Healthily

The Chatbot Will See You Now - on any platform

2022

Chatbots first began to surface in sectors such as Banking and E-commerce

Gareth Thomas
Chief Technology Officer

but in recent years there has been a big growth in their use within the Healthcare sector. Here at Healthily we released the world's first Chatbot symptom checker in 2015, and the Healthily API provides the means by which anyone can embed our technology into their own products or services to improve user care.

We use it ourselves within our mobile apps to provide a smart symptom checker we call DOT, but the API is simple and flexible enough that it can easily be embedded within other processes such as users triage for Telemedicine or as a specific condition checker for the Pharmaceutical industry.

The definition of Chat is to:

"talk in a friendly and informal way", and Bot is short for Robot, chatbots

therefore are a form of technology that allow users to interact with quite complex software in a more human and natural way, but for the Chatbot to respond in such a way it must be able to understand the context and meaning of user input. This of course can be very challenging in a general conversational arena whereas in a specific field such as healthcare the boundaries provided make this process easier.

As you will see below, when you focus on safety and operate with hundreds of conditions the resulting service is incredibly complex .

Many companies have gone down a full AI path to make managing this complexity "easier"but for safety reasons that was never an option for us. The result is our AIMed™ product, the culmination of many years of work by talented teams of engineers, data scientists and doctors.

Self Care APIs from Healthily

Healthily AI brings medical knowledge out of the clinic and into the hands of consumers. Through our Condition Checker widgets and Smart Symptom Checker API, our self assessment and chat can be made available for use in your applications.

Our Smart Symptom Checker API gives users everything they need to assess their symptoms, receive advice, find relevant products and services and search for information on healthcare topics.

András Meczner
VP of Medical

Matin Cansdale
Chief Scientist

Accessing our symptom checker using the Chat API allows the display of consultation results to be tailored to your use case.

Our Condition Checkers allow users to check the likelihood that a particular condition is causing their symptoms - whether that's to identify people who should be screened for thyroid problems, or to keep patients with flu at home self caring.

Chat API

Guiding users to the information they need

The Healthily Chat API allows users to start a conversation with any health problem or question they need information on. They can enter anything from complaints about symptoms, such as "I have a cough and my throat is sore", to health questions, such as "What are good sources of vitamin D?"

Our Natural Language Processing service will then determine the best response to the user's query.

Users aren't restricted to a single symptom, but can list multiple symptoms which will all be taken into account by the Smart Symptom Checker.

The Chat APIs spell-checking module can correct common misspellings of medical terms as well as more general vocabulary.

1. For complaints about symptoms, the service will identify which symptoms the user has mentioned, and continue the conversation with the Smart Symptom Checker:
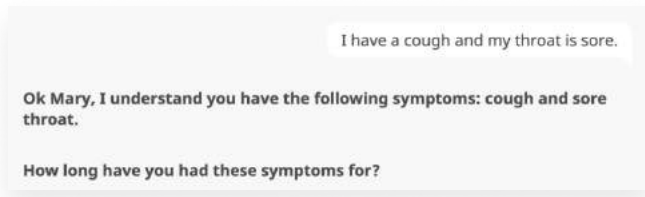

2. For general health questions, the service will identify any medical concepts mentioned, and display relevant articles:
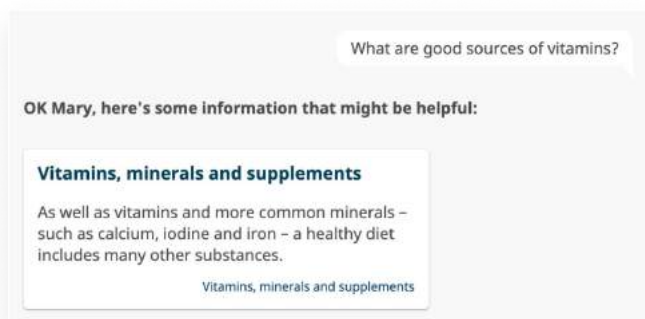

3. Some medical problems - such as injuries and animal bites - benefit from structured dialog rather than a symptom checker.

Other topics - such as pregnancy - also benefit from scripted follow up questions to guide the user to the information they need.

The service identifies queries matching these topics, and passes them on to our ChatBot:
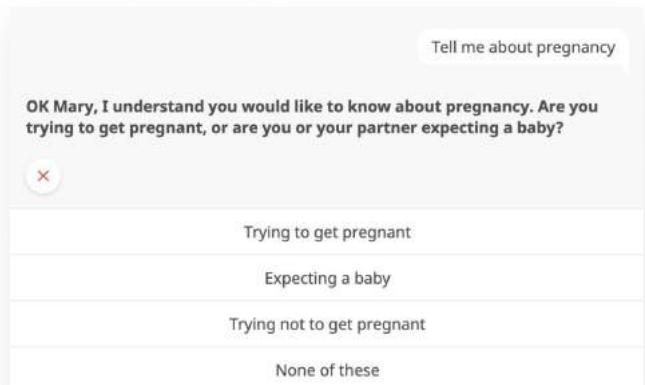

4. When a query doesn't reveal what a user is looking for, the service presents a range of options:
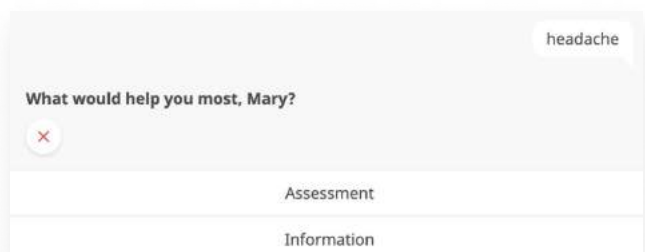
Self Assessment with AIMed™

Healthily AIMed™ Smart Symptom Checker takes the symptoms in a user's query, along with other demographic and health information about the user, and asks further questions to determine the correct information and advice to give.

We then use Bayesian inference to estimate the probability of a condition being the cause of the symptoms reported by a user given a certain set of personal factors.
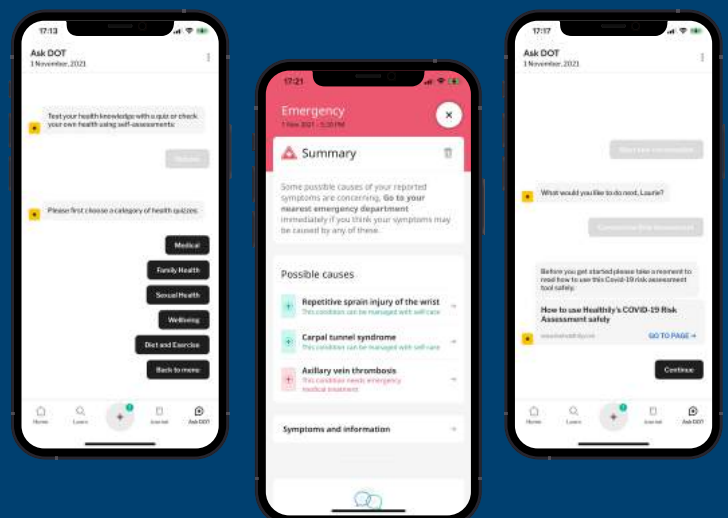
Why Bayesian inference?

AIMed™'s Bayesian approach uses probabilities related to different medical conditions and the symptoms they can cause, collated by our team of clinicians and epidemiologists.

This is in contrast to a Machine Learning approach, which would require a large amount of data on patients, the condition they are being treated for, and their symptoms. We don't believe that a suitable data set exists for this task:

- The further away from the pre-primary care environment the data is collected, the less useful it will be - symptoms that are highly predictive of a particular condition in patients referred to a hospital consultant may be much less significant in the population as a whole

- Any data set collected in a medical setting will be missing most cases of conditions which are self-limiting or for which self care is appropriate - two of the areas of most interest to Healthily

- The data would need to be accurate, reliable, and give complete demographic and geographical coverage

How does a Bayesian approach work?

To find the relative probability of one of two conditions being the cause of a user's symptoms, we need two pieces of information:

- The probability of a condition causing the pattern of symptoms the user has - for example, how likely is the condition to cause a dry cough and a headache, but not a sore throat?

- The prior probability of the user having the condition - the probability before we have any information about the user's symptoms, adjusted for the user's age and gender, medical history, time of year, etc.

With this information we can then calculate the posterior probability of the conditions - how likely each one is once we've taken all the available information into account.

For example, we can consider a random sample of 50 users:
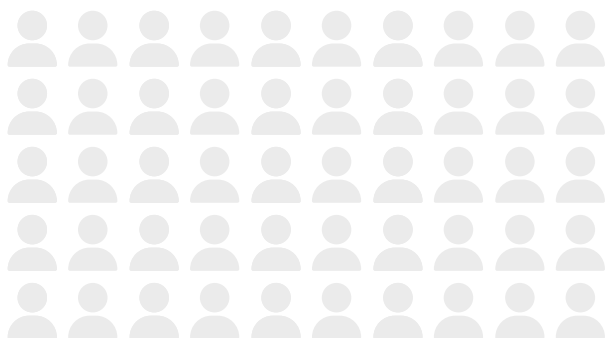
Of those, we know that 40 percent (20 users) will have condition B, and 20 percent (10 users) will have condition R:
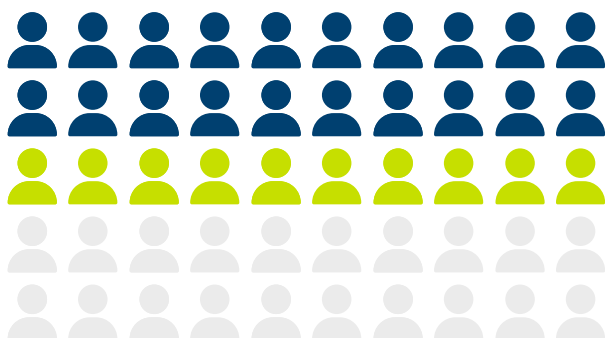
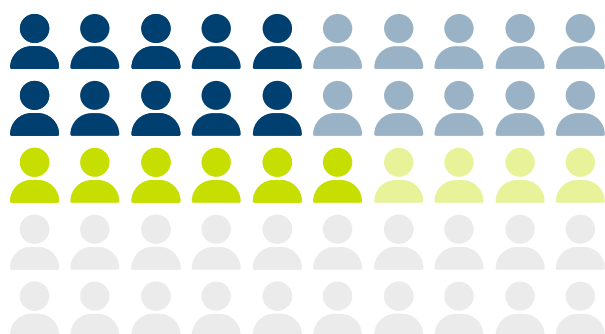We can now look at the symptoms that the user does and doesn't have. From our model of symptoms and their attributes (e.g. a cough being dry, a headache being mild) and the data we have on the two conditions, we can calculate that 40% of people with condition B have the same pattern of symptoms as the user, as do 60% of people with condition R:

With this information, we can calculate that there is a 8/14 (57%) chance that condition B is the cause of our user's symptoms, and a 6/14 (43%) chance that it is condition R:

Our full model of conditions and symptoms is more complex than this - for example, a condition might cause joint swelling more often when joint pain is also present - but uses the same fundamental principles.

The consultation process

Consultations with the Smart Symptom Checker go through a number of stages.

Clarification:

Before the consultation starts, the user can be taken through a clarification process, where the user is asked for more detail on any ambiguous symptoms they may have entered.

For example, a user complaining of difficulty moving their arm will be asked what type of symptom is causing the difficulty, and where on the arm that symptom is occuring.

it's difficult to move my arm

I picked up the following symptom: difficulty moving arm. I'd like to make sure I understand what that means. Please choose the options that best describe this symptom - you can choose more than 1.

❊

Weakness

Stiffness/reduced movement

Pain

None of these

Characterising and triggered questions:

After answering an initial question on how long they have had their symptoms, the user is presented with further questions about their symptoms and medical history.

These can be characterising questions - establishing more detail on a user's headache - or triggered questions. These are questions that a clinician would ask any user presenting with a particular symptom, to first explore any possible worrying causes of the symptom.

These questions are selected using rules created by our medical team, based on clinical best practice.

Bayesian question selection

For further rounds of questions, our Bayesian probabilistic calculations come into play. At every stage of the consultation process, AIMed™ calculates the relative probabilities of each possible condition that could explain the user's symptoms. From this, we can derive an estimate of how likely the user is to answer yes or no to each possible question.

Combined with the effect each answer would have, this allows us to choose questions that maximise the information we expect to gain from asking the question. We take into account both information on which condition is most likely to be causing the user's symptoms, and how severe the user's condition is likely to be.

This allows us to gain information on whether a suggestion to seek urgent medical attention is likely to be appropriate, as well as information on what sort of self care advice might be useful.

Consultation results

At the end of a consultation with the Smart Symptom Checker, a consultation report is created. This contains all of the information needed to tailor consultation output to your audience, from medical professionals to app or website users.

Consultation details

The consultation report includes details of the consultation including the user's initial symptoms and their duration, the user's answer to any symptom questions, and any aspects of the user's medical history used in the consultation. This can be used to recap the consultation for the user, or to give a clear summary of the consultation to any clinician or service the user is sent on to.

Probable conditions

The most likely causes of a user's symptoms are shown, along with relative probabilities for each one. These probabilities allow you to display the conditions from most to least likely.

Triage

The most important output of the symptom checker is triage recommendation. This allows users who may need urgent medical attention to be given appropriate recommendations. Users who may be able to manage their own symptoms, or seek less urgent medical attention, can be given the recommendations and information they need to do this.

Condition/Symptom

Triage is based on a combination of conditions and symptoms. This allows AIMed to combine information on the condition probabilities calculated by our Bayesian calculations with safety rules that check for concerning patterns of symptoms. For example, a 50 year old smoker may have have a cough, which is a symptom typical of the common cold. But if they complain of a unexplained cough that has lasted for a few weeks, clinical best practice tells us that they should seek medical attention to exclude more serious causes such as lung cancer.

Level/Urgency

Triage is divided into a number of levels, ranging from a need for emergency or urgent medical attention, through routine medical attention, to conditions that are self-limiting or where self care is possible. Advice can also specify how urgent the need is:

- **Emergency medical attention advised - the user should call an ambulance**
- **Emergency medical attention advised - the user should attend Accident and Emergency**
- **Medical attention advised within 12 hours**
- **Medical attention advised within 48 hours**
- **Medical attention advised within 2 weeks**

- **Self limiting conditions**
- **Conditions for which self-care is possible**

Services

For conditions and symptoms which require urgent or routine medical attention, the recommendation can also include what sort of medical professional or service may be able to help - from doctors and midwives to opticians and pharmacists.

Medical Safety

Safety is always our priority. Our clinical safety team is made up of clinical safety officers trained by NHS Digital. We have a clinical safety review process that identifies any potential hazards, and specifies solutions to prevent them, before any new feature is released. Our commitment to safety is reflected by:

- **A self registration as a Class I medical device and a CE marking for our app**
- **A Professional Record Standards Body (PRSB) audit of our quality management system to check that the way we work is safe**
- **A level 4 Quality Mark from the Organisation for the Review of Care and Health Apps (ORCHA)**

We have also submitted Healthily to scrutiny by Imperial College's Self Care Research Unit and the Royal College of GPs. The results showed that our triage was unsafe only in 3.7% of the test stories. We have since reduced this figure to 3.1%.

Overall our triage was completely accurate 64%. After the implementation of multiple improvements the accuracy of our condition outcomes is now 72%. This will continue to improve as we refine the tool continuously.
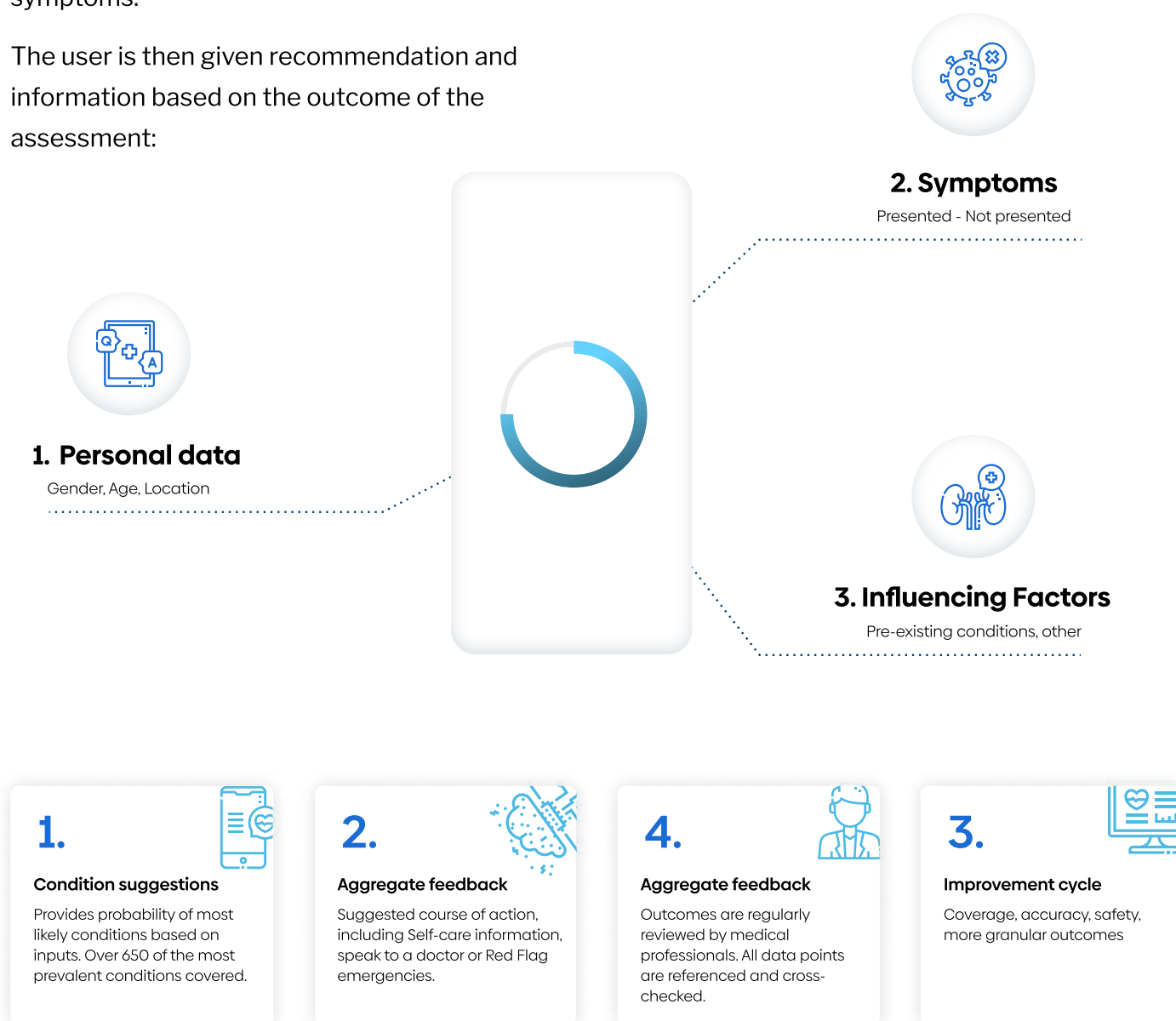
It is worth noting that the average accuracy score of general practitioners using the same vignettes in the Imperial Study was 74%.

Condition Checkers

Healthily's Condition Checkers are designed to determine whether a user's symptoms are likely to be explained by a condition of interest, or an unrelated condition which leads to similar symptoms.

The user is then given recommendation and information based on the outcome of the assessment:

- A user likely to have one of the target conditions can be given information on the condition, and recommendation on what to do next - whether that's to seek further medical advice, or to stay out of the waiting room for a self-limiting or self-care condition

- A user likely to have a different condition, or whose symptoms don't match any of the conditions, can be given appropriate advice on when they should seek further medical attention

2. Symptoms
Presented - Not presented

1. Personal data
Gender, Age, Location

3. Influencing Factors
Pre-existing conditions, other

1.
Condition suggestions
Provides probability of most likely conditions based on inputs. Over 650 of the most prevalent conditions covered.

2.
Aggregate feedback
Suggested course of action, including Self-care information, speak to a doctor or Red Flag emergencies.

4.
Aggregate feedback
Outcomes are regularly reviewed by medical professionals. All data points are referenced and cross-checked.

3.
Improvement cycle
Coverage, accuracy, safety, more granular outcomes

Conclusion

Healthily has been pioneering the personalisation of health information with AI since 2015.

01   **Our approach is pragmatic**: we identify a problem and then look for the best technologies to solve it.

02   Companies that choose to use our API should know they are leveraging our **continuous efforts to improve** as we expand our condition set and strive to understand our users without compromising patient safety.

03   **Our approach prioritises transparency, security and clinical safety.** We use a combination of Hardcoded Rules, Machine Learning and Bayesian Inference (plus other algorithms) depending on the type of problem and on a case-by-case basis.

Glossary

AI - Artificial Intelligence, the application of computers to problems that require some form of intelligence to solve. This includes approaches such as Machine Learning (see below) and expert systems, which combine a knowledge base of information on a subject with an inference engine that can make use of that knowledge to make decisions.

API - Application Programming Interface, a specification that allows two different systems to communicate by exchanging information in an agreed format.

Bayesian Inference - a method of inferring the probability of a hypothesis, based on the current probability and how well the evidence fits the hypothesis. In our case, this is the probability of a particular condition in a population, and the probability of that condition causing a user's pattern of symptoms.

Chatbot - software that allows a user to interact with it via an online text conversation.

Condition Checker - a consultation routine that evaluates the probability of a user's symptoms being caused by particular conditions of interest rather than other conditions with similar symptoms, e.g. to determine whether a user is likely to be suffering from flu or a cold or similar infection.

Machine Learning - a branch of AI where a model is trained on a body of sample data. This model can then be used to make decisions based on previously unseen data.

Natural Language Processing - the user of computers to process text. Applications include detecting the sentiment of a piece of text, and identifying concepts and proper names.

Self-Limiting - a condition that tends to go away on its own or remains the same, with no long term effects for an otherwise healthy individual. E.g. a small skin tag

Self Care - a condition which an otherwise healthy individual can usually manage on their own with the help of home remedies or over the counter medication. E.g. The common cold

Symptom Checker - a consultation routine that allows the user to enter any symptoms that are troubling them, and asks follow up questions to provide advice on what to do next and relevant articles.

Personal Factors - information about the user that is not related to symptoms. For example, demographic factors such as age and gender, or aspects of medical history such as smoking or a previous diagnosis of asthma.

Pre-Primary Care - provision of self-assessment, education, motivation, services and monitoring to help people manage their health on their own.

Triage - decisions on how urgently someone requires medical attention,(and what service is most appropriate).

For more information or to contact us:

Visit: www.livehealthily.com/business
Email: partners@livehealthily.com