

A blue arrow-shaped graphic pointing to the right, containing the text "IMMC 2018".

IMMC 2018

The Best Hospital

End User Hospital Ranking Model

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Abstract line art consisting of several thin, curved lines in dark blue and light grey, originating from the bottom left corner and extending upwards and to the right.

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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 hospitals 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 States¹. The HSMR compares a hospitals 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.