
ST HELENA HOSPITAL	139	100	3.35	5.72	15.2
SUTTER AMADOR HOSPITAL	112	100	4.22	1.57	15.9
MERCY GENERAL HOSPITAL	84	100	4.32	3.61	15.4
PACIFIC ALLIANCE MEDICAL CENTER	120	100	3.89	4.69	15.2
RIVERSIDE COMMUNITY HOSPITAL	121	100	4.59	6.37	16.6
PARADISE VALLEY HOSPITAL	115	100	3.95	2.37	15.5
UC SAN DIEGO HEALTH HILLCREST - HILLCREST MED CTR	111	100	4.09	6.17	15.7
GROSSMONT HOSPITAL	126	100	3.30	5.36	16.1
MAD RIVER COMMUNITY HOSPITAL	134	100	4.68	4.02	14.7
OROVILLE HOSPITAL	109	100	5.00	3.39	19.2
BAKERSFIELD MEMORIAL HOSPITAL	89	100	3.34	6.03	16.2
SANTA CLARA VALLEY MEDICAL CENTER	83	100	3.42	5.87	15
ENLOE MEDICAL CENTER	76	100	3.26	3.67	15.6
LAC/OLIVE VIEW-UCLA MEDICAL CENTER	82	100	4.02	5.30	14.7
ST ELIZABETH COMMUNITY HOSPITAL	123	100	4.60	5.09	14.6
ALTA BATES SUMMIT MEDICAL CENTER	63	100	4.66	5.30	13.9
EL CENTRO REGIONAL MEDICAL CENTER	66	100	4.93	6.55	14.9
CALIFORNIA PACIFIC MEDICAL CTR-PACIFIC					
CAMPUS HOSP	95	100	4.20	5.08	15.3
SAN GORGONIO MEMORIAL HOSPITAL	100	100	3.69	5.84	15.1
CALIFORNIA PACIFIC MEDICAL CTR - ST. LUKE'S CAMPUS	104	100	4.64	4.81	14.8
ANTELOPE VALLEY HOSPITAL	111	100	3.61	4.72	16.2
KAWEAH DELTA MEDICAL CENTER	106	100	5.56	5.80	15.3
GLENDALE MEM HOSPITAL & HLTH CENTER	88	100	4.03	4.64	15.9
COMMUNITY REGIONAL MEDICAL CENTER	119	100	4.83	7.74	16.7
HOLLYWOOD PRESBYTERIAN MEDICAL CENTER	80	100	4.08	7.45	17.1
OAK VALLEY HOSPITAL DISTRICT	136	100	4.10	3.65	15.1
ST JOSEPH HOSPITAL	104	100	3.63	5.41	14.8
KAISER FOUNDATION HOSPITAL-SANTA CLARA	95	100	4.72	4.98	15.3
KAISER FOUNDATION HOSPITAL AND REHAB CENTER	120	100	4.40	4.61	15.1
KAISER FOUNDATION HOSPITAL - OAKLAND/RICHMOND	120	100	4.29	5.41	15.1
SCRIPPS MERCY HOSPITAL	114	100	3.69	4.87	15.3
PROVIDENCE LITTLE CO OF MARY MED CTR SAN PEDRO	103	100	4.57	4.37	14.1
ST JOHNS REGIONAL MEDICAL CENTER	132	100	3.33	3.02	15.2

ST JOSEPH'S MEDICAL CENTER OF STOCKTON	96	100	2.94	3.11	15
COMMUNITY HOSPITAL OF SAN BERNARDINO	81	100	4.32	2.49	16.1
SONOMA VALLEY HOSPITAL	92	100	5.14	6.16	14.7
COMMUNITY HOSPITAL OF HUNTINGTON PARK	96	100	4.36	4.41	17.1
SAINT AGNES MEDICAL CENTER	72	100	3.54	4.79	16.1
SAN ANTONIO REGIONAL HOSPITAL	115	100	4.57	5.11	15.5
SHARP MEMORIAL HOSPITAL	112	100	4.72	5.40	15
SUTTER SOLANO MEDICAL CENTER	78	100	3.49	4.72	15.2
PARKVIEW COMMUNITY HOSPITAL					
MEDICAL CENTER	131	100	3.73	9.52	17.1
WHITE MEMORIAL MEDICAL CENTER	71	100	1.96	3.31	15.8
SAINT FRANCIS MEDICAL CENTER	95	100	2.77	4.04	15.6
MARIAN REGIONAL MEDICAL CENTER	113	100	4.27	2.94	14.6
Average:	103	100.00	4.08	4.97	15.45

## Outcome Normalised Data:

Hospital Name	HSMR	Specific Mortality Rate	Serious Complications	Infection Rate	Readmission Rate
ST ROSE HOSPITAL	0.0	0.0	22.8	64.1	11.5
ST JOSEPH HOSPITAL	36.6	0.0	64.4	23.5	24.5
MILLS-PENINSULA MEDICAL CENTER	58.6	0.0	6.6	59.5	29.2
CALIFORNIA PACIFIC MEDICAL CTR- DAVIES CAMPUS HOSP	22.6	0.0	10.7	42.9	24.5
QUEEN OF THE VALLEY MEDICAL CENTER	36.0	0.0	14.2	6.6	25.0
ST HELENA HOSPITAL	8.6	0.0	39.8	39.9	20.8
SUTTER AMADOR HOSPITAL	26.3	0.0	24.1	83.5	17.2
MERCY GENERAL HOSPITAL	44.6	0.0	22.4	62.0	19.8
PACIFIC ALLIANCE MEDICAL CENTER	21.1	0.0	30.1	50.8	20.8
RIVERSIDE COMMUNITY HOSPITAL	20.5	0.0	17.5	33.0	13.5
PARADISE VALLEY HOSPITAL	24.6	0.0	29.1	75.1	19.3
UC SAN DIEGO HEALTH HILLCREST - HILLCREST MED CTR	27.3	0.0	26.5	35.2	18.2
GROSSMONT HOSPITAL	17.0	0.0	40.7	43.7	16.1
MAD RIVER COMMUNITY HOSPITAL	12.2	0.0	16.0	57.8	23.4
OROVILLE HOSPITAL	28.2	0.0	10.1	64.4	0.0
BAKERSFIELD MEMORIAL HOSPITAL	41.7	0.0	40.0	36.6	15.6
SANTA CLARA VALLEY MEDICAL CENTER	45.6	0.0	38.5	38.3	21.9
ENLOE MEDICAL CENTER	50.0	0.0	41.4	61.5	18.8
LAC/OLIVE VIEW-UCLA MEDICAL CENTER	46.4	0.0	27.8	44.3	23.4
ST ELIZABETH COMMUNITY HOSPITAL	19.3	0.0	17.4	46.5	24.0
ALTA BATES SUMMIT MEDICAL CENTER	58.5	0.0	16.3	44.3	27.6
EL CENTRO REGIONAL MEDICAL CENTER	56.8	0.0	11.3	31.2	22.4
CALIFORNIA PACIFIC MEDICAL CTR- PACIFIC CAMPUS HOSP	37.7	0.0	24.5	46.6	20.3
SAN GORGONIO MEMORIAL HOSPITAL	34.4	0.0	33.7	38.6	21.4
CALIFORNIA PACIFIC MEDICAL CTR - ST. LUKE'S CAMPUS	31.5	0.0	16.7	49.5	22.9
ANTELOPE VALLEY HOSPITAL	27.2	0.0	35.1	50.4	15.6
KAWEAH DELTA MEDICAL CENTER	30.2	0.0	0.0	39.0	20.3
GLENDALE MEM HOSPITAL & HLTH CENTER	42.0	0.0	27.5	51.3	17.2
COMMUNITY REGIONAL MEDICAL CENTER	21.7	0.0	13.2	18.6	13.0
HOLLYWOOD PRESBYTERIAN MEDICAL CENTER	47.7	0.0	26.8	21.7	10.9
OAK VALLEY HOSPITAL DISTRICT	10.8	0.0	26.4	61.7	21.4
ST JOSEPH HOSPITAL	31.6	0.0	34.7	43.2	22.9
KAISER FOUNDATION HOSPITAL-SANTA CLARA	37.5	0.0	15.2	47.7	20.3
KAISER FOUNDATION HOSPITAL AND REHAB CENTER	21.1	0.0	21.0	51.5	21.4
KAISER FOUNDATION HOSPITAL - OAKLAND/RICHMOND	21.0	0.0	22.9	43.1	21.4
SCRIPPS MERCY HOSPITAL	25.1	0.0	33.6	48.9	20.3
PROVIDENCE LITTLE CO OF MARY MED CTR SAN PEDRO	32.6	0.0	17.8	54.1	26.6
ST JOHNS REGIONAL MEDICAL CENTER	13.2	0.0	40.1	68.2	20.8
ST JOSEPH'S MEDICAL CENTER OF STOCKTON	36.6	0.0	47.2	67.3	21.9
COMMUNITY HOSPITAL OF SAN BERNARDINO	46.9	0.0	22.4	73.9	16.1
SONOMA VALLEY HOSPITAL	39.5	0.0	7.5	35.3	23.4
COMMUNITY HOSPITAL OF HUNTINGTON PARK	36.6	0.0	21.7	53.6	10.9
SAINT AGNES MEDICAL CENTER	52.8	0.0	36.3	49.7	16.1
SAN ANTONIO REGIONAL HOSPITAL	24.2	0.0	17.9	46.3	19.3
SHARP MEMORIAL HOSPITAL	26.3	0.0	15.2	43.3	21.9

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SUTTER SOLANO MEDICAL CENTER	49.0	0.0	37.2	50.4	20.8
PARKVIEW COMMUNITY HOSPITAL MEDICAL CENTER	13.9	0.0	32.9	0.0	10.9
WHITE MEMORIAL MEDICAL CENTER	53.6	0.0	64.8	65.2	17.7
SAINT FRANCIS MEDICAL CENTER	37.4	0.0	50.3	57.5	18.8
MARIAN REGIONAL MEDICAL CENTER	25.6	0.0	23.2	69.1	24.0

## Process Raw Data:

Hospital Name	Waiting Time (Days)	Patient Score (%)	Cost (\$)	Travel Time (Min)
ST ROSE HOSPITAL	29	86	\$22,262	95
ST JOSEPH HOSPITAL	39.6	86	\$17,360	41
MILLS-PENINSULA MEDICAL CENTER	24.6	93	\$18,209	16
CALIFORNIA PACIFIC MEDICAL CTR-DAVIES CAMPUS HOSP	27.3	87	\$19,348	116
QUEEN OF THE VALLEY MEDICAL CENTER	30.5	88	\$17,834	37
ST HELENA HOSPITAL	23.6	88	\$19,527	62
SUTTER AMADOR HOSPITAL	31.8	89	\$19,466	96
MERCY GENERAL HOSPITAL	33.6	90	\$20,040	103
PACIFIC ALLIANCE MEDICAL CENTER	25.1	86	\$20,431	115
RIVERSIDE COMMUNITY HOSPITAL	43.2	85	\$21,101	103
PARADISE VALLEY HOSPITAL	31.6	86	\$22,282	85
UC SAN DIEGO HEALTH HILLCREST - HILLCREST MED CTR	53.4	89	\$19,713	21
GROSSMONT HOSPITAL	43	89	\$19,174	43
MAD RIVER COMMUNITY HOSPITAL	29	88	\$18,954	39
OROVILLE HOSPITAL	30.8	82	\$19,019	46
BAKERSFIELD MEMORIAL HOSPITAL	52.5	88	\$19,086	55
SANTA CLARA VALLEY MEDICAL CENTER	39.8	86	\$19,474	111
ENLOE MEDICAL CENTER	30.2	92	\$18,846	10
LAC/OLIVE VIEW-UCLA MEDICAL CENTER	62.7	90	\$18,732	114
ST ELIZABETH COMMUNITY HOSPITAL	29.4	88	\$17,869	113
ALTA BATES SUMMIT MEDICAL CENTER	33.2	89	\$20,310	93
EL CENTRO REGIONAL MEDICAL CENTER	49.5	84	\$19,048	50
CALIFORNIA PACIFIC MEDICAL CTR-PACIFIC CAMPUS HOSP	33.9	87	\$18,041	88
SAN GORGONIO MEMORIAL HOSPITAL	41.6	84	\$18,440	70
CALIFORNIA PACIFIC MEDICAL CTR - ST. LUKE'S CAMPUS	29.6	85	\$18,878	92
ANTELOPE VALLEY HOSPITAL	50.7	82	\$20,004	5
KAWEAH DELTA MEDICAL CENTER	43.7	89	\$18,759	86
GLENDALE MEM HOSPITAL & HLTH CENTER	27.9	87	\$22,127	35
COMMUNITY REGIONAL MEDICAL CENTER	105.9	89	\$19,775	81
HOLLYWOOD PRESBYTERIAN MEDICAL CENTER	36.5	82	\$22,351	103
OAK VALLEY HOSPITAL DISTRICT	28.8	86	\$19,155	67
ST JOSEPH HOSPITAL	34.9	93	\$21,230	75
KAISER FOUNDATION HOSPITAL-SANTA CLARA	26	89	\$19,742	118
KAISER FOUNDATION HOSPITAL AND REHAB CENTER	34.3	91	\$19,742	61
KAISER FOUNDATION HOSPITAL - OAKLAND/RICHMOND	38.5	89	\$19,742	70
SCRIPPS MERCY HOSPITAL	36	89	\$18,644	95
PROVIDENCE LITTLE CO OF MARY MED CTR SAN PEDRO	35.9	89	\$18,383	50
ST JOHNS REGIONAL MEDICAL CENTER	29.3	89	\$19,742	81
ST JOSEPH'S MEDICAL CENTER OF STOCKTON	47.2	86	\$21,067	32
COMMUNITY HOSPITAL OF SAN BERNARDINO	29.4	90	\$20,517	104
SONOMA VALLEY HOSPITAL	31.9	87	\$22,067	39
COMMUNITY HOSPITAL OF HUNTINGTON PARK	48.8	86	\$20,700	7
SAINT AGNES MEDICAL CENTER	52	86	\$20,596	18
SAN ANTONIO REGIONAL HOSPITAL	31.2	89	\$19,899	119
SHARP MEMORIAL HOSPITAL	37.6	84	\$20,959	71
SUTTER SOLANO MEDICAL CENTER	47.4	87	\$19,078	70
PARKVIEW COMMUNITY HOSPITAL MEDICAL CENTER	47.4	89	\$21,396	81
WHITE MEMORIAL MEDICAL CENTER	23.6	93	\$19,609	51
SAINT FRANCIS MEDICAL CENTER	35.4	85	\$20,673	96
MARIAN REGIONAL MEDICAL CENTER	35	81	\$21,640	14
Average:	37.88	87.44	19820.79	68.86



## Process Normalized Data:

Hospital Name	Waiting Time (Days)	Patient Score (%)	Cost (\$)	Travel Time (Min)
ST ROSE HOSPITAL	72.6	26.3	0.4	20.2
ST JOSEPH HOSPITAL	62.6	26.3	22.3	65.5
MILLS-PENINSULA MEDICAL CENTER	76.8	63.2	18.5	86.6
CALIFORNIA PACIFIC MEDICAL CTR-DAVIES CAMPUS HOSP	74.2	31.6	13.4	2.5
QUEEN OF THE VALLEY MEDICAL CENTER	71.2	36.8	20.2	68.9
ST HELENA HOSPITAL	77.7	36.8	12.6	47.9
SUTTER AMADOR HOSPITAL	70.0	42.1	12.9	19.3
MERCY GENERAL HOSPITAL	68.3	47.4	10.3	13.4
PACIFIC ALLIANCE MEDICAL CENTER	76.3	26.3	8.6	3.4
RIVERSIDE COMMUNITY HOSPITAL	59.2	21.1	5.6	13.4
PARADISE VALLEY HOSPITAL	70.2	26.3	0.3	28.6
UC SAN DIEGO HEALTH HILLCREST - HILLCREST MED CTR	49.6	42.1	11.8	82.4
GROSSMONT HOSPITAL	59.4	42.1	14.2	63.9
MAD RIVER COMMUNITY HOSPITAL	72.6	36.8	15.2	67.2
OROVILLE HOSPITAL	70.9	5.3	14.9	61.3
BAKERSFIELD MEMORIAL HOSPITAL	50.4	36.8	14.6	53.8
SANTA CLARA VALLEY MEDICAL CENTER	62.4	26.3	12.9	6.7
ENLOE MEDICAL CENTER	71.5	57.9	15.7	91.6
LAC/OLIVE VIEW-UCLA MEDICAL CENTER	40.8	47.4	16.2	4.2
ST ELIZABETH COMMUNITY HOSPITAL	72.2	36.8	20.1	5.0
ALTA BATES SUMMIT MEDICAL CENTER	68.6	42.1	9.1	21.8
EL CENTRO REGIONAL MEDICAL CENTER	53.3	15.8	14.8	58.0
CALIFORNIA PACIFIC MEDICAL CTR-PACIFIC CAMPUS HOSP	68.0	31.6	19.3	26.1
SAN GORGONIO MEMORIAL HOSPITAL	60.7	15.8	17.5	41.2
CALIFORNIA PACIFIC MEDICAL CTR - ST. LUKE'S CAMPUS	72.0	21.1	15.5	22.7
ANTELOPE VALLEY HOSPITAL	52.1	5.3	10.5	95.8
KAWEAH DELTA MEDICAL CENTER	58.7	42.1	16.1	27.7
GLENDALE MEM HOSPITAL & HLTH CENTER	73.7	31.6	1.0	70.6
COMMUNITY REGIONAL MEDICAL CENTER	0.0	42.1	11.5	31.9
HOLLYWOOD PRESBYTERIAN MEDICAL CENTER	65.5	5.3	0.0	13.4
OAK VALLEY HOSPITAL DISTRICT	72.8	26.3	14.3	43.7
ST JOSEPH HOSPITAL	67.0	63.2	5.0	37.0
KAISER FOUNDATION HOSPITAL-SANTA CLARA	75.4	42.1	11.7	0.8
KAISER FOUNDATION HOSPITAL AND REHAB CENTER	67.6	52.6	11.7	48.7
KAISER FOUNDATION HOSPITAL - OAKLAND/RICHMOND	63.6	42.1	11.7	41.2
SCRIPPS MERCY HOSPITAL	66.0	42.1	16.6	20.2
PROVIDENCE LITTLE CO OF MARY MED CTR SAN PEDRO	66.1	42.1	17.8	58.0
ST JOHNS REGIONAL MEDICAL CENTER	72.3	42.1	11.7	31.9
ST JOSEPH'S MEDICAL CENTER OF STOCKTON	55.4	26.3	5.7	73.1
COMMUNITY HOSPITAL OF SAN BERNARDINO	72.2	47.4	8.2	12.6
SONOMA VALLEY HOSPITAL	69.9	31.6	1.3	67.2
COMMUNITY HOSPITAL OF HUNTINGTON PARK	53.9	26.3	7.4	94.1
SAINT AGNES MEDICAL CENTER	50.9	26.3	7.9	84.9
SAN ANTONIO REGIONAL HOSPITAL	70.5	42.1	11.0	0.0
SHARP MEMORIAL HOSPITAL	64.5	15.8	6.2	40.3
SUTTER SOLANO MEDICAL CENTER	55.2	31.6	14.6	41.2
PARKVIEW COMMUNITY HOSPITAL MEDICAL CENTER	55.2	42.1	4.3	31.9
WHITE MEMORIAL MEDICAL CENTER	77.7	63.2	12.3	57.1
SAINTE FRANCIS MEDICAL CENTER	66.6	21.1	7.5	19.3
MARIAN REGIONAL MEDICAL CENTER	66.9	0.0	3.2	88.2

**Outcome Weightings:**

HSMR	Specific Mortality	Serious Complications	Infection Rate	Readmission Rate
46%	46%	2%	1%	4%

**Process Weightings:**

Waiting Time (Days)	Patient Score (%)	Cost (\$)	Travel Time (Min)
25%	45%	15%	15%

**User Details:**

Life Expectancy	Time to be spent in hospital (Years):	Process Weighting	Outcome Weighting
1	1	80%	20%

**Overall Scores:**

Hospital Name	Outcome	Process	Overall	Rank
ST ROSE HOSPITAL	1.7	33.1	26.8	47
ST JOSEPH HOSPITAL	19.3	40.7	36.4	19
MILLS-PENINSULA MEDICAL CENTER	29.4	63.4	56.6	1
CALIFORNIA PACIFIC MEDICAL CTR-DAVIES CAMPUS HOSP	12.3	35.2	30.6	36
QUEEN OF THE VALLEY MEDICAL CENTER	18.1	47.7	41.8	6
ST HELENA HOSPITAL	6.0	45.1	37.3	16
SUTTER AMADOR HOSPITAL	14.5	41.3	35.9	22
MERCY GENERAL HOSPITAL	22.8	42.0	38.1	14
PACIFIC ALLIANCE MEDICAL CENTER	11.8	32.7	28.5	40
RIVERSIDE COMMUNITY HOSPITAL	10.8	27.1	23.9	48
PARADISE VALLEY HOSPITAL	13.7	33.7	29.7	38
UC SAN DIEGO HEALTH HILLCREST - HILLCREST MED CTR	14.4	45.5	39.2	8
GROSSMONT HOSPITAL	9.8	45.5	38.4	13
MAD RIVER COMMUNITY HOSPITAL	7.7	47.1	39.2	9
OROVILLE HOSPITAL	14.1	31.5	28.0	43
BAKERSFIELD MEMORIAL HOSPITAL	21.1	39.4	35.8	23
SANTA CLARA VALLEY MEDICAL CENTER	23.2	30.4	29.0	39
ENLOE MEDICAL CENTER	25.5	60.0	53.1	2
LAC/OLIVE VIEW-UCLA MEDICAL CENTER	23.6	34.6	32.4	33
ST ELIZABETH COMMUNITY HOSPITAL	10.9	38.4	32.9	31
ALTA BATES SUMMIT MEDICAL CENTER	29.2	40.8	38.4	12
EL CENTRO REGIONAL MEDICAL CENTER	27.9	31.3	30.7	35
CALIFORNIA PACIFIC MEDICAL CTR-PACIFIC CAMPUS HOSP	19.4	38.0	34.3	27
SAN GORGONIO MEMORIAL HOSPITAL	17.9	31.1	28.5	41
CALIFORNIA PACIFIC MEDICAL CTR - ST. LUKE'S CAMPUS	16.5	33.2	29.9	37
ANTELOPE VALLEY HOSPITAL	14.5	31.3	28.0	44
KAWEAH DELTA MEDICAL CENTER	15.4	40.2	35.2	26
GLENDALE MEM HOSPITAL & HLTH CENTER	21.3	43.4	39.0	10
COMMUNITY REGIONAL MEDICAL CENTER	11.1	25.5	22.6	49
HOLLYWOOD PRESBYTERIAN MEDICAL CENTER	23.3	20.8	21.3	50
OAK VALLEY HOSPITAL DISTRICT	7.2	38.7	32.4	32
ST JOSEPH HOSPITAL	16.8	51.5	44.5	4
KAISER FOUNDATION HOSPITAL-SANTA CLARA	19.2	39.7	35.6	24
KAISER FOUNDATION HOSPITAL AND REHAB CENTER	11.7	49.6	42.1	5
KAISER FOUNDATION HOSPITAL - OAKLAND/RICHMOND	11.6	42.8	36.5	18
SCRIPPS MERCY HOSPITAL	13.7	41.0	35.5	25

PROVIDENCE LITTLE CO OF MARY MED CTR SAN PEDRO	17.3	46.8	40.9	7
ST JOHNS REGIONAL MEDICAL CENTER	8.6	43.6	36.6	17
ST JOSEPH'S MEDICAL CENTER OF STOCKTON	19.6	37.5	33.9	29
COMMUNITY HOSPITAL OF SAN BERNARDINO	23.8	42.5	38.8	11
SONOMA VALLEY HOSPITAL	19.9	42.0	37.5	15
COMMUNITY HOSPITAL OF HUNTINGTON PARK	18.5	40.5	36.1	20
SAINT AGNES MEDICAL CENTER	26.4	38.5	36.1	21
SAN ANTONIO REGIONAL HOSPITAL	13.0	38.2	33.2	30
SHARP MEMORIAL HOSPITAL	14.0	30.2	27.0	46
SUTTER SOLANO MEDICAL CENTER	24.9	36.4	34.1	28
PARKVIEW COMMUNITY HOSPITAL MEDICAL CENTER	7.4	38.2	32.0	34
WHITE MEMORIAL MEDICAL CENTER	27.5	58.3	52.1	3
SAINT FRANCIS MEDICAL CENTER	19.7	30.1	28.1	42
MARIAN REGIONAL MEDICAL CENTER	14.2	30.4	27.2	45

## References

<sup>i</sup> *What Is the HSMR?* n.d., Canadian Institute for Health Information, accessed 20 March 2018, <[https://www.cihi.ca/en/hsmr\\_info\\_hospitals\\_may08\\_en.pdf](https://www.cihi.ca/en/hsmr_info_hospitals_may08_en.pdf)>.

<sup>ii</sup> *Hospital-Acquired Infections 2016*, Medscape, accessed 19 March 2018, <<https://www.https://emedicine.medscape.com/article/967022-overviewww.usnews.com/info/blogs/press-room/articles/2017-08-08/us-news-announces-2017-18-best-hospitals>>.

<sup>iii</sup> *U.S. News Announces 2017-18 Best Hospitals 2017*, US News, accessed 19 March 2018, <<https://www.usnews.com/info/blogs/press-room/articles/2017-08-08/us-news-announces-2017-18-best-hospitals>>.