Data Insights Application for Obesity

SP23 Capstone Design in ECE: *Final Design Report*
Group SP23-05
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Abstract—Comorbidity risk is an ever-present concern in patients with obesity, leading to chronic illnesses such as type II diabetes, hypertension, respiratory disease, cancer, stroke, etc. The comorbidity risks in patients with obesity are also correlated with their physique, social and economic situation, and other underlying health issues. Novo Nordisk, a leading global pharmaceutical company, has built a machine learning model that analyzes the comorbidity risks and costs associated with obesity based on input information of a patient's clinical data, social determinants of health (SDoH), and other diagnosed health conditions. The goal of this project is to build a data insight application tool that provides a quantitative view into the comorbidity risks of a patient with obesity and the cost associated with their treatment. We develop a working iOS-based prototype of an end-user platform accessible from tablets. The application tool will primarily be used by market access representatives at Novo Nordisk in their outreach to healthcare payer programs, such as insurance companies and employers, to ensure an equitable access to medical solutions for all patients with obesity, staying true to the pharmaceutical industry's market access standards.

Index Terms—Obesity, Comorbidity Risk, Healthcare, Pharmaceuticals, Market Access, Software Development, Data Analytic, Prediction Modeling, Data Visualization.

I. INTRODUCTION

A. Background

Trust for America's Health recently reported that the obesity rate in America has consistently increased in the past decade, with no signs of plummeting. Nationwide, this rate is 41.9% with higher rates in rural areas than urban and suburban area [1]. Obesity is a multifaceted health condition that leads to different comorbidities. Comorbidity risk is an ever-present concern for patients with obesity, leading to chronic illnesses such as type II diabetes, hypertension, respiratory diseases, cancer, stroke, etc. The comorbidity risks in patients with obesity are also correlated with their physique, socioeconomic context, and other underlying health issues.

Obesity rises from relationships between "genetic, socioeconomic, and cultural influences" [2]. Obesity can also be onset by pharmacologic treatment or disease. Obesity is a risk factor for the development of comorbidity diseases. People who have obesity have reduced earning potential, higher healthcare costs, and less school attendance. Obesity patients are at increased risk of morbidity from "dyslipidemia, T2D, hypertension, coronary heart disease, stroke, gallbladder disease, respiratory problems, sleep apnea, osteoarthritis, and some cancers" [2]. In addition to the oneset of various diseases, obesity-related medical care costs in the United States "were estimated to be nearly $173 billion" [3]. Annual nationwide producitivty costs of obesity related absenteeism range from "$79 - $132 per individual" [3].

B. Problem Addressed

Novo Nordisk, a leading global pharmaceutical company, has built a machine learning model that analyzes the risks and costs associated with obesity based on input information of a patient's clinical features, social determinants of health (SDoH) factors, and other diagnosed comorbidities. The machine learning model outputs enormous data sets which are hard to interpret and analyze. Regional Account Managers and other market access representatives would find it difficult to understand the technical output data sets. They need to leverage the large data sets to help aid in making important market access decisions. Market access in pharmaceutical refers to a company's ability to provide appropriate treatments to patients.

To understand the need of the data insights application for obesity, market access research is necessary to understand the relationship between patients and treatment. Effective market access strategies are needed to keep drugs, therapies, and solutions affordable for consumers while providing constant access[4]. Also, market access is about generating and communicating data for the stakeholders involved in the adoption and funding of the drug. The two main activities of market access are national pricing/reimbursement and local negotiations/prescribing guidelines[5]. Before the patient receives access to the drugs, price and target patients must be agreed upon. The problem addressed with this project is to deal with accurately visualizing and filtering data that can be used by market access representatives in their outreach easily.

C. Objective

The goal of this project is to create a data insight application tool that provides a quantitative and visual overview into the comorbidity risks present in patients with obesity through the modification of clinical, SDoH, and associated risk factors. The application tool will provide concise and clear quantitative and visual insight into predicted comorbidity risks, cost of care estimation, and a regional context of SDoH factors. Our aim has been to develop a working iOS-based prototype of an end-user platform accessible from primarily tablets. The goal of the tool is to make the machine learning model predictions accessible for stakeholders to gain quantitative insights into risks faced by patients with obesity to guide data-driven conversations/discussions with healthcare payer programs about the risks and costs associated with it, while maintaining the pharmaceutical industry's market access standard.

D. Adopted Approach

The approach we are taking is using XCode and the Swift programming language to build the application that approaches the problem. Storyboard and SwiftUI of XCode are used to leverage various XCode components.

II. METHODS/APPROACH/RESULTS

A. Methods

1) Conceptual Design: This quantitative application tool was designed to provide the best possible experience for the regional account managers when using the application with clients. Using Figma, the application front end was prototyped in a few iterations and revisions. Figma is a collaborative web application for interface design. The final revision is shown in Figure 1. The design reflects the user flow for the regional account managers.
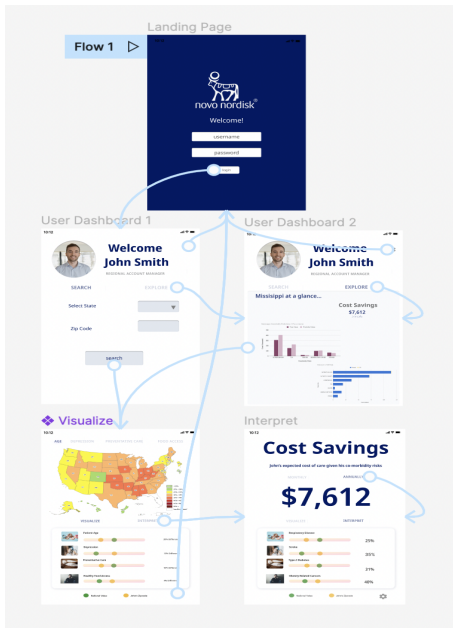

Fig. 1. Figma Wireframe

The initial planning of the design also included conforming to the recommended query structure from Novo Nordisk. This involved creating a login functionality as well as configuring states for our application when in use by regional account managers and market access personnel as displayed in Figure 2.
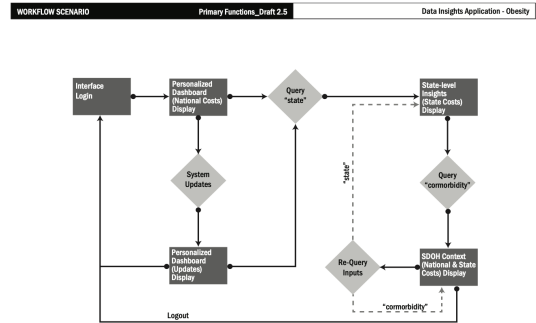

Fig. 2. Query Structure of the App

2) UX Design: To begin developing the application and finalizing designs, it was imperative to perform user experience research. This research would assist in development as we are able to consider our application's functionality and design choices through the eyes of the user and not just as developers. The research specifically involved pointing out goals, needs and pain points from the perspective of what the regional account manager would need from our application to be able to perform their function to the best of their ability. Therefore, we came up with the following points and considerations for an example user John Smith as shown in Figure 3.
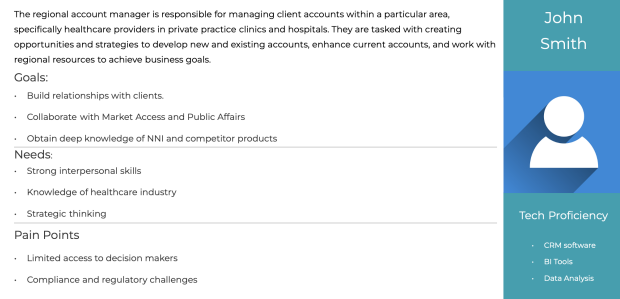

Fig. 3. User Profile for John Smith

3) Detailed design: Figure 4 is the overall detailed design of the application that was implemented on XCode. The final detailed result of the project will be discussed in the results section.

Required Software Tools and Accessibility

- *XCode:* Xcode is Apple's integrated development environment for macOS. XCode provides developers a unified workflow for user interface design, coding, testing, and debugging. Accessible to anyone with a Macbook.

Fig. 4. Detailed Design

- *Swift:* Swift is a high-level compiled programming language developed by Apple and the open-source community.
- *Excel:* Excel is a spreadsheet developed by Microsoft and features calculation or computation capabilities, graphing tools, and pivot tables.

System Design and Implementation Challenges

- *Storyboard:* Storyboards help create all the screens of an application and interconnect the screens under one interface MainStoryboard. storyboard. It also helps in reducing the coding of pushing/presenting view controllers. Storyboard was used to design the login screen and user dashboard.
- *SwiftUI:* SwiftUI aids to higlights user experience and creating an interactive app. SwiftUI is easier to create a reusable view and avoid conflicts related with the simultaneous use of one project. SwiftUI was used for graphics and visualizations.

Time Constraints and their Impact on Design

- We had a limited time to complete the project. Our NDA with Novo Nordisk was signed at the end of February and so we only had a little over 2 months, until end of April, to completely design the project.

Technology Limitations

- Our most significant limitation was our lack of experience in iOS development. We had had a steep learning curve while desinging the application on iOS. Additionally one of our group members did not own/have access to a device running macOS which caused delays in starting development due to procurement issues.

B. Standards: Visual Identity

Novo Nordisk has a specific corporate visual identity. They have set guidelines to be followed for all products and applications that Novo Nordisk creates. Since we are creating an application for Novo Nordisk we have to meet certain requirements and guidelines. We followed three main elements in the corporate visual identity. The first is the logo; the logo of Novo Nordisk is a bull. The bull has been the symbol of the company since Novo Nordisk was founded in 1923. We placed the logo as part of the app icon, login page, and insights/costs page. The second core element is maintaining Novo Nordisk colors: True Blue, Snow White, 18 different tints, and spot colors. We included True Blue and Snow White in most pages of the application. The third core element is the font. The corporate font is called Apis, Apis is a Sans-Serif style font. We made sure to use a Sans-Serif font as well.

C. Results

The quantitative application tool is an iOS application developed in Swift that provides key insights to Novo Nordisk associates about comorbidity risks associated with obesity. The application features a unique dashboard for each user. In order to access the dashboard, the Novo Nordisk market access representative enters their username and password. The application will authenticate the user by checking the login information against a database of users, and validate the information. Upon successful authentication, the dashboard will be presented to the user. The login in page can be seen in Figure 5.
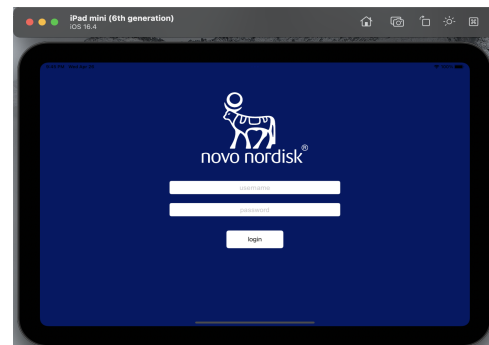

Fig. 5. Login Screen

In Figure 6, the code for the connection between the login and user dashboard is shown. The username and password is authenticated and checked for accuracy. If it is right, then the dashboard screen appears. Else, an error is printed. In addition, if a user just hits login with an empty username and password field then an error appears as well.


```
func authenticateUser(username: String, password: String) -> Void {

    var data = readDataFromCSV(fileName: "dummy_auth.csv")
    data = cleanRows(file: data!)
    let csvRows = csv(data: data!)
    let database = csvRows[1...]

    for info in database {
        if info[0] == username {
            if info[1] == password {
                performSegue(withIdentifier: "goToDashboard", sender: self)

            } else {
                print("Error")
                return
            }
        }
    }
    print("Error")
    return
}
```

Fig. 6. Login to Dashboard Code

Within the dashboard, there are two pages: Search and Explore. The Search page allows the user to specify a state

and zip code. The state field is a drop down scroll-able area that allows the user to scroll through and choose one of the fifty states, whereas the zip code is a text field in which a zip code can be typed. The user dashboard with can be seen in figure 4. The user has selected the state of Mississippi to look at. This is before the user hits the search button.
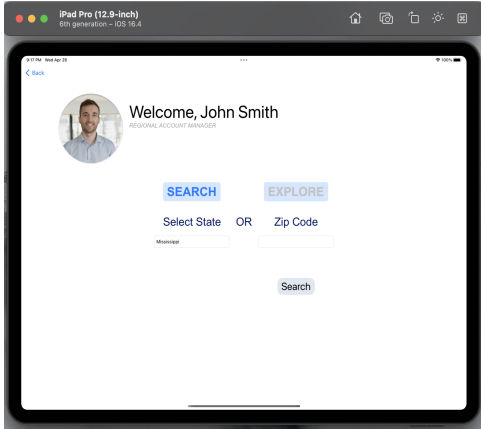

Fig. 7. Mississippi Selection

After specifying the information, the user can press the "Search" button, which presents numerous graphs and lists that the Regional Account Manager can use.

The insights page slides are broken down into different sections: graphs and lists.

Graphs: The first 3 page slides are graphs. The first graph is a double bar graph showing the true and predicted number of patients with varying comorbidities in the state. The double bar graph allows Regional Account Managers to trust and understand the machine learning output data that is powering our visualizations. The second graph is a simple pie chart that gives a quick breakdown of obesity in the state. The third bar graph shows the correlating percentages of the state population that has various social determinants of health, ranging from expenses spent on housing and education levels.
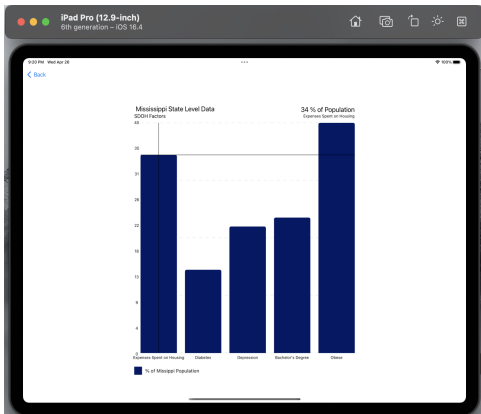
Fig. 8. SDoH Percentages for Mississippi
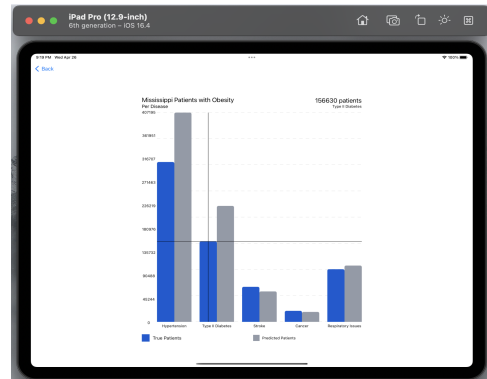
Fig. 9. Patient Levels for Mississippi
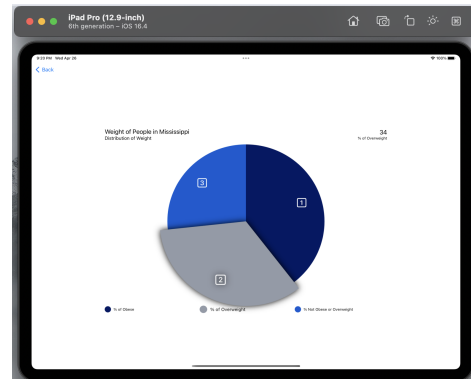
Fig. 10. Obesity in Mississippi

As an example, the SwiftUI code can been seen for the double bar graphic Figure 11. The SwiftUI function is called for the grouped bar graph for the correlating data and visualization specifics.

```
9  import SwiftUI
10 import SwiftUICharts
11
12 struct GroupedBarChartDemoView: View {
13
14     let data = makeData()
15     var body: some View {
16         VStack{
17             GroupedBarChart(chartData: data, groupSpacing: 25)
18                 .touchOverlay(chartData: data, unit: .suffix(of: "patients"))
19                 .yAxisGrid(chartData: data)
20                 .xAxisLabels(chartData: data)
21                 .yAxisLabels(chartData: data)
22                 .headerBox(chartData: data)
23                 .legends(chartData: data, columns: [GridItem(.flexible()), GridItem(.flexible())])
24                 .id(data.id)
25                 .frame(minWidth: 500, maxWidth: 600, minHeight: 400, idealHeight: 500, maxHeight:
26                     800, alignment: .top)
27                 .padding(.horizontal)
28         }
29     }
30 }
31
```

Fig. 11. Double Bar Graph Code

Lists: Following the graphs, there are 5 lists of top 10 SDoH drivers of comorbidities. The comorbidities are stroke, obesity-related cancers, respiratory diseases, and hypertension. There are different driving factors for each comorbidity. For example, the top 10 drivers of stroke for Missisppi include rate of stroke in population, percentage of population that is Hispanic, and rate of coronary heart disease. Whereas, the top 10 drivers of

hypertension for Missipppi include median hispanic household income, percentage of families in poverty, and rate of fitness and recreation centers. This is because different diseases have different social determinants that drive the total number of patients in that state.
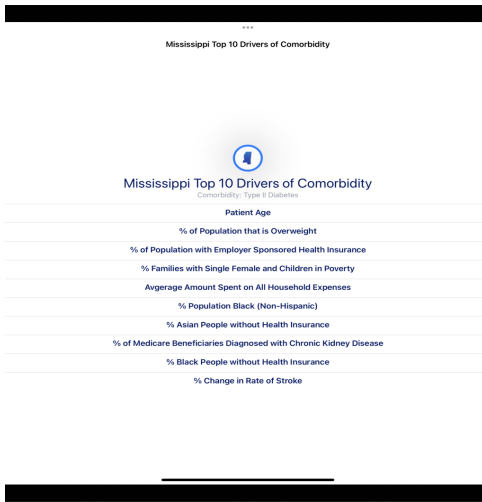

Fig. 12. Top 10 SDoH Drivers in Mississippi

Additionally, there is an interpret page which explains the data by visualizing the associated comorbidity risks. Specifically, the interpret page details the cost incurred either by a patient (out of pocket), or insurance companies like Medicaid, Medicare, etc, due to obesity related comorbidities. This allows the user to know the potential cost savings if obesity is properly treated and the patient is cared for. Furthermore, the bars on the bottom indicate the percentage of the population who suffer from those comorbidities.

The second page of the dashboard is the Explore page, which allows the user to view brief SDoH information from across all states. The page visualizes the data analysis from the data set provided.
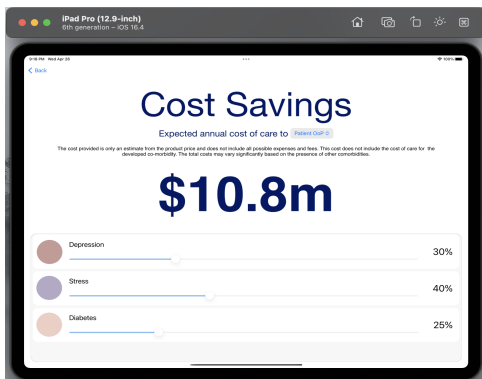
Fig. 13. Cost in Mississippi

Finally, the last page in our application is the Cost Savings page. This page is an anchor page in the sense that it is meant to create an impact on the client with the big bold
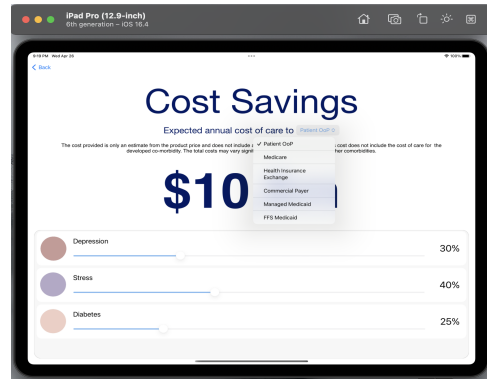
Fig. 14. Cost Selection

number in the center of the screen. The number that is shown on screen is the estimated annual cost of care for obesity related comorbidities in that specific state. It includes a disclaimer from Novo Nordisk's side indicating that they are estimated costs and do not account for additional developed comorbidities. The user is able to filter for which payer they would like to view such as Patient Out of Pocket costs, Managed Medicaid costs, etc. The sliders at the bottom of the page display the percentage of people in that selected state that have the indicated obesity related comorbidity. The statistics are displayed only for the information of the client and user and are connected to genuine data.

Fig. 15. Cost Selection

The overall architecture of the application can be described as a number of Swift Storyboards connected together. Storyboards were chosen because they allowed for rapid prototyping and development that mirrored the design on Figma. Specifically, Storyboards allow components to be dragged and dropped to specific locations, as opposed to coding those locations. Additionally, the Storyboards and their associated components could be linked to a ViewController file, which allows behavior to be programmed. This way, less time needed to be spent on getting the application to look as it did in the design, and more time was spent on the functionality.

III. Cost and Sustainability Analysis

The cost of mass production for this application tool can be contextualized under the three following divisions:

A. Economics Impact

1) Materials and Equipment: There is no initial cost of production for this application. We have used Figma and Xcode for developing it, which do not require any subscription. For mass deployment later it would be needed to subscribe to an Apple Developer Account which costs approximately $99/year. Currently, Novo Nordisk stores all the patient data in a cloud storage platform called Snowflake, which is a partner of Amazon Web Services (AWS). However, in future, it might be required to purchase additional storage which can have a monthly cost between $25 and $50 depending on the volume of stored data.

2) Labor: The initial development of this application has been free of cost as we worked on it as a part of our Capstone project. However, after primary deployment, a full-time Software Engineer would need to be hired for regular maintenance and upgrades to the app. The standard annual salary of an entry-level Software Engineer is $100K-$120K.

3) Facilities: There was no cost associated with the initial development of the application as we worked on it on our personal devices and no new machine had to be purchased. But post-deployment, the maintenance of the application may entail a varying range of costs.

B. Social Impact

The high-level purpose of this application tool is to ensure access to appropriate medication and treatment options to as many people diagnosed with obesity in the most efficient way possible, by leveraging the power of data science and software engineering. This application provides an efficient tool for Market Access representatives to use in extending medical solutions equitably to people with obesity and related comorbidities. Through the succinct quantitative and visual insights, this application equips Novo Nordisk's Regional Account Managers and other Market Access representatives to formulate effective strategies for outreach to healthcare payer programs, like health insurance companies. In turn, this impacts what medical solutions are available to bariatric patients of varying socioeconomic statuses, diagnosed with different comorbidities. Novo Nordisk has been a champion in ensuring equitable choice of medical solutions to people from all demographics, and this application works as a powerful tool to reinforce that.

IV. Conclusion/Summary

We have successfully developed a working model iOS application in Swift utilizing data from Novo Nordisk's machine learning model and provided an intuitive front-end for our users and NNI clients. The app provides a quantitative and visual overview into the comorbidity risks present in patients with obesity through the modification of clinical, SDoH, and associated risk factors. Through this application we aim to help Novo Nordisk achieve their goal of providing and distributing equitable healthcare to the wider population of the United States. Helping combat obesity and its related comorbidities through our application would benefit affected individuals by allowing a healthier lifestyle and general well-being. In the future, the app can be additionally developed to add more visualizations and filters. In addition, the back end of the application can be connected to actual Novo Nordisk databases and storage units with live data.

References

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