

Oakkar Oakkar. Online Triage for Patients: Implementing a Scalable and Cost-Effective Triage Platform Using Expert System, Machine Learning and Natural Language Processing Techniques. A Master's Paper for the M.S. in I.S degree. July, 2013. 39 pages. Advisor: Javed Mostafa

Keona Health, a spin-off company from the University of North Carolina (UNC) at Chapel Hill and in partnership with the National Institute of Health, has developed a triage platform called Online Triage. UNC Chapel Hill's Campus Health Services piloted the Keona platform by offering it to over 28,000 students. The pilot demonstrated significant nurse time savings, improved patient safety, and increased nurse satisfaction. Students used Online Triage from home using a link on the university website, as well as from kiosks in Health Services facilities. We tracked data on several variables including nurse review time and concordance between the nurse and our Clinical Decision Support (CDS) system.

A total of 93% of students said they would use Online Triage to save time, but also to get reassurance and save money. Additionally, 77% of patients said they were moderately, very, or extremely likely to use it next time they had a health problem. Compared to traditional triage using Online Triage resulted in a 31% reduction in nurse time. The CDS system was able to safely screen patients for potential emergencies, and improve safety over patient's pre-dispositions. Nurses also reported a high degree of satisfaction with Online Triage and valued how it prepared them for patient interactions and reduced their documentation time. More work needs to be done improving the questionnaires, emergency screening, and display of information to nurses.

Headings:

Web/Mobile Triage

Clinical Decision Support

Natural Language Processing

Machine Learning

Electronic Medical Record Integration

Expert Systems

ONLINE TRIAGE FOR PATIENTS: IMPLEMENTING A SCALABLE AND COST-  
EFFECTIVE TRIAGE PLATFORM USING EXPERT SYSTEM, MACHINE  
LEARNING AND NATURAL LANGUAGE PROCESSING TECHNIQUES

by  
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Approved by

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Javed Mostafa

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## **1. Introduction**

Triage is the process of determining the priority of patients' treatment options based on the severity of their conditions. This enables efficient allocation of resources especially when resources are limited to allow for all patients to be treated immediately. Through a course of traditional telephone triage, nurses get all information from patients who need help at the time of the phone call. One such call typically takes at least 15 minutes since the patient's demographics and symptom information need to be collected by the nurse to properly triage the patient. Based on the availability of on-duty triage nurses at the time of the calls, patients may have to wait on the line for 15-20 minutes before being able to speak to a nurse. In case of emergency time is invaluable and the delay could result in serious health consequences. In addition, triage calls are extremely expensive because they utilize tremendous amount of time from nurses, and yet they are not reimbursed. Hospitals and clinics across the country have been looking for ways to better manage the triage process.

Keona Health, a spin-off company from the University of North Carolina at Chapel Hill (UNC), has developed an Online Triage, which allows patients to report their symptoms using either a web or mobile application and alerts their healthcare provider regarding the triage encounter. In addition, this system allows recommendations, which are based on the patient's symptoms and health history directly pulled from the patient's Electronic Health Record (EHR), to be sent back to the patient in a short period of time via

e-mail, text message or a phone call. Keona Health is designed to improve cost savings for healthcare providers and patient safety over traditional telephone triage.

The purpose of this study was to assess cost savings and patient safety of the Online Triage by conducting a randomized controlled trial (RCT) in partnership with Campus Health Services (CHS) at the UNC. We compared cost savings and safety of Online Triage against their current phone triage. We will focus on four disease categories including Upper Respiratory Infection (URI), Urinary Tract Infection (UTI), Flu (Influenza), and Sexually Transmitted Infections (STI), because they are most common at UNC CHS.

## **2. Problems**

Providing patients with a tool they can use to assess their health at the time that they need and with a personalized healthcare recommendation directly from their healthcare provider is more important than ever. This is a reason why many clinics and hospital groups have telephone triage services available for their patients, although they are not reimbursed by insurance companies. Most hospitals provide telephone triage services at a deficit due to “the perception that they are a valuable mechanism for marketing and increasing patient and physician satisfaction” (Melzer & Poole, 1999). Each of these triage calls can take up to 15 minutes to answer. A typical 100-bed hospital receives approximately 100,000 calls per year. Therefore, their nurses spend more than 25,000 hours per year answering these calls. It is important to note that the demand for triage is constantly increasing. With the recent healthcare reform, more patients will enter the

healthcare system resulting in an increasing number of triage calls. According to current reports, the average patient wait time is already 10-20 minutes leading to frustrated patients who need to wait on the line. Patients could leave a message, but most healthcare providers have limited resources, and frequently require several hours to respond when they do. This is especially critical when it comes to urgent issues. It has been shown that 62% of patients who tried to call their primary care doctor before going to emergency room (ER) could not reach them (Tranquada, Denninghoff, King, Davis, & Rosen, 2010). Furthermore, most practices urged patients to call 911 if they think they are experiencing a medical emergency, before patients are assessed by a triage nurse and given the next available appointment. There is little or no screening to determine the severity of the patient's medical problem. This causes 70% unnecessary ER visits, which is one of the largest wasteful costs of our healthcare system (Gold, 2013).

On the other hand, there are a lot of patients that should be going to the ER, but decide not to. This can result in serious complications and even death for some patients. Triage is proven to improve safety by identifying emergencies that patients did not recognize themselves. Previous research showed that more than 20% of callers to a telephone triage service were recommended a more acute level of care than they originally anticipated, including 1.8% with unrecognized emergencies (O'Connell, Stanley, & Malakar, 2001). Given the high volumes of telephone triage every year in the U.S., this 1.8% could be millions of patients.

The current fee-for-service model encourages patients to visit the physician although there could be a more cost effective and more convenient option for patients. For illnesses like the common cold, patients often just need to be reassured and advised on reliable and trusted self-care instructions. Based on a recent study, self-care is appropriate in about 15% of cases in primary care (Nijland, Cranen, Boer, Gemert-Pijnen, & Seydel, 2010). Moreover, an efficient utilization of mid-level providers and nurses can yield lower costs (Roblin, Howard, Becker, Adams, & Roberts, 2004). A telephone triage study also found that more than 50% of patients ended up needing a less acute level of care than they originally intended (O'Connell, Stanley, & Malakar, 2001). Furthermore, about half the ER visits were considered inappropriate by triage nurses and physicians (O'Brien, Shapiro, Woolard, O'Sullivan, & Stein, 2008).

Due to rising costs of healthcare in the U.S., there has never been a greater need than now to keep costs down while maintaining the quality of care. One study has shown that telephone triage can reduce physician visits by 4 to 6% and ER visits by 5 to 14% (Hogenbirk, Pong, & Lemieux, 2005). Although it may seem low, it could be a significant saving for the entire country. Using standard Centers for Medicare and Medicaid Services (CMS) reimbursement rates and an average number of physician visits, this can result in potential savings of \$18/patient/year. Extrapolating this to the whole population of 307 million people in the U.S., this savings could add up to hundreds of millions every year. Another study in the UK found even larger benefits (Lattimer, 1998). This review of previous literature highlights the need for improvement in our healthcare admission process by revolutionizing the current triage process. It clearly

shows the need for a triage tool, which empowers patients to report their symptoms in a secure and easy-to-use manner directly to their healthcare provider, and allows healthcare providers to efficiently manage their entire triage process all in one place for fast and secure response directly back to their patients.

### **3. Methodology**

#### **3.1. Keona Online Triage**

In order to validate the safety and efficacy of Keona Online Triage, the following methodology was implemented at UNC CHS.

##### **3.1.1. Smart Intake**

When a patient has a question about their health, they are directed to Keona Smart Intake either by the doctor's homepage or patient portal. The patient reports their problem and the system intelligently identifies the chief complaint and guides them through a medical interview. This interview follows industry standard triage protocols, and it is simple and natural for patients to follow. Once the request is completed, the UNC CHS nurses are notified and they can review what the patient has entered as well as their health history retrieved from the patient's EHR.

##### **3.1.2. Clinical Decision Support System**

Keona Clinical Decision Support System (CDSS) makes the triage disposition based on the patient's symptoms and health history. The triage disposition can be Emergent, Urgent, Next Available Appointment and Self-Care. The system provides the nurses all



the information they need all in one place and all they have to do is review to make sure the system's recommendation is congruent with what they would normally recommend on the phone and confirm. The patient then receives a personalized recommendation from the nurse via text message, email or phone call, whichever one the patient prefers. The recommendation along with the entire triage episode is subsequently copied into the patient's chart as web triage encounter in the EHR for UNC CHS. After the doctor has examined the patient and provided an actual diagnosis, this information is used to track quality measures and improve accuracy of the CDS system recommendations. One thing to note is that the system does not diagnose patients or recommend medical treatments. Limiting our scope to urgency and level of care is an easier problem and it is simpler to guarantee a correct result.

### **3.1.3. Triage Nurse Express**

Currently, when patients call triage nurses and the nurses are not available, the calls are put into a queue. There is no way of ensuring that the calls are returned within a specified time frame. Furthermore, it lacks the way to identify and move urgent cases to the front of the queue other than by listening to all the voice mails on the answering machine. Non-urgent problems can take several hours, sometimes a couple of days for a return call. The Keona system provides an instant recommendation to the patient, providing improved responsiveness for the majority of patients. However, the triage nurse has the ultimate responsibility and authority for reviewing the system's decision for every case and following up at least as quickly as their current phone triage process requires. The Triage Nurse Express enhances this process with a timer and deadline for each patient

report (Figure 1). It is also able to red flag cases requiring a more emergent follow-up. Nursing staff is able to set criteria specifying deadlines and red flags based on patient indicators and history. If the specified deadline is approaching and the nurses still have not reviewed the patient report, the system can send an alert to their mobile device reminding them to review it. This helps to ensure that all patient reports are reviewed in a timely manner. Additionally, the system is integrated with our quality management process (See below). When the nurse overturns the recommendation made by the CDS, the decision will be automatically recorded in the Quality Dashboard, triggering the case review process.

### TRIAGE NURSE EXPRESS

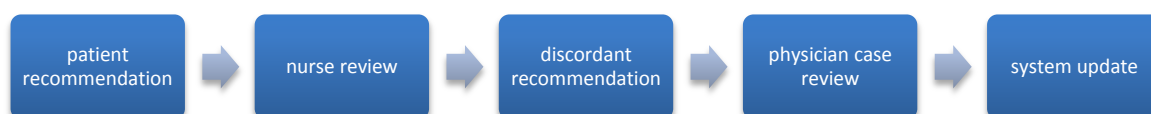
PATIENTS   WAIT TIME	PATIENT HISTORY	DECISION SUPPORT	RECOMMENDATION
<b>PRIORITY 1 (Immediate)</b> Jane Doe 4 days 08:00	<b>INTERVIEWEE INFORMATION</b> PID: -1 Name: Jane Doe Email: oakkar@keonahealth.com Phone: 8082211436	<b>RECOMMENDATION</b> Level 2 Urgent - Same Day Appointment with Next Available Provider	<div> <div>CDS</div> <div>Nurse</div> </div> <div> <div>Triage Level</div> <div>Urgent</div> <div>- Select Triage Level</div> </div>
<b>PRIORITY 2 (4 Hours)</b> Jane Doe 13 days 03:21 Jane Doe 10 days 07:58 Jane Doe 4 days 05:28 Jane Doe 2 days 06:50	<b>PATIENT INFORMATION</b> Age: 30 DOB: 10/14/82 Sex: Female	<b>PERTINENT POSITIVES</b> <ul style="list-style-type: none"> <li>Vomiting a prescribed medication or recently started on a new medication</li> </ul>	<b>EDUCATIONAL CONTENT</b> <input type="text"/> <input type="button" value="Search"/>
<b>NOT FOR TRIAGE</b> No Patients in Queue	<b>REASON FOR VISIT</b> Health Problem	<b>PERTINENT NEGATIVES</b> None	<b>CALL NOTE IF UNABLE TO REACH PATIENT</b> <div> <input type="text"/> </div> <div> <input type="button" value="Add Call Note and Save"/> </div>
<b>WAITING FOR PATIENT TO VIEW</b>	<b>CHIEF COMPLAINT</b> Vomiting		
	<b>RECORD UPDATES</b> Medications: None Specified Medication Allergies:		

**Figure 1.** User Interface of Triage Nurse Express

### 3.1.4. Quality Management

The Quality Dashboard contains key metrics which were monitored throughout the research including safety, service utilization, time savings, patient participation, patient

compliance, call volume, rate of reporting for urinary tract infections (UTI) and sexually transmitted infections (STI), errors from case review, and adverse events. We performed case reviews of all cases where the nurse indicated a different level of care than the CDS, and made any necessary updates to the system (Figure 2).



**Figure 2.** Case review process

The case reviews determined whether the discordant recommendation was clinically relevant, whether an error was made by the CDS system or the nurse, and whether the patient was at risk for an adverse event. We also classified the type of error as technical or clinical. Technical errors, such as the CDS missing a risk factor for UTI, can be reduced or eliminated by improving the software or protocol. Clinical errors were defined as discordant recommendations between the CDS and triage nurse that were determined to be clinically relevant, and were not fixable through a technical change to the CDS. For example, it is not a clinical error if the discordance is primarily due to an ambiguous disease state, but it is if the nurse forgot to ask the patient about a critical risk factor. When a discordant professional opinion between the nurse and case reviewer occurred, we preferred the most conservative and safest option for the patient. The rates and types of errors were included in the Quality Dashboard.

### **3.2. Study Design**

This study was a randomized controlled clinical trial. Our subjects were patients seeking care at UNC CHS for four disease categories including Influenza, Upper Respiratory Infection (URI), Sexually Transmitted Infection (STI), and Urinary Tract Infection (UTI). We were using these disease categories because they cover the majority of triage calls at UNC CHS. We identified patients with one of these diseases based on symptoms reported in our cohort interview questions. Patients were randomized to the experimental or the control group. Patients in the control group did not receive any intervention, and continued to use the usual process of calling the nurse triage line and scheduling appointments on the phone. Patients randomized to the experimental group who agreed to participate in our study were directed to use Online Triage via the UNC CHS homepage and received a recommendation. Since we needed limited identification in order to link records from different systems and monitor for adverse events, eligible participants had to be able to read and answer health questions on a computer in English, were adults over 18 years of age who were enrolled as UNC students, and were not decisionally impaired. We did not discriminate based on gender, ethnicity, or race. We had a total of 84 encounters in the system where patients were selected for our cohort and completed the interview.

We also recruited five nurses from CHS for the study. They were asked to participate by their Executive Director, but their participation was voluntary and their individual privacy was protected.

### **3.2.1. Study Phases**

This study had a two-phase approach. In the first phase, patients completed the Online Triage through kiosks assembled by the reception desk at Campus Health Services. The purpose of this phase was to ensure the quality of the software under the supervision of the Campus Health staff before it was going live on the web for 28,000 patients in Phase 2.

#### ***3.2.1.1. Phase 1***

In the first phase, patients who walked into CHS and were seen by the triage nurse were randomized to either use our system or the standard triage process. Patients were given an information sheet by the receptionist describing the study. Those randomized to the control group received standard nurse triage, while those randomized into the experimental group used an on-site computer at a terminal in the CHS waiting room to access the Online Triage tool. The tool offered patients Informed Consent and HIPAA Authorization documents that they could electronically sign to enroll in the study. Patients who accepted these terms continued to perform an automated, guided interview, which asked them questions about their current health problem and medical history. The patient then waited for a response from the nurse. The triage nurse reviewed the encounter using the Triage Nurse Express tool where nurses were able to see the interview responses. However, nurses did not use the tool to provide a recommendation, but followed their usual process for triage. We sent out a follow-up Qualtrics survey to the patients to assess patient satisfaction and gather additional feedback.

The regular CHS triage nurse staff was responsible for reviewing the data collected by the Online Triage tool, gathering any necessary missing or additional information from the patient, and providing a triage recommendation. The investigators were not involved in the care recommendations made, so there was minimal safety risk to patients over usual practice. We had a training session for nurses to go over their responsibilities and Informed Consent before we enrolled patients.

### ***3.2.1.2. Phase 2***

In the second phase nurses were able to provide recommendations to patients through the web to offsite patients. We launched a new link on the CHS website page that took patients to the Online Triage tool. The tool offered patients Informed Consent and HIPAA Authorization documents that they could electronically sign to enroll in the study. For enrolled patients, we performed an automated, guided interview, which asked them questions about their current problem and medical history. If the patient's answers met protocol criteria for emergency or life-threatening problems, they were given immediate advice to seek medical care or call 911. For all non-emergency problems the patient then waited for response from the nurse. The triage nurse reviewed the encounter using the Triage Nurse Express tool. The tool randomized non-emergency patients to either the Online Triage group or the control group. For patients in the control group, the nurse was not able to see this information, and followed up over the phone or in-person to collect it and provide recommendations as usual. Patients were told they are in the control group and that they would need to repeat the information. For patients in the Online Triage group, nurses received the interview responses and decision support

recommendations based on the telephone triage protocol. They reviewed this information and followed up over phone if needed and completed the encounter as normal. After the review was complete, the patient received an e-mail with a link to see the information the nurse provided, including when to schedule their appointment, educational materials, and self-care instructions. We also sent out a follow-up Qualtrics survey to assess patient satisfaction and gather additional feedback. For the control group, we simulated the traditional triage process by blanking out the interview and decision support so that nurses had to collect data verbally, type it into the electronic record, and make their disposition without support. Patients were told they are in the control group and that they would need to repeat the information.

Although the nurse often responded sooner, patients were instructed that responses may take up to 4 hours business hours. If the patient needed immediate medical attention, they were told to seek care urgently or call 911. Patients who sought care advice using the Online Triage tool did not receive delayed care compared to the current process of calling over the phone to speak with the nurse or leave a voicemail.

### **3.2.2. Measures**

Our independent physicians Dr. Medlin and Dr. Ferguson case reviewed encounters where the CDS simulation was discordant, and suggest improvements. Our independent biostatistician Dr. Lin reviewed the data analysis and calculations to ensure correctness.

A focus group for nurses using open-ended questions helped us understand how CHS triage nurses like the Online Triage process compared to their usual process and what kind of improvements they would like to see. We held the focus group after the nurses have had a chance to try the tool and learn how it works. We also completed a patient awareness survey by distributing paper surveys to students on campus opportunistically. To incentivize participation, they were given a choice to enter in a drawing for an iPod Nano.

- **Nurse Review Time**

We measured the speed of the triage nurse's review process by calculating the mean review time for the encounters in Triage Nurse Express, and then compared that to the mean review time for telephone and in-person triage. We recorded times by tracking the time from when the patient encounter was opened until it was confirmed and closed. Due to a problem with the window remaining open too long, we filtered out spurious cases with more than 45 minutes of nurse time per encounter.

- **Patient Safety**

We measured the percentage of patients given a higher level of care compared to their predispositions. This demonstrated a potential improvement to patient safety helping patients get appropriate care faster.

- **Decision Support Accuracy**

We compared the recommendation of the decision support system to that of the nurse to measure concordance.



- **Patient Awareness**

We measured the percentage of patients who were aware of the Online Triage service offered by CHS in order to determine the effectiveness of our recruitment activities.

- **Patient Demand**

We measured how likely patients say they were to use Online Triage next time they had a health problem. This helped us estimate how many patients would use it, if they were aware of it.

- **Patient Satisfaction**

We measured patient satisfaction by e-mailing patients in the experimental group a Qualtrics survey. The survey also asked additional questions about their experience.

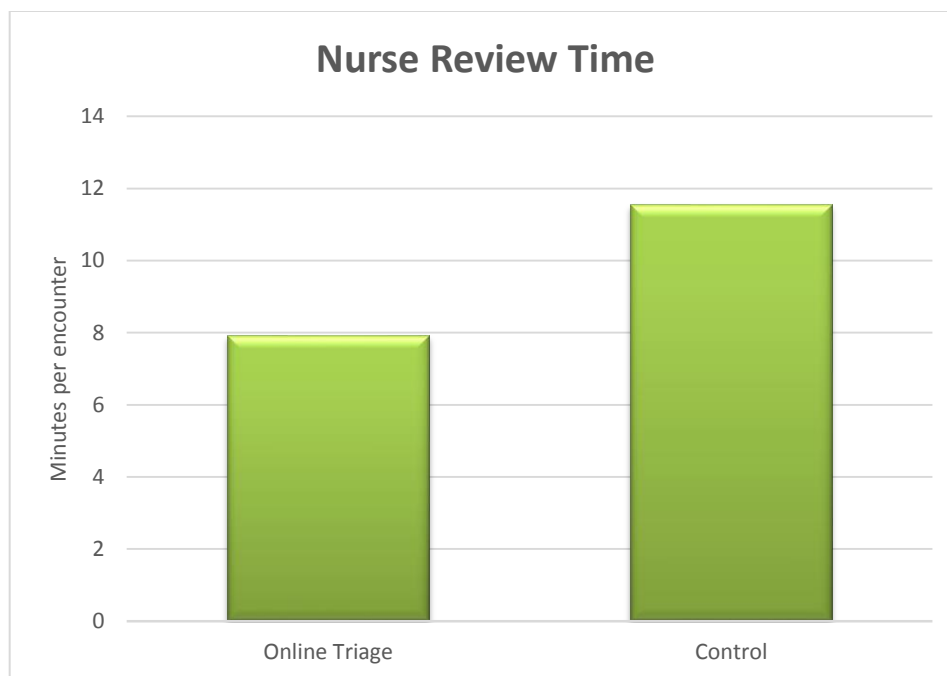
- **Nurse Satisfaction**

We held a focus group with the staff at Campus Health to determine their satisfaction with the Online Triage system, and to collect suggestions for improvement.

## **4. Results**

### **4.1. Nurse Review Time**

Using Online Triage the nurse review time was on averaged 31% shorter per encounter than traditional triage (Figure 2). Specifically, traditional triage had an average nurse time of 11.5 minutes per encounter, while Online Triage had an average of 7.9 minutes per encounter.



**Figure 3.** Nurse review time comparing Online Triage to traditional triage

#### **4.2. Improving Patient Safety**

The triage process was able to improve patient safety compared to patient's predispositions. A total of 43% of patients had a predisposition that was too low, indicating they were not aware of the urgency of their problem (Table 1). In 6.3% of cases patients' predisposition was routine or urgent and the nurse upgraded them to an emergency disposition, showing that many patients don't even know they had emergencies.

Additionally, in 9.5% of cases patients thought they had emergencies and the nurse was able to guide patients to a lower and more appropriate level of care. Finally, 11.1% of patients were recommended home care, which can also serve as a valuable way for patients to self-care under the guidance of a nurse. This can also result in savings by

reducing complications from delayed care, and by decreasing unnecessary usage of emergency or primary care services.

**Table 1.** Concordance between nurse disposition and patient predisposition (percent of total encounters)

	Nurse Disposition					Total
	Emergency	Urgent	Routine	Home Care	No Health Issue	
<i>Patient Predisposition</i>						
Emergency	0.0%	6.3%	0.0%	1.6%	1.6%	9.5%
Urgent	3.2%	28.6%	0.0%	0.0%	0.0%	31.7%
Routine	3.2%	25.4%	6.3%	0.0%	1.6%	36.5%
Home Care	3.2%	6.3%	1.6%	9.5%	1.6%	22.2%
No Health Issue	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
<b>Total</b>	<b>9.5%</b>	<b>66.7%</b>	<b>7.9%</b>	<b>11.1%</b>	<b>4.8%</b>	<b>100%</b>

### 4.3. Decision Support Accuracy

The decision support engine performed well with 100% sensitivity to emergent cases when comparing the CDS recommendation to the nurse disposition (Table 2). For the small number of potential emergency cases, it was programmed to err on the side of caution. The false positive rate was high and for 38.6% of the patients CDS recommended an emergency level of care, while the nurse only identified 10.5% of the patients as emergency cases. However, this was deemed acceptable because the benefits of catching an emergent case early outweigh the cost of receiving an unneeded alert. For approximately half of the encounters the CDS recommended an urgent level of care and the nurse agreed with CDS' recommendation for 38.6% of the patients, while for 12.2% of the encounters she gave the patient a lower acuity triage level.

**Table 2.** Concordance between CDS recommendation and nurse disposition (percent of total encounters)

	CDS Recommendation					Total
	Emergency	Urgent	Routine	Home Care	No Health Issue	
<i>Nurse Disposition</i>						
Emergency	10.5%	0.0%	0.0%	0.0%	0.0%	10.5%
Urgent	24.6%	38.6%	0.0%	0.0%	0.0%	63.2%
Routine	3.5%	5.3%	0.0%	0.0%	0.0%	8.8%
Home Care	7.0%	5.3%	0.0%	0.0%	0.0%	12.3%
No Health Issue	3.5% %	1.8%	0.0%	0.0%	0.0%	5.3%
<b>Total</b>	<b>49.1%</b>	<b>50.9%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>100%</b>

Our decision support engine even identified 67.9% of the encounters where the patients had a lower predisposition with 24 patients being upgraded to an emergency level of care (Table 3). This demonstrates a potential improvement to patient safety. We are currently upgrading the protocols used by the CDS to the better Schmitt-Thompson standard, so we expect the performance to increase in the next version.

**Table 3.** Concordance between CDS recommendation and patient predisposition (percent of total encounters)

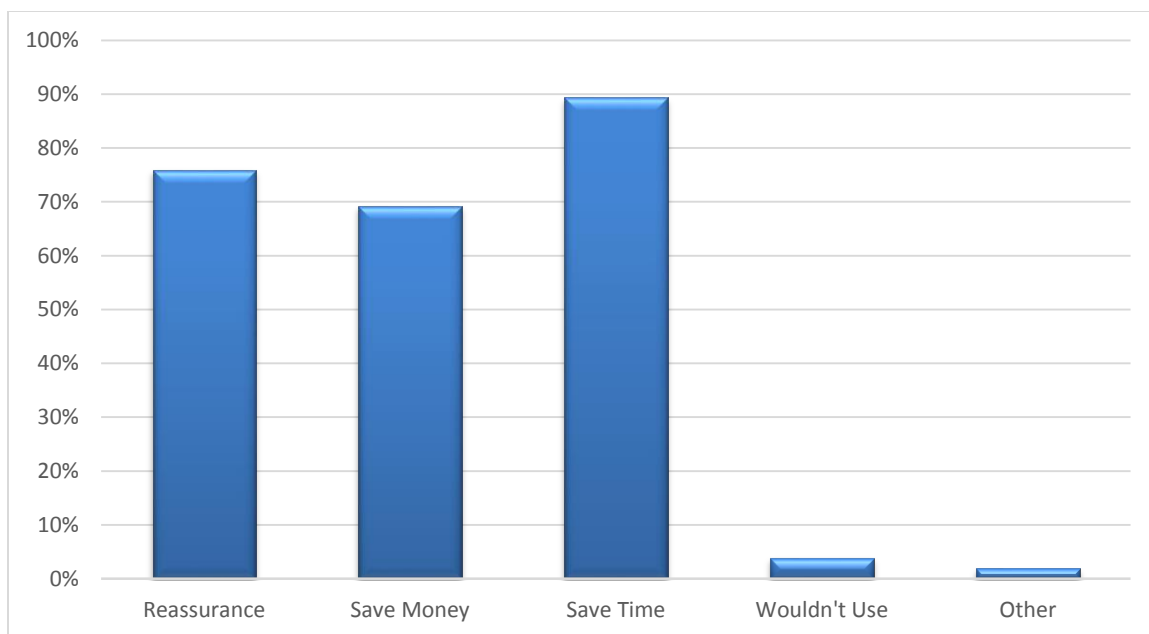
	CDS Recommendation					Total
	Emergency	Urgent	Routine	Home Care	No Health Issue	
<i>Patient Predisposition</i>						
Emergency	5.4%	5.4%	0.0%	0.0%	0.0%	10.7%
Urgent	10.7%	21.4%	0.0%	0.0%	0.0%	32.1%
Routine	17.9%	14.3%	0.0%	0.0%	0.0%	32.1%
Home Care	14.3%	10.7%	0.0%	0.0%	0.0%	25.0%
No Health Issue	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
<b>Total</b>	<b>48.2%</b>	<b>51.8%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>100%</b>

#### 4.4. Patient Awareness and Demand

We surveyed 105 students opportunistically using paper surveys on campus. A total of 77% were moderately, very, or extremely like to use Online Triage next time they had a health problem (Figure 3). The most popular reason for using it was to save time with 93% of students confirming that reason, followed by getting reassurance and saving money on inappropriate care. However, only 10% of students were previously aware that CHS offered Online Triage. This shows that there is still much room for improvement in informing students about the availability of the service, and that they are likely to engage once they are aware. Our future work with CHS will include a more extensive campaign to inform students.



**Figure 4.** Likelihood of UNC students to use Online Triage the next time they had a health problem



**Figure 5.** Proportion of UNC students indicating specific reasons to use Online Triage

#### **4.5. Patient and Nurse Satisfaction**

We have sent patients an email survey after they have used Keona Online Triage. Among those who used Keona Online Triage 17% responded to the satisfaction survey. We found that patients had a 79% satisfaction rate and a net promoter score of -14%. In written comments, several said it was a great service that worked well. Others had issue with the restrictions on disease categories we setup for the trial, the fact that it was difficult to find on the CHS website, the length of the questionnaire, and false positive emergency warnings. We will fix or improve these issues and expect to see our scores increase next semester.

We also conducted a focus group with the five UNC CHS nurses who used Online Triage. They all reported higher satisfaction with Online Triage than their old system.

They also valued how it prepared them in advance of interacting with the patient, and how it reduced their documentation time. However, they asked us to improve the way clinical notes show up in their EHR system. They wanted us to improve the quality and quantity of information provided by the questionnaire, as well as to group and display it in a way that was easier to read. The next version will have the new Schmitt-Thompson protocols, and early feedback from the nurses indicates it will be a big improvement.

## **5. Limitations**

Usually pilots like this take at least two years to see fruitful results. We performed this research in six months, which is considered a very short pilot. It has to be kept in mind that the results presented here cannot be extrapolated to the general population. This population (college students) is generally inclined to use web/mobile to communicate with their healthcare provider. We hear from the UNC CHS nurses that their patients never pick up the phone or listen to their voice mails. However, if the nurses email or text-message them, students would look at the message right away. Nonetheless, there is still a large population who would rather use the telephone, because they want to talk to somebody. Another limitation of our study is that traditional telephone triage time is hard to determine. UNC Campus Health does not have a record of it. Therefore, we took the industry average.

## **6. Commercialization**

The reason we chose CHS is because college students are generally healthy and a perfect fit for the clinical trial. We are planning on commercializing this technology by rolling it

out to OB/GYN and Pediatrics and Primary Care practices as these practices receive the most triage calls. In addition to hospitals and practices, third-party health call centers also expressed a lot of interest in our Online Triage. Hospitals and private practices outsource these call centers to handle their after-hour patient calls and, therefore, third-party call centers also receive a lot of patient phone calls. Phone calls to physician practices have increased between 25 to 50% since 2008 (Wall Street Journal, 2013) and most of them come in after-hours. Health care call centers have been looking for solutions to effectively manage their ever increasing call demand. They have been hiring more and more nurses to meet that demand, and 80% of their overhead cost comes from hiring and recruitment of nurses (Lazarus, 2013). This cost structure is no longer sustainable, and call centers are looking into Keona Online Triage, which can significantly reduce the unit cost of triage, yet providing high-quality and personalized care to their patients. Keona Health is already making great progress in commercializing Online Triages because pilots have already been signed with UNC OB/GYN, Geriatrics Department at UNC Family Medicine, Tulane University, and UNC HealthLink, which is one of the largest health call center in North Carolina.

## **6.1. OB/GYN**

The OB/GYN department at UNC has multiple locations within the state of North Carolina. Dr. John Thorp, professor and director of UNC Women's Primary Healthcare said his department receives 80,000 phone calls annually (Wall Street Journal, 2013). The nurses are overwhelmed with these phone calls, while they have to care for patients who are already in their clinics. It is distracting and interfering with the direct patient care. In



addition, having too many triage calls can bring a lot of risks into practices. Telephone triage errors are the leading cause of medical malpractice settlements (Wall Street Journal, 2013). Dr. Thorp has been looking for innovative solutions to address his challenge with current telephone triage. Specifically he was interested in solutions which have a platform to manage their standardized triage questions, automate the documentation, integrate with their EMR, and ideally allow patients to electronically communicate with the providers instead of using phone calls. Dr. Thorp also mentioned in a personal interview that “of the hundred calls in a day, 80 are trivial, 19 are important, and one is urgent. That voice and brain of our practice needs to give great customer service to all 100 and be able to pick out the one or two for whom our response is life altering (Thorp, 2013)”. When Dr. Thorp heard about Keona Online Triage, he immediately signed up to begin a pilot at the Timberlyne Location of UNC Women’s Primary Healthcare. The pilot has been running for six months, and we are getting great feedback from both patients and nurses.

We understand the UNC Health Care’s vision to create an information system across all UNC Health Care locations that has one patient ID, one problem list, one medication list, and one bill for each patient (UNC Health Care, 2013). We also understand that we can no longer have stand-alone health IT systems, and they all need to be connected to each other to create clinical efficiency and to provide the best patient care possible. This is where future of health care is going to be, and many Electronic Medical Record (EMR) companies, including Epic, realized that. In fact, Epic has phenomenal connectivity and

data exchange components for third-party health IT vendors like Keona Health to provide value added services on top of their EMR platform (Epic Systems Corporation, 2013).

When Epic is up and running at UNC OB/GYN, we will integrate Keona Health System with Epic using their Care Everywhere Application Programming Interface (API), which is currently used by hundreds of Organizations (Epic Systems Corporation, 2013). Keona Health was built from ground-up with the clear vision on seamless integration with EMRs and patient portals using industry standard clinical data exchange mechanisms, such as HL-7 and CCD. We have already integrated with Allscripts and we are currently working with Athenahealth and GE to integrate with their EMR.

## **6.2. Healthcare Call Centers**

UNC HealthLink is one of the largest after-hour triage call centers in North Carolina and their mission is to provide nurse based telephone triage to populations of patients to guide them to the appropriate level of care at the appropriate time (Herman, 2012). HealthLink employs 35 triage nurses who address more than 150,000 triage encounters per year on behalf of approximately 70 physician practices across North Carolina (Herman, 2012). Their primary interest in using Keona Online Triage is to significantly reduce their unit time while improving responsiveness to patients whenever they need it, wherever they are. Patients enter their symptom information into the system using the industry standard triage protocols faster than providers resulting in decreasing margins per patient. Thus, implementation of Keona Online Triage will to substantially decrease their cost of triage and increase high-quality personalized care for patients.

Keona Health is planning to launch the pilot with UNC HealthLink in August 2013, starting out with three of their client sites including UNC Campus Health Services, UNC Family Medicine, and Chapel Hill Children's Clinic. UNC Campus Health Services and Chapel Hill Children's Clinic are also clients of Keona Health. Therefore, their patients will have consistent care 24/7, because during the day time, they can use Keona Online Triage to reach out to the nurses on site, and during after-hours they will also be using Keona Online Triage to connect with the UNC HealthLink nurses. This will bring unmatched patient experience because of the consistent access they have to their health care providers at any given time.

UNC HealthLink uses a health care call center solution from LVM Systems, and we will ensure data integration and transparency between the two systems. The Keona Health team has significant experience in integrating among different systems and meeting the needs of data sharing among systems. Having gone live at UNC OB/GYN, Keona Health saw the need from nurses to enter the patient reported symptom information into their EMR, so that it would become part of the patient's chart. This step is crucial because not only does it need to be part of a standard of care documentation procedure, it also saves physicians' data collection and review time when patients come in for an appointment. Keona Health has developed a feature to automatically copy the data from Keona Triage Nurse Express into the computer station's clipboard as part of the routine triaging task. After the nurse reviews the data she then can easily transfer it into the patient's chart. Thus, instead of typing the entire triage encounter into the patient's chart in the EMR,

they can now do this with a click of a button. This feature is now in our operational version and has been in use for a couple of years.

Keona Health will do the same with LVM's software. We will evaluate where the data needs to go in which format, and we will develop a feature to copy the data into the clipboard of the nurse's computer, and the nurses can then transfer the data into the appropriate field in LVM's system.

### **6.3. Geriatrics**

While working with Chapel Hill Children's Clinic, Keona Health came to understand the importance of caregivers/parents to give the best care possible to patients. The knowledge and expertise of incorporating caregivers in triage also became very applicable when Keona Health started working with the Geriatrics Department at the UNC Family Medicine for their Alzheimer Management Project. Caring for someone with Alzheimer is challenging. Its progression leads to increased susceptibility to acute medical problems and to impaired communication and decision-making capacity (Sloane, 2012). As a result, informal caregivers, which are often family members, must evaluate, manage, and communicate with health care providers about physical symptoms, such as pain and shortness of breath, and signs that can indicate illness such as fever, agitation, and hollering (Sloane, 2012). In addition, getting someone with Alzheimer Disease (AD) to a health care provider is often difficult, due to suspiciousness, symptom denial, and refusal to go, and due to physical challenges, such as mobility impairment and agitation associated with delirium (Sloane, 2012). These and other factors result in informal

caregivers having a high need for resources such as Keona Online Triage to help them evaluate and manage physical and behavioral symptoms at home (Sloane, 2012).

UNC Family Medicine partnered with Keona Health to develop, pilot test, refine, evaluate, and disseminate Keona Online Triage in assisting informal caregivers of persons with AD in the identification, evaluation, communication with health professionals, and management of new or increasing symptoms and signs (Sloane, 2012). Our strategy draws from the best evidence, research, and expert opinion available and will utilize state-of-the art educational methods. Our interdisciplinary project team includes faculty from nursing, medicine, social work, public health, education, health services research, and informatics. Project activities will be conducted as a partnership between the Cecil G. Sheps Center for Health Services Research of the University of North Carolina at Chapel Hill (UNC Sheps Center); the Duke Family Support Program, one of the nation's oldest and most distinguished resources for caregivers of persons with AD; the Carolina Alzheimer's Network, a statewide Alzheimer's education and research program affiliated with the Clinical and Translational Science Award program; and Keona Health, a company devoted to providing online protocol and nurse-assisted triage and decision support on symptom evaluation and management (Sloane, 2012).

Unlike pediatrics and primary care, there are no industry standard protocols for Alzheimer. Therefore, Dr. Slone is currently developing the protocols and the Keona Health CDS has already been equipped with ten Alzheimer protocols including Agitation, Abdominal Pain, Bleeding, Blood Pressure Concerns, Breathing/Respiratory Problems,

Eating/Drinking Less, Falls, Fever, Sleep/Insomnia, and Urinary Problems. The project is scheduled to go live with the first set of patients/caregivers in early September 2013.

## **7. Technology Advancements**

Along with the commercialization plan, Keona Health needs to add new features and product enhancements to stay cutting edge and provide innovative solutions to current and future customers. Most highly requested features include mobile applications, Natural Language Processing (NLP) and Interactive Voice Response (IVR).

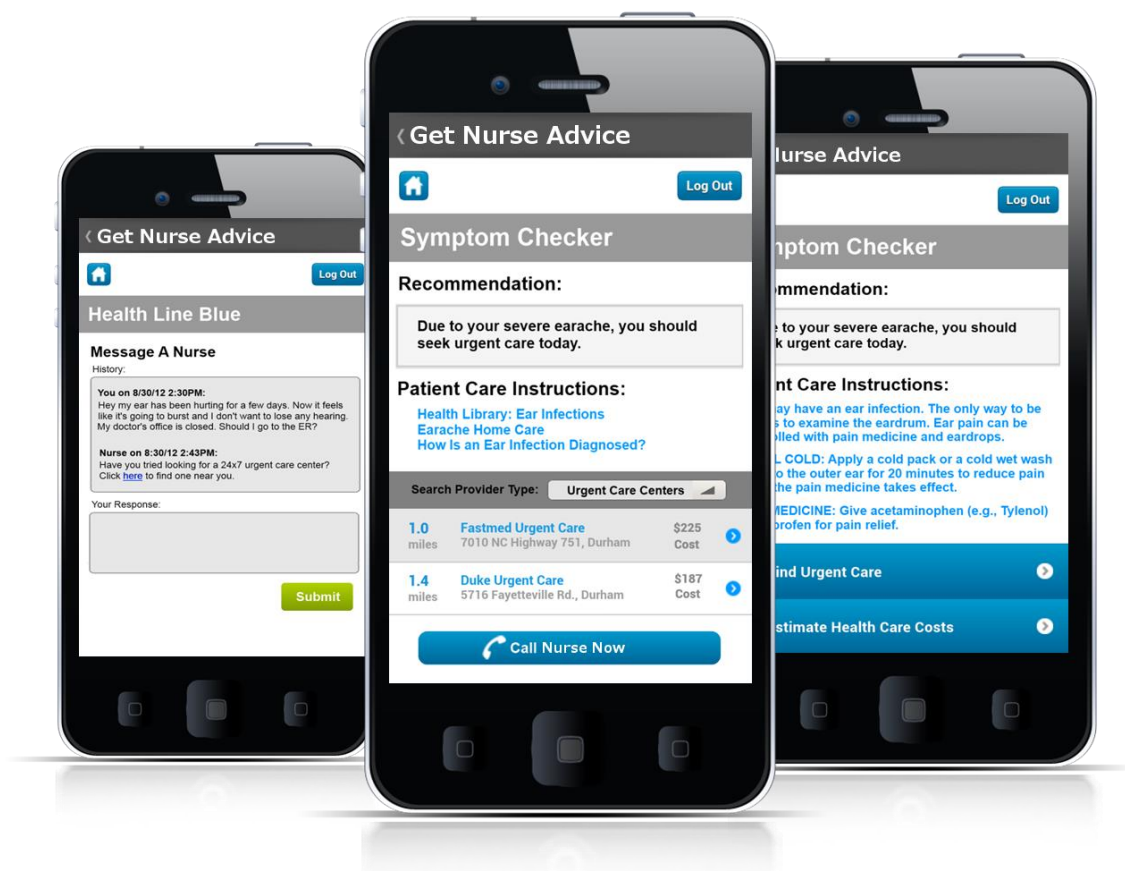
### **7.1. Mobile Applications**

Keona Health Online Triage is originally a web-based software for both patients and clinicians. We made numerous changes in the application to make it mobile friendly for both patients and clinicians, so they can be anywhere getting care or giving care. During our research at UNC Campus Health, approximately 60% of students use their mobile devices to access Keona Online Triage. The mobile application was usable, but not optimum. We had a lot of feedback from patients requesting a mobile app for the application. Moreover, the nurses at UNC OB/GYN described the need of a tablet version of Triage Nurse Express, so that they can carry it along and get alerted of new triage encounters while they are away from their computers caring for patients. It will help them increase their response time, which will ultimately increase patient satisfaction.

### **7.1.1. Patient Mobile Application**

The patient mobile access for Keona Health Online Triage is not straight forward, because there are many different scenarios on how patients utilize the application. The first scenario would be a traditional mobile application, which patients can download from iTunes or Google Play. Upon the installation of the app, it will ask the user to choose their healthcare provider from the list of Keona Health's current clients. If the client already has a patient portal, the patient can login to Online Triage using single sign-on. Online Triage was built from the ground up using single sign-on technology so that both patients and healthcare providers only have to remember their organizational login/password credentials. For patients, it would be their credentials for the patient portal, and for healthcare providers, it would be their credential for the EMR. If a patient is new to the practice, they can register as a new patient, if the practice allows new patients to use Online Triage. Some hospitals and practices see this as an incredible opportunity to gain new patients at the very moment they need care advice. However, some would like to limit the Online Triage to their existing patients. Keona Health works with clients to customize the workflow based on the clients' needs.

The second scenario involves integration with other existing patient portal mobile apps, such as Epic MyChart. For this scenario, Keona Health needs to build mobile friendly pages using HTML5 for Online Triage, which is accessible from any other patient portal mobile app, such as Epic MyChart (Figure 6). The link to the Online Triage HTML5 site must be embedded within the patient portal mobile app and the Online Triage HTML5 site must also be single sign-on enabled.



**Figure 6.** Keona Health Patient Mobile Application Prototype

### 7.1.2. Clinician Tablet Application

To increase the response time, clinicians must be able to triage the patient anytime, anywhere, not only when they are at their computer. In a tablet version of Online Triage clinicians will be alerted of new triage encounters and their urgency, so that they can choose to respond appropriately. Triage Nurse Express will be developed as a native iPad app and tablet apps running on Android, such as Nexus 10.

## 7.2. Natural Language Processing

Through patients' feedback we found out that some of them would prefer to report their symptoms in free text rather than going through series of protocol questions. Therefore,



we are developing a system to extract symptoms from patients' free text and then determine the recommendation for the proper level of care using Natural Language Processing (NLP) techniques.

We will first need to build a system which can detect phrases such as 'abdominal pain', 'sexual intercourse', 'nasal discharge', etc... We can use this feature to generate the dictionary of terms (vector list) and their TF/IDF score from all the questions in the industry standard protocols. An example of a vector list with the terms' TF/IDF score is provided in Figure 7. After generating the vector list, we can generate another vector for each question looking up the terms and score from the dictionary. We can then run that feature representation against different machine learning algorithms to evaluate the accuracy. The dictionary will be dynamic and new terms will be constantly added. We can use patients' free text to add more terms or we can use educational content service, such as Medline Plus connect, to add more rich content. The more comprehensive the dictionary is, the better the model will be.

Id	Term	Score
2520	dianrhea	52.536658100282
2521	ulcer	52.536658100282
2522	cry	52.536658100282
2523	sexual intercourse	52.536658100282
2524	recurent chronic problem	52.536658100282
2525	muscle	49.9429725095604
2526	size	48.7097670709423
2527	new onset	47.6415159299462
2528	tetanus shot	47.6415159299462
2529	bone	47.6415159299462
2530	antibiotic ointment	47.6415159299462
2531	fullness	47.6415159299462
2532	comea	47.6415159299462
2533	CLEAN cut	47.6415159299462
2534	grunting noise	47.6415159299462
2535	nasal discharge	47.6415159299462

**Figure 7.** Term extraction with meaningful phrases and their TF/IDF score

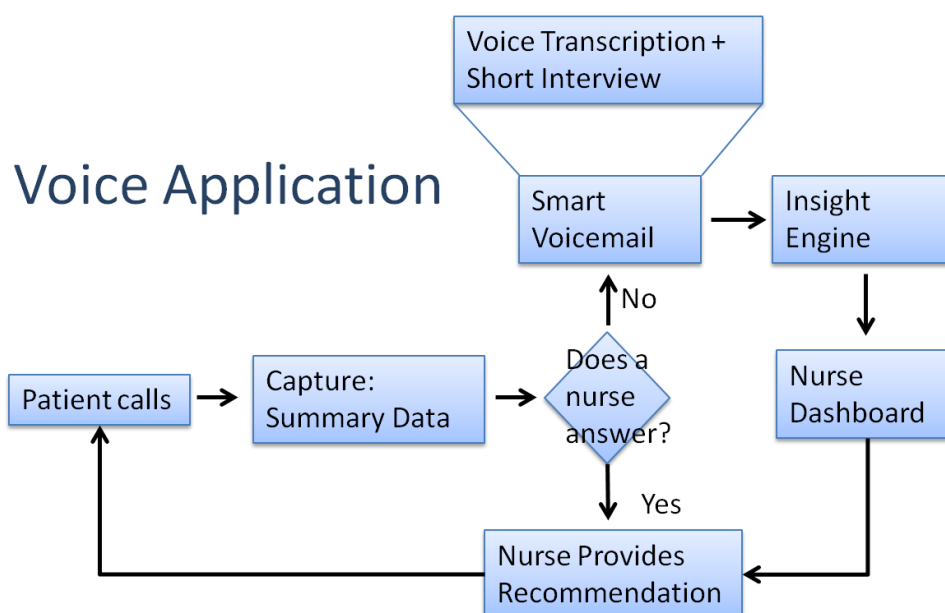
Since the majority of patients are assumed to have little to no prior medical knowledge, the text they enter could be rather noisy. Identical symptoms can be described using a variety of ways, which provide unexpected noise into the data. To minimize this noise, a patients' free text needs to be mapped to a controlled medical vocabulary which provides an unanimous way of symptom description. This hybrid approach is expected to significantly boost the performance of the models.

### 7.3. Interactive Voice Response

Online Triage covers 50% of all triage encounters at UNC Campus Health. Utilization for OB/GYN, pediatrics and primary care is also constantly increasing. So far we are caring for a population with a significant proportion of technologically savvy patients, who are very familiar with web and mobile technologies from using Facebook, Twitter and other

social media applications. However, in order to capture 100% of all triage encounters, we will need to address the portion of the population who would like to be triaged over the phone. Thus, we plan to build Visual Interactive Voice Response (VIVR) inside Online Triage. Originally pioneered by AT&T, it allows users to interact with a mobile app through voice, touch/click, or both modalities at the same time. The closest analogy we can provide for this way of interacting is what is now widely known as the SIRI software available on Apple iPhones. However, combined with this technology will be the common means of pointing or clicking for selection and interaction. In other words, if users wish to answer and activate a function they can speak to the app or touch/click an icon/menu option to execute it. Our goal is to make the interaction as smooth and effortless as possible for users by allowing this dual modality of interaction with the app.

The detailed process is shown in Figure 8. When a patient calls the provider's phone line and says they have a medical question, our software will take their name, the problem, and a timestamp. The patient data will be generated based on a structured interview with a set of options to choose from. Additionally, if the patient prefers, he/she can take advantage of visual features displayed on the phone's screen synchronized with the voice-based interview (this is the "visual" part of the interactive voice response system). Once the data has been collected a voice service such as Twilio (<http://www.twilio.com>) will be used for transcription and VIVR before sending the information to a nurse. The dual, synchronized modality, permits a more enriched and user-friendly way to interact and generate more accurate data from such interviews. As a result, every telephone call will yield basic structured information that can be used in reports and analytics.



**Figure 8.** Voice Application System Flow

## 8. Summary

In summary, Keona Online Triage has the potential to transform how patients interact with their primary care providers. Patients are getting frustrated waiting on the phone for a long time, while they have healthcare needs. Keona Online Triage addresses this problem by providing patients with an intelligent way to report their own symptoms and get reassurance and recommendation in the matter of a few minutes directly from their healthcare providers. Additionally, patients can access this service anytime, anywhere. Patients see it as a way to save time and get reassurance for their problems and the majority of patients indicated they would use it again next time they have a health problem. Keona Online Triage has also been shown to improve patient safety by directing a substantial proportion of patients to a more appropriate level of care than they originally

anticipated. Additionally, this solution substantially reduces nurse time due to lower documentation time and phone time. Nonetheless, we are aware that we need to do more work on improving the patient questionnaires and displaying information to nurses. Especially the emergency screening needs to have improved specificity without sacrificing sensitivity.

## 9. Bibliography

- Epic Systems Corporation. (2013, July 20). *Epic: Connectivity*. Retrieved July 20, 2013, from Epic Corporate Website: Epic Connectivity
- Gold, A. (2013, April 29). *70% of ER visits unnecessary for patients with employer-sponsored insurance*. Retrieved from Fierce Healthcare: <http://www.fiercehealthcare.com/story/70-er-visits-patients-employer-sponsored-insurance-deemed-unnecessary/2013-04-29>
- Herman, S. (2012, November 28). Director. (O. Oakkar, Interviewer)
- Hogenbirk, J. C., Pong, R. W., & Lemieux, S. K. (2005). Impact of Telephone Triage on Medical Service Use: Implications for Rural and Remote Areas. *Journal of Agricultural Safety and Health*, 229-237.
- Kriebs, J. M. (2005). Trouble in the Office: Liability Issues in Ambulatory Care. *Journal of Midwifery and Women's Health*, 479-484 . Retrieved from Medscape: [http://www.medscape.com/viewarticle/516439\\_4](http://www.medscape.com/viewarticle/516439_4)
- Lattimer, e. a. (1998). Safety and effectiveness of nurse telephone consultation in out of hours primary care: randomised controlled trial. *British Medical Journal*, 317:1054-1059.
- Lazarus, I. (2013, January 22). Principal. (O. Oakkar, Interviewer)
- Melzer, S., & Poole, S. (1999). Computerized pediatric telephone triage and advice programs at children's hospitals: operating and financial characteristics. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/10437761?dopt=Abstract>
- Nijland, N., Cranen, K., Boer, H., Gemert-Pijnen, J. E., & Seydel, E. R. (2010). Patient use and compliance with medical advice delivered by a web-based triage system in primary care. *Journal of Telemedicine and Telecare*, 8-11.
- O'Connell, J. M., Stanley, J. L., & Malakar, C. L. (2001). Satisfaction and Patient Outcomes Of a Telephone-Based Nurse Triage Service. *Mnaged Care*, 55-65.

- O'Brien, G. M., Shapiro, M. J., Woolard, R. W., O'Sullivan, P. S., & Stein, M. D. (2008). "Inappropriate" Emergency Department Use: A Comparison of Three Methodologies for Identification. *Academic Emergency Medicine*, 252 - 257.
- Roblin, D. W., Howard, D. H., Becker, E. R., Adams, E. K., & Roberts, M. H. (2004). Use of Midlevel Practitioners to Achieve Labor Cost Savings in the Primary Care Practice of an MCO. *Health Care Economics*, 607 - 626.
- Sloane, D. P. (2012, August 18). Associate Chair, Department of Family Medicine. (O. Oakkar, Interviewer)
- Thorp, D. J. (2013, July 5). Director, UNC Women's Primary Health Care. (O. Oakkar, Interviewer)
- Tranquada, K. E., Denninghoff, K. R., King, M. E., Davis, S. M., & Rosen, P. (2010). Emergency Department Workload Increase: Dependence on Primary Care? *The Journal of Emergency Medicine*, 279-285.
- UNC Health Care. (2013, July 20). *Epic@UNC*. Retrieved July 20, 2013, from UNC Health Care News: <http://news.unchealthcare.org/epic>
- Wall Street Journal. (2013, July 16). *Market Watch*. Retrieved July 20, 2013, from The doctor won't take your call: <http://www.marketwatch.com/story/the-doctor-wont-take-your-call-2013-07-16>