



# Evaluation of the Predictive Analytics Project



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## 1. Background

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The NHS is currently dealing with an escalating demand for urgent care services and mental health issues play a significant role in this. With the dual pressures of increasing demand and financial constraints, there is a policy drive to improve quality of care while reducing costs. As part of the NHS England Test Bed, Birmingham and Solihull Mental Health NHS Foundation Trust collaborated with core partners Telefonica Alpha, Birmingham Community Healthcare Trust, West Midlands Police, West Midlands Academic Health Science Network and the Midlands and Lancashire Commissioning Support Unit. The Test bed was focused in Birmingham and Solihull where 1.3million people are resident and around 25,000 people experience a mental health crisis every year.

The purpose of the collaboration was to create a streamlined and efficient system for mental health service users by introducing predictive technology and digital interface solutions to reduce both the incidence and intensity of mental health crisis, while improving the system's response to crisis. The Predictive Analytics project started as a part of the Test bed and continued following the Test bed closure with support of The Health Foundation through their Advancing Analytics Programme.

The aim of the Predictive Analytics project was to develop a risk prediction model that predicts the likelihood of a patient experiencing a mental health crisis which could be used to reduce the intensity and/or incidence of crisis. Telefonica Alpha (our digital innovation partner) used four years of pseudonymised Trust historical health data to capture potentially robust predictors that would inform a model to identify patients at risk of experiencing a mental health crisis.

### 1.1. Mental Health Crisis

A mental health crisis is an adverse event for a patient with mental health problems and it is often described as the stage where a person is no longer feeling able to cope or be in control of their mental health situation and it impacts their wellbeing (1). Mental health crisis cannot be easily defined and has previously been defined using varied approaches including 'self' or risk-focused definition but these are subjective and are hard to quantify.

In this project, mental health crisis (and/or acute spell) is measured using an informatics derived definition that defines the crisis or acute spell as a period of time in which a service user is considered to be in ongoing crisis or acute psychiatric need based on the services he or she has contact with. Each crisis spell encompasses an initial crisis presentation and all subsequent activity until the service user's level of need has 'stabilised' at a level below that requiring support from crisis or acute services. The end of a crisis spell is reached when the

patient is no longer in receipt of crisis or acute psychiatric care for more than 28 days. Crisis & Acute Spells will always start with a 'Crisis Episode', and may include multiple 'Crisis Episodes' if there are repeat new presentations to crisis services before the person has had a 28-day period without any acute or crisis activity. This objective and measurable definition supports predictive modelling to identify people within the general service user population who are at risk of experiencing an acute mental health crisis, with a view to intervening in advance to prevent a crisis developing. Please refer to Annex 1 for more information.

The number of crisis services across Birmingham and Solihull now includes the Rapid, Assessment, Interface and Discharge Team (Liaison psychiatry) in A&E, Street Triage, Place of Safety, Psychiatric Decision Unit, Home Treatment teams, mental health inpatient beds and Crisis Houses. These services are more tailored to manage mental health crises but are only available once a patient is experiencing a crisis. There is no mechanism to predict a crisis and intervene before a patient's condition escalates.

## **1.2. Risk Prediction Model**

Telefonica Alpha used 5 years of pseudonymised Trust historical health data and sociodemographic information to develop different models to identify those with the best predictive power. XGBOOST, a supervised machine learning algorithm that belongs to the family of Boosted Tree algorithms (2), was adopted for feature selection and model construction as it demonstrated better predictive power than other machine learning techniques and deep learning methods.

This algorithm was tested using Stratified 5-Fold Cross Validation with ROC-AUC score as metric. It is a well-known metric used for binary classification problems that is robust in case of having a large unbalance between the two classes as found in this data (i.e. the number of no-crisis outcomes in one week greatly outnumbers the number of crises encountered in one week for the entire sample). The gradient boosting model had an area under the curve (AUC) of 0.77, which indicates a good predictive power. The algorithm uses a wide range of variables (167) to make a prediction at a weekly basis of whether a patient will experience a crisis event during the following four weeks but it does not identify the responsible risk indicators for a given patient.

## **1.3. Clinical Risk Stratification Tool and Feedback Platform**

Prior to prospectively testing the Risk Prediction Model, a pre-pilot study was conducted to ensure that there was viability to continue to the pilot phase (Annex 2). This included input from several clinicians from two community mental health teams (CMHTs) who looked at retrospective data generated by the risk prediction model and assessed the use of the tool and whether the outputs were considered operationally useful. The findings suggested that

while the clinician's found the tool useful in practice and there was some insight gained from using it. It was difficult to gauge the effectiveness of the algorithm in its current form because of the time taken to review a patient's record when only provided with a patient ID number. Additionally, due to the high number of false positives on the list, a step up process was required which after further stratification highlighted the most 'at risk' patients and provided any important information about a patient that would reduce the time spent on a case. In addition, there were also some recommendations shared with Telefonica to refine the algorithm to reduce the high number of false positives. The pre-pilot also highlighted the need to reduce the predictions presented to clinicians from a weekly to a bi-weekly basis due to workload commitments. The pre-pilot also emphasised the importance of establishing strong clinical engagement with the project to ensure a robust implementation of the tool.

As a result of the retrospective testing of the risk prediction model with clinicians, a risk stratification 'tool' was developed that encompassed the recommendations of having the key clinical information highlighted. This tool ranked the cases predicted as 'at risk' of crisis using information from their health record data and takes into account several factors such as the patient's recent medical history, care level and whether their risk assessment/care plan is up to date. Adding this additional tool was integral to implementation and clinical buy-in as it provided the clinicians with context on their cases and presented some of the risk factors in a structured format.

The risk prediction model's output was stratified further using a risk stratification tool scoring system to rank the cases from the highest to lowest risk of crisis. This combined system of the risk prediction model and risk stratification tool is referred to as the Risk Prediction Tool. The Risk Prediction Tool was used in the pilot phase and was presented to clinicians via a feedback platform which was developed to allow clinicians to receive/use the list of flagged patients and to provide feedback after reviewing them. Further detail on the approach to developing the tool and an example of the feedback platform can be found in Annex 3.

#### **1.4. Implementation of the Risk Prediction Model**

As highlighted by the pre-pilot findings, clinical engagement would be crucial to successful implementation of the Risk Prediction Tool. Effective engagement with clinicians started prior to implementation and involved engaging the Team managers and selected Clinical Leads from the pilot CMHTs to be involved in the development stages of the pilot study including the development of the risk stratification tool and the feedback platform.

All the pilot teams had designated 'digital champions', of which there were at least two per team. They were supported by the predictive analytics Clinical Lead to have a more in-depth understanding of the project and were given more responsibilities from being the first line of contact when there were any issues to allocating cases to individual clinicians. The tangible presence of a champion who could respond to queries and encourage uptake and

engagement was established to create a sense of partnership and ownership in the project, on a localised team level.

The Risk Prediction Tool was introduced to each team via training sessions; these were provided for all clinicians who would be involved in the project. The sessions included a presentation on the project, explaining the project aims, how the prediction tool works and what is expected from them in using the tool. The feedback platform was also presented to them in these sessions with a demonstration on how to use it and the opportunity to practice using it provided. They were also given access to a shared drive which contained all the training resources, including an electronic guide and background information. This included contact information on how to liaise with the project team and especially the clinical lead for support on using the platform.

Prior to the start of the pilot study, once all the teams were trained, the feedback platform was tested out with the teams to ensure any technical difficulties or problems were addressed. This allowed for some modifications based on the feedback received from the clinicians before the start of the study.

Service User Engagement also formed an integral part of the project with drop-in sessions arranged prior to implementation and ongoing throughout the project. Service users were provided with information on the project including the intended benefits and improvements it could generate for their care. They were updated on the progress of the project and feedback was collated through questionnaires and group discussion. Any issues or suggestions were addressed and used to inform the project when appropriate. Please see Annex 4 for further information.

## 2. Methodology

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### 2.1. Aim of the Study

The implementation of the Risk Prediction Tool was accompanied by a formative evaluation that assessed the clinicians' perception of usefulness and value of the tool as a clinical decision support tool in identifying people who are at risk of experiencing a mental health crisis. The evaluation also aimed to explore their views on the implementation of the Risk Prediction Tool.

### 2.2. Study Design and Participants

The pilot study was a mixed method study in four community mental health teams (CMHTs) in Birmingham and Solihull Mental Health NHS Foundation Trust. The CMHTs were chosen based on their capacity to adopt the Risk Prediction Tool although consideration was also taken in ensuring the pilot teams covered a variety of demographic and variance in caseload. The pilot teams were Erdington and Kingstanding CMHT, Warstock Lane CMHT, Sutton CMHT and Orsborn House CMHT (Ladywood and Handsworth team). Clinicians (or participants) were recruited from each CMHT to take part in the pilot study to test the outputs of the Risk Prediction Tool as a decision support tool in identifying patients at risk of mental health crisis.

The Risk Prediction Model was run by the Trust's Information Team on the Trust's patient administration data every two weeks. The predictive model output was further stratified using the risk stratification tool and ranked from highest to lowest risk of crisis. The top 25 patients that were identified as being at high risk of a mental health crisis from each CMHT's list were then selected and presented on the feedback platform. The model outputs contained a list of patient names, patient identifier, risk score and relevant clinical and demographic information (Annex 3).

The clinical lead would then conduct a check of the list of patients to ensure that the data being presented was up to date; they would then contact the designated digital champions and managers/clinical leads of the relevant team to inform them that the list was available to view. The patients on the list are allocated to clinicians by the digital champions and/or managers and were then given two weeks to complete the feedback on the platform. Upon reviewing the list they would complete F1 feedback form where they provide their estimation of the patient's risk level and specify their intended action as result of the prediction. A week after the initial review, clinicians were asked to record, on the F2 feedback forms, if they had changed their assessment of the patient's risk level upon further assessment and feedback on how useful the information provided to them was in either preventing a crisis or identifying a patient deteriorating to provide support or in managing their caseload priority. See Annex 5 for more information.

In addition, some clinicians were selected for follow up interviews to gain a better understanding of the usefulness of the tool and its effect on clinical decision making and to gauge their perspective on the implementation of the tool. The semi-structured interviews featured questions on perception of the participants on the use of the tool. In particular these were:

- Views on implementation and training
- Usefulness of the Risk Prediction Tool in practice
- Facilitators and Barriers to the use of the tool



### 3. Results

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The complete data set contained 1011 predictions that were presented to the four CMHTs for review over the 6 month pilot. The expected number of predictions was 1200 but due to reduced prediction output throughout the study, there was reduced number of predictions (refer to 4.1). Sixty participants took part in reviewing the Risk Prediction Tool's output and in providing feedback on its use. Out of the sixty participants in the pilot study, the majority (51) were nurses which included clinical leads and team managers (Figure 1).

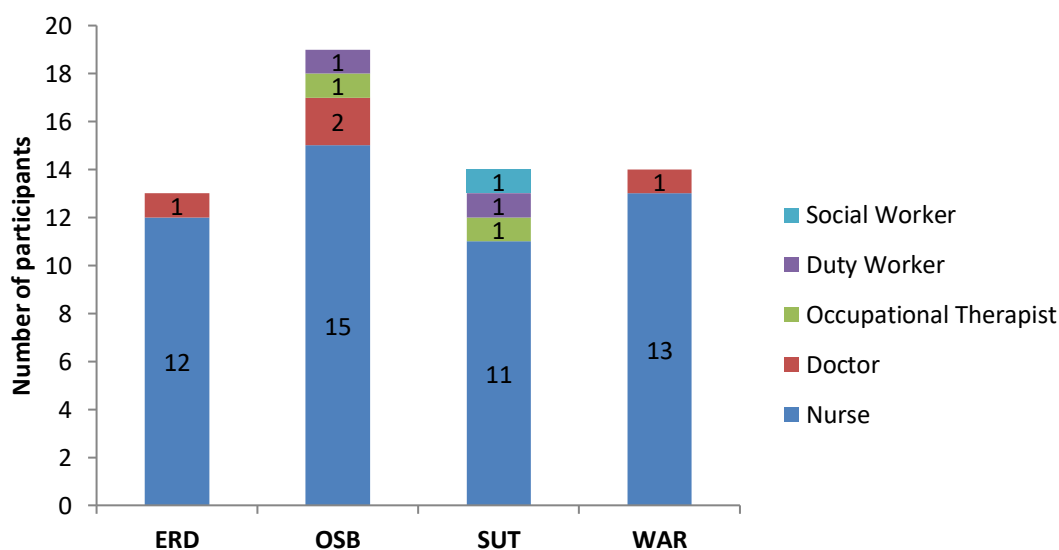


Fig 1: The chart shows the number of staff and the range of professions involved in the pilot per community mental health team.

#### 3.1. Engagement of participants

The level of engagement with the Risk Prediction Tool was measured by the completion of the F1 feedback form as it indicated that the clinicians had reviewed the case flagged by the tool. The participants across all the CMHTs completed the F1 feedback forms for 92% of the predictions made by the tool as shown in figure 2.

Erdington and Handsworth CMHT had the highest completion rate of F1 feedback forms and also the highest number of predictions accounting for 29% of the overall 1011 predictions to all CMHTs. This indicated that the participants reviewed all of the cases flagged by the Risk Prediction Tool. Orsborn House CMHT had the lowest completion rate of F1 feedback forms, however they still reviewed 242 cases, which was the second highest number of cases reviewed from the 4 CMHTs; they also had the second highest number of predictions generated which accounted for 28% of the overall predictions in the pilot. The cases flagged

to Warstock lane and Sutton CMHTs made up 24% and 19% respectively of overall predictions.

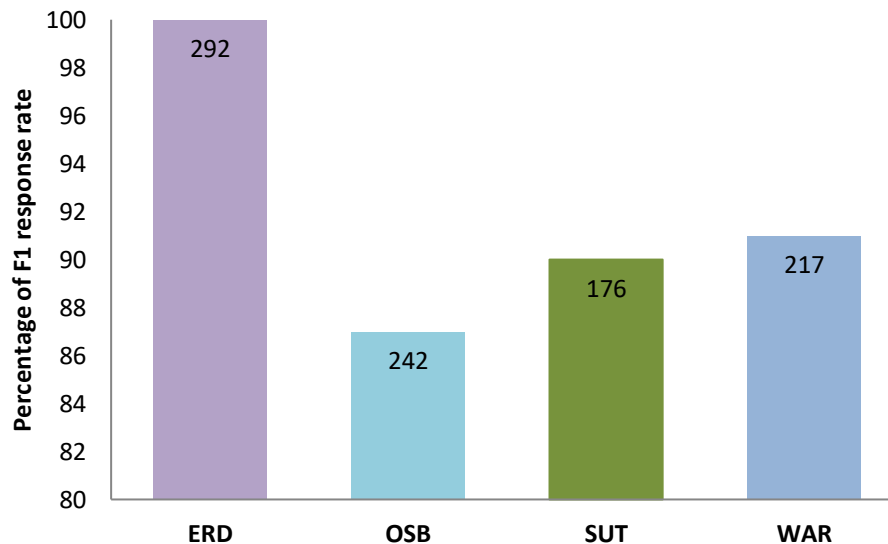


Figure 2: Completion rate of F1 feedback forms and number of predictions.

### 3.2. Clinicians' feedback

Out of the 1011 cases flagged, 84% (846) had both F1 and F2 feedback forms completed and these were the only predictions that were included in the analysis. The F2 feedback forms were designed to capture if risk assessment of a case had changed a week after the receipt and review of the patient list and how the prediction of risk was useful for the clinician.

Erdington and Handsworth CMHT had the highest rate of F2 completed feedback forms at 94% (272 out of 292 predictions) and Orsborn house CMHT the lowest rate at 78% (217 out of 279 predictions). Sutton CMHT had 81% (157 out of 196 predictions) and Warstock lane CMHT had 80% (200 out of 244 predictions)

Upon initial review of the cases flagged by the Risk Prediction Tool, the clinicians across all the CMHTS rated about 38% of the cases as low risk, 44% as medium risk, 13% as high risk and less 0.1% as being at an imminent risk of experiencing a mental health crisis. They also reported that just fewer than 6% of the cases were already in crisis.

On the following week, the clinicians reassessed the risk level of the cases flagged again and the majority of the initial assessments stayed the same at 76% of overall responses. The clinicians' reduced their perception of risk for about 17% of the cases while their perception of risk increased for about 8% of the cases flagged as being at risk of mental health crisis.

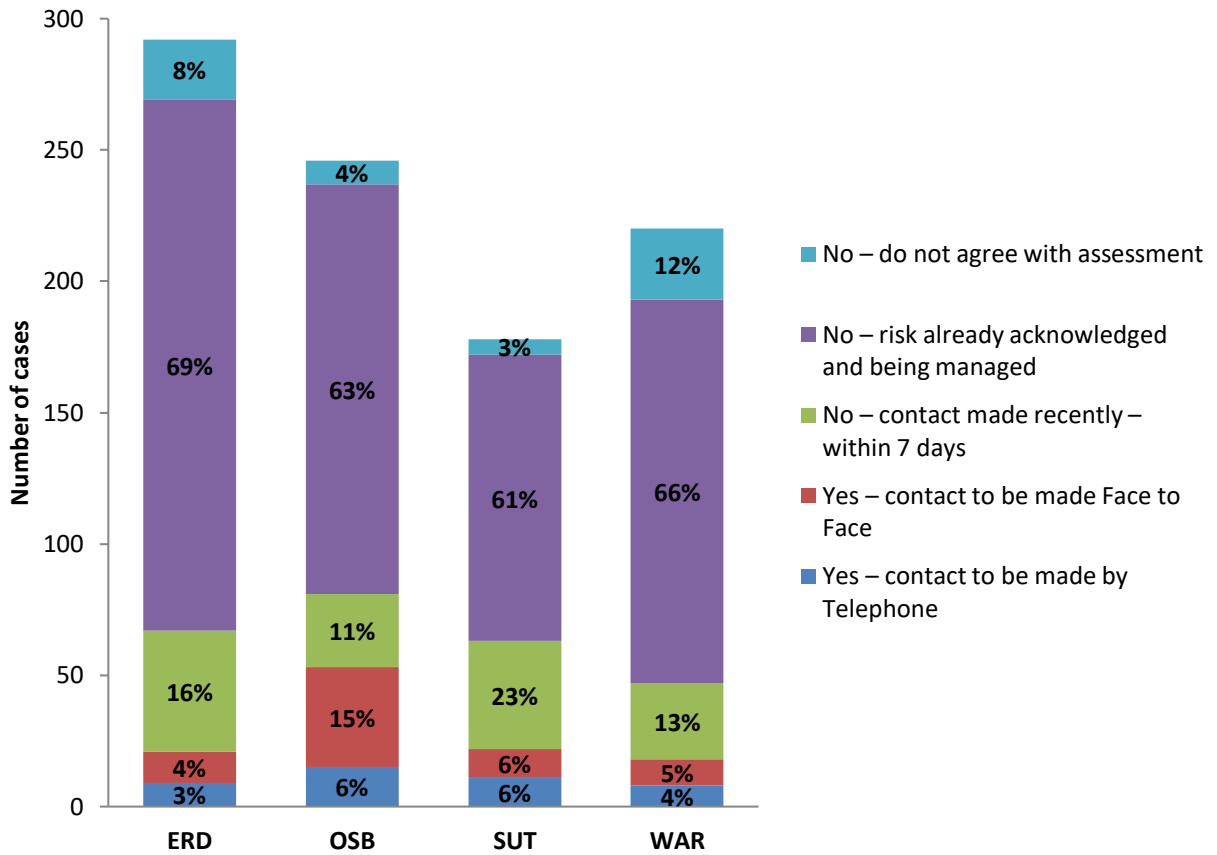


Figure 3: The graph shows the responses by clinicians given on whether they intend on taking action based on a prediction and the type of action.

As shown in figure 3, the clinicians across the entire pilot CMHTs only disagreed an average of 7% of the predictions presented indicating that patient was at risk of going into crisis. The disagreement with the prediction varied across the CMHTs with Warstock lane CMHT demonstrating the highest prevalence at 12% and Sutton CMHT the lowest, whereby they only disagreed with the crisis prediction on 3% of all cases presented to them.

Upon reviewing the cases flagged by the tool, the clinicians on average responded that they would make contact, based on the prediction, either by telephone or face to face in about 5% and 8% of the cases respectively. In the majority of the cases, it was considered that no further action was required as the clinicians deduced that the risk was already being managed and/or that a recent contact was made that would address the risk.

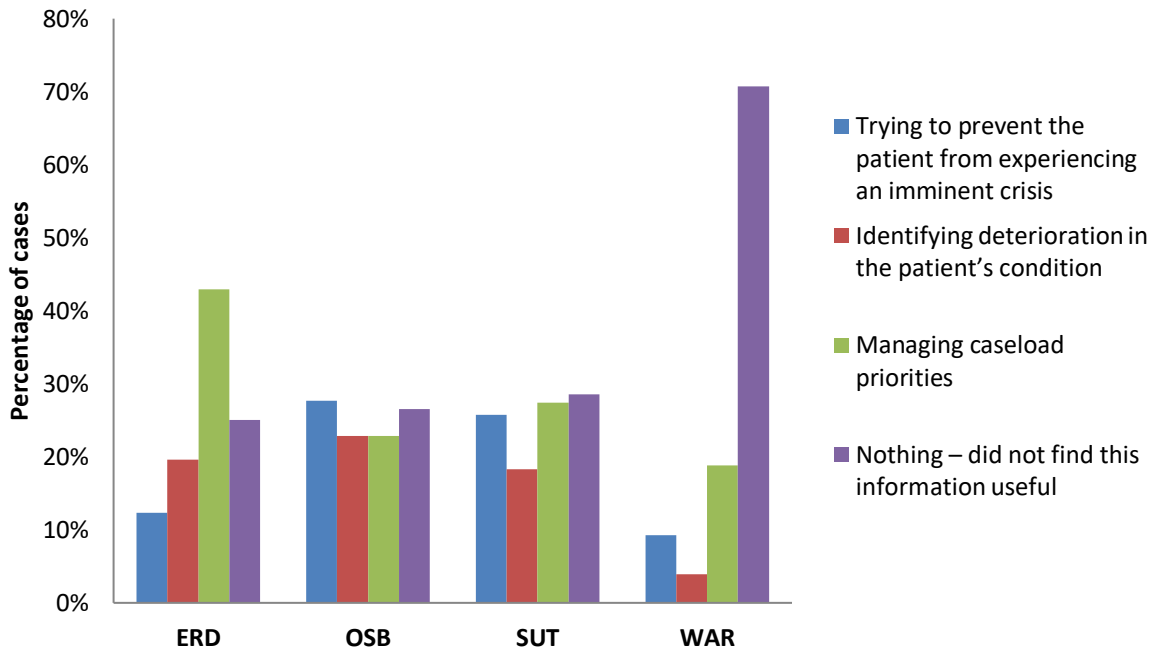


Figure 4: The graph show the responses provided by clinicians on how the Risk Prediction Tool's output was useful in practice.

When asked how the information provided by the Risk Prediction Tool was useful in practice clinicians responded that they used it to prevent a patient experiencing a crisis in 19% of the cases presented and identified the deterioration in a patient's condition in 17% of the cases as shown in figure 4. Clinicians reported that the Risk Prediction Tool's output was used to manage caseload priorities in 28% of the cases flagged. On average across all the CMHTs, the clinicians reported that they did not find value in the information provided by the Risk Prediction Tool in 36% of the predictions, however, when comparing responses between the teams, Warstock Lane CMHT reported that they did not find the information useful in 71% of their cases compared to 25%, 27%, and 29% of the other CMHTs (Figure 4). Overall, the clinicians found the Risk Prediction Tool's output useful in some manner in about 64% of the cases flagged.

### 3.3. Qualitative views on implementation and use of the Predictive Risk Stratification Model

There were five respondents in the qualitative interviews from three out of the four CMHTs which included a range of professions such as managers, doctors and nurses. The interviews were held 5 months after the start of the pilot to allow sufficient exposure of the participants to the Risk Predictive Tool.

Five themes were identified: 1) Views on implementation and the use of the Risk Predictive Tool; 2) How the Risk Predictive Tool affected the work of the participants and how they responded to patient needs; 3) Perceived relevance and value of the Risk Predictive Tool; 4) Facilitators and barriers affecting the use of the Risk Predictive Tool; 5) Suggestions for ways to improve the Risk Predictive Tool. These themes are elaborated below and evidenced by key quotations embedded within the text.

### **Views on implementation and the use of the Risk Predictive Tool**

All the respondents were in consensus that the implementation including the training received on the use of the Risk Prediction Tool was very well executed and useful. The tool was straightforward to use and easier to use than they expected.

*"It was very useful and I had no problems after I left the (training) in terms of using it as I felt very confident and able to use it"*

*"The training didn't take long at all and it was quick, informative and much easier to do than I assumed it was going to be"*

*"It was very helpful and I had no problems after I left there in terms of doing it as I felt very confident and able to use it"*

The feedback platform was perceived to be easy to use and navigate by all respondents with some respondents mentioning that there were some early technical difficulties in using it such as the system (SharePoint) disabling, information not being saved, inability to open a shared document due to multiple logins or misunderstanding on how to correctly open the feedback platform by few individuals. However, they felt that these issues were addressed promptly when mentioned to the project's clinical lead and the project manager. A respondent mentioned that it helped that participants knew who to contact in times of need and that they had direct access to a clinical lead and champions for assistance and support.

*"There were a few kind of small technical issues with it...whilst things got up and running but they were quickly resolved and it was easy to use"*

*"The tool is not complicated which is good as it would put people off it if there was too much to do"*

### **How the Risk Predictive Tool affected the work of the participants and how they responded to patient needs**

Respondents said they used the tool as an additional resource in their workflow and that it had not required extensive additional work in its current form. However, they believed that if the workload or number of cases being flagged increased, this may be harder to manage.

*"It is manageable as it is but if the cases reviewed increased from the four every two weeks, people would be annoyed and would likely have less time to spend on cases"*

Others welcomed the increase in the cases flagged every two weeks but believed more clinicians from other disciplines needed to participate in the project to allow for distribution of workload.

*"If that would be increased, I think that is fine but other disciplines need to be involved in this, it doesn't need to be just nurses but doctors, psychologist, OTs, Students and support workers. I think a lot more people can be a part for this and they are not"*

Most of the respondents mentioned that the feedback platform was very easy to navigate and that the scoring criteria and the information given was useful but mainly to highlight some key points and that they still needed to access the notes to get a better understanding of the situation. Additionally, almost all of the respondents didn't attribute much value to the overall risk score received by an individual patient in assessing their risk.

*"If the scoring criteria weren't displayed, we have to go into different places to draw that information and it is drawn together for you so it saves time when assessing a patient"*

The respondents said that the tool had not influenced how they perceived risk but that it had highlighted interesting features in some cases that they wouldn't have known about or cases that would have gone unnoticed.

*"It has not changed how I view risk and I don't think more of about risk, as I think of risk all the time, It is part of my job to have that mind set where as some of the other roles may feel differently, such as in a care coordinators role but as a clinical lead I am continuously thinking about how to reduce the risk to someone. I think we would lose, if we didn't have this in place, a lot of people who would slip through the net and get lost in the system"*

Respondents described types of actions they took in response to a patient being flagged by the Risk Predictive Tool. They contacted many patients by telephone, they made home visits, rearranged visits, brought forward outpatient appointments and/or reviewed patients in multidisciplinary meetings. Some of the examples included:

*"There has been a few times when the patients that come up have been a bit of a surprise and then I thought I should be more alert to them and making sure I see them a bit more regularly or see them as soon as I can by moving appointments"*

*"Sometimes I have asked GPs to give them a telephone call or taken cases to MDTs for discussion... which is always a good place to put them in as medics will bring the outpatients appointments forward or put them on the care coordinators waiting list which is positive"*

One respondent mentioned that there were instances when they didn't understand after reviewing cases why some of the patients were on the list therefore they didn't follow up and the patient subsequently went into crisis which made them realise that they needed to be more thorough in their reviewing process.

*"There was a patient that was allocated to me that is in hospital now but when I reviewed her, I didn't understand why she was on there so did not act on this but on my next follow up with her, I had to call an ambulance"*

*"There has been many times when patients have been missed in the service, maybe they didn't turn up for their doctors appointment and another appointment wasn't sent out or when there has been contact with our duty team where there were signs of relapse but this hasn't been picked up on or escalated, the tool is very helpful to identify these cases which would have otherwise been followed up on"*

### **Perceived relevance and value of the Risk Predictive Tool**

Some respondents mentioned that the information presented in the feedback platform could sometimes be out of date and that they had to refer back to the patient's notes to get more up to date information of patient's status.

*"The scoring criteria used pulls information that can sometimes be out of date"*

*"The scoring criteria hasn't always been helpful as it hasn't always been accurate and I know sometimes that is the only thing available to use but sometimes it is a patient you know and you know that there has been other progress notes...but obviously there is the ability to check patient notes (RiO) if you wanted to check further"*

The respondents said that the patients being flagged included a lot of patients already having continued contact for whom they were aware of them being high risk based on their own clinical judgement and in those instances they didn't find much value in it. However, some questioned how it should be used, whether it was more suited to bringing up patients on care support as they tend to know the risk level for patients on care coordination.

*"We have found a lot of value in some of the cases...but a lot of the cases we are coming across, we know about especially those with care coordinators as that care coordinator would be seeing them regularly and will have very up to date information on what is going on ... so the tool telling us they are at risk doesn't particularly add any value...the people most at risk are the ones that aren't having any contact with any service"*

*"It highlights people that would otherwise, in my opinion, fall through the net and get lost in the system"*

*"The tool is more useful for patients not under care coordination as patients on care support tend to see a doctor every 3 to 4 months and in between they do not see anyone and we are relying on them making contact if they are unwell"*

*"For patients on CPA, the nurses and CPNs tend to know if their patients are bubbling and becoming unwell and this is more beneficial for care support patients that don't get as much of*

*a look in as these CPA patients who are seen every two weeks or so. The nurses are good as they look at the notes and they know if they presented somewhere or they have something happen in their lives that could put them at risk of crisis but care support patients see medics every 6 months if they are lucky and often longer so I think it would be more beneficial for them"*

Overall, the respondents said that they believed the Risk Prediction Tool added value as, they believed, it identified patients that otherwise would have been lost in the system and that it sometimes acted as a reminder for clinicians with busy schedules. It also identifies any cases that have been lost due to miscommunication or gaps in the system.

*"I think it is good in terms of a manager's perspective, it helps care coordinators look more thoroughly at their cases and as you know with busy jobs, it is easy to forget things at times and it acts as a reminder, such as so and so's anniversary is coming up, so I probably should visit them next week. It just makes people more on the ball"*

*"There was a patient of mine that came up and I didn't know she had been on the home treatment team and there wasn't an appointment in place for her because we weren't alerted that she had been discharged"*

*"Sometimes even if the information of a patient should be related to us there sometimes are communication issues because people are busy... so we may lose that one person in crisis and nobody remembered to tell another person about it...this is sometimes picked up by the tool"*

All respondents believed that the tool should be embedded in their everyday working practice and expressed that they would like the use of the tool to carry on as business as usual.

*"I definitely think it should be incorporated as part of our normal working practice because I think it has shown, and everyone I have looked at I found informative, and of course there are some that I think I know this person and they won't go into crisis and they will be fine but others where I have reviewed and I thought oh my goodness, I can't believe this person has never had any contact and we would never have known and so I believe that it should be used in everyday practice"*

*"The tool is useful in flagging up people who need help that have gone missed or unnoticed or haven't made contact themselves before going into crisis"*

### **Facilitators and barriers affecting the use of the tool**

Most respondents mentioned that the ability to have a digital champion and a clinical lead for the project helped support the participants and aided in the engagement with the tool as concerns were directly addressed.



*"It was helpful to have (clinical lead) to better explain things that we didn't understand and also to relay issues to when there were issues with the system like logging in and saving responses"*

*"The training was very helpful and then having the (clinical lead) was helpful as he is on site at least once or twice a week to help people if they need it so if there has been any questions I can ask him then or email him and he will get back to me quickly so that kind of resolved any issues quickly"*

Some respondents voiced concerns that they had during the initial phases of the project about where the responsibility of using the tool lies and they believe if this was going to be rolled out needs to be addressed.

*"I think initially it was just what if we don't call the patient that we have been allocated to... if we don't see or speak to them and if anything happened to them, whether that would be seen as the fault of the clinician because that was one of the patients we were looking at that week and if this is rolled out, and not just a trial, that was going to be like an everyday practice worry"*

One concern raised was the time constraints of the participants to be able to fully review all the patients, especially new patients that are not on their existing caseload as it identified unmet need that would need to be addressed in addition to their workload.

*"I know of care coordinators who have struggled to do it just because of our time constraints and if the patient is somebody you are already care coordinating, they are on your case load anyway which is fine but if it is not, then you end up having to make calls to people or seeing them face to face and following up which takes a lot of time"*

*"I do find value in it but I will admit that sometimes when I am really busy because of the time frame to get things done I feel like I am rushing it more than other times so probably not getting as much value of it when I'm rushing it. But when I can take the time, not that it's very time consuming, it's just the nature of the job that it's so busy sometimes you can't even use the toilet, which is typical. So it is not that I feel this is time consuming in any way and it is very easy to use. But when I use it properly I find it very beneficial"*

Respondents also mentioned that the tool flagged a lot of patients who were already in crisis, either in home treatment or in hospital. The concern was raised that this might cause clinicians to be "dismissive of it (the tool)" which meant that they were less inclined to follow up on flagged patients in the future.

### **Suggestions for ways to improve the Risk Predictive Tool in practice**

The respondents suggested some ways that they believed would be useful in addressing the barriers of a lack of capacity and integration to workflow. There was a fairly consistent theme

running through the responses that the future use of the Risk Prediction Tool would depend on time capacity within their practice and being able to access resources and support to meet identified needs.

*"We have a dashboard that alerts us if our patients have had contact with out of hours or haven't been seen in 28 days and that sort of thing, I don't know whether it would be possible for something to be on there to alert you that within the predictive analytics section, that your patient is showing up with a high score or something like that"*

*"Maybe having a nominated person have a look at the list and assess it initially and then go to the relevant person such as the care coordinator and say this person has been flagged and may need reviewing"*

*"I think it is fine to be incorporated in every day practice but other disciplines need to be involved in this as it doesn't need to be just nurses but doctors, psychologists, occupational therapists, student and support workers too must be a part of this project"*

*"There should be a way to remove patients that we are already aware about, either if they are already in crisis or we have put in place interventions as there is not much we can do about those cases"*

## 4. Discussion and Conclusions

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### Clinician engagement

The F1 feedback form response rate indicates that the clinicians found value in maintaining the usage of the Risk Prediction Tool's output by reviewing the cases flagged. While there was a certain level of variability in the usage level of the tool's output between CMHTs, the overall average across all teams was still very high at 92% which demonstrates that the clinicians accepted the use of the tool in their clinical practice. However, as stated this does not indicate that they agreed with the prediction of individual cases presented, more the buy-in of the use of the tool in assessing individual cases flagged by the Risk Prediction Tool.

The variability in usage between the CMHTs is unlikely to be a result of the implementation of the Risk Prediction Tool given that each team received the same input of training, technical support and project resources. This shows that the difference with engagement is more likely due to internal factors that could be studied further to inform future implementations.

The qualitative component of the project also highlighted that the clinicians were engaged in using the tool despite their time constraints and increasing workloads. Engagement with the tool was affected during some weeks due to high levels of annual leave and the Christmas period but the teams still tried to review most of the cases and provide feedback.

### Risk Perception

The clinicians found 13% of flagged patients at high risk of experiencing a mental health crisis while about 6% of flagged patients already being in crisis. The majority of the cases flagged were classed as low risk or medium risk with only 6% of those cases where the perception of risk was increased. This indicates that the risk prediction model could have picked up on risk markers that clinicians didn't initially capture from reviewing a case but that was highlighted upon further review with the support of the clinical decision support tool. Additionally, this could have been due to further interaction with the patients which provided more information. This would also apply to the cases where perception of risk level was decreased.

It is important to consider how clinicians will interact with the tool when integrated into routine practice and whether clinicians revisit cases or decide on what action to take based on their initial assessment. The responses show that clinicians in general do not tend to change their original assessment of risk as a result of using the tool and therefore it would be more clinically effective to review flagged cases once. Furthermore, all the clinicians interviewed responded that the introduction of the tool has not changed how they perceive or assess risk but that it had been useful in highlighting new cases or in helping to prioritise existing caseloads.

## Usefulness of Risk Prediction Model

Clinicians found the information provided by the Risk Prediction Tool useful in either preventing a crisis, identifying a patient's condition deteriorating or managing caseload priorities in about 64% of the cases flagged by the algorithm across all the CMHTs. This is even higher at over 70% in three out of the four CMHTs with Erdington and Handsworth at 75%. This demonstrates that in the majority of the cases, the clinicians found usefulness in the Risk Prediction Tool's output which is also reflected in the continuing engagement of clinicians with the Risk Prediction Tool in their practice.

While about 36% of the completed responses indicated that the clinicians did not find value in the information provided, it is important to note that the clinicians only disagreed with 7% of the prediction. This is very positive as it indicates that they did agree with the risk flagged by the Risk Prediction Tool but that it did not add value to their working practice for other reasons besides disagreeing with the prediction. For instance, one interviewee suggested that the clinicians had sometimes already identified the risk of a patient in their caseload and put measures in place to mitigate the risk so the information did not add any new insight. This was also reflected in the feedback received where 65% of overall predictions, the clinicians responded that they didn't need to take action as the risk was already being managed.

The high number of predictions where clinicians have responded that they are proactively managing the risk is backed up by statements made by participants in the interviews. These responses indicate that the Risk Prediction Tool is more effective to the patients on care support as care coordinators tend to be more aware of when patients on their caseload (CPA). However, some clinicians did indicate that it was useful as a reminder to review some cases on their caseload and therefore, it is important to consider how the predictions are distributed to clinicians and whether the alerting method should be the same for all patients. This could be further explored with the clinicians to develop a more informed and collaborative output mechanism that is both efficient and useful to clinicians in their practice.

Additionally, the clinicians who were interviewed found value in most of the information provided by the tool, whether it was to identify at risk patients that were not being picked up, to encourage them to intervene with identified high risk patients sooner or as a case management tool to prioritise some of their cases as flagged by the tool. They also mentioned that while it is very useful that there were concerns that the sometimes the teams did not have the time to review cases thoroughly or did not have the resources to respond efficiently. They believed having more disciplines and team members involved in using the tool would result in a collaborative response that was not resource intensive. Finally, these clinicians wanted to better understand the accuracy of the tool in preventing crisis in clinical practice and how this would translate into their own working practice.

## **4.1. Strengths and limitations of study**

The introduction of the project and the tool to the teams was conducted gradually and in collaboration with team managers and digital champions. This approach ensured ownership of the project and encouraged participation which was integral to the engagement in the pilot study. Several digital champions were recruited to drive implementation of the tool to advocate the work of the project and to provide localised support within the teams.

The study looked at the acceptability of the tool by CMHTs in their clinical practice only and did not look at whether the clinicians agreed with the prediction. Identifying this would be helpful to allow further analysis of their perception of the information provided and to understand other factors that may influence how they use the information.

During the course of the pilot, there was a gradual decline in the number of predictions generated for each 14 day cycle. The cause of this was traced back to July 2018 when there was a coding error accidentally introduced. This became more impactful over time and resulted in a reduced number of crises being predicted over the course of the pilot. This was identified and resolved but not until mid-way through the pilot study. While the model was still generating numbers of valid predictions for clinical teams to continue to use the tool, this could have had an impact on their perception of its usefulness as the output generated included patients already in crisis which affected the value they found in the information provided. The issue of flagging patients already in crisis was also highlighted by some clinicians in the qualitative component of the study.

## **4.2. Conclusions**

This evaluation sought to assess the clinicians' perception on the usefulness of the Risk Prediction Tool including implementation, engagement and their use of the tool. We conclude that the clinicians in the CMHTs included in the pilot study found the Risk Prediction Tool beneficial and felt that it fitted into their workflows and clinical practice. They also appear to have found value in receiving the predictions to improve their proactive engagement with patients at risk of experiencing mental health crisis. This clearly shows potential that this predictive clinical decision support tool could become a part of routine clinical care and can be used as a resource by clinicians in order to identify which of their patients are at risk of experiencing an imminent mental health crisis or to identify patients who may benefit from case management/intervention to avoid them going into crisis.

To aid better proactive management of cases, it is recommended that wider ranges healthcare professionals are engaged in the project across the CMHTs. The process of iterative implementation prior to full rollout of the Risk Prediction Tool to teams was identified to enable favourable clinical engagement in addition the clinical lead and digital champions to promote a seamless integration of the digital tool into practice.

## References

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2. Tianqi Chen and Carlos Guestrin (2016). XGBoost: A Scalable Tree Boosting System. In Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining (KDD '16). ACM, New York, NY, USA, 785-794.

## **Annexes**

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Annex 1: Definition of Mental Health Crisis

Annex 2: Retrospective testing of the risk prediction model

Annex 3: Risk Stratification Tool development and feedback platform example

Annex 4: Service User Engagement Report

Annex 5: Feedback Questionnaire







## **Annex 1 – Definition of Mental Health Crisis**

A mental health 'Crisis & Acute Spell' is a period of time in which a service user is considered to be in ongoing crisis or acute psychiatric need based on the services he or she has contact with. Each Spell encompasses an initial crisis presentation and all subsequent activity until the service user's level of need has 'stabilised' at a level below that requiring support from crisis or acute services. The Spell's end is defined by the start of a period with no acute or crisis mental health service activity for at least 28 days.

'Crisis & Acute Spells' will always start with a 'Crisis Episode', and may include multiple 'Crisis Episodes' if there are repeat new presentations to crisis services before the person has had a 28-day period without any acute or crisis activity.

Beginning of a 'Crisis & Acute Spell' – the initial crisis event based on presentation to one of the following crisis services:

1. Liaison Psychiatry assessment in A&E and Medical Assessment Units
2. Home Treatment Team assessment (to become/include Crisis Teams)
3. Street Triage Referral
4. Place of Safety referral
5. Psychiatric Decision Unit referral
6. Bed management referral
7. Inpatient admission (excluding Neuropsychiatry)
8. Out of area inpatient admission

Continuation of a 'Crisis & Acute Spell' – further crisis/acute psychiatric care as follows

1. Liaison Psychiatry assessments in Accident and Emergency and Medical Assessment Units
2. Home Treatment Team contacts during acute phase of a person's care
3. Street Triage referrals – each referral is counted as a crisis event
4. Place of Safety admissions – all time spent on a unit
5. Psychiatric Decision Unit admission – all time spent on a unit
6. Bed management – all time open to bed management
7. Inpatient admissions – all time in inpatient service
8. Out of area inpatient admissions – all time in inpatient service

End of a 'Crisis & Acute Spell' – no further crisis/acute psychiatric care:

1. When no further crisis/acute psychiatric care is provided for more than 28 days, then the Spell is considered to have ended with the last recorded crisis/acute care activity.





## **Annex 2: Predictive Analytics – Retrospective Sampling Exercise Findings**

### **Predictive Work Stream Overview**

BSMHFT's Test Bed programme is focusing in 2018-19 on further refinement and testing of a predictive algorithm that is able to a) identify patients at risk of experiencing a crisis in the near future and b) thereby help staff reduce the rate of presentation at urgent care. In order to realise the objectives of this work stream, the Trust partnered with Telefonica Alpha to develop a predictive model using historical Trust data spanning five years.

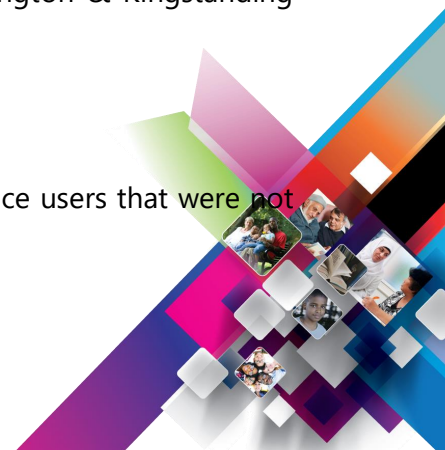
It was envisaged that Telefonica would produce an algorithm that outputs a list of service users at risk of going into crisis in a given period. The Information team would then make a risk stratified caseload list (based on risk of presenting to our urgent care services) available to our Community Mental Health Teams (CMHT's) on a regular basis. This list is intended to be used as a decision support tool (like how Risk Stratification is used in Primary Care) to help CMHT's prioritise their caseload. Over the longer term we would hope to see this have an impact on reducing the number of patient presenting in to a crisis service.

### **Progress since January 2018**

Telefonica Alpha completed the latest iteration of the algorithm in January of this year with a view to the Trust testing the output. The main objective was for the Trust to engage with the host clinical teams to determine the algorithm's practical usefulness, and to feedback on any features that were either missing or could be used differently. Prior to this, it was agreed at the Clinical Reference Group (CRG) in 2017 that the Community Mental Health Teams (CMHTs) were the most appropriate setting to host the predictive algorithm as the patients cared for by these teams were, generally speaking, not currently experiencing a mental health crisis, and were usually living at home, and seen on a regular basis by their care coordinator. The Trust operates 13 such Community Mental Health teams, but it was agreed with NHS England that during the pilot phase (June 2018 - March 2019), we would operate the algorithm in 6 teams in a phased approach. The results would then be evaluated by comparing the rate of crises in the 6 pilot CMHTs (cases) against the remaining 7 CMHTs (controls).

In anticipation of the formal pilot phase in June 2018, it was agreed within the project team to pre-pilot the algorithm within 2 teams (Warstock Lane CMHT and Erdington & Kingstanding CMHT). The purpose of this pre-pilot was;

1. To ensure that there is viability to continue to the Pilot phase
2. To gauge the effectiveness of the algorithm in its current form
3. To consider whether it is operationally useful i.e. does it flag service users that were not already on the team's radar.



4. To use this opportunity to identify any additional features that could be included in future iterations.

The Trust has also taken the opportunity to investigate what the impact might be of providing CMHTs with a more limited subset of the cases predicted by the full model, if applying further filtering to try and minimise 'false positives'(based on "step change criteria", more detail below) .

### The Algorithm

A set of predictions were generated for the weeks leading up to [and including] the first week of January 2018, based on predicting whether service users were likely to experience a crisis in the following 4 weeks. The chosen machine learning methods for the algorithm (Long Short Term Memory (LSTM) and XGBoost) are not able to determine the responsible risk indicators for a given service user's risk profile. However, the modelling process generates an ordered list of the most predictive indicators ("features") – in order of influence (top 22 included in **Appendix 1**) – A "feature" is a characteristic that relates to a service user and can be identified within the anonymised dataset that has been made available for model development. In the context of the algorithm, the features were chosen based on analysis of how well they correlate with crisis activity.

The algorithm achieved very high levels of predictive power in distinguishing between people likely to experience a crisis in the next 4 weeks and those not. However, there remains a concern that accurate predictions are substantially outweighed by 'false positives', and that this may limit the model's practical application. The Trust Informatics team have therefore been studying the outputs over the last few months to understand the predictions in more detail, and also where possible to "group" service users based on diagnoses and other factors to see if that has any bearing on the predictive strength. "step change" features was explored following discussions with CMHTs in December 2017 and January 2018to try and stratify or segment service users based on recurrent themes identified when reviewing a list of people predicted to go into crisis (**Appendix 2**).

### **Sampling Method**

The sample study used the latest algorithm output (prediction date: 31 Dec 2017), and limited the cohort to service users that were on the selected two community team caseloads on the prediction date. The samples were limited to 30 Service users per team (*total = 60*) in agreement with the respective service managers of both teams that agreed to take part in this study. *Table 1* shows how the sample number corresponds with the total predictions for each team.

**Table 1.**

	<b>Erdington &amp; Kingstanding</b>	<b>Warstock Lane</b>
<b>Total Predicted</b>	149	79
<b>Sample</b>	30	30
<b>% of Total</b>	20%	38%

The samples were not chosen completely at random. Fifteen out of the thirty for each team were chosen at random from within the full set of predictions, but up to a further fifteen were chosen based on a step change criteria. As neither team had fifteen such service users that met these criteria, the shortfall was made up of service users that did not have a contact with the community team in the 28 days following the prediction date, to try and ensure that there were at least some records in the samples where the course of events without clinical intervention following the prediction could be reviewed. This resulted in the following sample breakdown:

<p><u>Erdington &amp; Kingstanding</u></p> <ul style="list-style-type: none"> <li>a. 'Step Up' Cohort - 10 Service Users</li> <li>b. 'Full Sample' Cohort – 20 Service Users             <ul style="list-style-type: none"> <li>a. Random – 15</li> <li>b. No Contact Group – 5</li> </ul> </li> </ul>	<p><u>CMHT Adult Warstock Lane</u></p> <ul style="list-style-type: none"> <li>a. 'Step Up' Cohort - 9 Service Users</li> <li>b. 'Full Sample' Cohort – 21 Service Users             <ul style="list-style-type: none"> <li>a. Random – 16</li> <li>b. No Contact Group - 5</li> </ul> </li> </ul>
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**Analysis**

Once the cohorts were identified, the teams were contacted and 2-3 meetings were arranged with each team to go through the list, and took place between 8<sup>th</sup> and 25<sup>th</sup> May 2018. A set of questions were identified and signed off with approvals from the Trust Information Team lead, the participating community team managers and respective service managers, as well as Telefonica Alpha. The questions have been included in **Appendix 3**.

**Summary of Findings**

In summary, 59 out of 60 service users were eligible. 1 was excluded because there were no notes on the service user as he had recently been transferred over from a young adults' service provided by another Trust.

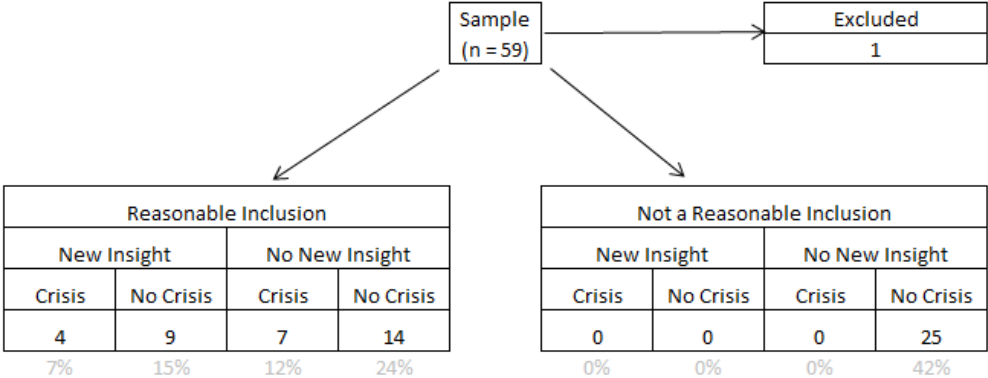
Of the 59, more than half were deemed to be a reasonable inclusion (n=34) – i.e. the clinical team agreed that the person was at high risk of crisis at the time of the prediction; and in 13 of these cases their inclusion was also deemed to be adding a new insight or at least serving as a new prompt for the CMHT to intervene.

11 of the people overall in the sample actually went on to use crisis services in the following 4 weeks, of which all were recognised by the CPNs as being a reasonable inclusion on the list, and 4/11 were also deemed to be a new insight. Of those that were not deemed to be a new insight (n=7), CPNs acknowledged in 4 instances that a different intervention may have averted the crisis. On the remaining 3 instances, they noted that either an intervention would not have helped (n=1), there was no engagement (n=1) or that there was regular contact and the service user has presented well (n=1).

25/59 service users were not considered to be a reasonable inclusion on the list. The main reasons/feedback for these includes:

- The clinical notes suggest the service user had been presenting well
- There was vulnerability (e.g. severe post-natal depression), but that did not equate to potential crisis where there is a care coordinator involved, and regular contact.
- Discharge from HTT should not itself be an indicator for a potential crisis. The service user may be risky, but if the follow up procedures are adhered to, this should by definition be the end of a crisis not the beginning of a new one.
- Service users in care homes are very unlikely to go into crisis as they are in 24 hour care.
- DNAs are indicative, but where there is a successful follow up after the DNA, that risk is reduced.

**Diagram 1**



**Team Level Findings**

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

**Narrative**

- [REDACTED]  
[REDACTED]  
| [REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]

- [REDACTED]  
  | [REDACTED]  
  | [REDACTED]

**Narrative**

- [REDACTED]  
| [REDACTED]  
[REDACTED]  
[REDACTED]

- [REDACTED]  
  | [REDACTED]  
    [REDACTED]  
  | [REDACTED]  
    [REDACTED]

**Narrative**

- [REDACTED]  
[REDACTED]  
[REDACTED]  
| [REDACTED]  
[REDACTED]  
[REDACTED]  
| [REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]

[REDACTED]

[REDACTED]

- | [REDACTED]
- [REDACTED]
- [REDACTED]

[REDACTED]

- | All 7 were deemed suitable to be on the list
- 4 out of the 7 were seen to be adding "new insight".
  - One of these was a Service User who had recent suicidal thoughts (December) and was not followed up regularly whilst the Service User's Care Coordinator was on annual leave for 2 weeks.
- Of the 3 that were not deemed to be adding new insight:
  - 1 service user was not engaging with the service – and was well known within the team
  - Another was recently with home treatment, and was contacted by the CMHT for follow up but was a physical health inpatient at the time. It was acknowledged by the CPN that a prompt to follow up could have potentially averted the crisis.
  - The third Service User passed away within the crisis period. Although there was some contact with the CMHT early in January, there was not further information until the service user attended a private clinic 2 days before passing away. It was acknowledged by the CPN that perhaps a different approach may have averted a crisis.

- | [REDACTED]
- [REDACTED]
- [REDACTED]

[REDACTED]

- || [REDACTED]
- | [REDACTED]
  - [REDACTED]
  - [REDACTED]
  - [REDACTED]
  - [REDACTED]
  - [REDACTED]
  - [REDACTED]
  - [REDACTED]
- | [REDACTED]
- [REDACTED]
- [REDACTED]
- [REDACTED]
- [REDACTED]

## **Conclusion and Recommendation**

Although a lot of 'false positives' were identified, the algorithm does seem to be identifying high risk/vulnerable service users. Additionally, it also does provide insight or at least a prompt to intervene in some cases – so there is value being added. There were exceptional cases where staff could not identify why the service user was included on the list – but in all cases, the information that the CPN was using to determine risk was the most recent progress notes – and unstructured data has not yet been included in the algorithm so there is scope for some refinement in this regard.

The main area of concern from a practical point of view is the amount of time it took to get through 30 sets of notes with each CPN (2-3 visits, 3 - 3.5 hours in total or around 6-7 minutes per person on average); in practice this would be very difficult if this depth of review were needed for each person included on the predictions list before a decision to make contact with the person as the CMHTs are already stretching their resources. On the other hand, this concern may be mitigated by the fact that the churn rate is very small, so only a handful of service users will be "newly added" to the list each week.

A number of potential refinements to the algorithm were identified during the pre-pilot which will be shared with Telefonica Alpha in the hope that this further reduces the number of service users incorrectly identified ("false positives"). Additionally, the frequency in which the lists are shared with the CMHTs, as well as including key data to support decision making will be scoped to further reduce the amount of time spent on each case.

## **Recommendation**

Notwithstanding the practical difficulties outlined above, due to the number of reasonable inclusions (58%) and the additional insights (22%) that the algorithm has provided, it is recommended that the project move in to the pilot phase to test the algorithm across the 6 CMHTs.



**Appendix 1.**

Below is a list of the top 22 features that were included in the predictive model. Using statistical techniques, the Telefonica Alpha team were able to identify these features as having the most "predictive power" i.e. these features (in combination and/or isolation) seemed to correlate most to a service user having a mental health crisis.

Rank	Importance	Description
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		

**Appendix 2.**

Step Change Criteria

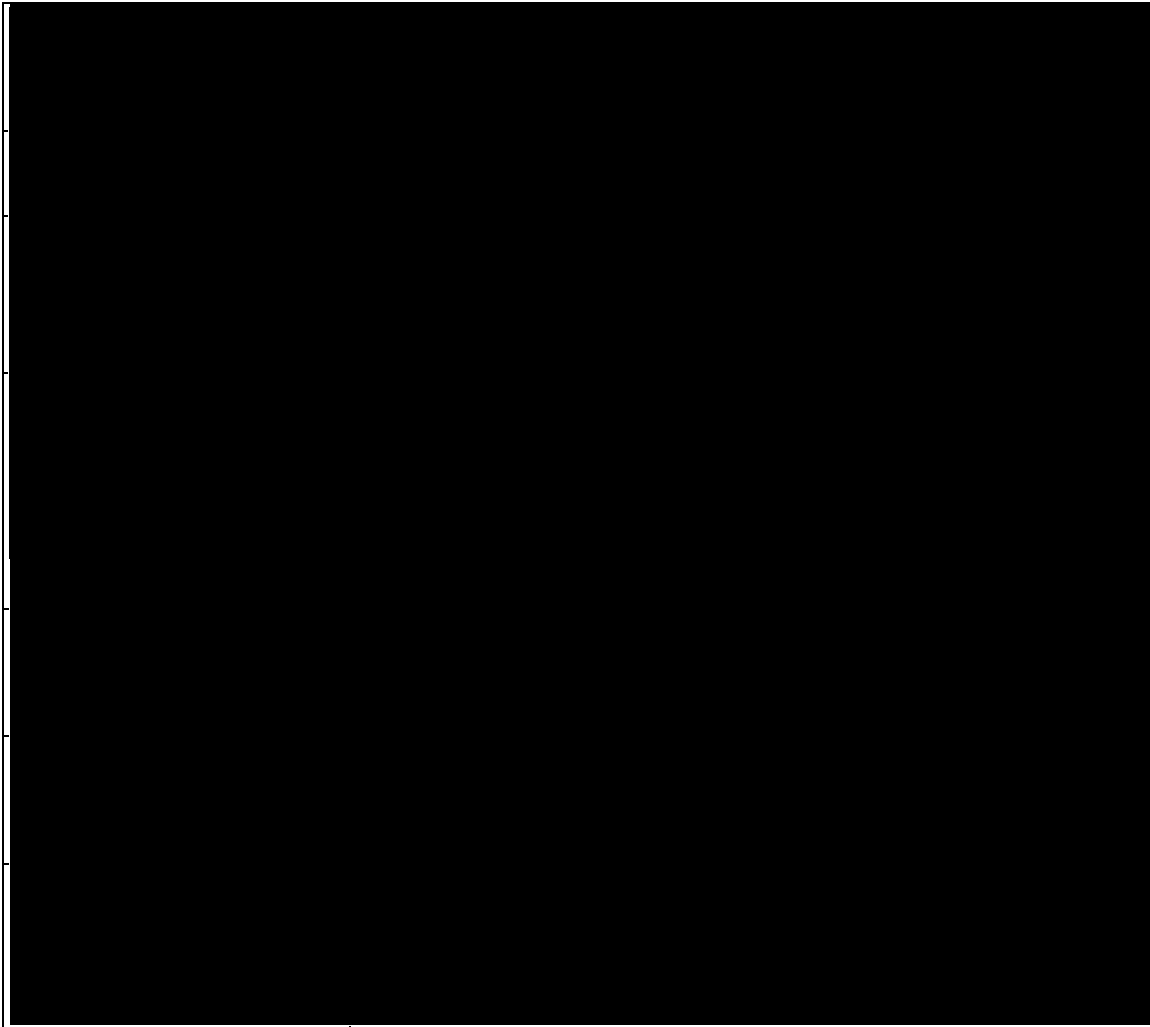
The step change criteria is an attempt to further segment service users in to groups based on criteria identified as a result of meetings that took place between the Informatics team and two community teams in December and January this year.\_The following features were raised as possible risk factors:

- Changes in the number of contacts
- Change in Care Level from CPA to Care Support
- Change in diagnosis
- Negative change in employment
- Negative change in accommodation

- Recent DNAs
- Whether the service user is a frequent attender or not
- A recent eclipse

The Informatics team applied the above criteria to the Telefonica algorithm output, and service users that were flagged as "crisis predicted" and a "Step Up" according to the above criteria were flagged as a "Step Up".

Criteria in More Detail



### Appendix 3.

Below is the questionnaire that was used to evaluate the 60 samples. Questions one and two are pre-populated through RiO so were used to add context for the clinician to answering the remaining 6 questions.

#### **From RiO:**

1. Did the person actually have a crisis in the next 28 days (or since)? If so, when and where
2. Was the person seen in the next 28 days without having a crisis presentation first? If so, when and in what context?

#### **From the CMHT:**

3. Based on what was known as at 31st December, does including this person on the List seem reasonable? If not, why not?
4. Would it have provided your team with any new insight? i.e. was this service user already on your radar as being at high risk at the time? Please provide details
5. Why would you have thought at the time that the service user WOULD/WOULD NOT be at high risk of going into crisis in the next 28 days? Please provide a brief description, referring to past events and/or observations at the time.
6. Please answer one of the following depending on what actually happened in the 28 days:
a. If crisis without another contact first – do you think having followed the person up based on the algorithm could have helped avoid the crisis presentation?
b. If contact(s) and then a crisis – do you think anything could have been done differently to avoid the crisis presentation?
c. If contact(s) and no crisis – do you think the contacts helped prevent a potential crisis presentation?
d. If no contacts and no crisis – any comments?
7. What are the Key Risk Indicators for this Service User?
8. Any Other Comments

## Appendix 4.

Below is a list of sample service users, along with key risk indicators that were identified by the CMHT following review of their respective progress notes:

PatientId	Step Change	Major Risk Indicators													Diagnosis Related (including chaotic, paranoid, psychotic episodes,	Personal (including relationships, bereavement)	Domestic Violence	Physical Health	Recent Inpatient/CTO	Recent Section History					
		Reasonable Inclusion	New Insight	Suicidal Ideation	Substance Misuse	Self Harm (Inc Overdose)	Self Neglect	Risk to Others (Inc threats)	Social Conditions (inc housing, social isolation)	Hostility (inc anger, aggression)	Missing Appointments	Medication (missing or refusing)													
1	Group 2	x	✓	x	x	✓	x	x	x	✓	x	x	x	x	x	x	x	x	x						
2	Group 2	x	✓	x	x	✓	x	x	x	✓	x	x	x	x	x	x	x	x	x						
3	Group 2	x	✓	x	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
4	Group 2	x	✓	x	x	x	x	x	✓	x	x	x	✓	x	x	x	x	x	x						
5	Group 2	x	✓	x	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x						
6	Group 2	✓	✓	✓	x	x	x	x	x	x	x	x	✓	x	x	x	x	x	x						
7	Group 2	x	✓	x	x	x	x	x	✓	x	x	x	x	x	✓	x	x	x	x						
8	Group 2	x	x	x	x	x	x	x	x	x	x	x	✓	x	x	x	x	x	x						
9	Group 2	✓	✓	✓	x	x	x	x	✓	x	x	x	x	x	x	✓	x	x	x						
10	Group 1	✓	✓	x	x	x	x	✓	x	x	x	x	x	✓	x	x	x	x	✓						
11	Group 1									Excluded															
12	Group 1	x	✓	x	x	x	x	x	x	x	x	x	✓	✓	x	x	x	x	x						
13	Group 1	x	x	x	x	x	x	x	x	x	x	x	✓	x	x	✓	x	x	x						
14	Group 1	✓	✓	x	✓	✓	x	x	x	x	x	x	✓	x	x	x	x	x	x						
15	Group 1	x	x	x	✓	x	x	x	x	x	x	✓	x	x	x	x	x	✓	x						
16	Group 1	x	x	x	x	x	x	x	x	x	x	✓	✓	x	x	x	x	x	x						
17	Group 1	x	✓	x	x	x	x	x	x	x	x	x	✓	x	x	x	x	x	x						
18	Group 2	x	✓	x	x	x	x	x	✓	x	x	x	x	x	x	x	x	x	x						
19	Group 2	x	✓	x	x	x	x	x	x	x	x	✓	✓	x	x	x	x	x	x						
20	Group 2	x	x	x	x	x	x	x	x	x	x	x	x	x	✓	x	x	x	x						
21	Group 2	x	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
22	Group 2	x	✓	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
23	Group 2	✓	✓	x	✓	x	x	x	x	x	x	x	✓	x	x	x	x	x	x						
24	Group 2	✓	✓	x	✓	x	x	x	✓	x	x	x	x	✓	x	x	x	x	x						
25	Group 1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
26	Group 1	✓	✓	x	x	x	x	x	x	x	x	x	x	✓	x	x	x	x	x						
27	Group 1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
28	Group 1	x	x	x	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x						
29	Group 1	x	✓	x	x	x	x	x	x	✓	x	x	x	x	x	x	x	x	x						
30	Group 1	x	x	x	x	x	x	x	x	x	✓	x	✓	x	x	x	x	x	x						
31	Group 1	x	x	x	x	x	x	x	✓	x	x	x	x	x	x	x	x	x	x						
32	Group 1	x	x	x	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
33	Group 1	x	✓	x	x	✓	x	x	x	✓	x	x	✓	x	x	x	x	x	x						
34	Group 1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
35	Group 1	x	✓	x	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
36	Group 1	x	x	x	x	x	x	x	x	✓	x	x	✓	x	x	x	x	x	x						
37	Group 1	x	x	x	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
38	Group 1	x	✓	x	✓	x	x	x	x	x	x	✓	x	x	x	✓	x	x	x						
39	Group 1	x	x	x	x	x	✓	x	✓	x	✓	x	x	x	x	x	x	x	x						
40	Group 2	✓	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
41	Group 1	✓	✓	x	✓	x	x	x	✓	x	x	x	x	x	x	x	x	x	x						
42	Group 1	x	x	x	x	x	x	x	✓	✓	x	x	x	x	x	x	x	x	x						
43	Group 1	x	x	x	✓	x	x	x	x	x	x	x	✓	x	x	x	x	x	x						
44	Group 1	✓	✓	x	✓	✓	x	x	x	x	x	x	x	x	✓	x	x	x	x						
45	Group 1	✓	✓	x	x	x	x	x	x	x	x	x	✓	x	x	✓	x	x	x						
46	Group 1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
47	Group 1	x	✓	x	x	x	✓	x	x	x	x	x	x	x	x	x	x	x	x						
48	Group 1	x	x	x	x	x	x	x	x	✓	✓	x	x	x	x	x	x	x	x						
49	Group 1	x	x	✓	x	x	x	x	x	✓	x	x	x	x	x	x	x	x	x						
50	Group 1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
51	Group 1	x	✓	✓	x	x	x	x	x	x	x	x	✓	x	x	x	x	x	x						
52	Group 1	x	✓	x	✓	x	x	x	x	x	x	x	✓	x	x	x	✓	x	x						
53	Group 1	x	✓	✓	x	x	✓	✓	x	x	x	x	x	x	x	x	x	x	x						
54	Group 1	x	✓	x	x	✓	x	x	✓	x	✓	x	x	x	x	x	x	x	x						
55	Group 1	x	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
56	Group 1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
57	Group 1	x	x	x	✓	✓	x	x	x	x	x	x	x	x	✓	x	x	x	x						
58	Group 1	x	x	x	✓	✓	x	x	x	x	x	x	✓	x	x	x	x	x	x						
59	Group 2	x	✓	x	✓	x	x	x	x	✓	x	x	✓	✓	x	x	x	x	x						
60	Group 2	x	x	x	x	x	x	x	x	x	x	x	✓	x	x	x	x	x	x						



### **Annex 3: Risk Stratification Tool Development and feedback platform example**

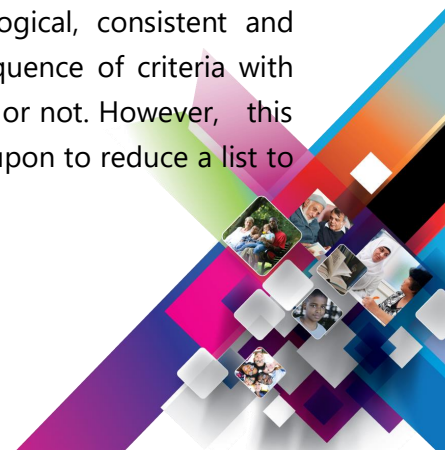
This documentation explains the principles and purpose of the bespoke Risk Stratification element of the Predictive Analytics Pilot (November 2019 to June 2020) developed by the project team in consultation with the clinicians involved in the pilot.

Two Community Mental Health Teams (CMHTs) were engaged in the pre-pilot phase (Erdington & Kingstanding and Warstock Lane). For this testing, a 'step-up' model was used in order to split the predicted crises into those to be reviewed by the clinical teams and those not, based on specified criteria. This was to consolidate the list to 30 patients per team. When the project moved towards the pilot testing phase, lessons learned from the pre-pilot suggested several issues were going to be present during the pilot:

1. The first issue was the large number of crises being predicted per team. Initial analysis suggested that for the larger teams, more than 100 patients would be predicted for crisis every week. Through prior experience and feedback directly from clinical teams it was suggested that on top of already-stretched workloads, this would not be manageable for teams to work with.
2. The second issue was that algorithm outputs provided no context for the prediction being made, i.e. it couldn't state why a patient might go into crisis, only that they were likely to. The project team identified this as a unique problem and was concerned that a flat list of patient names only would be both impersonal and difficult to review efficiently.
3. The third issue was related to how much work reviewing each patient predicted for crisis would entail, i.e. working through a list and revising RiO for relevant information, which would be required in order to make a sensible judgement as to risk of crisis. It was thought and confirmed by clinicians that an overly burdensome review and feedback process would severely limit the ability of CMHTs to engage with the pilot. As the central point of the pilot was to test the applicability of patient-level crisis predictions, failure to engage was a fundamental risk to success of the project.

This instigated the development of the Risk Stratification tool. It was decided, in conjunction with team managers that 100+ patients would indeed constitute too much additional work for teams, especially for a pilot operating on a voluntary basis. 25 patients, refreshed every second Monday was deemed to be an acceptable number for each team to work with and still generate enough feedback data to allow for meaningful analysis of results over the course of the pilot.

To narrow a fortnightly list of 100+ predictions to 25 required a logical, consistent and automated approach. Initially the project team worked on a logic sequence of criteria with yes/no answers to dictate whether a patient would be included in the 25 or not. However, this approach was found to be difficult to automate and could not be relied upon to reduce a list to the appropriate number.



Using this as a basis, the project team therefore developed a 'scorecard' of clinical characteristics which could be applied to every patient and be used to 'order' them high to low, with the 'top' 25 being those released to the relevant team for review.

The characteristics applied, after consultation between the project clinical lead and CMHT managers were broadly: recent inpatient status; recent medical contact; recent non-medical contact; PD or dual diagnosis status; care level; up-to-date care plan; up-to-date risk assessment; DNA without follow-up; an FTB or FEP patient; aged 65 or above; mental health act with appropriate scores for each of those characteristics applied. These categories and the scores applied make up the Risk Stratification tool. These characteristics align to the established risk assessment parameters reflected in the trust's risk management policy and the ICR (integrated care records) risk assessment tool in RiO.

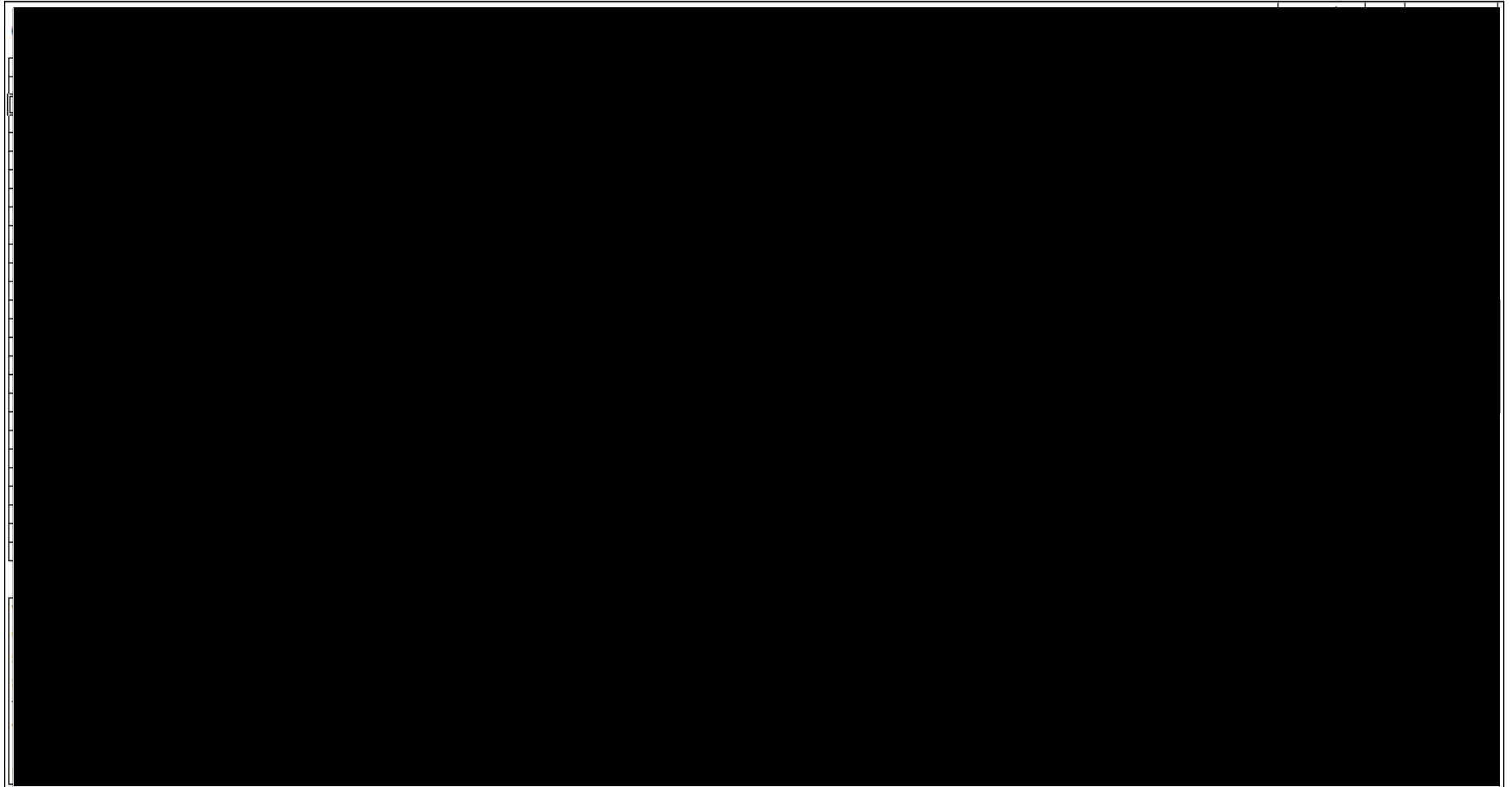
The included characteristics were developed over time (e.g. the age of the patient was included at a later stage, after the project team met with an external organisation that had developed a similar approach). The exact weighting (score range) of each characteristic was revised following review with clinicians, so to promote some parameters more than others. As well as allowing for ordering of patients and applying a consistent method of identifying the top 25, this approach enabled some easy-to-understand context for clinicians, and a logical place for their review to begin.

As part of the pilot review, an assessment on the value of the risk stratification as a standalone tool for predicting crisis will be carried out, though the matrix was developed purely in response to the barriers to engagement described above. Should it be determined that the risk stratification could be utilised further across the trust, the project team would undertake a review of the risk categories and weighting scores applied to ensure these are underpinned by a sound clinical evidence base. Sources to be drawn upon include the national confidential inquiry and NICE/Department of Health clinical guidance.

### **Supporting Literature**

- NATIONAL CONFIDENTIAL INQUIRY into Suicide and Safety in Mental Health Annual Report 2018. <https://www.hqip.org.uk/resource/national-confidential-inquiry-into-suicide-and-safety-annual-report-2018/>
- BSMHFT Clinical Risk Assessment Policy (November 2017) <http://connect/corporate/governance/Policies/Clinical%20Risk%20Assessment%20Policy.pdf>
- BSMHFT The Reporting, Management & Learning from Incidents Policy (May 2018) <http://connect/corporate/governance/Policies/Incident%20Policy.pdf>
- BSMHFT Care Management & CPA/Care Support Policy (April 2019) <http://connect/corporate/governance/Policies/Care%20Programme%20Approach%20and%20Care%20Support%20Policy.pdf>

**BSMHFT Predictive Analytics Risk Stratification Tool Example**



Document contains dummy patient data.



## **Annex 4: Service User Feedback Report: 'You Said, We Did'**

### **Background**

This report provides an extension to the initial summary report completed in response to the Service User drop-in sessions held in Sept/Oct 2018, prior to the pilot testing phase of Predictive Analytics.

The project team proposed to take a 'You said, We did' approach following the sessions to ensure that service user perspectives are upheld and actioned as far as possible, as the research of predictive analytics approaches the testing phase.

Captured below is a more detailed collation of the responses received and questions asked during discussions with service users and carers. A questionnaire was provided to participants (where possible), which included the questions 1-6 below. Where service users felt unable to complete the questionnaire, discussions were centred on the topics covered within the questionnaire. All written/verbal feedback has been formulated below.

### **Questions/Comments & Associated Responses**

#### ***1. Do you feel that the risk predictive tool will be helpful to your mental health team to identify whether you could be/are at risk of crisis?***

	<b>You Said</b>	<b>We Did/ Our Response and Actions</b>
1.	'Will this replace what my CPN does?'	Service User was reassured that the tool was not designed to override clinical decision making and is designed to support clinicians only.  <b>Action:</b> This is documented within the operational and research protocol for Predictive Analytics
2.	"Prevention is always better than cure"	It was relayed that the overall aim of the tool was to identify and predict crisis and that armed with this information, clinicians may be able to act proactively to prevent a crisis.
3.	"I think it is good if the nurses have a technology that can help them do their job"	It was agreed that the tool is not intended to 'override' clinicians standard practice/ decision making but the use of technology has the potential to generate new insights and enhance how clinicians manage caseloads and mitigate the risk of crisis episodes.
4.	"It would help the service users get the allocated support they need"	Like other public sector organisations, there is the challenge of providing high quality care with limited resources. In order to not compromise on the quality of care, innovation provides a significant role in maintaining quality in line with the resource available. Hopefully the tool will help manage and prioritise the allocation of existing resources more efficiently and effectively.
5.	"With some conditions, a	It was acknowledged that at times service users find it





<p>patient is not always in the mood to discuss their problems or feelings”</p>	<p>difficult to discuss how they are feeling and equally will not contact mental health services for support on their own volition.</p> <p><b>Action:</b> It is anticipated that this tool we will be able to predict impending crises and staff can act proactively by contact the service user, therefore initiating dialogue.</p>
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**2. Would you feel comfortable with your care co-ordinator/ mental health team following up with you if the tool indicated potential risk of crisis? (For example making a telephone call to you or arranging an outpatient appointment?)**

	You Said	We Did/ Our Response and Actions
1.	“Yes, because many people, including myself feel uncomfortable asking for help directly”	The proactive nature of the tool means that, at times, clinicians will be contacting people and initiating conversations around potential risk and management of this risk. This potentially alleviates anxiety for those who wouldn’t ordinarily seek help on their own accord.
2.	“It would be nice if people know I am in a crisis and give me a call as I don’t like to call and ask for help”	The tool has potential to transform the way CPN’s work in terms of prioritising clients most at risk and averting incidences of crises.
3.	“It will be helpful... we will have a piece of mind that the help is there rather than going to the GP to request for help”	A longer term benefit of the predictive tool is that it can direct care in the areas where it is most urgently needed.
4.	“ Someone that I am familiar with and has seen me in the past would be the best person to contact me. It would need to be someone to make you feel immediately comfortable”	<p>Service user was thanked for sharing their experience. Gaining trust is important in the recovery process.</p> <p><b>Action:</b> Nurses will always try to build rapport and trust with the service user and follow up interventions resulting from the predictive tool will be patient centred and where possible, executed by someone the service user is familiar with.</p>
5.	“I feel reassured due to the Data Protection Act”	How we use information is governed by various laws including The Data Protection Act, Information Governance, and GDPR. The way in which data has been processed within the research of Predictive Analytics was explained to the service user.

**3. Do you feel reassured by the data usage regulations and protocols that are in place to ensure that patient health data is kept anonymous?**

	You Said	We Did/Our Response
1.	"How will my information be used?"	Historical health data of BSMHFT service users has been used in the development of the algorithm but has been completely pseudonymised within this process. The information has been very helpful in creating the algorithm and learning patterns in crisis presentations of service users, in order to help us prevent further crisis episodes.
2.	"No concerns regarding this"	Key principles of data protection and risk assessments undertaken within the data processing of the research to ensure service user data has been utilised anonymously and ethically, was relayed.
3.	"Just concerned with the potentials of hacking as it happens to big businesses, but the potential of someone accessing my medical data is a bit worrying"	It was acknowledged that these are valid concerns and therefore discussed the various systems/processes in place including pseudonymisation and regulatory procedures undertaken to ensure data has been utilised safely and securely.
4.	"My GP uses my data to send to the hospital if I have to do a test, so I guess you will use it similarly"	Agreed that in much the same way that a GP uses service user information to provide the appropriate care and interventions based on health history, the algorithm uses information from historical data to predict the occurrence of a mental health crisis.
5	"I don't know much about data protection, however I assume that you guys will protect my personal information "	This is reassuring to understand that service users have trust in staff in the context of data protection. It was explained that staff adhere to policy and procedures to protect service users data/information as far as possible. This has been upheld throughout the development of the predictive tool and will be maintained during the testing phase.

**4. What benefits of the Crisis Prevention Support Tool can you identify? (If any)**

	You Said	We Did/ Our Response
1.	"I think it is good if the nurses have a technology that can help them do their job"	<b>Action:</b> Feedback provided to the project team, Service user engagement and recovery team as well as all clinicians supporting with the testing of the technology
2.	"To help reducing any crises that may occur"	<b>Action:</b> This is the overall aim of the tool and this will be continually evaluated during the testing phase
3.	"It will help me cope with my mental health as I know someone will contact me"	The predictive aspect of the tool will potentially allow CPN's to prioritise their caseload. It will not necessarily change existent care plans but will provide an additional

	when I become unwell”	insight and identification into those at risk of crisis
4.	“At least I will be on the mental health services radar and wont be overlooked”	The tool provides an additional mechanism for teams to identify and prioritise those most at risk of crisis which potentially alleviates concerns of being ‘overlooked’.
5.	“To prevent suicides and breakdowns which can lead to even greater strain on the NHS Mental health Services”	The tool aims to allow for a proactive approach to prevent crisis episodes in place of reactive intervention when incidences of crises do occur. It was acknowledged that the prevention of suicide and increasing the provision of support for people with mental health issues is a significant and prioritised area for the NHS on both a local and national level.

**4. What challenges/disadvantages of the Crisis Prevention Support Tool can you identify?**

	You Said	We Did/ Our Response
1.	“People not cooperating and using the tool wisely”	<p>Training for staff is being provided on how to use the tool and the overall objectives of the predictive analytics research.</p> <p><b>Action:</b> Staff will continuously be supported by the project team to test/utilise this in the most effective way possible.</p>
2.	“It might not be accurate and you may be dragged in for an appointment you don’t need”	The predictive accuracy cannot be fully guaranteed although the algorithm is currently expected to generate 80-85% accuracy within its predictions. In many instances a telephone call will normally precede an appointment and should an appointment be offered, the service user is obligated to decline if felt to be unnecessary.
3.	“People do not always go into a crisis at the same time every year. There may be identifiable patterns but this will not always be the case”	It is accepted that this may be the case, however the tool is not solely reliant on yearly/seasonal patterns and utilises additional risk filters to try and accurately predict the likely occurrence of a crisis episode.
4.	“If the help provided is not correct/sufficient it could add more stress to the individual. For example contact being made by someone you don’t know or who doesn’t know your history ”	<p>Clinicians will have access to historical records so should have knowledge of your diagnoses, involvement with services, medication etc.</p> <p><b>Action:</b> A team approach in supporting service users in the most person centred way will be upheld throughout the research period, aiming for follow up interventions to be carried out by those that have seen or have familiarity of the individual.</p>

5.	"No disadvantages. The challenge is to make it fit for all"	<b>Action:</b> Testing of the tool will take place over a 6 month period and will be continually evaluated for its effectiveness. It is anticipated that learning will be taken from this process in order to ensure the tool is suitable for use across all teams and clinicians can use it effectively.
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**6. What further information do you feel is required to help you better understand the Crisis Prevention Support Tool and how this will be used within your care?**

	You Said	We Did/ Our Response and Actions
1.	"An App or Website might help"	<b>Action:</b> Further development of the technology remains a working progress for the project team and this is a helpful suggestion in the overall, long term vision of a predictive tool.
2.	"Probably a drop in session to show how it works, or YouTube/email videos on how to access and set it up"	This is certainly worthwhile and valued feedback in understanding how service users may be better able to understand the technology and development of media sources can be explored for use in further service user engagement events.
3.	"Testing it out with potential users is key. At every stage of development it needs to be checked with a wide selection of potential users"	This has been a key consideration of the project team and ensuring that a number of teams/clinicians trial the tool to determine the usability and benefits of the tool is detrimental in understanding just how effective it is.
4.	"I can always discuss this with my CPN and this will help me to understand it more overtime"	<b>Action:</b> The project team are working closely with clinical teams to ensure understanding of usage and benefits is achieved across all levels. This aims to inform further discussions arising from service users on the topic of predictive analytics/preventing crisis.
5.	"I found the information leaflets and brochures useful"	This was positively relayed to the project team and Communications department who have ensured that literature and information provided on the project has been timely, usable and understandable for the receiving audience.

## Summary

The feedback received from service users has been highly valuable for the project team in understanding their perspectives on the use of digital technology to reduce incidences of mental health crisis.

The project team plan to hold further engagement sessions during the testing period in the form of focus groups, to further explore in more detail, some of the key topics that arose during these discussions, for example:

- What follow up interventions to expect as a result of being 'flagged' by the algorithm and how these will be best received from a service user perspective
- How data has been used and will continued to be used throughout the testing period
- How service users feel about the use of digital technology as part of their care and whether benefits can be derived from such innovations.

The support of the Trust's Service User Governor will be maintained in further sessions as this continues to be an imperative component in engaging and upholding service user perspectives within the predictive analytics research. Continued collaboration with the Trust's Service User engagement and recovery team will also continue as further events are planned.



## **Annex 5: Feedback Questionnaire**

How useful is a risk stratification tool/Predictive Analytics tool at supporting timely and effective clinical decision making?

### **Q1. What was your recent assessment of this patient's condition? Please select one option.**

- 1a. Low risk of crisis
- 1b. Medium risk of crisis
- 1c. High risk of crisis
- 1d. Imminent risk of crisis
- 1e. Patient in crisis

### **Q2. Have you taken /do you intend to take any actions as a result of this notification?**

**Please select one option.**

- 2a. Yes – contact to be made  
Option – Telephone or Face to Face
- 2b. No – contact made recently – within 7 days
- 2c. No – risk already acknowledged and being managed
- 2d. No – do not agree with assessment

### **Q3. What is your current assessment of this patient's condition? Please select one option.**

- 3a. Low risk of crisis
- 3b. Medium risk of crisis
- 3c. High risk of crisis
- 3d. imminent risk of crisis
- 3e. Patient in crisis

### **Q4. Do you think that this additional information has helped you with..? Tick any/all options**

- 4a. Trying to prevent the patient from experiencing an imminent crisis
- 4b. Identifying deterioration in the patient's condition
- 4c. Managing caseload priorities
- 4d. Nothing – did not find this information useful

