

NHS COVID-19 App+

Risk-scoring Algorithm (Interim):

Technical Information

Last updated: 11 May 2020

This paper summarises how the NHS COVID-19 app will initially calculate a risk-score for an individual based on their recent contact with people who report that they have coronavirus symptoms.

The NHS COVID-19 app uses Bluetooth to anonymously record the distance over time between people who have downloaded the app. If a person reports coronavirus symptoms, their recent history of interactions is uploaded to a database and this algorithm is used to update the risk-score for every app user they have come into contact with.

Overview

There are three factors which go into calculating the risk-score for an interaction:

- *Distance* between devices
- *Duration* of the contact between the devices
- *Infectiousness* of the coronavirus carrier at the time of this interaction

The risk from an individual's interactions with other people who report symptoms is aggregated over two weeks to give their total risk-score at a given point in time.

If the risk-score for an individual ever crosses a given threshold, they will be notified and directed to further guidance.

Distance

The distance between people is estimated based on the Bluetooth signal strength between their devices.

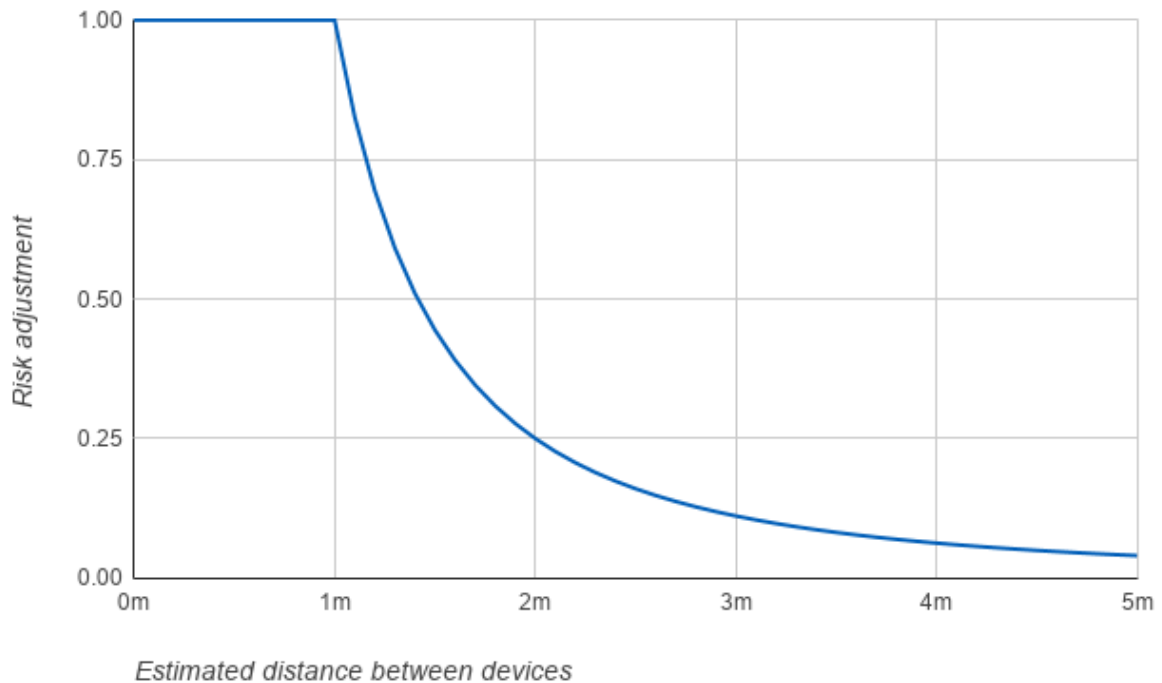
This calculated distance is then used to estimate an individual's risk of infection. Maximum risk is assumed to be at less than one metre away. This is based on standard breathing expelling air up to one metre. At more than one metre, droplets will travel through the air at a known rate¹. It is important to note that there is still a risk of infection when more than one

¹ Bourouiba et al, J. Fluid Mech. (2014), vol. 745, pp. 537-563;
Xie et al, J. R. Soc. Interface (2009) 6, S703–S714;
Kwon et al, Chemosphere 87 (2012) 1260–1264;
Nature 580, 175 (2020);

metre away, and the government asks individuals to try and stay 2 metres or more away from other people.

For distances of less than one metre, the risk is maximised at 1. For distances greater than one metre, the risk would be 1 over the square of the distance in metres (for instance at 2 metres, the risk will be 1/4; at 4 metres, 1/16).

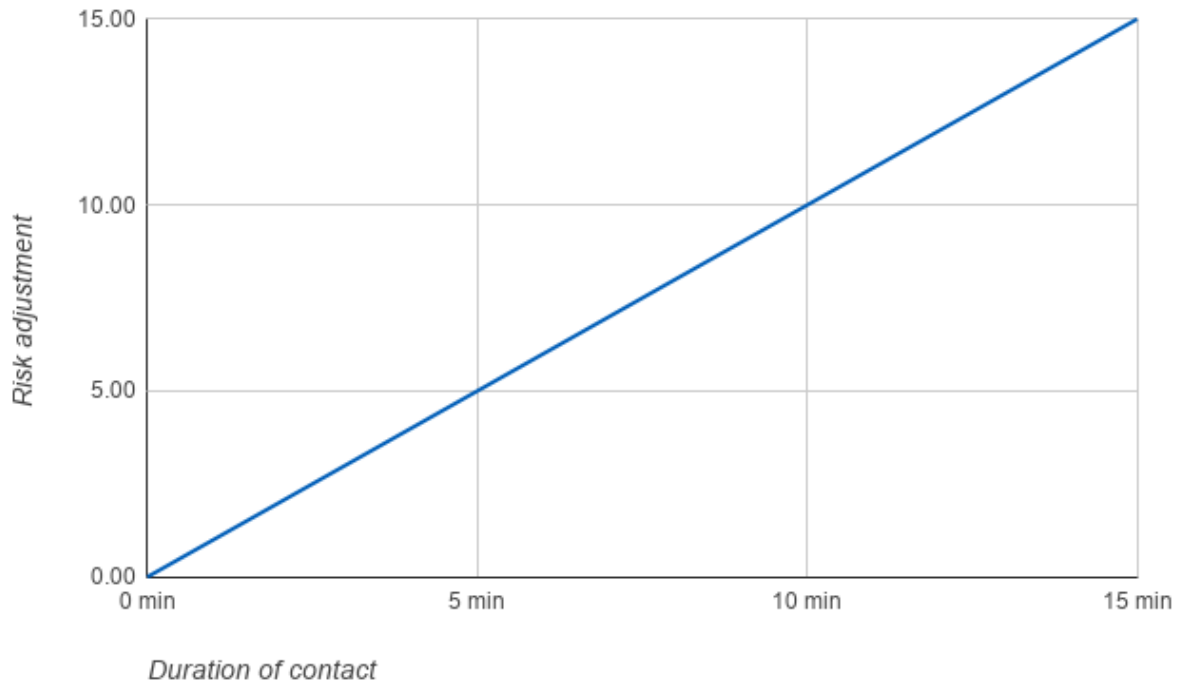
The graph below shows how the risk score for an interaction changes based on how far away the devices are from each other.



Duration

The Bluetooth signal is measured every 12-20 seconds, so that the length of time that this interaction occurred can be calculated. The algorithm assumes that risk increases linearly over time and measures duration in minutes, so every additional minute of contact increases a user's risk score by the same amount.

The graph below shows how the risk score for an interaction changes based on how long the interaction lasts.



Infectiousness

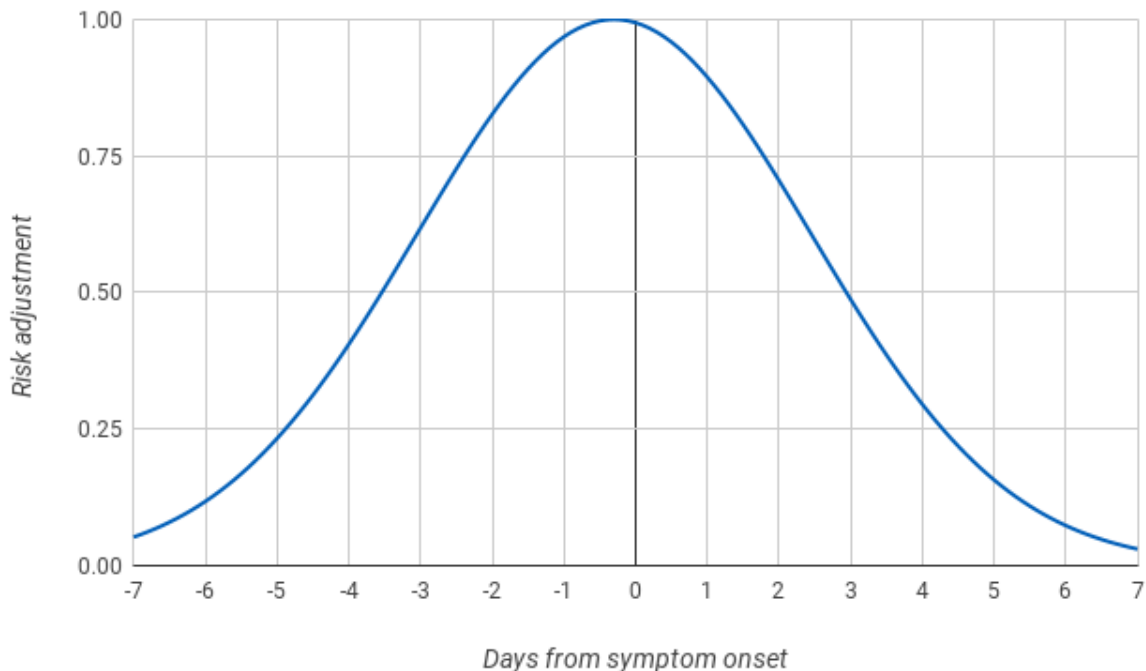
When someone tells the app they have symptoms of coronavirus, they are asked when these symptoms first appeared. The algorithm uses this date to calculate who they are most likely to have infected.

Infectiousness is assumed to follow a bell curve, with the most infectious time being early morning of the first day someone developed symptoms, and decreasing both before and after this first day.

This is modelled as a normal distribution, with a median of 0.3 days before midday on the symptom onset date (equivalent to 4:48am), and a standard deviation of 2.75 days.²

The graph below shows how the risk score for an interaction changes based on when one person develops symptoms.

² These parameters are calculated using the methodology outlined in [Ferretti, Wymant et al, Science 2020](#)



Aggregation

An individual's risk score at any point in time is calculated from all of their interactions over the previous 14 days with potentially infected people.

Decision-making

These risk scores will be used to decide who gets notifications from the app with additional guidance.

At the time of writing³, the initial risk threshold is set to be **1.83**, and individuals with this risk score or higher will be sent notifications with further guidance.

This has been set to match the PHE criteria for a single high-risk contact, **2 metres** away for **15 min**, and adjusted to a contact occurring **3 days after onset of symptoms**.

Worked Examples

Example one

Mo is waiting in line at the supermarket. He is following social distancing guidelines and so is 2 metres away from Nicole, who is in front of him in the line. They are waiting in line together for 10 minutes. Later that day, Nicole starts to develop a cough.

³ This threshold can be changed as more data is available about the transmission rate of the virus, changes to other lockdown measures, uptake of the app, and how likely app users are to follow the guidance.

The next day, when Nicole puts her symptoms into the app, she says that her cough had started the day before. The algorithm then updates Mo's risk score because of his interaction with her.

The risk of a 2 metre distance is 0.25, and they were at that distance for 10 minutes, so the risk for their interaction is 2.5. As it was on the same day Nicole developed symptoms, she is most infectious (~99%) and so Mo's risk score increases by **2.49**.

Given the initial threshold of 1.83, Mo is considered high risk based on this interaction alone, and would be given further guidance.

Example two

Zara takes the bus to work. In the past two weeks, there have been two occasions where someone else on the bus had coronavirus but did not know about it.

Last week, William had been sitting on the seats across the aisle from Zara for 5 minutes. Three days later, he developed a fever and put it into the NHS COVID-19 app. As they were sitting two metres apart for those five minutes, this interaction would have a risk score of 1.25. As it was three days before his symptoms, his infectiousness would be calculated at ~62% of the maximum, so Zara's risk score increased by 0.77.

At this point, she is not high-risk, and would still be advised to follow the standard guidance.

Yesterday, Vicky had been sitting in the row behind Zara for 90 seconds before Zara got off the bus. Today, Vicky woke up with a fever and inputted it into the app. As they were sitting 1 metre apart for 90 seconds, the risk score would be 1.5. As it is the day before Vicky developed symptoms, her infectiousness would be calculated as ~97% of the maximum, and so Zara's risk score increases by 1.45.

Zara's total risk score is now 2.22 based on these two interactions over the last two weeks. This puts Zara at high risk, and she would be given further guidance.

Example three

Alice approaches Bob's desk at work to ask whether he has any hand sanitiser she can borrow. Their devices first register each other when she is walking over to him. When she reaches his desk, Alice and Bob talk briefly, before Bob leans over to his bag to search for his hand sanitiser. After he hands it to her, they make small talk for 30 seconds before Alice walks away.

Assuming that measurements are taken every 15 seconds, the risk from this interaction is calculated as

- Approach: 4 metres for 15 seconds, 0.02
- Initial chat: 1 metre for 15 seconds, 0.25
- Reaching for his bag: 2 metres for 15 seconds, 0.06
- Making small talk: 1 metre for 30 seconds, 0.5

The total proximity risk for this interaction is 0.83.

Bob develops a cough two days later, and inputs it into the app, so Alice's risk score is updated. Bob's infectiousness is calculated as ~83% of the maximum as it was two days before he developed symptoms, so Alice's total risk of getting the virus increases by **0.68** because of this interaction.

This is not enough on it's own to pass the threshold of 1.83. If Alice had three equivalent interactions with coronavirus cases in a two week period, she would be considered high risk and given further guidance.

Changes to this algorithm

This document describes the initial implementation of the algorithm, pending feedback and evidence after the app is launched. Changes to this algorithm, either to change the relationship between these parameters, or include new ones, will be published. We will provide a further update on the process.

The risk threshold and related guidance may change as we adapt to information about the transmission rate of the virus, changes to other lockdown measures, data on the uptake of the app, and how likely app users are to follow the guidance.