

## **Executive Summary**

This report provides an in-depth analysis of ComfortHealth, a healthcare services company. The report begins by introducing the company and discussing the managerial questions that they are currently facing. These questions include determining the optimal operating and opening plan for the company and identifying how to effectively hire and allocate staff to meet the needs of the business.

The demand model predicts the number of patients expected to seek services at a specific time, and its results are utilized as an input in the profit optimization model. The optimization model's output is the net profit, which considers the satisfaction of either full or partial demand, and the results are analyzed and compared.

To further explore the impact of changes in demand, a sensitivity analysis is conducted. This analysis aims to identify the breakeven point of the percentage of demands that need to be satisfied to generate zero profit. And also based on different threshold, the results are also used to determine the breakeven point of the percentage of demands that need to be satisfied to open a new center.

Based on the analysis and findings, a recommendation is proposed to balance company's profitability with social responsibility. The recommendation suggests that ComfortHealth should open a new center (Center E) in 2023 to serve more patients while maintaining a balance between profitability and social responsibility. And the detailed HP allocation and new hiring plan are stated in the proposed plan section.

In conclusion, this report provides an analysis of the operations of ComfortHealth, a healthcare services company. The report highlights the importance of balancing profitability and social responsibility and provides recommendations for the company to achieve this balance. The findings of this report can be used to guide future decision-making processes for the company.

## Introduction

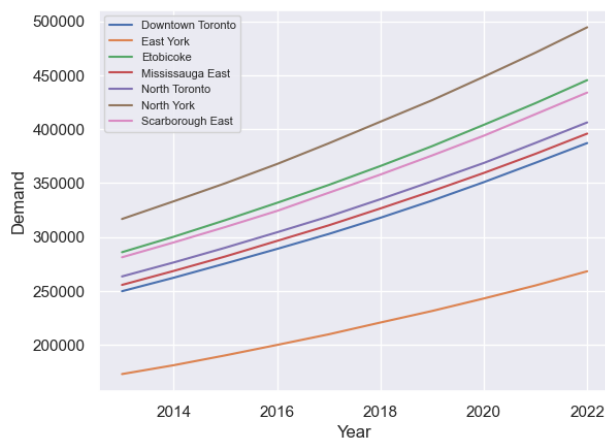
ComfortHealth is a Canadian home care agency that provides medical and support services to patients in their homes. The purpose of this report is to assist in creating a three -year annual service plan by designing a proposal that outlines the hiring and deployment of the workforce and medical facilities. The plan will also determine how the various geographic regions covered by ComfortHealth will be served over the next three years.

To accomplish this, several managerial questions were addressed, including assessing the feasibility of opening two new medical centers (Center E and F), determining the number of new hires required, deciding how healthcare providers (HPs) should be allocated to different regions, analyzing the impact of accepting or rejecting patients, and ensuring that the solution is adaptable to changes in demand. All the models and associated analyses are based on the data provided by ComfortHealth on demand, distances, and center costs.

Overall, this report aims to provide comprehensive and actionable recommendations to support ComfortHealth's growth and expansion while ensuring the efficient allocation of resources and maintaining a high level of patient care. By addressing these managerial questions and utilizing data - driven analyses, this report can serve as a valuable tool for ComfortHealth in making informed decisions to achieve its strategic goals.

## Mathematical Model

Based on the linear chart below, each color represents a different region, and it shows that the demand growth for each region is approximately linear. Therefore, linear regression analysis has been performed to predict the future demand for all regions in the years 2023, 2024, and 2025.



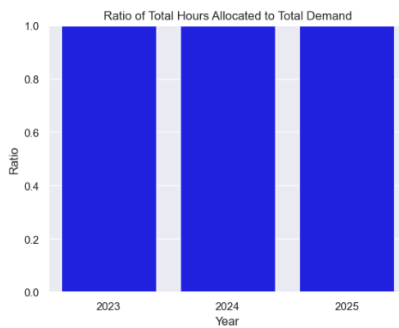
Three different mathematical models are being used to progressively achieve the final model, the details of which can be found in the appendix. The first model is a location model that specifically targets the year 2023 and aims to maximize ComfortHealth's profits. The second model expands upon the first by incorporating multiple time periods while maintaining the same objective. The third and final model considers all relevant decision-making factors, such as the hiring of workers and their associated costs.

## Analysis of Results

In the final model, it included a constraint that allowed ComfortHealth to decide whether to accept or reject patients seeking their services, ensuring that the allocated hours to each demand zone did not exceed the expected demand hours. This led to a total profit of approximately 4110439.69 dollars over three years, with a total revenue of 86940000 dollars and a cost of 82829560.31 dollars. The model recommended that centers A, B, and D maintain their capacities of 322,500, 187,500, and 180,000, respectively, for all three years. However, the bar chart below displayed that less than 24% of the overall demand would be met in the following year. Additionally, ComfortHealth's services would only cater to a specific portion of the population in North York, Scarborough East, and Mississauga East, with no service to other areas. This raises ethical concerns about the company prioritizing profit over social responsibility, which could potentially damage its reputation.



To address the ethical concern mentioned earlier, some modifications are made to the demand allocation constraint in the final model. Instead of limiting the hours allocated to each demand zone to the expected demand hours, it is changed to be equal to the expected demand hours. This change ensured that ComfortHealth would serve 100% of the demand in each zone for every year. As depicted in the left-hand side bar chart below, this adjustment resulted in all expected demand hours being met for all three years. However, in this scenario, all centers, including E and F, would need to be operational starting from 2023, leading to a total loss of approximately 13203783.86 dollars, with a total revenue of 380593164 dollars and a total cost of 393796947.86 dollars. While this change would fully satisfy ComfortHealth's social responsibility and enhance its reputation, as a profit-oriented organization, it is not acceptable to operate at a negative profit.



## Sensitivity Analysis

As mentioned in the above part, there is a trade-off between the level of social responsibility that ComfortHealth should uphold and the profitability of the company. By prioritizing a smaller group of patients, the company can generate more profit, while catering to a larger population would demonstrate greater social responsibility and potentially attract more customers through positive reputation. And it is not possible to simultaneously achieve both tasks without compromising the benefits that could be gained from the other side which leads me to my third revision of the model.

Another constraint is being implemented which force the company allocate hours to at least x% of the overall expected demand for all three years. The break-even point is when roughly 76.3% overall expected demand can be satisfied. At this point, the total profit is about 0, where total revenue matches total cost.

When the threshold is increased to 77%, the company incurs a total loss of 187537.04. Conversely, when the threshold is decreased to 75.6%, the company generates a positive profit of 176961.25. Based on these findings, it appears that increasing or decreasing the threshold has a relatively similar dollar value impact on the company's profit or loss.

When fully prioritizing profitability, it appears that there is no justification for opening new locations E and F. However, as the company increases the percentage of patients it plans to serve each year, center E tends to be the next viable option to open. Center F, on the other hand, is considered only when no other center can accept new patients due to the percentage of patients the company plans to serve constraint not being met. At the breakeven point where there is almost no profit, center E is scheduled to open in 2023. However, since the company aims to be profitable, they are unlikely to choose exactly the breakeven point for running their business. Instead, they will choose to satisfy less than 76.3% of the overall demand each year. Therefore, center F is not expected to be opened, and the only center that has the potential to be opened is center E.

One possible reason for opening center E over F is that the average distance between center E and other zones is the shortest among all six centers, as shown in the text box below. This means that if the company decides to open either center E or F, it would be better to choose center E since it has lower travel costs to other zones.

```
Average distance for Center A to other zones is: 16.254285714285714
Average distance for Center B to other zones is: 22.712857142857143
Average distance for Center C to other zones is: 21.204285714285714
Average distance for Center D to other zones is: 21.69142857142857
Average distance for Center E to other zones is: 15.325714285714287
Average distance for Center F to other zones is: 20.21142857142857
```

Also, when at least 54% of demand are being satisfied in each year, center E has to be opened in year 2023 and the total profit is about 3072208.63, and when at least 53% of demand are being satisfied in each year, center E is not suggested to be opened and the total profit that can be generated is about 3150435.03.

## **Proposed Plan**

Based on the previous discussion, it is recommended that the company invest in Center E as it would enable them to cover more regions and meet a higher percentage of demand, and investing in Center F would not be a rational decision, according to the optimization model, opening Center F means that all other centers, including Center E are already operate at their highest productivity level. In such cases, the net profit is already negative, and opening Center F would only increase the losses further.

In addition, it is important for the company to consider not only profitability, but also its reputation and social responsibility. Thus, the company should aim to serve a relatively large percentage of demand each year. Based on the optimization model results, a percentage between 54% and 76.3% is recommended. This range represents a positive profit-generating area for the company, while also considering the social responsibility aspect by opening Center E.

The company must prioritize the trade-off between reputation and profitability. Accepting all patients will result in a loss, while rejecting patients to maximize profit will harm the company's reputation. Therefore, the company should strike a balance between the two to become both highly reputable and profitable.

To provide more specific recommendations, a demand fulfillment threshold of 60% is suggested, as it is the point at which the company can generate a profit of approximately 2858615.45. The detailed hiring and assignment plan for the HP can be found in the appendix. At a high level, the plan involves hiring new HP for Centers A, B, and D in 2023, opening Center E with new HP hiring, and no additional hiring is required after that year. Center C does not hire at all, and Center F will not open in 2023. The company's main focus is to serve patients living in East York, North York, Scarborough East, Mississauga East, and North Toronto. In addition, a section of patients residing in Downtown Toronto will also be served, but only in the year 2023.

## **Conclusion**

In conclusion, ComfortHealth should adopt a dual focus on profitability and social responsibility to achieve long-term success. By opening center E in 2023, they can expand their reach and serve more customers while also contributing to the well-being of the communities they serve. This approach can not only enhance ComfortHealth's reputation but also generate sustainable profits and growth. By embracing this balance, ComfortHealth can demonstrate its commitment to both its customers and society and become a role model for other companies in the healthcare industry.

## Appendix



### 1.1 : demand fulfillment ratio when threshold=0.6

Center Center A with existing workers of 397.0 at the end of year 2023  
Center Center A with new workers hiring 182.0 at the beginning of year 2023  
Center Center A with existing workers of 397.0 at the end of year 2024  
Center Center A with new workers hiring 0.0 at the beginning of year 2024

Center Center A with existing workers of 397.0 at the end of year 2025  
Center Center A with new workers hiring 0.0 at the beginning of year 2025

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Center Center B with existing workers of 297.0 at the end of year 2023  
Center Center B with new workers hiring 172.0 at the beginning of year 2023

Center Center B with existing workers of 297.0 at the end of year 2024  
Center Center B with new workers hiring 0.0 at the beginning of year 2024

Center Center B with existing workers of 297.0 at the end of year 2025  
Center Center B with new workers hiring 0.0 at the beginning of year 2025

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Center Center C with existing workers of 100.0 at the end of year 2023  
Center Center C with new workers hiring 0.0 at the beginning of year 2023

Center Center C with existing workers of 100.0 at the end of year 2024  
Center Center C with new workers hiring 0.0 at the beginning of year 2024

Center Center C with existing workers of 100.0 at the end of year 2025  
Center Center C with new workers hiring 0.0 at the beginning of year 2025

Center Center D with existing workers of 271.0 at the end of year 2023  
Center Center D with new workers hiring 151.0 at the beginning of year 2023

Center Center D with existing workers of 271.0 at the end of year 2024  
Center Center D with new workers hiring 0.0 at the beginning of year 2024

Center Center D with existing workers of 271.0 at the end of year 2025  
Center Center D with new workers hiring 0.0 at the beginning of year 2025

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Center Center E with existing workers of 288.0 at the end of year 2023  
Center Center E with new workers hiring 288.0 at the beginning of year 2023

Center Center E with existing workers of 288.0 at the end of year 2024  
Center Center E with new workers hiring 0.0 at the beginning of year 2024

Center Center E with existing workers of 288.0 at the end of year 2025  
Center Center E with new workers hiring 0.0 at the beginning of year 2025

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Center Center F with existing workers of 0.0 at the end of year 2023  
Center Center F with new workers hiring 0.0 at the beginning of year 2023

Center Center F with existing workers of 0.0 at the end of year 2024  
Center Center F with new workers hiring 0.0 at the beginning of year 2024

Center Center F with existing workers of 0.0 at the end of year 2025  
Center Center F with new workers hiring 0.0 at the beginning of year 2025

### 1.2 : Worker allocation with threshold=0.6

Ratio for year 2023, center Center E, and zone Downtown Toronto: 3.73%  
Ratio for year 2023, center Center A, and zone East York: 31.54%  
Ratio for year 2023, center Center D, and zone Mississauga East: 99.91%  
Ratio for year 2023, center Center E, and zone North Toronto: 100.00%  
Ratio for year 2023, center Center A, and zone North York: 100.00%  
Ratio for year 2023, center Center B, and zone Scarborough East: 99.91%  
Ratio for year 2024, center Center A, and zone East York: 23.47%  
Ratio for year 2024, center Center D, and zone Mississauga East: 96.24%  
Ratio for year 2024, center Center E, and zone North Toronto: 99.76%  
Ratio for year 2024, center Center A, and zone North York: 100.00%  
Ratio for year 2024, center Center B, and zone Scarborough East: 96.24%  
Ratio for year 2025, center Center A, and zone East York: 15.97%  
Ratio for year 2025, center Center D, and zone Mississauga East: 92.82%  
Ratio for year 2025, center Center E, and zone North Toronto: 96.24%  
Ratio for year 2025, center Center A, and zone North York: 100.00%  
Ratio for year 2025, center Center B, and zone Scarborough East: 92.84%

### 1.3 : demand fulfillment ratio in each region served by each center in each year when threshold=0.6

Center Center A is opened in 2023  
 Serves zone East York - with capacity 86814.0  
 Serves zone North York - with capacity 508686.0  
 Center Center A is opened in 2024  
 Serves zone East York - with capacity 67073.0  
 Serves zone North York - with capacity 528427.0  
 Center Center A is opened in 2025  
 Serves zone East York - with capacity 47331.0  
 Serves zone North York - with capacity 548169.0  
 Center Center B is opened in 2023  
 Serves zone Scarborough East - with capacity 445500.0  
 Center Center B is opened in 2024  
 Serves zone Scarborough East - with capacity 445500.0  
 Center Center B is opened in 2025  
 Serves zone Scarborough East - with capacity 445500.0  
 Center Center D is opened in 2023  
 Serves zone Mississauga East - with capacity 406500.0  
 Center Center D is opened in 2024  
 Serves zone Mississauga East - with capacity 406500.0  
 Center Center D is opened in 2025  
 Serves zone Mississauga East - with capacity 406500.0  
 Center Center E is opened in 2023  
 Serves zone Downtown Toronto - with capacity 14810.0  
 Serves zone North Toronto - with capacity 417190.0  
 Center Center E is opened in 2024  
 Serves zone North Toronto - with capacity 432000.0  
 Center Center E is opened in 2025  
 Serves zone North Toronto - with capacity 432000.0

*1.4 : hours capacity in each center that serves each region in each year when threshold=0.6*

## Final Model

$$\text{Max} \quad \sum_k \sum_j \sum_i 42 x_{ijk} - \sum_k \sum_i c_{ik} y_{ik} - \sum_k \sum_j \sum_i z_{ijk} x_{ijk} - \sum_k \sum_j \sum_i s_{ijk} x_{ijk} - \sum_k \sum_i 15000 h_{ik}$$

s.t.

$$\sum_{i=1}^6 x_{ijk} \leq D_{jk} \quad \text{for } j=1, \dots, 7, \quad k=2023, 2024, 2025$$

$$\sum_{j=1}^6 x_{ijk} \leq K_{ik} \times y_{ik} \quad \text{for } i=1, \dots, 6, \quad k=2023, 2024, 2025$$

$$\sum_{j=1}^6 x_{ijk} \leq W_{ik} \times 6 \times 250 \quad \text{for } i=1, \dots, 6, \quad k=2023, 2024, 2025$$

$$W_{ik} = h_{ik} + W_{ik-1} \quad \text{for } i=1, \dots, 6, \quad k=2023, 2024, 2025$$

when  $k=2023$ ,  $W_{i,2022}$  are given in  
the centers dataset

$$h_{i,k} \leq 300 \quad \text{for } i=1, \dots, 6, \quad k=2023, 2024, 2025$$

$$\sum_{j=1}^7 \sum_{i=1}^6 x_{ijk} \geq 0.6 \times \sum_{j=1}^7 D_{jk} \quad \text{for } k=2023, 2024, 2025 \quad (\text{this constraint is the one related to the threshold in the report})$$



## Parameters & Variables

$x_{ijk}$ : hours allocated from  $i^{\text{th}}$  center to  $j^{\text{th}}$  zone in year  $k$

$y_{ik}$ : 1 if center  $i$  open in year  $k$

$w_{ik}$ : workers in center  $i$  in year  $k$

$h_{ik}$ : new workers hired in center  $i$  in year  $k$

$c_{ik}$ : operating cost for center  $i$  in year  $k$  (for center E & F,  $c_{ik}$  is operating + opening cost in year 2023)

$z_{ijk}$ : travel cost from center  $i$  to zone  $j$  in year  $k$  / hour

$s_{ijk}$ : salary for workers from center  $i$  to zone  $j$  in year  $k$  / hour

$d_{jk}$ : expected demand in zone  $j$  in year  $k$

$k_{ik}$ : center  $i$ 's hour capacity in year  $k$