Utility and Evaluation of MeTree on Family Health History Collection in Sri Lanka

by

Ruoyu Hu

Duke Global Health Institute
Duke University

Date: _____

Approved:

_____
Joseph Egger, Supervisor

_____
Truls Ostbye

_____
Lori Orlando

Thesis submitted in partial fulfillment of
the requirements for the degree of
Master of Science in the Duke Global Health Institute
in the Graduate School of Duke University

2019

ABSTRACT

Utility and Evaluation of MeTree on Family Health History Collection in Sri Lanka

by

Ruoyu Hu

Duke Global Health Institute
Duke University

Date: _____

Approved:

_____
Joseph Egger, Supervisor

_____
Truls Ostbye

_____
Lori Orlando

An abstract of a thesis submitted in partial
fulfillment of the requirements for the degree
of Master of Science in the Duke Global Health Institute
in the Graduate School of Duke University

2019

Abstract

Introduction: Information about family history of illness is increasingly important to ensure each patient receive optimal promotion advice, preventive health services and appropriate treatment. MeTree is a web-based tool used to collect family health history directly from participants through a website. Despite growing evidence regarding the importance and efficacy of using family history, and the need for healthcare providers to have family history triage tools for personalized healthcare delivery, tools like MeTree have not been broadly applied in clinical practice. Little is known about its utility in settings with different disease profiles, health care systems and traditions and different cultural and socioeconomic contexts.

Methods: This study enrolled 304 medical students from the University of Ruhuna in Sri Lanka. Participants constructed family pedigree and entered family health history in MeTree with the help of the researcher and a local research assistant. Once participants had created a full family pedigree, they were asked to complete a paper-based questionnaire asking about their experience with MeTree and what perceived to be the benefits of MeTree.

Results: The proportion of males and females were relatively similar, 52.6% and 47.4%, respectively. Family health histories were entered for 3352 relatives in total. All diseases were divided into 21 groups. Diabetes was the most common disease group reported and accounted for 24.58% of all diseases reported. The following two most frequent diseases were hypertension (14.51%) and cardiovascular diseases (12.06%). Relatives had much higher numbers of all disease groups compared to

index participants. Prevalence for each disease was different between index participants and the relatives. Hypertension was present in at least one or more family members in 65.13% of all pedigrees. On average, 29.92% of relatives in each family have diabetes. The mean time to complete entering information into MeTree was 36.3 minutes. The overall feelings and satisfaction level towards MeTree were favorable. Over 90% of participants indicated that MeTree could be generalized in the context of Sri Lanka. Results from t-test at the significance level of 5% didn't indicate any significant preference for completion time used by males ($M = 35.51$, $SD = 11.47$) over completion time used by females ($M = 37.04$, $SD = 11.04$), $t = 0.65$, $p = 0.5177$. A significant effect of grade on completion time wasn't observed at the $p < 0.05$ level in the ANOVA procedure either, for the three conditions $F(3, 83) = 1.80$, $p = 0.1539$. According to the correlation procedure, completion time and age were not correlated ($r = 0.2129$, $p = 0.13182$). Among all questions in the questionnaire, significant difference was only observed between males and females for reported awareness ($p=0.0184$) and knowledge ($p<0.0001$) change after being introduced to MeTree.

Conclusions: Most medical students found it easy to use MeTree and considered it a useful experience. The majority of the students thought it possible to generalize MeTree in the context of Sri Lanka, while barriers still needs to be overcome to have a web-based tool like MeTree put into real practice in Sri Lanka.

Contents

List of Tables

List of Figures

Acknowledgements

I would first like to express my deepest gratitude to my mentor and committee member, Dr. Truls Ostbye, for his leadership in both the conduct of my summer fieldwork project in Sri Lanka and the development of this thesis, his guidance and patient help throughout my whole stay at Duke Global Health Institute. I would also like to thank my committee chair, Dr. Joseph Egger, for his support with this thesis. I would like to thank my committee member, the Director of the Precision Medicine Program in the Center for Applied Genomics and Precision Medicine at Duke University, Dr. Lori Orlando, along with Dr. Ryanne Wu and the MeTree developing team, for introducing us to this software tool, for Dr.Orlando's support in using the software, also for her suggestions in both preparing for the project and the development of this thesis. I would also like to recognize Dr. Rachel Myers, for her help with the extraction, organization and data analysis of this project. I want to thank Prof. P.V. De Silva, Head and Professor in Community Medicine at Faculty of Medicine, University of Ruhuna, Sri Lanka, for his help and guidance for my summer fieldwork project at the University of Ruhuna in Sri Lanka. I would also like to recognize Ashley Price, Research Program Leader at Department of Duke Community and Family Medicine, and Shayna Clancy, previous Research Program Leader at Duke Health, for their help with this thesis. I would also like to thank my classmate, Ashley Wittmer, for sharing her results with me. Last but not least, I would like to thank Duke Global Health Institute, my family and my country, for always supporting me throughout my whole master program.

1. Introduction

1.1 Family Health History

Family health history is a record of the diseases and health conditions in your family[1]. Observational studies show that at least 15–20% of all cancer and coronary heart disease family histories demonstrate hereditary risk patterns[2]. Identification of family histories demonstrating a hereditary disease pattern is important for presymptomatic disease screening and detection[3]. Discovering and knowing one's family history is important for both the patients and the providers, since one's medical history includes the traits the family shares that can't be observed. These traits may increase one's risk for many hereditary conditions and diseases[3] and family history plays a critical role in assessing the risk of inherited medical conditions or acting as a genetic risk predictor for the development of some common non-communicable diseases[4]. According to previous studies, people with a family history of a certain disease have a higher risk of developing that disease than people without a family history[5,6,7,8]. For example, certain types of cancer, such as breast cancer and colon cancer, appear more frequently among people with a family history[9]. For the patients, knowing about their family health history can help them find out if they and their children are at increased risk for any medical conditions. Understanding family history is also an important part of family medicine education and helps increase the patients' awareness of disease prevention and management[10]. For the providers, family health history is of great value to identify potential health risks and personalize care for their patients. It enables the providers to know about the patients' social background and combine some clues from the family history to

the patients' symptoms[4]. Information about family history of illness is also increasingly important for patients to take preventive steps and initiate mitigating strategies to reduce disease[11]. It also helps identify individuals at increased risk and improve monitoring system for common diseases[12]. Many guidelines for screening and prevention rely upon risk assessment using family health history to guide the appropriate use of alternative screening procedures or genetic counseling and strongly recommend that primary care providers collect family health history for disease risk stratification and risk management[13,14,15]. For example, the U.S. Preventive Services Task Force (USPSTF) strongly recommends cholesterol screening beginning at age 35 years for men but at age 20 years for men and women who are at increased risk of cardiovascular disease based on collected family health history[16].

1.2 Barriers in collecting family health history

Despite growing evidence regarding the importance and efficacy of using family history, and the need for healthcare providers to have family history triage tools for personalized healthcare delivery, tools like MeTree remain underutilized in clinical practice constrained by time, accuracy, and physician expertise[17]. Recent studies have indicated insufficient collection of family history information by primary care providers[18]. One of the primary barriers for clinicians to better utilize family history in clinical practice is time. It often takes 20–30 minutes to create a complete family health history file, but clinicians typically only have a few minutes to both collect medical information from patients and discuss resulting clinical recommendations with patients[18,19]. The fact that there is simply not enough time during a busy clinic schedule to collect and analyze a three-generation family

pedigree emphasizes the importance of allowing patients collect and organize their own family health history through a simple and efficient way, namely, the development and generalization of self-collection tools.

Other barriers also exist considering from the patients and health system perspective. For the patients, the lack of adequate medical knowledge can hinder them from accurately describing and recording their medical history without any help. From the health system side, the current system for collecting data and providing actionable information is still inadequate, making family health history collection difficult to complete[20]. However, all the barriers mentioned above can be mitigated with the help of a web-based tool for collecting family health history.

1.3 MeTree and other web-based tools for family health history collection

A number of web-based tools have been developed to help both providers and patients organize and use family health history accurately and efficiently. The rapid development of web-based tools may offer one solution to the existing barriers for family health history collection mentioned above. Patient-facing web-based tools can transfer the data collection procedure from the clinical setting to the patient's home. Web-based tools can also provide algorithm-based risk calculations and actionable suggestions as part of the risk management plan for the provider which can be difficult to fulfill manually[21]. The benefits of using such tools are twofold. First, patients are able to collect and organize their own family health history outside of the clinic, with enough time to contact relatives and consult family records, which guarantees a more complete and accurate family health history. Second, a visit to the patients' provider will begin with a completed family health history file every time

the patients come to a clinical visit, which allows the clinician to better guide care in limited routine time rather than spending time collecting imprecise medical histories[22]. Third, when the patients' information is entered into a web-based system, a documented resource can be updated and passed down to other providers when the patients are refereed or to their offspring so that the information is recorded indelibly and in perpetuity. Although there are concerns raised in terms of the validity and accuracy of the patient-entered family health history collected outside the setting of the clinical encounter, strong agreement (70%–100%) was found between patient-entered data and the presumed gold standard of genetic counsellor-acquired data based on previous studies[21,23]. Patient-entered data are significantly superior compared to data collected during daily routines[3,24].

There are a wide variety of web-based tools currently available to help patients collect their family health history. Tools vary by organization information, family history collection and display, clinical data collected, and clinical workflow integration[22].

MeTree is a patient-facing, web-based tool developed in collaboration with Duke University, the University of North Carolina Greensboro, and Cone Health System known as the Genomedical Connection, to collect family health history from the primary care population[25]. MeTree is designed to collect family and personal health history directly from participants through a website and can be completed by participants themselves. It can also be used to support clinical decision-making by providing risk assessment report and suggestions for both the patient and health care provider. It collects personal history on medical conditions, diet, exercise,

smoking, vital signs and laboratory data in addition to family health history to calculate various health-risk scores and assess risk for 20 cancers including 14 hereditary cancers, cardiovascular syndrome, and 21 other conditions[26]. The benefits of using MeTree include reducing burdens on providers, improving quality of data collection by involving the patients themselves and their whole family, improving quality of care by providing information on potential risk in diseases and needs for screening and prevention, as well as promoting the patient participation in care[17]. Thus far, MeTree has been used in both providing clinical advice after risk assessment and evaluating the occurrences of diseases and improving the patients' risk awareness without providing specific clinical advice.

1.4 Study Aims and Rationale

Previous studies conducted using MeTree indicate that MeTree can be effectively implemented in diverse primary care settings and can effectively engage patients and providers[27], while little is known about MeTree's utility in settings with different disease profiles, health care systems and traditions and different cultural and socioeconomic contexts due to limited use in developing worlds. To generalize the use of web-based tools like MeTree, the patterns of data collected by these tools need to be clarified, and usefulness should be evaluated to determine whether using MeTree is feasible in different contexts.

The aims of this study include: 1. To explore patterns of collected data using MeTree in the context of Sri Lanka, describe the participants' health and family health histories and characterize the occurrences of some common diseases (i.e. diabetes) based on data collected from MeTree; 2. Evaluate the participants'

experiences with the system and participants' perceived benefits of using MeTree in the Sri Lankan context; 3. Compare the results of disease occurrences and use experience between two researches conducted both using MeTree in the United States and Sri Lanka.

2. Methods

The study used a descriptive and cross-sectional study design. The data were collected by the web-based tool MeTree and also by a paper-based questionnaire.

2.1 Settings

The study was conducted between June to August of 2018 at the University of Ruhuna, located in Galle, Sri Lanka. Sri Lanka is an island country in South Asia, with a total population of around 20,000,000. The life expectancy for males and females respectively are 72 and 78 according to data in 2016[28]. The island is home to many cultures, languages and ethnicities. The disease profiles, health care systems, traditions, cultural and socioeconomic contexts in Sri Lanka are quite different from the United States and other developed countries, which makes it an applicable location to explore the utility of MeTree in developing contexts. Galle is a major city in Sri Lanka and the administrative capital of Southern Province, with a population of 93188[29].

Sri Lanka is one of the few countries in the world with free healthcare. The government provides universal healthcare to its citizens, while the public health sector has inadequate capacity which makes it more difficult for the providers to collect and analyze family health history for their patients during each routine visit[30]. On the other hand, the demand for genetic risk assessment to identify hereditary predisposition to certain diseases such as cancer is growing rapidly in Sri Lanka as a result of the public's increasing awareness[31]. Implementing family health history

collection technology like MeTree in Sri Lanka can help mitigate the gap between supply and demand for hereditary assessment. Besides, paper-based profiles are still used for medical records in most hospitals and clinics in Sri Lanka. Paper-based systems have limited functionality and can impede the collection of family health history and even the continuity and quality of patient care[32,33]. Introducing tools like MeTree in the context of Sri Lanka might be hard at this time but can help increase the governments' and providers' awareness of collecting family health history from disease identification and prevention perspectives and their intention of improving data collecting and monitoring system at the same time.

2.2 participants

The participants enrolled in this study were all medical students at the Faculty of Medicine, University of Ruhuna. The inclusion criteria for the participants included: must be ≥18 years old; must be able to read and speak English; and must attend courses at the University of Ruhuna.

There were several considerations when making the inclusion criteria. First, the contents on MeTree website and the questionnaires we used were not translated into the local language, therefore the participants needed to be able to read and speak English in order to complete the study. The medical students in Sri Lanka are trained in English and thus should be capable of completing forms and communicating in English. Second, medical students should be more familiar with some of the medical terminology used in MeTree. Enrolling participants with medical backgrounds can be a first step to explore the feasibility to generalize MeTree in the context of Sri Lanka.

All medical students were contacted with the help of Prof. Vijitha De Silva, head of Department of Community Medicine, Faculty of Medicine, University of Ruhuna. The total sample size was 304. The participants were compensated with 500 Sri Lankan Rupees (approximately $3USD) for participation.

2.3 Instruments

- MeTree

MeTree is a web-based tool which is designed for easy use and the collection of family health histories from patients, with collected information including a full 3-generation pedigree with age of disease onset, current age or age at death, and cause of death for each relative[34]. Patients collect their family health history from their family members, then enter it into MeTree along with other relevant personal history needed to run the integrated risk calculators. MeTree then risk-stratifies patients for entered diseases. MeTree is also capable of recommending risk-guided prevention strategies endorsed by evidence-based guidelines[35].

The account in MeTree for each participant in this study was created by the researcher before the participant came to enter information into MeTree and the informed consent had been obtained from each participant.

The first step for participants to use MeTree was to complete a survey that collected the participants' basic information including gender, age, education, income and so on (figure 1). The first and last name of participants were replaced by the study id in order to protect the privacy of the study participants. The participants were only asked for their birth year to calculate ages but not their specific birth date

as well. The email address provided by the participants was only used to send the MeTree generated report to the participants. The following page asked about lifestyle habits, medical history, and knowledge and beliefs about genetic disease risks for the participants themselves (figure 2). Once these two surveys were completed, the participant was given access to MeTree's data entry interface to enter the family health history for their family members. In the MeTree program, the participant was asked to enter at least three generations of their family health history (Figure 3)[36]. MeTree generated a pedigree for the user to view after entering their family health history information (Figure 4). The participants were asked to select any of the 48 important familial and hereditary conditions compiled in MeTree that affected any of their relatives. Then after completing their family health history in MeTree, the system automatically generated a report based on responses, which showed the participants' conditions that they might have an increased risk for (Figure 5). The participants were provided with this report and recommended to discuss the potential increased risk with their doctors.

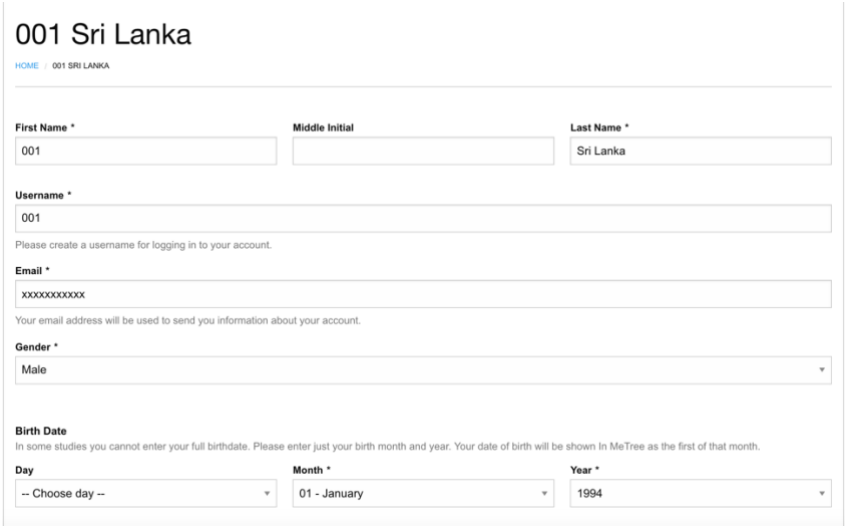

Figure 1 – Example of Account Page in MeTree

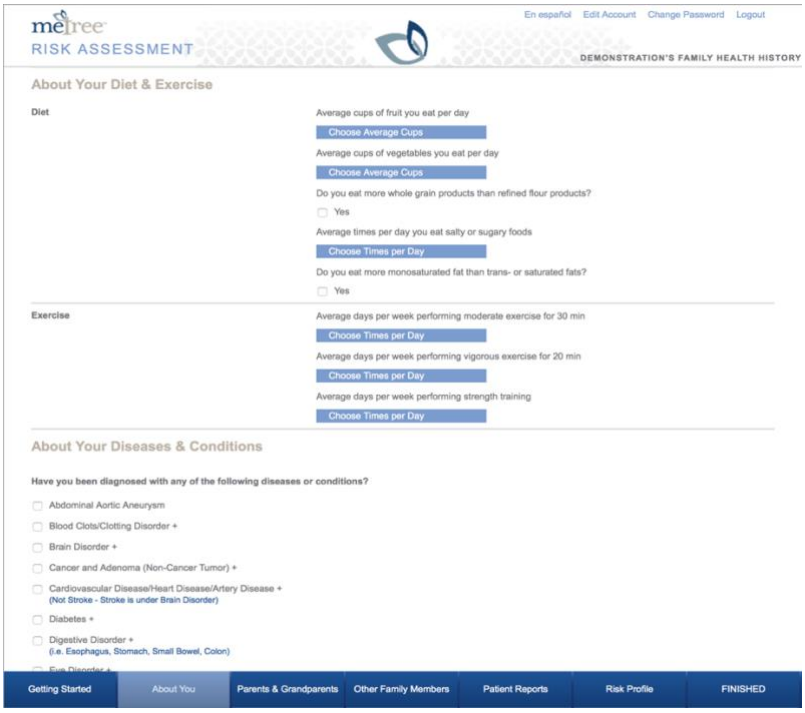

Figure 2 – MeTree Example of Gathering Medical Information for The Index Participant

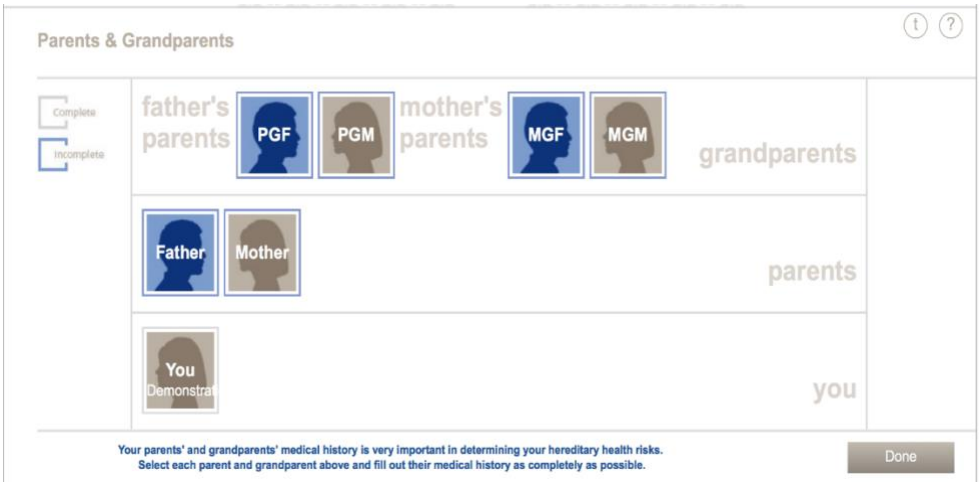

Figure 3 – MeTree Example of Patient Pedigree

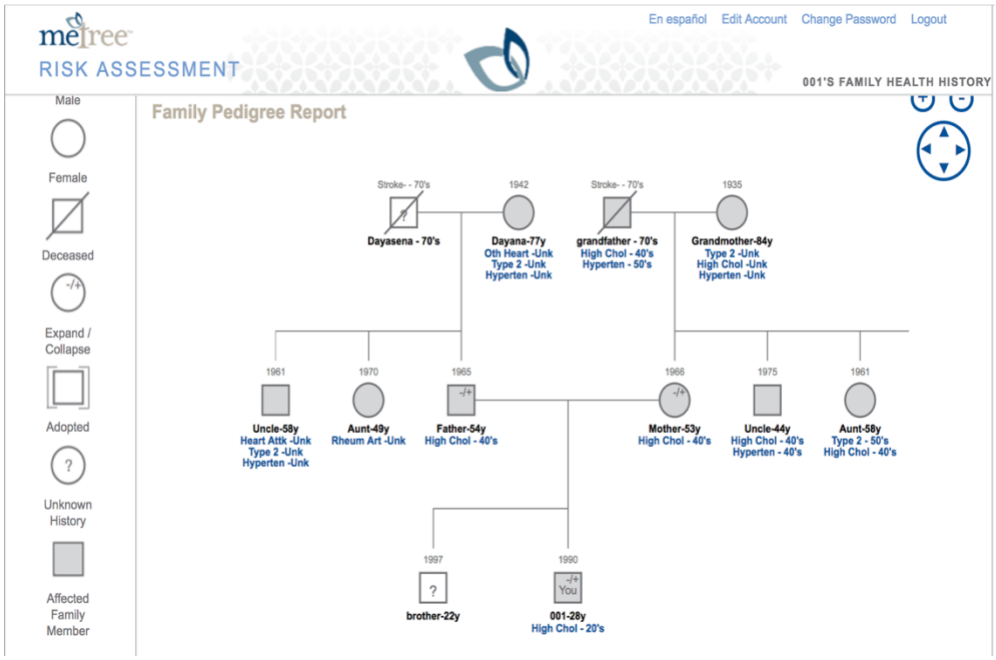

Figure 4 – MeTree example of Finalized Patient Pedigree Report

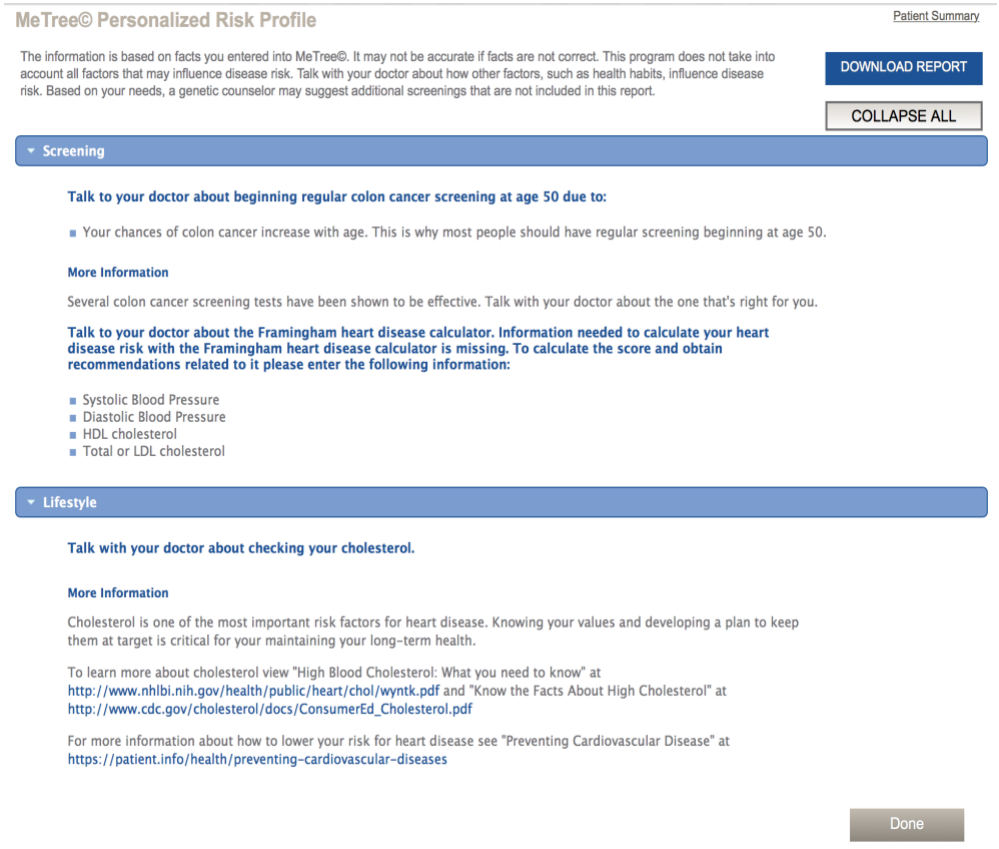

Figure 5 – Example of MeTree Personalized Patient Risk Report

- Paper-based questionnaire

A paper-based questionnaire was developed by the researcher based on previous questionnaires used in researches focused on evaluating participants' experience and perceived benefits with MeTree conducted by the MeTree team. There were 21 questions in total in the questionnaire. The questions included the participants' general information such as gender, major and grade, how easy and useful the participants thought to use MeTree, as well as how the participants' awareness of the increased risk for diseases changed after being introduced to MeTree.

2.4 Procedures

There were mainly two parts in the data collection procedures:

- Entering information into MeTree

All participants were asked to give informed consent prior to participation. An information letter which introduced what MeTree was and what would be asked in MeTree was distributed to each of the participants after they gave consent to participate. The information letter also included a worksheet which helped the participants collect family health histories from their relatives. The students took the worksheet back home, collected medical information from their family members and then came back to enter their family health histories into MeTree by themselves, with the help from the researcher and a local research assistant in a computer lab provided by the University of Ruhuna. The time for each participant to complete entering all family health histories was recorded. MeTree was capable of generating a report suggesting that the participants might be at increased risk for certain

diseases and might need to talk to their doctors about the increased risks based on the records entered into MeTree. All participants were provided with the report through email after they completed all procedures in this study. MeTree's function of providing specific clinical suggestions was not used in this study out of ethical considerations.

- Experience related questionnaire

All participants were asked to complete a questionnaire about the experience and perceived benefits after being introduced with MeTree right after they finished entering information into MeTree. The completion time for each participant to finish entering information into MeTree was also recorded and kept records on the questionnaires. The paper-based questionnaires were then collected and entered into RedCap by the researcher.

All study procedures were approved by the ethical review boards at both Duke University and the University of Ruhuna.

2.5 Measures

The main summary measures in this study are:

1. The occurrences of diseases based on the records collected using MeTree. All diseases collected through MeTree will be grouped according to the disease pedigree provided by MeTree developing team. Frequencies and percentages among all participants and their relatives, among index participants only, and among the relatives only will be reported.
2. The characteristics of the family structure for each participant and the distribution of diseases within each family pedigree. The frequencies and

percentages for each of those disease groups which rank in the top 10 in terms of frequencies and percentages among all records will be calculated for relatives only and participants only.

3. The proportions of participants who have different feelings about the experience after being introduced with MeTree.
4. The proportions of participants who indicated their perceived benefits and the awareness of potential risk changed after being introduced with MeTree.
5. Differences between findings of studies conducted using MeTree in the United States and Sri Lanka.

2.6 Analysis

Data collected by MeTree was extracted from MeTree with the help of the MeTree team. Family health history pedigree data entered into MeTree was stored in a SQL database and analyzed using SAS statistical software. In order to measure the occurrences of common diseases among all participants and their relatives, we divided the reported diseases into 21 disease groups according to the pedigree of diseases developed by MeTree team and then calculated the frequency and percentage for each reported disease group. Frequency and prevalence of each disease group were also calculated for only among the index participants and only among the relatives to see if there were any differences in the distribution of the diseases between the index participants and the relatives. To explore the distribution of common diseases with pedigrees, for the top 10 most frequent disease groups among all participants and their relatives, number and percentage were calculated for participants who have at least one relative with the disease and for relatives with

this disease among all relatives. The average percentage of the relatives with this disease within each family was also calculated to see how many relatives on average within one family would have a certain common disease.

Paper-based questionnaires collected in this study were safely kept by Faculty of Medicine, University of Ruhuna, and data collected using questionnaires was entered into RedCap by the researcher right after the questionnaires were collected. Descriptive statistics were used to summarize participants' demographic characteristics. A mean and standard deviation (SD) was calculated for the time each participant used to complete entering all information into MeTree. To determine if there were any significant differences in completion time between different genders or grade years, we conducted a t-test for completion time by genders, an ANOVA procedure comparing completion rime by grades. We also correlated age and completion time. An alpha level of 0.05 was used for all hypothesis tests. In order to explore the answers gathered by paper-based questionnaires, the frequency and percentage for each different answer of each question asking about the participants' experience and the change in their perceived benefit and awareness for potential risk introduced by family health history were calculated. To determine if there were significant differences in any of the answers for each question among different genders and grades, we performed Chi-square test of independence for each question in terms of gender and grade at the 5% significance level.

During the summer of 2018, there was another study conducted in Robeson County, a rural county in North Carolina, using MeTree to collect family health history. To explore if there were any differences between results from two studies

conducted both using MeTree in the United States and Sri Lanka, comparison was made between this study and the Robeson study with the permission from the authors of the Robeson study. Fisher's exact test was conducted to compare results of family health completion rate, occurrences of common diseases and distribution of diseases between index participants and relatives.

3. Results

3.1 Participant Characteristics

Three hundred four participants in total were enrolled in this study. All participants were medical students at the Faculty of Medicine in the University of Ruhuna, with a median age of 25. The proportion of males and female were relatively similar at 52.63% and 47.37%, respectively. Since all students were born and raised in Sri Lanka, the ethnic group for all participants were marked as Asian according to the records in MeTree. Education level for all participants were all marked as 4-year college according to the categories provided in MeTree, while some of the students were from the fifth grade or higher grade. Students were not supposed to have income at the time this study was conducted, therefore the income level for all participants were marked with the lowest income level provided in MeTree as up to $20000. Other specific characteristics are listed in Table 1.

Family health histories were entered for 3352 relatives in total. The mean pedigree size was 11, ranging from 7-30 family members. The distribution of gender for relatives, living status and relative types are summarized in Table 2.

Table 1 - Study Index Participant Demographics (N=304)

Age	Median 25
	Mean 26
	Range 22-30
Gender	Male 160(52.63%)
	Female 144(47.37%)
Ethnic group	Asian (100%)
Occupation	Student (100%)
Education level	4-year College (100%)
Income level	Up to $20000 (100%)

Table 2 – Study Relatives Characteristics (N=3352)

Measures	Frequency (Percentage)
Relative types	Aunt on the mother's side 223 (6.65%)
	Cousin on the mother's side 12 (0.36%)
	Grandfather on the mother's side 304 (9.07%)
	Grandmother on the mother's side 304 (9.07%)
	Uncle on the mother's side 194 (5.79%)
	Bother 195 (5.82%)
	Nephew 4 (0.12%)
	Father 304 (9.07%)
	Niece 6 (0.18%)
	Mother 304 (9.07%)
	Sisters 187 (5.58%)
	Aunt on the father's side 169 (5.04%)
	Cousin on the father's side 8 (0.24%)
	Grandfather on the father's side 304 (9.07%)
	Grandmother on the father's side 304 (9.07%)
	Uncle on the father's side 226 (6.74%)
	Index participant 304 (9.07%)
Gender for relatives	Female 1649 (49.19%)
	Male 1703 (50.81%)
Living status	Alive
	Dead
	Unknown
	Missing

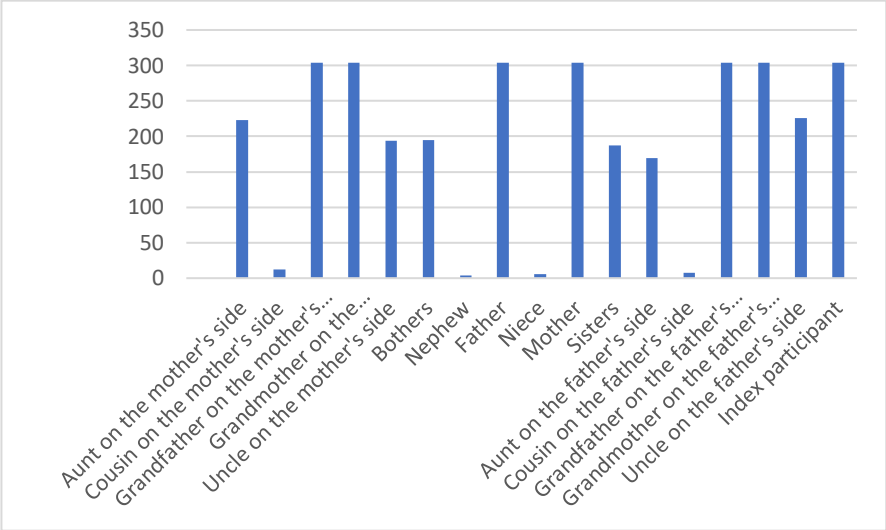

Figure 6 – Distribution of Relative Types

3.2 Disease Occurrences and Characteristics within Pedigrees

- Frequencies and Percentages for Common Diseases

The total records entered into MeTree for all index participants and their relatives were 3308, and the number of diseases present among all participants and relatives was 87. All diseases were divided into 21 groups according to the pedigree of diseases developed by MeTree team. The name for each disease group represented a parent disease under which contains sub-category diseases, or a disease which couldn't be assigned under any parent disease. Disease frequency and prevalence for 21 disease groups among all participants and relatives, among index participants only and among relatives only are listed in Table 3.

We also evaluated the conditions reported by index participants themselves (n=304) compared to conditions reported for their relatives (n=3352) for each disease group. As showed in Table 3, most reported diseases were for the relatives instead of the index participants themselves. Relatives had much higher counts of all disease groups compared to index participants. Percentage of relatives accounted for the reported disease were all higher than 80% except for digestive disorder (62.50%). Index participants accounted for 37.50% reported records for digestive disorder, which was the highest proportion index participants accounted for among all disease groups, but still lower than 50%. Prevalence for each disease was different between index participants and the relatives. For the index participants, the most common disease according to the prevalence was lung disease with a prevalence of 6.58%, followed by eye disorder (5.92%) and digestive disorder (4.93%). For the relatives, the ranking of disease groups according to the prevalence only among the relatives

corresponded to the ranking of disease groups according to the frequency and percentage among all records (both index participants and their relatives.)

The top ten common disease groups in terms of the frequency those diseases showed in the records entered into MeTree among all index participants and their relatives were diabetes, hypertension, cardiovascular diseases, high cholesterol, cancer, lung disease, eye disorder, obesity, kidney disease, and brain disorder. Diabetes was the most common disease group reported and accounted for 24.58% of all diseases reported. The following two most frequent diseases were hypertension, listed as a separate category, accounted for 14.51% of all diseases reported and cardiovascular diseases, accounted for 12.06% of all diseases reported.

- Characteristics of Disease Distribution within Pedigrees

The top 10 most frequent disease groups were used to explore the distribution of common diseases within each pedigree. Diabetes, the most frequent disease reported, was present in at least one or more family members in 60.86% of all pedigrees. Hypertension was present in at least one or more family members in 65.13% of all pedigrees, higher than diabetes although its frequency among all records was less than diabetes. The average percentage of the relatives with this disease within each family was calculated by averaging the proportion of relatives who have the certain condition or disease among all relatives within each pedigree, showing that for each common disease, what was the average proportion of relatives who have this disease for each pedigree. Diabetes was still the leading disease regarding to the average percentage of the relatives with this disease within each family. On average, 29.92% of relatives in each family would have diabetes. The

specific number/percentage of participants who had at least one relative with the disease, number/percentage of relatives with this disease among all relatives, and the average percentage of the relatives with this disease within each family for each top 10 disease are listed in Table 4.

Table 3 – Frequency and Prevalence for Disease Groups

Disease group	Frequency (percentage) among all participants and relatives	Frequency among index participants	Prevalence among index participant	Frequency among relatives	Percentage of relatives accounted for the reported disease	Prevalence among relatives
Diabetes	813 (24.58%)	0	0.00%	813	100%	24.25%
Hypertension	480 (14.51%)	0	0.00%	480	100%	14.32%
Cardiovascular Disease	399 (12.06%)	4	1.32%	395	99.00%	11.78%
High Cholesterol	364 (11.00%)	4	1.32%	360	98.90%	10.74%
Cancer	227 (6.86%)	8	2.63%	219	96.48%	6.53%
Lung Disease	205 (6.20%)	20	6.58%	185	90.24%	5.52%
Eye Disorder	165 (4.99%)	18	5.92%	147	89.09%	4.39%
Obesity	93 (2.81%)	6	1.97%	87	93.55%	2.60%
Kidney Disease	81 (2.45%)	4	1.32%	77	95.06%	2.30%
Brain Disorder	78 (2.36%)	0	0.00%	78	100%	2.33%
Psychological Disorder	77 (2.32%)	6	1.97%	71	92.21%	2.12%
Other	75 (2.27%)	13	4.28%	62	82.67%	1.85%
Thyroid Disease	66 (1.99%)	5	1.64%	61	92.42%	1.82%
Osteoporosis	50 (1.51%)	0	0.00%	50	100%	1.49%
Rheumatoid Arthritis	45 (1.36%)	0	0.00%	45	100%	1.34%
Digestive Disorder	40 (1.21%)	15	4.93%	25	62.50%	0.75%
Liver Disease	34 (1.03%)	2	0.66%	32	94.12%	0.95%
Blood Clots/Clotting Disorder	9 (0.27%)	0	0.00%	9	100%	0.27%
Hereditary Cardiovascular Syndrome	4 (0.12%)	0	0.00%	4	100%	0.12%
Abdominal Aortic Aneurysm	1 (0.03%)	0	0.00%	1	100%	0.03%
Lupus	1 (0.03%)	0	0.00%	1	100%	0.03%

* Prevalence among index participant = frequency among index participant / total number of index participants (n=304)

Prevalence among relatives = frequency among relatives / total number of relatives (n=3352)

Table 4 – Distribution of Top 10 Frequent Diseases within Pedigrees

	Number (percentage) of participants who have at least one relative with the disease	Number (percentage) of relatives with this disease among all relatives	Average percentage of the relatives with this disease within each family
Diabetes	185 (60.86%)	813 (24.25%)	29.92%
Hypertension	198 (65.13%)	480 (14.32%)	17.58%
Cardiovascular Disease	120 (39.47%)	395 (11.78%)	14.15%
High Cholesterol	165 (54.28%)	360 (10.74%)	13.07%
Cancer	71 (23.36%)	219 (6.53%)	7.60%
Lung Disease	69 (22.70%)	185 (5.52%)	6.87%
Eye Disorder	68 (22.37%)	147 (4.39%)	5.87%
Obesity	61 (20.07%)	87 (2.60%)	3.25%
Kidney Disease	32 (10.53%)	77 (2.30%)	2.81%
Brain Disorder	30 (9.87%)	78 (2.33%)	2.78%

* Percentage of participants who have at least one relative with the disease = number of participants who have at least one relative with the disease / total number of index participants (n=304)

Percentage of relatives with this disease among all relatives = number of relatives with this disease among all relatives / total number of relatives (n=3352)

Average percentage of the relatives with this disease within each family = $\frac{\sum \frac{number\ of\ relatives\ who\ have\ a\ certain\ disease\ in\ this\ pedigree}{total\ number\ of\ relatives\ in\ this\ pedigree}}{total\ number\ of\ pedigrees\ (n=304)}$

3.3 Users' Experience with MeTree

There were originally 21 questions in total in the paper-based questionnaire, 2 were deleted due to duplication in content. Among the remaining 19 questions, the first 4 questions asked about the basic information of the participants including gender, age, major and grade. The following 15 questions were divided into three parts for data analysis, and the three parts were: overall feelings for MeTree, users' experience with MeTree and perceived benefits after being introduced with MeTree.

Under "Overall feelings for MeTree" part, questions included the overall satisfaction level for using MeTree, as well as the probability for the participants to recommend MeTree to others and for MeTree to be generalized in the context of Sri

Lanka. 68.3% of the participants reported their satisfaction level above as "very satisfactory" and "superior"; 97.7% participants indicated they would be very likely, likely or somewhat likely to recommend MeTree to others; 94.4% of participants indicated that MeTree would be very likely, likely or somewhat likely to be generalized in the context of Sri Lanka.

Table 5 – Questions and Answers for "Overall Feelings for MeTree"

	Very poor	Somewhat Unsatisfactory	About Average	Very Satisfactory	Superior	Missing
How satisfied are you with your experience using MeTree	1 (0.3%)	4 (1.3%)	85 (28.3%)	180 (60.0%)	25 (8.3%)	5 (1.7%)
	Very Likely	Likely	Somewhat Likely	Unlikely	Not Likely	Missing
Overall how likely would you be to recommend MeTree to others?	89 (29.7%)	171 (57.0%)	33 (11.0%)	1 (0.3%)	0 (0.0%)	6 (2.0%)
Overall how likely do you think MeTree can be put into real practice in the context of Sri Lanka?	60 (20.0%)	165 (55.0%)	58 (19.3%)	12 (4.0%)	1 (0.3%)	4 (1.3%)

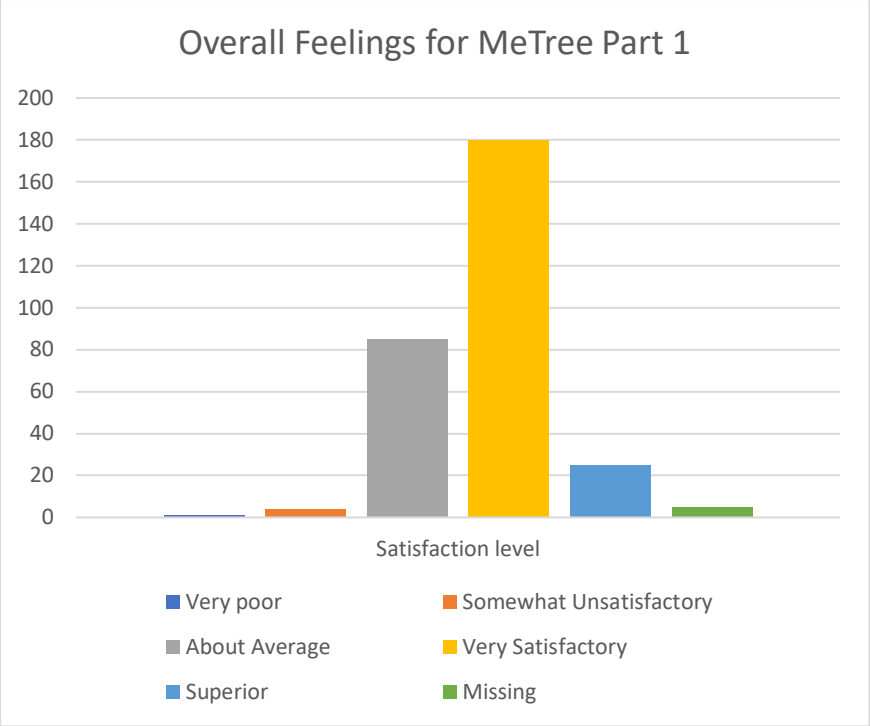

Figure 7 - Histogram for "Overall Feelings for MeTree", Part 1

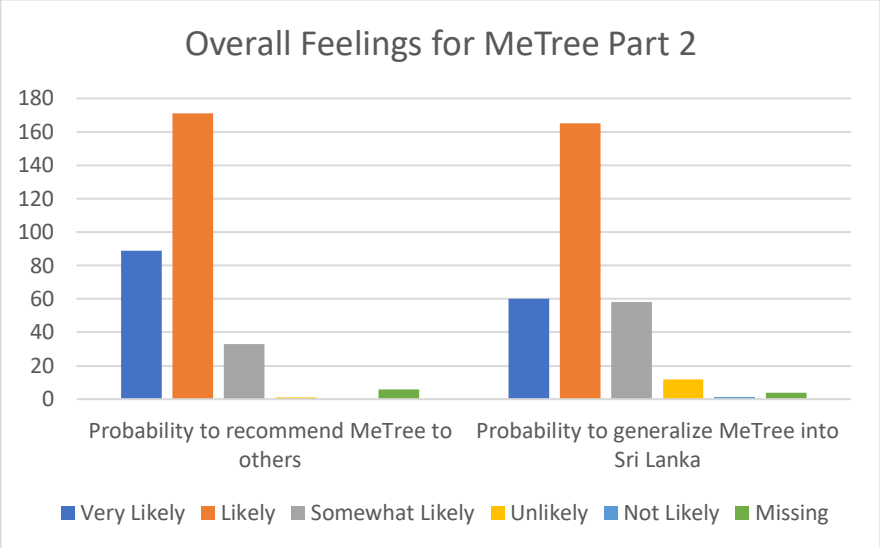

Figure 8 – Histogram for "Overall Feelings for MeTree", Part 2

Under "Users' experience with MeTree" part, questions asked about the ease to complete MeTree, potential anxiousness participants experienced when completing MeTree, the layout of MeTree, the information collection process and the usefulness to complete MeTree. Over 90% of participants reported that MeTree was

easy to use and the questions were easy to understand; 81.3% of participants reported that they didn't experience anxiousness during entering information into MeTree; 95.3% of participants suggested the layout and design of MeTree made it easy to fill in the information; 96.3% of participants considered completing MeTree a useful experience; 95.7% of participants indicated that the worksheet and information sheet provided were helpful with collecting information; it's worth noting that, 60.3% of participants hadn't talked with relatives about our family's health history before using MeTree, and over half of the participants (53.3%) suggested they didn't have enough information about some people in my family when completing MeTree.

Table 6 – Questions and Answers for "Users' Experience with MeTree"

	Yes	No	I don't know	Missing
The MeTree program was easy to use.	292(97.3%)	2(0.7%)	2(0.7%)	4(1.3%)
Answering the questions made me anxious.	28(9.3%)	244(81.3%)	22(7.3%)	6(2.0%)
The questions were easy to understand.	294(98.0%)	1(0.3%)	1(0.3%)	4(1.3%)
The layout and design of the interface made it easy to fill in the information.	286(95.3%)	4(1.3%)	6(2.0%)	4(1.3%)
Completing MeTree is a useful experience.	289(96.3%)	1(0.3%)	6(2.0%)	4(1.3%)
The family history form used to help collect information was helpful.	287(95.7%)	3(1.0%)	6(2.0%)	4(1.3%)
I talked with relatives about our family's health history before using MeTree.	108(36.0%)	181(60.3%)	6(2.0%)	5(1.7%)
I didn't have enough information about some people in my family when completing MeTree.	160(53.3%)	108(36.0%)	23(7.7%)	9(3.0%)

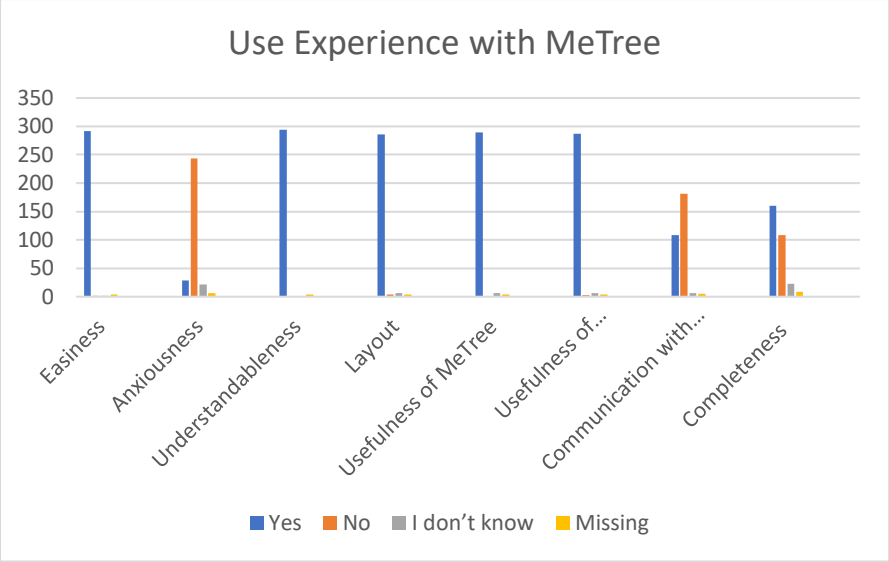

Figure 9 – Histogram for "Users' Experience with MeTree"

Under "Perceived benefits after being introduced with MeTree" part, questions asked about the change of awareness for increased risk and knowledge about family health history, as well as how helpful participants thought the suggestions provided by MeTree and drawing out a family tree in MeTree would be. 94.3% of participants indicated they agreed or somewhat agreed that completing MeTree made them more aware of health risks in general within their family; 85.4% of participants indicated they agreed or somewhat agreed that knowing their family health history has changed how they thought about their health; over 90% participants agreed or somewhat agreed the suggestions provided by MeTree and having their family tree drawn out would be helpful to them. Specific questions and proportions for answers are listed in Table 5,6,7 and Figure 7, 8, 9, 10.

Table 7 – Questions and Answers for "Perceived Benefits after Being Introduced with MeTree"

	Agree	Somehow agree	Neutral	Somehow disagree	Disagree	Missing
Completing MeTree made me more aware of health risks in general within my family.	85(28.3%)	198(66.0%)	13(4.3%)	0(0.0%)	2(0.7%)	2(0.7%)
Knowing my family health history has changed how I think about my health.	74(24.7%)	182(60.7%)	39(13.0%)	1(0.3%)	2(0.7%)	2(0.7%)
The suggestions MeTree gave are helpful to me.	76(25.3%)	195(65.0%)	22(7.3%)	0(0.0%)	3(1.0%)	4(1.3%)
Having my family tree drawn out is helpful to me.	101(33.7%)	175(58.3%)	18(6.0%)	1(0.3%)	2(0.7%)	3(1.0%)

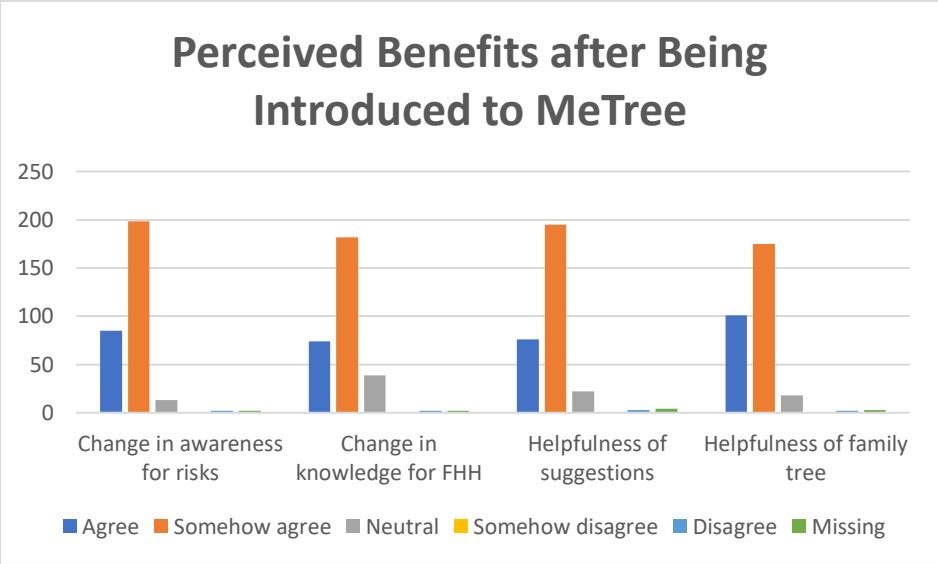

Figure 10 – Histogram for "Perceived Benefits after Being Introduced with MeTree"

The mean time to complete entering information into MeTree was 36.3 minutes. The minimum time used to complete entering was 10 minutes, and the maximum was 78 minutes, with a range of 68 minutes. A t-test was conducted for completion time by genders, an ANOVA procedure was conducted for completion time by grade years, and a correlation procedure was conducted between completion

time and age, to see whether there were any differences in completion time among different genders, grade years, and ages. Results from t-test didn't indicate any significant preference for completion time used by males (M = 35.51, SD = 11.47) over completion time used by females (M = 37.04, SD =11.04), t = 0.65, p = 0.5177. A significant effect of grade on completion time wasn't observed at the $p< 0.05$ level in the ANOVA procedure either, for the three conditions F (3, 83) = 1.80, p = 0.1539. According to the correlation procedure, completion time and age were not correlated (r = 0.2129, p = 0.13182).

A chi-square test of independence was performed to examine the relation between answers for each question and genders or grades. The Chi-squared values and p values for each question between gender and grade are reported in Table 8. Among all questions, significant difference was only observed between males and females for reported awareness ($p=0.0184$) and knowledge ($p<0.0001$) change after being introduced with MeTree. Females were more likely to report "Agree" for those two questions. Significant difference was not observed according to Chi-square test for answers to other questions among different genders or grades.

Table 8 – X^2 and P Values for Each Question Between Gender and Grade

	Gender (X^2, p)	Grade (X^2, p)
How satisfied are you with your experience using the web-based portal to enter information?	5.3312, 0.2550	13.9154, 0.1254
Overall how likely would you be to recommend this process (using the web to provide information to your physician so that risk scores can be calculated and discussed at the time of your visit) to your family or friends?	2.3365, 0.3109	11.7459, 0.0678
Overall how likely do you think MeTree can be put into real practice in the context of Sri Lanka?	2.0194, 0.5684	8.7395, 0.4617
The MeTree program was easy to use.	0, /	0, /
Answering the questions made me anxious.	1.2300, 0.5406	12.0784, 0.0602
The questions were easy to understand.	0, /	0, /
The layout and design of the interface made it easy to fill in the information.	2.9340, 0.2306	7.1067, 0.3111
Completing MeTree is a useful experience.	1.1006, 0.2941	3.9336, 0.2687
The family history form used to help collect information was helpful.	0.9282, 0.3353	3.9336, 0.2687
I talked with relatives about our family's health history before using MeTree.	0.5246, 0.7693	2.5643, 0.8612
I didn't have enough information about some people in my family when completing MeTree.	4.1144, 0.1278	9.0074, 0.1732
Completing MeTree made me more aware of health risks in general within my family.	7.9887, 0.0184	8.9223, 0.1780
Knowing my family health history has changed how I think about my health.	19.1032, <0.0001	9.9708, 0.1259
The suggestions MeTree gave are helpful to me.	0.8730, 0.6463	5.1237, 0.5281
Having my family tree drawn out is helpful to me.	2.9016, 0.2344	9.3608, 0.1543

3.4 Comparison of Findings between U.S. and Sri Lanka

Based on the results from Fisher's Exact Tests conducted between the results from this study and the Robeson study, for the completion of family health history, all participants from the two studies entered information for at least three generations of relatives and for both maternal and paternal lineage. Genders for all relatives are entered in both studies as well, while the completion rate for age of onset, age of death and cause of death are different. For the frequencies of commonly reported diseases in two studies, significant difference was observed in all diseases except for hypertension. For the distribution of diseases between index participants and relatives in two studies, significant difference was observed for the prevalence

among index participants for all diseases, while the prevalence of hypertension and psychological disorder were not significantly different in two studies.

Comparison of commonly reported metrics and p-values for Fisher's Exact Tests are listed in Table 9,10,11.

Table 9 – Comparison of Completion of Family Health History in Two Studies

	Completion Rate for Wittmer. Et al., 2018	Completion Rate in This Study	Fisher's Exact Test Value (P<0,05)
Three Generations of Relatives	100%	100%	1
Maternal or Paternal Lineage	100%	100%	1
Gender of Relatives	100%	100%	1
Age of Onset of Disease	65.7%	55.8%	<0.00001
Age of Death	73.0%	87.8%	<0.00001
Cause of Death	74.7%	81.4%	0

Table 10 – Comparison of Frequencies for Common Diseases in Two Studies

	Frequency (Percentage) for Wittmer. Et al., 2018	Frequency (Percentage) for This Study	Fisher's Exact Test Value (P<0,05)
CVD	159(17.1%)	399 (12.06%)	0.0001
Cancer	113(12.2%)	227 (6.86%)	<0.00001
Hypertension	117(12.6%)	480 (14.51%)	0.1496
Diabetes	107(11.5%)	813 (24.58%)	<0.00001
Kidney Disease	12(1.2%)	81 (2.45%)	0.0313

Table 11 – Comparison of Distribution of Diseases Between Index Participants and Relatives in Two Studies

	Wittmer. Et al., 2018		This Study		Fisher's Exact Test Value (P<0,05)	
	Prevalence for Index Participants	Prevalence for Relatives	Prevalence for Index Participants	Prevalence for Relatives	Prevalence for Index Participants	Prevalence for Relatives
Cancer	13.64%	16.18%	2.63%	6.53%	0.04	< 0.00001
CVD	31.82%	20.99%	1.32%	11.78%	< 0.00001	< 0.00001
High Cholesterol	59.09%	4.23%	1.32%	11.74%	< 0.00001	< 0.00001
Hypertension	72.73%	12.39%	0.00%	14.32%	< 0.00001	0.2045
Kidney Disease	29.54%	4.37%	1.32%	2.30%	< 0.00001	0.0038
Obesity	22.73%	1.02%	1.97%	2.60%	< 0.00001	0.0116
Psychological Disorder	9.09%	2.33%	1.97%	2.12%	0.0265	0.6675

4. Discussion

4.1 Findings of Disease Occurrences and Characteristics within Pedigrees

Among all the diseases reported and listed in MeTree, the most common disease among all the participants and their relatives was diabetes, followed by hypertension and cardiovascular disease. Relatives had much higher counts of all disease groups compared to index participants. Percentage of relatives accounted for the reported disease were all higher than 80% except for digestive disorder. The distribution of diseases was different if we separated the index participants from their relatives when considering the disease frequency and prevalence. For the index participants, the most common disease was lung disease, followed by eye disorder and digestive disorder; for the relatives, the ranking of disease groups corresponded to the ranking of disease groups according to the frequency and percentage among all records (both index participants and their relatives). The reason for this could be that the participants included were all university students, which were not the major affected population for diseases such as diabetes, hypertension and cardiovascular diseases. The significant pressure and work load medical students experienced every day could explain why diseases such as lung disease, eye disorder and digestive disorder were more prominent than other diseases among the index participants.

Hypertension was the disease which had the most pedigrees with at least one relative having a certain disease, followed by diabetes and high cholesterol, indicating that these diseases were the most possible ones to appear in the pedigrees among the study population. On average, 29.92% of relatives in each family among

the study population would have diabetes, suggesting that diabetes was one of the urgent tasks to be faced considering from the family health history perspective.

According to the Sri Lanka non-communicable disease profile in 2016, the most prevalent NCD in Sri Lanka is cardiovascular diseases, followed by cancers and chronic respiratory diseases[28]. Diabetes is the 4th most prevalent NCD. The order of non-communicable diseases from the results in this study does not correspond to the country disease profile. Potential reasons could be that the disease profile has changed since 2016, and that results generated from the population included in this study were not able to be generalized to the general population. Reasons for this limitation will be discussed in a later section. Besides, the fundamental purpose of this study was to explore the patterns of collected data using MeTree in the context of Sri Lanka. Although the cohort of participants included in this study might not be representative enough so that we wouldn't be able to estimate the disease occurrences for the country or even for the area where this study was conducted based on the results obtained in this study, there are still values to report the diseases occurrences as the first step to explore patterns of collected data using MeTree in low-income settings. The results can also provide helpful evidence for the local governments in terms of future monitor and control for diseases from the family health perspective.

4.2 Findings of Users' Experience with MeTree

The overall feelings and satisfaction level towards MeTree were favorable according to the answers from the questionnaires. The majority of participants reported a satisfactory experience with MeTree and the willingness to introduce

MeTree to others. Most participants indicated that MeTree was an easy program to use, while there might still be some participants who find it difficult to enter information into MeTree considering the completion time for each participant to finish entering ranged from 10 minutes to 78 minutes. The potential reason could be that the questions in MeTree were not translated into the local language. Although the participants in this study were all capable of reading and speaking in English, sometimes it's still time-consuming to understand and answer questions in a language that was different from their first language. Besides, some participants provided some opinions in terms of the design of MeTree, including that the classification of "Occupation (Job)" was not very comprehensive and rational in the context of Sri Lanka; Some of the diseases listed in MeTree were not common in Sri Lanka, while some local common diseases were not mentioned (e.g. psoriasis, fibroadenoma, liver diseases); and it might be better to add a "No" or "Other" option for diseases that were not hereditary or if some details were not known by the participant. The majority of participants (over 80%) also reported that their awareness for increased risk and knowledge towards family health history had changed after being introduced with MeTree and they found using MeTree a useful experience.

Over 90% of participants indicated that MeTree would be very likely, likely or somewhat likely to be generalized in the context of Sri Lanka, while there were also some opinions raised through informal conversations and the suggestion section at the end of the questionnaire toward the existent barriers for MeTree to be generalized into Sri Lanka. Based on the feedbacks provided by the participants and

information we collected during the process of conducting this study, reasons why it might be difficult for MeTree to be put into real practice in Sri Lanka at this moment include:

1. Language limitation: The majority of the general population in Sri Lanka is not fluent in English, so it is difficult for them to enter information into MeTree if MeTree is not translated into the local language.
2. Knowledge limitation: The understandings about their own medical history can be limited for most of the general public. Therefore, some participants thought that MeTree could only be introduced to medical-related professionals.
3. Equipment limitation: Not everyone owns a computer or laptop in their homes in Sri Lanka, so it is difficult to have the general public complete MeTree at home by themselves; besides, the hospitals and clinics in Sri Lanka still use paper forms to collect medical records from the patients instead of using computers and digital forms. It is also difficult to have the providers use MeTree and collect family health history from the patients during daily outpatient service. The internet and Wifi coverage are limited as well.
4. Privacy consideration: Some people are not willing to reveal their personal information including medical records even to their family members.
5. System limitation: The system of keeping patients' medical records inside the hospital still needs to be improved. The medical history is mainly from the records on a booklet which is kept by the patients themselves.

There weren't any significant differences in either completion time or the answers to most of the questions among different genders, age or grades. The only two questions that significant differences were observed between males and females were about awareness and knowledge change after being introduced with MeTree. Females were more likely to report "Agree" than "Somehow agree" for those two questions. The sex ratio of participants in this study was nearly 1:1 (160:144), thus the observed difference could not be attributed to the difference in sexual distribution. Potential reasons could just be random differences by gender to report different answers under certain circumstances, such as completing a study with compensation.

Based on the results we got and what we learnt during conducting this study, MeTree can be considered helpful with increasing the awareness of risks and knowledge towards family health history in the context of Sri Lanka. MeTree can also be used to help organize and collect electronic medical history considering the current system for collecting data and providing actionable information in Sri Lanka is inadequate. It's worthwhile generalizing MeTree into the primary clinics or the general community in Sri Lanka after the previously mentioned barriers are thoroughly considered. Patients can use MeTree to collect and organize their own family health history with the help from the providers or the social health workers during their leisure time, so that they will be able to present a completed family history for the providers' reference during each visit or when they are referred to a different provider who might understand enough about the patients' histories. In that way, the current situation of disorganizing medical information and inadequate

utility of family health history in Sri Lanka can be better improved by introducing MeTree into Sri Lanka.

4.3 Findings of Comparison between Two Studies in the U.S. and Sri Lanka

In terms of the comparison made between this study and the Robeson study, we couldn't draw any specific conclusions from the comparison considering the sampling method and source population were totally different in these two studies, but could only look at the differences in the completion rate for MeTree and some occurrences for commonly reported diseases. One potential reason for the differences in the completion rate between two studies was that the participants in this study didn't have enough time to collect specific family health history such as the onset time of certain diseases from their relatives and had to enter information mostly based on their memories, which might lead to the incompletion of some information in their family health history.

Another prominent difference observed in the distribution of diseases between index participants and relatives was that the prevalence for each disease among index participants was much lower compared to the study conducted in the United States. The reason for this phenomenon is that all participants included in this study were university students, which should be considered as a relatively healthier population compared to the cohort included from an ongoing study for chronic kidney diseases, who were at a wide range of age, in the Robeson study.

4.4 Implications for Practice and Further Research

According to the feedback from the participants in this study, the next step for MeTree to be better generalized into different contexts is to translate MeTree into

different languages according to the areas where MeTree is going to be put into real practice. Besides, the diseases and conditions listed in MeTree might need to be adjusted according to the local disease profile. Furthermore, the developing team of MeTree can also consider making MeTree applicative on smart phones by either redesigning the web pages to be suitable for phone screens or developing an app so that MeTree can be run on smart phones as well. The reason to do so is that smart phones are way more prevalent compared to computers in low-income settings and using phones instead of computers for entering information into MeTree can be more convenient and realizable. Currently, more research is needed to better explore the utility of web-based tool like MeTree in different settings and the feasibility to generalize them into different contexts. The potential participants for future studies can be patients at primary clinics or general members from the communities, providing different thoughts and opinions from those provided by medical students in this study.

Different economic, cultural and health system backgrounds make it more challenging to generalize modern science technology into some underdeveloped countries like Sri Lanka. Despite the fact that having access to computer and internet is essential for using web-based tools, computers and the internet are not as widespread in Sri Lanka as in America or other advanced countries. This research was conducted on campus using a computer lab without worries about research required equipment or infrastructure. However, we will need to figure out a way to provide enough computers for the participants if we hope to target the general public or patients from primary clinics in future studies. Reflecting on the experience

from this research, it's of great importance for researchers to take into full consideration the background information about the target population and the location where the research is going to be conducted, so that potential barriers can be identified ahead of time and responding solutions can be made in the design stage to ensure a smooth implement of the research, as well as avoiding potential bias that can be introduced by improper study design.

4.5 Study Strengths and Limitations

This study is among the first studies to use web-based tools to collect family health history in a developing country. This study reveals the utility of web-based tools like MeTree for patients in developing settings like Sri Lanka, also provides enlightening evidence for improving and generalizing wed-based tools like MeTree as well. It also builds a foundation for future research about how studies about family health history can be better designed and conducted in developing settings, as well as inspires any further questions or hypothesizes that can be drawn about collecting family health history using a web-based tool like MeTree. The sample size of 304 in this research is relatively large and a large sample size helped to decrease sampling error. In addition, almost every enrolled student completed both of the two parts in this research, resulting in a high response rate and helped avoid nonresponse bias. Reflecting from the aspect of study design, this research is a cross-sectional study in design. The study design enables us to collect data for various types of variables within a short period of time with limited cost. It also allows us to provide an overall snapshot of the characteristics of the health histories in the

medical students' family structure and the occurrences of the common diseases in Sri Lanka at a given time point.

One major limitation in this study was caused by the sampling method. The sampling method used in this research can be considered as convenience sampling. The medical students recruited in this research were all contacted by Prof.Vijitha, who is the direct professor or supervisor to all the participants. Even though convenience sampling can lead to simplicity of sampling and the ease of research, it is highly vulnerable to selection bias[37].

Another limitation in this study was that participants might not have enough time to collect family health history from their family members due to the special settings of this study. Participants in this study were all current university students who often live far away from home at the time this study was conducted, which made it impossible for them to talk to their relatives in person about the health histories within a relatively short period of time. Some participants also indicated that they had a so large family that they couldn't reach out to every relative and they even didn't have much contact or connection with some relatives anymore. In addition, the medical students were very busy and therefore hard to be contacted at the time this project was conducted. We tried to distribute the worksheets to potential participants either through Prof.Vijitha or students who had already completed the study. Some of the students showed up for the study on the same day they received the worksheet because they didn't have time to attend the study afterwards. Some students heard about the study from their friends and came without the worksheet, so there was not enough time for those students to use the

worksheet to collect family health history from their relatives. Information entered into MeTree was mainly from the memories or the current knowledge of the participants for their relatives' medical history, which might introduce recall bias.

Furthermore, the collection of family health history was only conducted among medical students in this study. Although their relatives can be considered as sampled from the general population, there's still a limitation in the representativeness of the enrolled cohort by only including medical students as index participants, which made some results from this study hard to be generalized into other populations.

5. Conclusion

The top three most common diseases among the medical students and their relatives in Sri Lanka were diabetes, hypertension and cardiovascular diseases. Distribution of diseases among the students themselves and the relatives was different. Most medical students found it easy to use MeTree and considered it a useful experience to enter their family health histories into MeTree. Change in awareness of risks and knowledge towards family health history were reported by and reported by most students. Although the majority of the students thought it possible to generalize MeTree in the context of Sri Lanka, barriers such as limitations in language, equipment and health system still remained to be solved to have web-based tools like MeTree put into real practice in Sri Lanka.

Appendix:

Appendix 1 – Consent Form

Utility and evaluation of MeTree for family health history collection

(July, 2018)

INFORMATION SHEET

This research study is conducted by Dr.Truls Ostbye and Ruoyu Hu, Master's student at Duke University's Global Health Institute in collaboration with Dr. HMM Herath and Dr. Vijitha De Silva at University of Ruhuna.

You are being asked to take part in this research study because you are age 18 years or older and are able to read and speak English. Research studies are voluntary and include only people who choose to take part. You are being asked to read and sign this informed consent to indicate you agree to participate in this study. Please read this consent form carefully and take your time making your decision. We encourage you to talk with your family and friends before you decide to take part in this research study. The nature of the study, risks, inconveniences, discomforts, and other important information about the study are listed below. You are welcomed to ask any questions during or after reading this consent form.

1. Purpose of the study

Family health history is a record of the diseases and health conditions in your family. Information about family history of illness is increasingly important to ensure each patient receives optimal promotion advice, preventive health services and appropriate treatment. MeTree is a web-based tool used to collect family and personal health history directly from participants through a website and can be completed by participants themselves. Despite growing evidence regarding the importance and efficacy of using family history, and the need for healthcare providers to have family history triage tools for personalized healthcare delivery, tools like MeTree have not been broadly applied in

clinical practice. Little is known about its utility in settings with different disease profiles, health care systems and traditions and different cultural and socioeconomic contexts. The purpose of this study is to examine the usefulness and results of an internet-based family health history collection software program (MeTree).

2. Voluntary participation

Your participation in this study is voluntary. You are free to not participate at all or to withdraw from the study at any time despite consenting to take part earlier. If you decide not to participate or withdraw from the study you may do so at any time.

3. Duration, procedures of the study and participant's responsibilities

You will be in the study from the moment you sign this consent form to the time when you finish entry family health information using MeTree. We would expect the study to end within a week. If you decide to participate, you will first sign this consent form. Next you will be provided with a worksheet to collect your family health history from your relatives. Then you will enter your family health history into the MeTree software program.

4. Potential benefits

You will be provided with a report generated by MeTree where there might be the conditions that you may have an increased risk of a certain disease and the recommendation to discuss with your doctors.

5. Risks, hazards and discomforts

There are no expected risks to you for participating in this research study.

6. Reimbursements

You would be paid $3(around 479 rupees) as compensation for your participation.

7. Confidentiality

We will keep this signed consent form in a separate and secure location and it will not be linked to the information you enter into MeTree. While the data we collect from this study may be presented in a master's thesis or published in a scientific journal, your identity will not be revealed. The study results and documentation will be retained for at least six years after the study is completed.

8. Termination of study participation

You may stop participating in this study at any time (with no penalty or effect on medical care or loss of benefits). Please notify the investigator as soon as you decide to withdraw your consent.

9. Clarifications

This study has been approved by the Ethics Review Committee of the Faculty of Medicine, University of Ruhuna. For questions about your rights as a participant in this research study, contact the University of Ruhuna IRB at 0912234801/803 Ext: 161 or ethics@med.ruh.ac.lk. For questions about the study, here are the information of the investigators of this research, you are welcomed to contact them about the study at any time.

Investigator	Telephone number	Email
Ruoyu Hu (Master's student at Duke University's Global Health Institute)	0767375084	rh224@duke.edu
Dr. Truls Ostbye (Professor at Duke University's Global Health Institute)	0775342500	truls.ostbye@duke.edu
Dr. Vijitha De Silva (Professor at Faculty of Medicine of University of Ruhuna)	0777609703	pvijithadesilva123@yahoo.com
Dr. HMM Herath (Senior Lecturer Doctor at Faculty of Medicine of University of Ruhuna)	0773453217	hmmherath@med.ruh.ac.lk

Utility and evaluation of MeTree for family health history collection

(July, 2018)

CONSENT FORM

Part A - To be filled by the participant

1. Have you read the information sheet? (Please keep a copy for yourself) YES/NO
2. Have you had an opportunity to discuss this study and ask any questions? YES/NO
3. Have you had satisfactory answers to all your questions? YES/NO
4. Have you received enough information about the study? YES/NO
5. Who explained the study to you? ……..……..
6. Do you understand that you are free to withdraw from the study at any time, without having to give a reason and without affecting your future medical care? YES/NO
7. Information held by the investigators relating to your participation in this study may be examined by other research assistants. All personal details will be treated as STRICTLY CONFIDENTIAL. Do you give your permission for these individuals to have access to your records? YES/NO
8. Have you had sufficient time to come to your decision? YES/NO
9. Do you agree to take part in this study? YES/NO

Participant's signature: ……..……

Date:…….

Name (BLOCK CAPITALS):

……

Part B - To be filled by the investigator

I have explained the study to the above volunteer and she has indicated her willingness to take part.

Signature of investigator: ……..... Date: ……..…….

Name (BLOCK CAPITALS): ……..…

Appendix 2 – Paper-based Questionnaire

This survey asks for your views and feelings about your experience with MeTree. Please answer every question by selecting the answer as indicated. If you are unsure about how to answer a question, please give the best answer you can.

MeTree start time: _____

MeTree end time: _____

Completion time: _____minutes

Part A

Study ID: _____

What is the date today: _____(month/day/year)

Part B: Please tell us about yourself

1. What is your age? ( )
2. What is your gender?

   1☐ Male

   2☐ Female
3. What is your major?

   1☐ Medical

   2☐ Nursing

   3☐ Pharmacy

4☐ Other (please specify) _____

4. Which grade are you in?

1☐ 1st

2☐ 2nd

3☐ 3rd

4☐ 4th

5☐ 5th

6☐ 6th

7☐ Above 6th

Part C: Please tell us about your overall feelings of this research using MeTree©

1. How satisfied are you with your experience using the web-based portal to enter information?

1☐ Very Poor

2☐ Somewhat Unsatisfactory

3☐ About Average

4☐ Very Satisfactory

5☐ Superior

2. Overall how likely would you be to recommend this process (using the web to provide information to your physician so that risk scores can be calculated and discussed at the time of your visit) to your family or friends?

1☐ Very Likely

2☐ Likely

3☐ Somewhat Likely

4☐ Unlikely

5☐ Not Likely

3. Overall how likely do you think MeTree can be put into real practice in the context of Sri Lanka?

1☐ Very Likely

2☐ Likely

3☐ Somewhat Likely

4☐ Unlikely

5☐ Not Likely

If not, please simply state why:

_____

Part D: Please tell us about your experience using MeTree©

1. The MeTree program was easy to use.

1☐ Yes

2☐ No

3☐ I don't know

2. Answering the questions made me anxious.

1☐ Yes

2☐ No

3☐ I don't know

3. The questions were easy to understand.

    1☐ Yes

    2☐ No

    3☐ I don't know

4. The layout and design of the interface made it easy to fill in the information.

    1☐ Yes

    2☐ No

    3☐ I don't know

Part E: Please tell us about your perceived benefits after using MeTree©

1. Completing MeTree is a useful experience.

    1☐ Yes

    2☐ No

    3☐ I don't know

2. The family history form used to help collect information was helpful.

    1☐ Yes

    2☐ No

    3☐ I don't know

3. I talked with relatives about our family's health history before using MeTree©

    1☐ Yes

    2☐ No

    3☐ I don't know

4. I didn't have enough information about some people in my family when completing MeTree.

    1☐ Yes (If yes, please simply specify why_____)

    2☐ No

    3☐ I don't know

5. I learned a lot about my family's health history that I did not know.

    1☐ Yes

    2☐ No

    3☐ I don't know

6. I am more aware of my health risks.

    1☐ Yes

    2☐ No

    3☐ I don't know

7. On a scale of 1 to 5, how much do you agree or disagree with each of the following statements. Please check in the corresponding box.

On a scale of 1 to 5, how much do you agree or disagree with each of the following statements.					
	Strongly Agree 1	**Agree 2**	**Neutral 3**	**Disagree 4**	**Strongly Disagree 5**

Completing MeTree made me more aware of health risks in general within my family.					
Knowing my family health history has changed how I think about my health.					
The suggestions MeTree gave are helpful to me.					
Having my family tree drawn out is helpful to me.					

Do you have any opinions or suggestions to our study?

Thank you for your time!

Appendix 3 – Family History Worksheet

(Please get as much information as possible from your relatives. The least things we need from you are the health histories from yourself, your parents and your grandparents.)

Yourself	Age now	Diseases you have had and age you were diagnosed Example: Breast Cancer (age 40); blood clots (age 20)

Your Brothers and Sisters	Age now or at death*	Diseases this person has had and age they were diagnosed Example: Breast Cancer (age 40); blood clots (age 20) If the person has died, please write cause of death

Your Parents	Age now or at death*	Diseases this person has had and age they were diagnosed Example: Breast Cancer (age 40); blood clots (age 20) If the person has died, please write cause of death
Mom		
Dad		

Your aunts and uncles on your *Mom's* side	Age now or at death*	Diseases this person has had and age* they were diagnosed Example: Breast Cancer (age 40); blood clots (age 20) If the person has died, please write cause of death

Your grandparents on your *Mom's* side	Age now or at death*	Diseases this person has had and age* they were diagnosed Example: Breast Cancer (age 40); blood clots (age 20) If the person has died, please write cause of death
grandmother		
grandfather		

* If you don't know their exact age, put approximate age.

Your aunts and uncles on your *Dad's* side	Age now or at death*	Diseases this person has had and age* they were diagnosed Example: Breast Cancer (age 40); blood clots (age 20) If the person has died, please write cause of death

Your grandparents on your *Dad's* side	Age now at death*	Diseases this person has had and age* they were diagnosed Example: Breast Cancer (age 40); blood clots (age 20) If the person has died, please write cause of death
grandmother		
grandfather		

* If you don't know their exact age, put approximate age.

Refences:

1. Family Health History: The Basics | CDC 2019. https://www.cdc.gov/genomics/famhistory/famhist_basics.htm (accessed February 22, 2019).

2. Sweet K, Sturm AC, Rettig A, McElroy J, Agnese D. Clinically relevant lessons from Family HealthLink: a cancer and coronary heart disease familial risk assessment tool. Genet Med 2015;17(6):493–500. https://doi.org/10.1038/gim.2014.136.

3. Sweet KM, Bradley TL, Westman JA. Identification and Referral of Families at High Risk for Cancer Susceptibility. J Clin Oncol 2002;20(2):528–37. https://doi.org/10.1200/JCO.2002.20.2.528.

4. Klemenc-Ketis Z, Peterlin B. Family History as a Predictor for Disease Risk in Healthy Individuals: A Cross-Sectional Study in Slovenia. PLoS ONE 2013;8(11). https://doi.org/10.1371/journal.pone.0080333.

5. Lushniak BD. Family Health History: Using the past to Improve Future Health. Public Health Rep 2015;130(1):3–5. https://doi.org/10.1177/003335491513000102.

6. Family History as a Risk Assessment Tool - ACOG n.d. https://www.acog.org/Clinical-Guidance-and-Publications/Committee-Opinions/Committee-on-Genetics/Family-History-as-a-Risk-Assessment-Tool?IsMobileSet=false (accessed April 5, 2019).

7. Reference GH. Why is it important to know my family medical history? Genet Home Ref n.d. https://ghr.nlm.nih.gov/primer/inheritance/familyhistory (accessed April 6, 2019).

8. Family History and Cancer | CDC 2019. https://www.cdc.gov/cancer/gynecologic/basic_info/family-history.htm (accessed April 6, 2019).

9. Family Cancer Syndromes n.d. https://www.cancer.org/cancer/cancer-causes/genetics/family-cancer-syndromes.html (accessed April 5, 2019).

10. Bulc M, Švab I, Pavlič DR, Kolšek M. Specialist training of Slovene family physicians. Eur J Gen Pract 2006;12(3):128–32. https://doi.org/10.1080/13814780600780759.

11. Welch BM, Dere W, Schiffman JD. Family Health History: The Case for Better Tools. JAMA 2015;313(17):1711–2. https://doi.org/10.1001/jama.2015.2417.

12. Hariri S, Yoon PW, Qureshi N, Valdez R, Scheuner MT, Khoury MJ. Family history of type 2 diabetes: A population-based screening tool for prevention? Genet Med 2006;8(2):102–8. https://doi.org/10.1097/01.gim.0000200949.52795.df.

13. Greenland P, Alpert JS, Beller GA, et al. 2010 ACCF/AHA Guideline for Assessment of Cardiovascular Risk in Asymptomatic Adults. J Am Coll Cardiol 2010;56(25):e50–103. https://doi.org/10.1016/j.jacc.2010.09.001.

14. Levin B, Lieberman DA, McFarland B, et al. Screening and Surveillance for the Early Detection of Colorectal Cancer and Adenomatous Polyps, 2008: A Joint Guideline from the American Cancer Society, the US Multi-Society Task Force on Colorectal Cancer, and the American College of Radiology*†. CA Cancer J Clin 2008;58(3):130–60. https://doi.org/10.3322/CA.2007.0018.

15. Smith RA, Cokkinides V, Brawley OW. Cancer Screening in the United States, 2008: A Review of Current American Cancer Society Guidelines and Cancer Screening Issues. CA Cancer J Clin 2008;58(3):161–79. https://doi.org/10.3322/CA.2007.0017.

16. Final Recommendation Statement: Lipid Disorders in Adults (Cholesterol, Dyslipidemia): Screening - US Preventive Services Task Force n.d. https://www.uspreventiveservicestaskforce.org/Page/Document/RecommendationStatementFinal/lipid-disorders-in-adults-cholesterol-dyslipidemia-screening (accessed February 22, 2019).

17. MeTree software | Center for Applied Genomics and Precision Medicine n.d. https://precisionmedicine.duke.edu/researchers/precision-medicine-programs/risk-assessment/family-history/metree-software (accessed February 22, 2019).

18. Acheson LS, Wiesner GL, Zyzanski SJ, Goodwin MA, Stange KC. Family history-taking in community family practice: Implications for genetic screening. Genet Med 2000;2(3):180–5. https://doi.org/10.1097/00125817-200005000-00004.

19. Fry A, Campbell H, Gudmundsdottir H, et al. GPs' views on their role in cancer genetics services and current practice. Fam Pract 1999;16(5):468–74. https://doi.org/10.1093/fampra/16.5.468.

20. Baria VR. Healthcare Provider Barriers to Family Health History Clinical Decision Support Tools n.d.:106.

21. Wu RR, Orlando LA. Implementation of health risk assessments with family health history: barriers and benefits. Postgrad Med J 2015;91(1079):508–13. https://doi.org/10.1136/postgradmedj-2014-133195.

22. Welch BM, Wiley K, Pflieger L, et al. Review and Comparison of Electronic Patient-Facing Family Health History Tools. J Genet Couns 2018;27(2):381–91. https://doi.org/10.1007/s10897-018-0235-7.

23. Reid GT, Walter FM, Brisbane JM, Emery JD. Family History Questionnaires Designed for Clinical Use: A Systematic Review. Community Genet Basel 2008;12(2):73–83. http://dx.doi.org.proxy.lib.duke.edu/10.1159/000160667.

24. Cohn WF, Ropka ME, Pelletier SL, et al. Health Heritage©, a Web-Based Tool for the Collection and Assessment of Family Health History: Initial User Experience and Analytic Validity. Public Health Genomics 2010;13(7–8):477–91. https://doi.org/10.1159/000294415.

25. Orlando LA, Wu RR, Myers RA, et al. Clinical utility of a Web-enabled risk-assessment and clinical decision support program. Genet Med 2016;18(10):1020–8. https://doi.org/10.1038/gim.2015.210.

26. Time to Focus on Your Family Health History n.d. https://today.duke.edu/2015/12/metree (accessed February 22, 2019).

27. Wu RR, Myers RA, Sperber N, et al. Implementation, Adoption, and Utility of Family Health History Risk Assessment in Diverse Care Settings: evaluating implementation processes and impact with an implementation framework. Genet Med Off J Am Coll Med Genet 2018. https://doi.org/10.1038/s41436-018-0049-x.

28. WHO | Sri Lanka. WHO n.d. http://www.who.int/countries/lka/en/ (accessed February 22, 2019).

29. Population of Cities in Sri Lanka (2019) n.d. http://worldpopulationreview.com/countries/sri-lanka-population/cities/ (accessed March 2, 2019).

30. Sri Lanka's healthcare challenges n.d. http://country.eiu.com/article.aspx?articleid=1502512534&Country=Sri%20Lanka&topic=Economy&subtopic=Forecast (accessed April 6, 2019).

31. Sirisena ND, Neththikumara N, Wetthasinghe K, Dissanayake VHW. Implementation of genomic medicine in Sri Lanka: Initial experience and

challenges. Appl Transl Genomics 2016;9:33–6. https://doi.org/10.1016/j.atg.2016.05.003.

32. Jeyakodi T, Herath D. Physicians' Intention To Use Electronic Medical Records In Sri Lanka 2015;3(12):5.

33. Jeyakodi T, Herath D. Acceptance and Use of Electronic Medical Records in Sri Lanka 2016:5.

34. Orlando LA, Buchanan AH, Hahn SE, et al. Development and Validation of a Primary Care-Based Family Health History and Decision Support Program (MeTree). N C Med J 2013;74(4):287–96.

35. Wu RR, Orlando LA, Himmel TL, et al. Patient and primary care provider experience using a family health history collection, risk stratification, and clinical decision support tool: a type 2 hybrid controlled implementation-effectiveness trial. BMC Fam Pract 2013;14:111. https://doi.org/10.1186/1471-2296-14-111.

36. Orlando LA, Hauser ER, Christianson C, et al. Protocol for implementation of family health history collection and decision support into primary care using a computerized family health history system. BMC Health Serv Res 2011;11:264. https://doi.org/10.1186/1472-6963-11-264.

37. Bornstein MH, Jager J, Putnick DL. Sampling in developmental science: Situations, shortcomings, solutions, and standards. Dev Rev 2013;33(4):357–70. https://doi.org/10.1016/j.dr.2013.08.003.