Human Computer Interface: Smoking Awareness Web App

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***Abstract*—People around the world frequently access the internet and its vast amount of information. Some of the information includes tips for healthy living, exercise routines and diet plans for people to keep healthy and in shape. However, we all have our own guilty pleasures that we give in to when keeping healthy starts to become too tiring. As such, these guilty pleasures lead to increasing numbers of deaths globally. As such, we need to make applications that not only inform users about the significance of the factors of death, but also to help them track their own consumption and ensure that they are still on track towards healthier living.**

I. Introduction

According to a study done by the World Health Organization (WHO), Smoking and High Blood Pressure has consistently been ranked first and second amongst risk factors that cause death in the world. Since smoking has been known to cause high blood pressure as well, we can definitively determine smoking to be a root cause for a significant number of deaths in the world.

With this in mind, we also have to consider the number of measures that each country has taken against smoking as a whole, not only because of it being a risk factor of death, but also due to the environmental harm it causes. As such, in order to curb smoking as a bad habit in the world, we want to make a web application that not only raises awareness of smoking and its risks, but also to provide a means of tracking personal cigarette consumption.

For this assignment, the team has chosen to develop the product based on the principles of Information Visualization (InfoVis) as well as Ethical Design. Before implementation could begin, the team started out by drawing on paper, certain prototypes or elements to include in the product.

II. Design Process

A. Initial Designs

While sketching the initial designs on paper, we took the following aspects into consideration:

- What types of charts will be easily readable by the end users?
- What purpose is the application supposed to serve?
- What kind of data will we be working with to present to the user?
- Why would users want to use the application?

All of the forementioned aspects take precedence over the outlook of the application during the design process. We believed that it was of the utmost importance that we identify exactly what it is that we should be developing before we can proceed with anything else.

The entire design process was done in three iterations:

1) Paper Prototype
2) Wireframe development
3) Final wireframe development

Since we wanted to develop the web application around the principles of InfoVis, we wanted to strike a balance between the attention of the user and the amount of information we provide. An abundance of comprehensible data will draw the attention of the user, but too much data would also inversely take away too much attention from the user and cause them to be unable to absorb even more valuable information.

The Design Process was tantamount to achieving the balance of information versus attention, for us to find out exactly what user interface elements we should be using and how much data to present to the user. An integral part of determining how much data to present was to simply perform research and identify valuable data that was made accessible to us.

B. Data Sets

The charts we chose to display in the paper prototypes were decided upon the types of data that we were able to obtain. This is because the data that we find may be of different natures, such as differing countries or years or range of data. It was definitely an issue trying to figure out what charts to use without first identifying the data we want to display. Listed below are the data which we found online [4] and used in the product:

- Top 10 Risks of Death in the World (1990 - 2017)
- Number of Deaths Caused by Smoking in Various Countries. Grouped into Age Groups (1990 - 2017)
- Average Price of a 20-Pack of Cigarettes in Various Countries (2008 - 2016)
- Consumption of Cigarettes Per Smoker Per Day (2008 - 2016)
- Smoking Prevalence in Various Countries, Grouped by gender (2019)

All of the data sets were downloaded and put in *csv* format. We extracted the data we needed from the spreadsheets and

put them into separate *JavaScript* files for easier handling by our web application.

C. Functional Specifications

Based on the data we had access to, we decided upon the following functional specifications for the web application:

- To persuade smokers of all ages to reduce their personal smoking consumption, or to quit smoking entirely with the use of InfoVis Concepts.
- An informative page that presents data such as death rates, smoking prevalence rates, prices of cigarettes, as well as percentage of deaths attributed to smoking in various countries.
- Upon proper analysis of the information presented by the charts, the user will think twice about their personal lifestyle habits and want to do something about it.
- User-specific generated charts that tracks the user's cigarette consumption, as well as their projected spending on cigarettes.
- The user-specific generated charts should also display the user's data plotted against the national average.
- Users can come back to the web application to re-enter their consumption information, after which the system will generate an updated chart based on their new input.

D. Target Audience

It was also important to identify our target audience, so that we are clear on the objectives of the web application before implementation begins. After much thought, we arrived at the following conclusions:

- The web application should target smokers of all age groups
- The web application can also be used by friends and families of smokers

By targeting these two groups of people, not only are we trying to raise awareness of the detrimental effects of smoking, we also hope that we are able to accurately portray logical reasons why smokers should reduce their personal cigarette consumption, or in the best case, to quit smoking entirely.

E. Wireframe Sketching

After sketching our paper prototypes, we proceeded to develop wireframes based on elements in the paper prototypes and put those wireframes through evaluation. Shown below are some samples of our paper prototypes and wireframes:

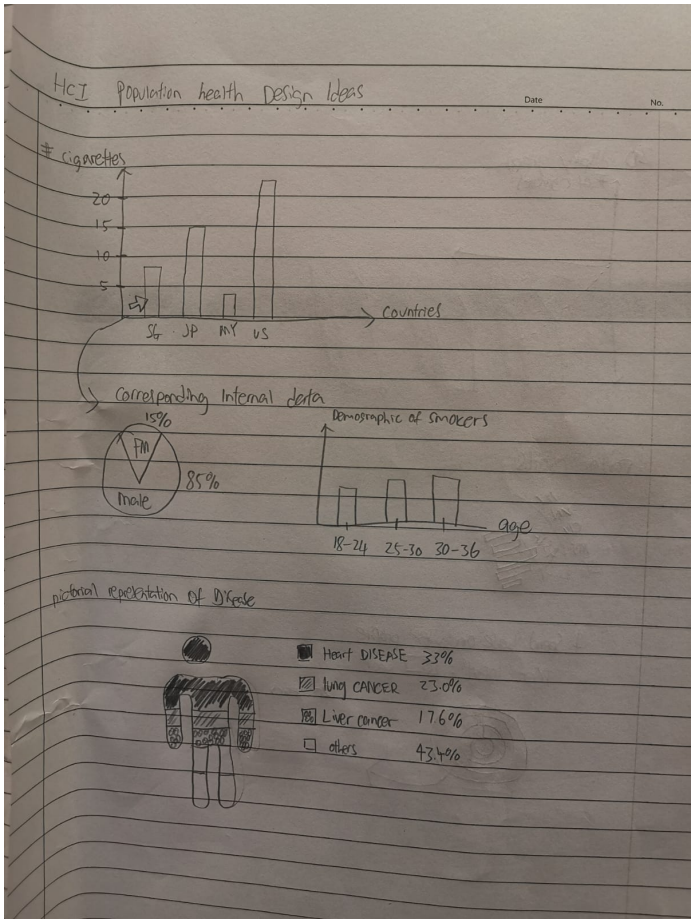

Fig. 1. Paper Prototype 1

F. Evaluation of the Paper Prototypes and Wireframes

We chose to employ the 10 Usability Heuristics developed by the Nielsen Norman Group [**?**] as a measure of evaluating and analysing our design prototypes. The Usability Heuristics Checklist is as follows:

- **Visibility of System Status** - The system should always keep users information about what is going on, through appropriate feedback within reasonable time.
- **Matching Between System and the Real World** - The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follows real-world conventions, making information appear in a natural and logical order.
- **User Control and Freedom** - Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue, Support undo and redo.
- **Consistency and Standards** - Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
- **Error Prevention** - Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
- **Recognition Rather than Recall** - Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable

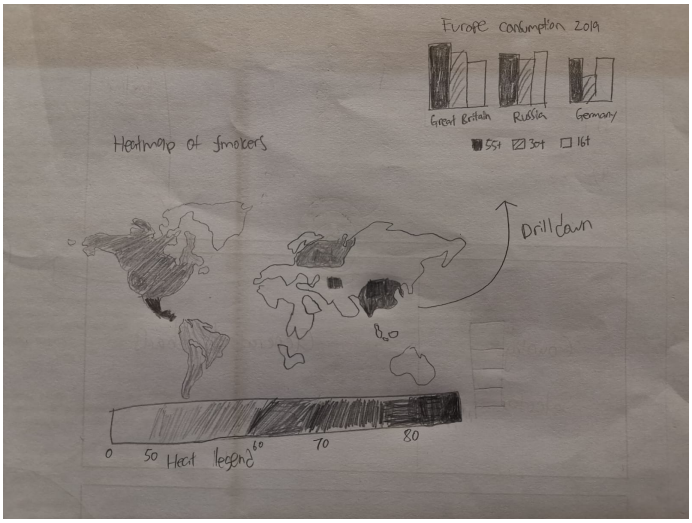

Fig. 2. Paper Prototype 2

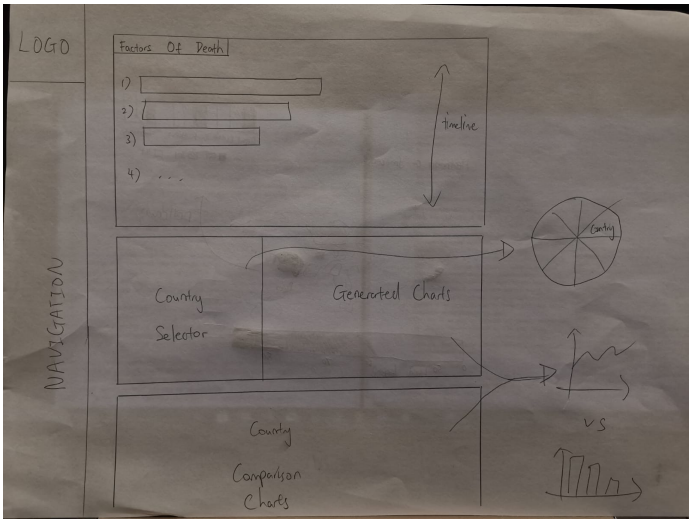

Fig. 3. Paper Prototype 3

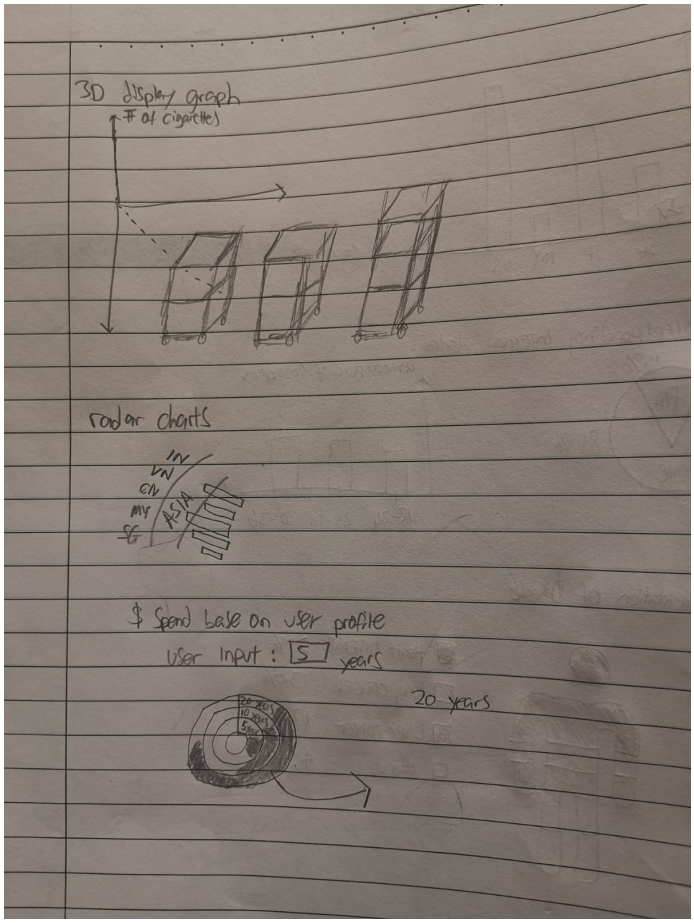

Fig. 4. Paper Prototype 4

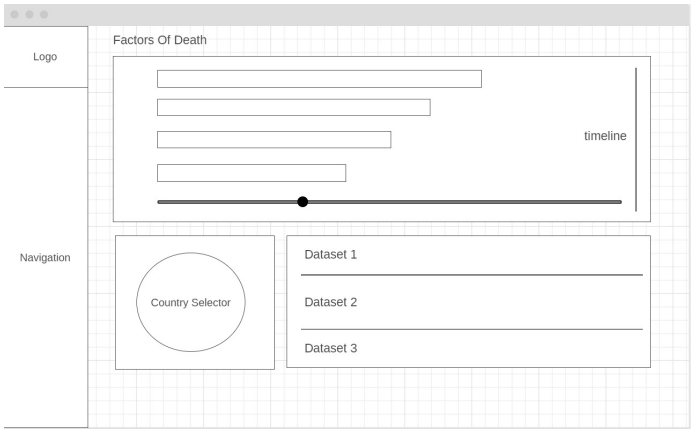

Fig. 5. Wireframe 1

whenever appropriate.

- **Flexibility and Efficiency of Use** - Accelerators - unseen by the novice user - may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
- **Aesthetic and Minimalist Design** - Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
- **Help Users Recognize, Diagnose and Recover from Errors** - Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
- **Help and Documentation** - Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

Prior to letting our users fill in the checklist, we first let them read and sign an Ethics Checklist. A copy of the ethics checklist has been attached in the submission folder.

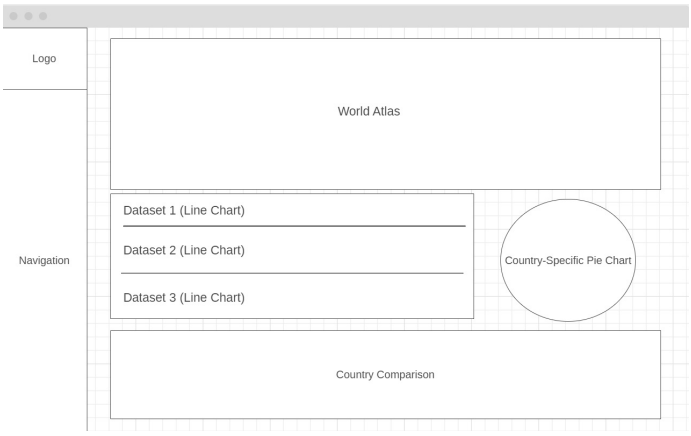

Fig. 6. Wireframe 2

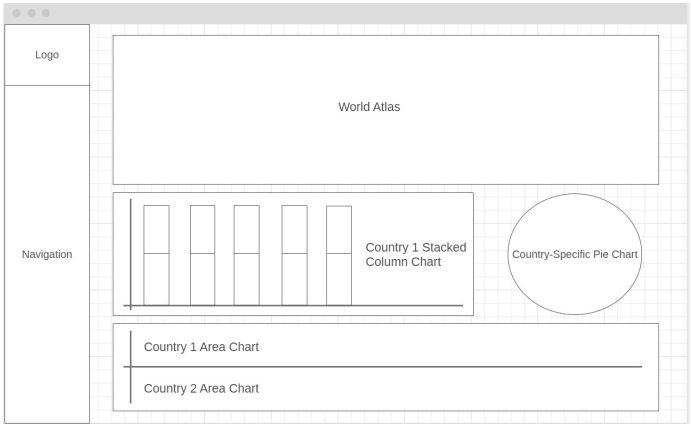

Fig. 7. Wireframe 3

G. Heuristic Evaluation Results

The evaluation checklist was given to 30 participants who are smokers themselves, whereby each of the 3 wireframes were evaluated by 10 participants each. Some of the feedback are as follows:

- "There are no instructions on how user should navigate, however due to the use of material design as well as good headers, the user will know where to click."
- "Perhaps with the aid of vibrant colors, the user will be able to better identify the main elements on the page."
- "The use of a country selector to generate information relative to the selected country prevents the user from having to remember which country they wanted to inspect."
- "Based on the prototype, any flow in saccades and viewing pattern is all up to the user to decide, with little to no emphasis on elements of the charts."
- "The use of an atlas to generate information relative to the selected country prevents the user from having to remember which country they wanted to inspect. However, there are some countries that are difficult to locate on the altas (such as Singapore)."
- "It is difficult for the average person to read complex graphs, so there needs to be a balance between readability and amount of information conveyed per graph."

We have taken the feedback obtained into consideration before we begun implementation. As a result of the entire design process with heuristic evaluation, we have come to the following conclusions:

- In order to allow the user to select a country, perhaps a sunburst chart should be used rather than an altas/globe to account for countries that are smaller and hard to locate.
- With regards to the risk factors leading to death, it might be useful to implement a race chart to emphasize the fact that smoking is consistently one of the top factors.
- With regards to the country-specific information, it would be better to have a mix of area and stacked-bar charts to display and compare the data between different countries.
- In order to achieve the principles of InfoVis while maintaining a level of user interaction, we need to find a library that supports our needs and is able to generate charts that have these interactive features.
- The charts that we implement should not be too complex such that it is not readable by the average person

With all the forementioned feedback taken note of, we proceeded with a second round of wireframe development. We combined the various elements that were better appreciated by participants and put them all into the final wireframe designs:

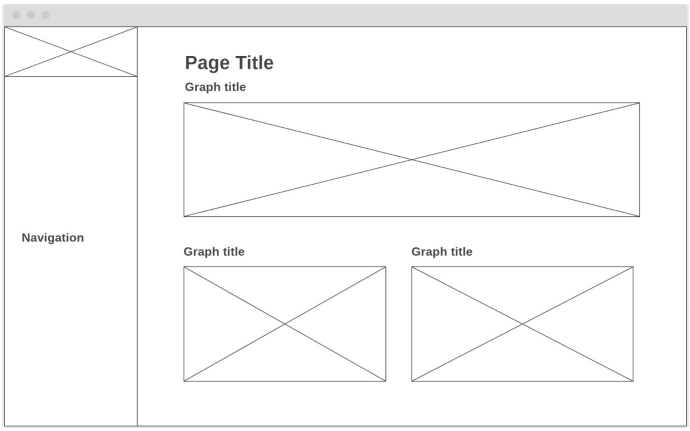

Fig. 8. Smoking Information Page

III. Implementation

Using the forementioned data sets, design prototypes and feedback from users, we decided to use ReactJS [1] for the framework of the product. In order to support the functional operation of the graphs, we decided to use EChartJS [2] ,ApexChartJS [3] and ChartistJS [5].

A. Implementation Process

We based the product's designs and User Interface elements based on the feasible options after evaluation of our wireframes. After analysis of the feedback given by participants

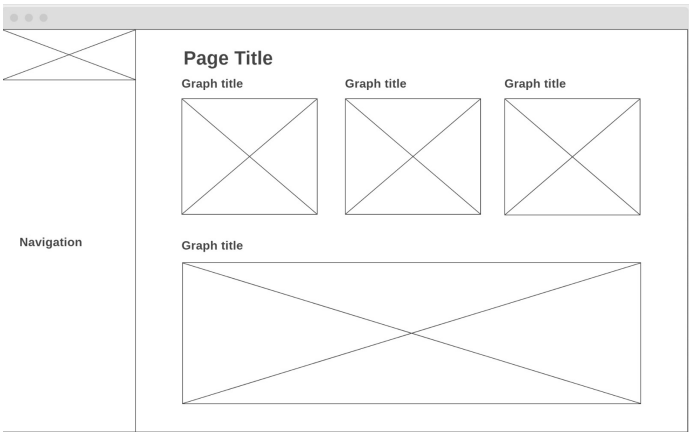

Fig. 9. User Information Page

of the Heuristal Evaluation, we noticed that each of the wire-frames developed had their individual elements that were well received. As such, we combined aspects of each wireframe that the users liked and were able to better appreciate. As such, we derive the following charts for the data we have:

- Race Chart presenting the top 10 risk factors for each year from 1990 to 2017
- Sunburst Chart presenting the continent and countries for the user to perform country selection
- Stacked Horizontal Column Chart presenting the Smoking Prevalance of Neighbouring Countries
- Stacked Vertical Column Chart presenting the Number of Deaths per 100,000 Capita in the selected country
- Linked Area Charts presenting the Prices and Consumption of Cigarettes Per Smoker
- Linked Area Charts presenting the Death Rates Attributed to Smoking in Neighbouring Countries

B. Interaction Techniques

The selection of library for the generation of charts was significantly important because we wanted to be able to deliver the right interaction techniques to our end users. These include, but are not limited to the following:

- Navigation (Zoom, Pan)
- Selection/Highlighting
- Filtering
- Sorting
- Data Extraction
- Exporting Visual Chart(s)

We also considered various Pointing Methods that were provided by the libraries. Again, including but not limited to the following:

- Data Point Selection
- Mouse Over Event
- Data Point Click Event
- Rectangular Region Selection

Finally, what really added to the aesthetics of the web application was the use of color palettes that appeal to the cognitive imagery of the human eyes. For example:

- Each individual Risk Factor of the Race Chart has its own unique colour to encode their nominal variables (number of deaths)
- Each Category on the Stacked Vertical and Horizontal Column Chart is given its own colour, again to encode their nominal variables (number of deaths). The colours used are also to appeal to the users' sense of recognition because we used the same colours as those you would see on a cigarette.
- Each continent in the Sunburst Chart is given its own unique colour to denote categorisation.

C. Working Product & Logical Reasoning

With regards to the concepts of InfoVis mentioned previously, the charts were developed with careful consideration for our target audience, especially in terms of usability and effectiveness of the graphs. Listed below are the screenshots of our working product, and our reasoning for using those particular visual models.

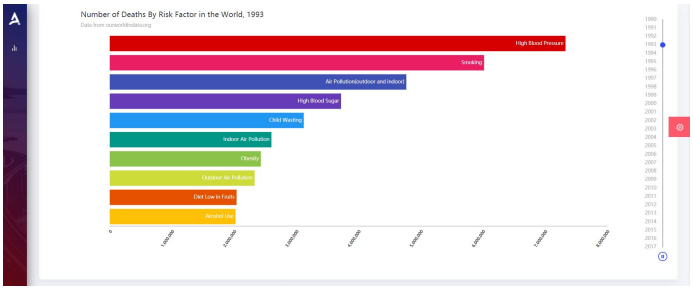

Fig. 10. Racechart

- Colors used here were to categorize the nominal values encoded from each other. For example, each risk factor here has been given its own color to denote unrelated values in each factor.
- We had several years worth of data. One considered option was a simple dropdownlist for the user to either select a specific year or a specific risk factor. However we thought that was too boring and decided to implement a moving race chart instead. With the aid of a timeline that the user can stop and play whenever they please, the user will be able to view any data point at any time.
- As the timeline plays and shuffles through the years of data, the user will be able to see the increment and decrement in each risk factor over the years.
- The sunburst chart used here was to replace a country selector. This is because we derived from our heuristic evaluation that users found an atlas or globe too general and only useful for viewing data of larger countries. Smaller countries would then be compromised.

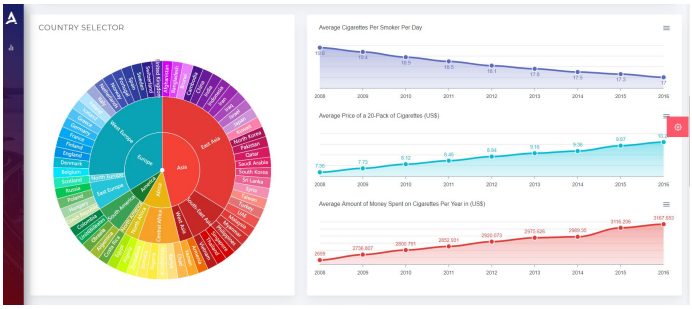

Fig. 11. Sunburst Chart & Generated Price Chart

- The colors used in the sunburst chart denote categorisation of the countries according to their regions and continents. For example, countries in Asia are red while countries in Europe are blue.
- The linked area charts on the right can all be interacted with at the same time. This is to allow the user to simultaneously compare data across all the charts. By allowing for simultaneous analysis, the user will also be able to see the correlation between the data encoded in the area graphs.

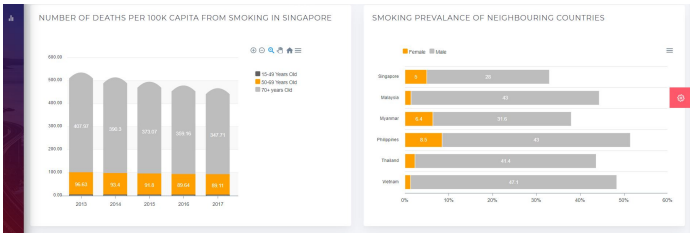

Fig. 12. Country-Generated Stack Column Charts

- The data generated from the selected country such as death rates by grouped by age and smoking prevalance grouped by gender are displayed in stack column charts as shown to denote an idea of categorisation and cumulation. For example, even though the data on death rates are split into the various age groups, they cumulate together to from one single number of deaths as a result of smoking.
- The colors used in these charts are a mapping to the real world, using colors which matched those that you would see on a cigarette stick. Simply having the stacks representing a value would seem too simple and not be of any significance when to the user.
- The linked area charts can all be interacted with at the same time. This is to allow the user to simultaneously compare data across all the charts. By allowing for simultaneous analysis, the user will also be able to see the correlation between the data encoded in the area graphs.
- The user will be able to perform comparison across countries that neighbour the selected country.
- With the use of small cards with encoded increasing/decreasing trends, the user will be able to tell in just a glance, the general progression they are making.

Fig. 13. Linked Country Comparison Chart

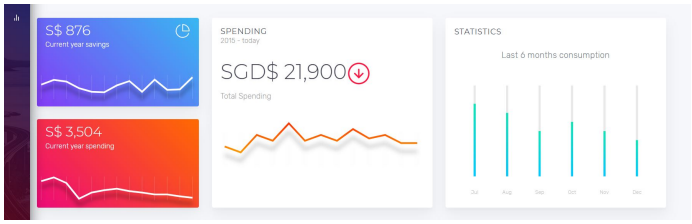

Fig. 14. User's Consumption Records

- Colors are also used here in conjunction with the trends to denote an uprise or downfall.

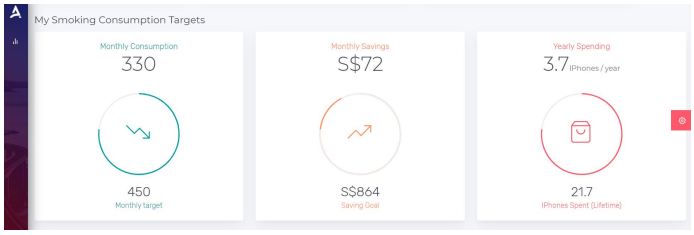

Fig. 15. User's Consumption Records

- Each card contains a donut chart which indicates the user's progression with relation to a set objective.
- Colors and icons used here indicate a mapping to the nature of the data. For example, the upward or downward arrow icon is used to represent their respective trends and patterns.

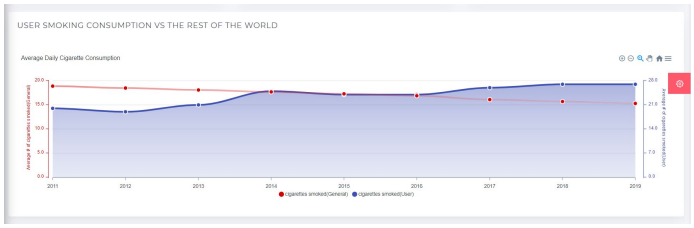

Fig. 16. User's Cigarette Consumption, Plotted Against the Global Average

- Each set of data in the graph is its own y-axis and their colors match each other. This is to give the user a clear segregation between the two sets of data.
- The red line represents the global average values for each year. This is so that the user is able to see clearly, which

years in particular that they had surpassed the global average. In general, going above the average value would seem like a bad thing, especially in the context of a health risk.

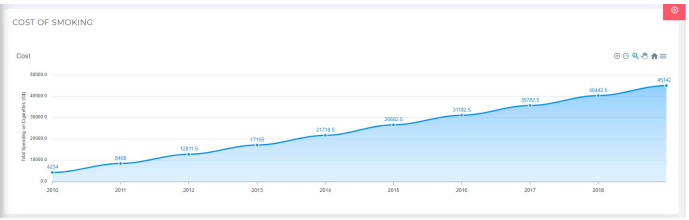

Fig. 17. User's Spendings Over the Years

- The user will be able to view their spendings as a result of smoking over the number of years that they had been smoking. We decided to use the compounded total amount of expenditure as of the year indicated in the graph, to properly show the user exactly how much they are spending. Had we decided to use the estimated total cost of each individual year, all the user would be able to see is the slight fluctuation of cigarette prices each year. In this case, we are trying to make the user picture the total amount of money they had spent to feed their habit. rather than to let them see relationships in the yearly spendings.

D. Problems Faced

During Implementation, it was challenging to visualise the data sets we had and presenting them on the graphs. Majority of the implementation phase was spent drawing our charts on whiteboards and identifying which category or subsets of data should be used on which types of charts. Since the data we had obtained was just spreadsheets of numbers that would make no sense to our end users, we had to break it down for ourselves to understand before we can expect our own graphs to make the end users understand the information as well. As such, the entire implementation process was more of understanding the data ourselves in order to make it easier on the user.

Another challenge we faced was the actual implementation of the charts and customizing them to our needs. The problem was that we had too much data to plot on our graphs, and yet we did not want to make the charts too complicated such that it becomes unreadable to our end users. As such, we made ample use of mouseover events and data labels that explicitly tell the user what each point on the graph means and the values assigned to them.

IV. Questionnaire Evaluation

In order to evaluate our web application, we determined the following metrics that we wanted to test:

- **Usability** - The charts developed should be readable to the end user and not be too complicated
- **Effectiveness** - The overall appeal of the web application and the information provided should influence the user to doubt their own habit of smoking

As such, we came up with the hypothesis that **The charts and data presented to the user will influence the user to want to keep track of their own cigarette consumption**. In order to test this hypothesis, we took to google forms to develop a survey which is aimed at giving ourselves a rough estimate of how usable or effective the web application is. The survey was taken by the same 30 participants of the previous round of evaluation. This is to ensure that we get a good estimate of the degree of improvement that we have made since the previous round of evaluation. Another issue we considered was the possibility that we may have overlooked certain aspects that should have been improved in the previous iteration.

A. Survey Questions

The survey questions were as follows [6]:

- How user-friendly was the interface of the web application? (rate 1 to 5)
- How informative was the web application? (rate 1 to 5)
- How would you rate the overall design of the web application? (rate 1 to 5)
- After using the web application, how likely are you to persuade yourself or your friends and family members to stop or reduce smoking? (rate 1 to 5)
- What did you like most/least about the web application? (Open-Ended)
- How do you think the web application can be improved? (Open-Ended)
- If given the chance, what kind of additional information about smoking would you want to be added to the web application? Why? (Open-Ended)

By letting our participants use the web application for themselves and answering the survey questions, we hope to find out the following information:

- Whether the graphs presented were intuitive and readable by the participants
- The number of users who would want to keep track of their cigarette consumption after understanding the information presented by the graphs
- What other aesthetic elements can be improved
- What other information should be added to the application
- In general, whether more users liked or disliked using the application

B. Survey Results

After collecting the survey results, we plotted all of them into a table as follows:

Questions and Ratings*					
	SD	D	N	A	SA
User-Friendly	0	0	0	16	14
Informative	0	0	1	17	12
Overall Design Rating	0	0	2	15	13
Effectiveness of Information	0	1	7	13	9

*SA: Strongly Agree, A: Agree, N: Neutral, D: Disagree, SD: Strongly Disagree

Open-Ended Question Responses:

- "I liked the use of the cigarette colours to express a relation to the real world."
- "I liked how the charts presented according to the country I selected."
- "I liked how I am able to compare the data across various countries."
- "I liked how I am able to get an overall estimate of how much I had spent on cigarettes."
- "In general, I like the outlook of the web page and the vibrant colours used."
- "The charts made me realise how much I need to quit smoking!"
- "I liked how the prices displayed were country-specific because the price of cigarettes in Singapore can not be compared to our neighbouring countries."
- "I liked how each set of data and charts were colour-coded and had numbers assigned to them. Otherwise, I may not have understood what they were trying to tell me."
- "I disliked how the cost projection was done because I might just interpret it in such a way that only dissuades me from smoking in Singapore."
- "I disliked how I am unable to compare the data of countries of different GDP and HDIs. It is unfair to compare Singapore to second or third-world countries like Myanmar and Philippines."
- "The data presented was clear and interactive."
- "I would also add in the price comparison between Singapore and other countries around us. Just to show how disgustingly expensive it is to smoke in Singapore. But I admit that the other relevant information does make me think twice about smoking."
- "If I had the chance, I would want the web page to display the various smoking laws and regulations. Sometimes the law itself is enough to dissuade us from smoking."
- "I might also add in information or recent news articles about each country's public smoking law enforcement, so that users know what countries are doing in order to curb harmful smoking as a whole."

The overall feedback from participants seemed positive, with majority of the negative feedback being more related to the nature of certain countries. However because the development and evaluation were all carried out in Singapore, it is not surprising that there would be certain sentiments and bias towards the country we live in. In order to get a more even distribution of feedback, perhaps the results would be clearer if the survey was also carried out outside of the country.

Regardless, we understand where the participants' sentiments were coming from and took note of their feedback for our future improvements.

V. Future Improvements

Should time permit, we would like to implement the following improvements:

- To add customizable country selection such that the user is able to make comparisons between countries of their choice.
- To add in data for more countries so that the user is not only limited to certain data from Singapore and the UK.
- To better integrate the user experience by enticing the user to revisit the web application even more regularly, such as the use of achievements or visual medals to give a more objective-oriented approach for the user.
- To add in data about each country's rules and regulations against smoking being a public disturbance.
- To add in preventive measures taken by countries with regards to smoking, in order to promote better lifestyle habits amongst citizens.

VI. Conclusion

The overall responses from the evaluation participants were positive, thus indicating a certain degree of user satisfaction. We took all feedback into consideration and applied them in reiterations of the design and implementation phases. We found this procedure extremely useful for us as it opened up our avenues for improvement. Had we not gotten the help of members from our target audience, we would not have been able to make improvements to the application as fast as we did. After incorporating the concepts of InfoVis into a useful application, we were able to give our product better value towards the needs of our target audience. All source code and some samples of material used are included in the GitHub Repository. [7].

Through the use of InfoVis and ethical user interface design, we hope that our web application will give users a means of tracking their own cigarette consumption while raising awareness of the risks of smoking in the world. The important issue to address was the readability and usability of the web interface while being informative at the same time. As mentioned in the previous sections, we had to find a proper balance between the user's attention span and the amount of information presented to the user. Once the balance has been achieved, the product can not only be effective in achieving its objectives, but being of value to our end users at the same time.

References

[1] ReactJS - A JavaScript library for building user interfaces, 'https://reactjs.org/'
[2] EChartsJS, 'https://echarts.apache.org/en/index.html'
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