Simulation Modeling of Constrained Resource Allocation using the Activity Based Conceptual Modeling Methodology

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Thank you.

In memory of Chitia, Toty and Yaya

Multi-Resource Capacity Planning with Follow-up Visits: A Case Study at the Mood and Anxiety Program at the Royal Ottawa

1 ABSTRACT

This thesis considers a common healthcare challenge of planning capacity for a system of care where patients receive multiple treatments sessions from multiple resources. As a case study of this more general problem, we considered the particular context of a capacity planning model for the Mood and Anxiety Program at The Ottawa Royal Health Centre (referenced as The Royal for simplicity) where a new service system known as CAPA (www.capa.co.uk) is being implemented to enhance the mental care provided to its patients. In order to develop the capacity planning model, we have created a simulation model using the Arena simulation software. We have also used the ABCMod Framework as the modeling methodology. The ABCMod is an activity based conceptual modelling framework that provides a set of guidelines as to how to build a conceptual model including its structural and behavioural aspects as well as a collection of constructs which include inputs, outputs and parameters among others. The ABCMod framework tools are expected to facilitate the model validation with project stakeholders. A series of scenarios relevant to The Royal were modeled and analyzed in order to determine how best to manage capacity so certain performance goals within the CAPA system implementation are met. These scenarios determine the service level The Royal can provide with its current capacity and also the amount and distribution of resources that is required to achieve its goals under the CAPA system.

As a result of our simulation runs, we defined the policy implications for The Royal in order to achieve its targets and successfully implement CAPA. Additionally, through the application of the ABCMod framework and standard process mapping tools, we were able to reach a consensus and validate our modeling approach with the project stakeholders at The Royal. Our model could be adapted to other settings in which multiple resources provide a series of sequential interventions to clients.

2 Problem Definition

Health care systems frequently face the difficult task of determining the necessary capacity for a given resource in the face of significant uncertainty and variability both in demand for the resource and in the service time per patient. This challenge is further exacerbated in settings where patients require more than one resource over multiple visits. In this thesis, we examine a specific instance of this general problem and seek to provide a robust capacity planning model in this setting.

The Royal Hospital of Ottawa (henceforth referred to as The Royal) specializes in a wide range of mental health services including inpatient and outpatient services for youth and adults as well as specialized mental health programs such as the mood and anxiety disorders program, the schizophrenia program, geriatric psychiatry (mental health for older adults), substance abuse and concurrent disorders program and the Operational Stress Injury Clinic. All adult programs at The Royal, with the exception of the Substance Abuse Program require a doctor's referral. (http://www.ementalhealth.ca/index.php?m=record&ID=9270)

This thesis focuses on planning capacity for treatment of patients in the Mood and Anxiety Outpatient Program. Currently, the Royal's Mood and Anxiety Outpatient program is implementing a Service Management System known as CAPA (Choice and Partnership Approach) as a way of managing patient appointments. Thus, in order to understand the capacity challenge facing the Royal it is important to first understand how the CAPA system works.

Background Notes about CAPA

The Choice and Partnership Approach (CAPA), first developed in the UK, is a flexible model that gives patients and families a stronger voice in their care. The CAPA model was developed by psychiatrists Dr. Ann York and Dr. Steve Kingsbury. The model was first published in 2005 and an updated version of the model has been published in 2013 in their book entitled "The Choice and Partnership Approach: A Service Transformation Model". CAPA aims to ensure that clinical capacity is used as effectively as possible to meet service demand.

The CAPA approach is people-centered where patients participate in the creation of an individualized treatment plan. CAPA provides a structure for mental health clinicians and patients to work in close partnership, focusing on the patient's individual strengths, defining clear goals and working together to determine the right care plan. As a result of the CAPA implementation and how patients are treated within this system, The Royal expects to reduce wait times and improve access to mental health care. (http://www.theroyal.ca/mental-health-centre/news-and-events/newsroom/14376/cheo-and-the-royal-launch-new-model-to-reduce-wait-times-for-children-and-youth-to-get-mental-health-care/)

Within the CAPA system, allied health workers review patient referrals in order to assess if the patient meets the criteria for the designated program. As the name indicates (Choice and Partnership Approach), CAPA is based on the principles of "choice" and "partnership". The initial session is called the Choice Appointment where the clinician and patient together determine the treatment pathway (including the number of future appointments) based on mutually agreed upon goals.

After the Choice Appointment, the client and referring physician receive a letter reviewing the results of the discussion and outlining the treatment and the goals. In CAPA parlance, this is known as the 'Choice Point'. Typically after this, the patient undergoes a series of alternating visits first with an Allied Health Professional and then with a psychiatrist over a number of months. (An 'Allied Health Professional' refers to a psychologist, social worker, occupational therapist or cognitive behavioural therapy nurse.) The visits with an Allied Health Professional are called "Partnership" appointments and the visits with the Psychiatrists are labeled "Follow-ups". At this point, The Royal estimates that an average of 10 Partnership sessions (slightly higher than the CAPA recommendation) will be required per patient. Additionally, based on experience, it is estimated that 20% of patients will not continue with the treatment following the Choice appointment. Within the CAPA implementation at The Royal, the Allied Health Professionals are the ones that will do most, if not all, of the Choice appointments and Partnership treatments.

Parallel to the Choice/Partnership treatment sessions, the patients at the Royal have follow-up sessions with a psychiatrist. In these sessions, it is determined if patients need any medication. Once treatment has started, physicians would typically follow up once every two weeks. The number of follow up sessions varies depending on the physician. These sessions are not typically part of the CAPA model but are required in the Ontario setting. The patient is discharged when the treatment goals have been reached. This step is also agreed upon between the patient and clinician. (http://www.theroyal.ca/mental-health-centre/medical-professionals/the-choice-and-partnership-approach/)

Figure 1 is a high level view of the process flow at The Royal. As shown, the Central Intake Unit manages the waiting list were patients referred to the Mood and Anxiety Program are recorded. Patients then will subsequently booked their treatment sessions. Those provided by Psychiatrists/MDs (Choice and Follow Up sessions) as well as those provided by the Allied Health Professionals, aka Clinicians, (Choice and Partnership sessions). When a patient has the last session with the Psychiatrists it exits the program. More details of this process are to be provided later.

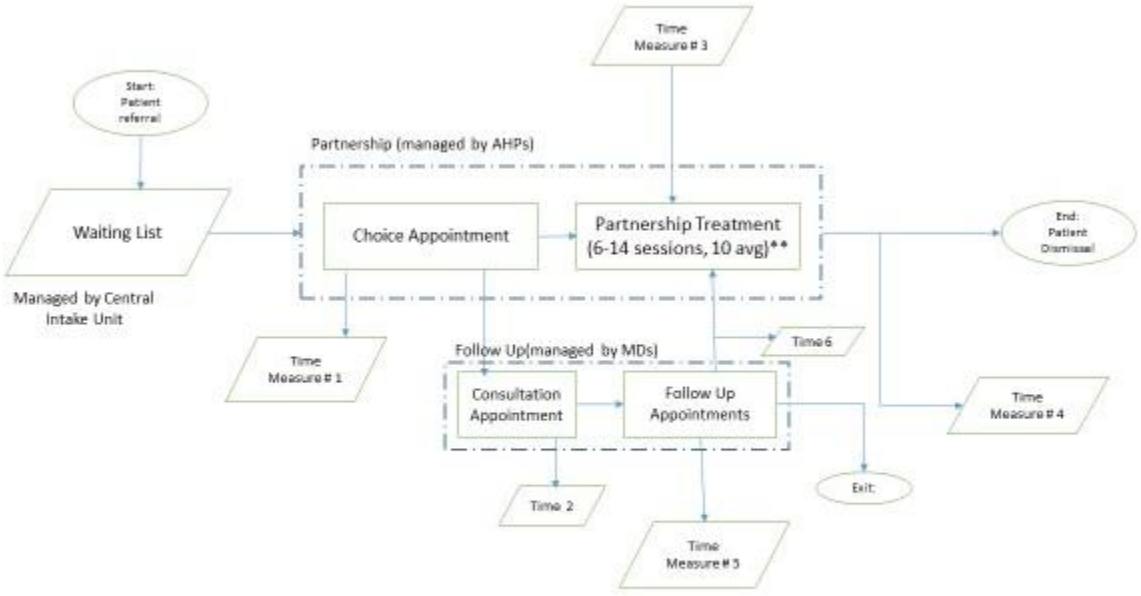


Figure 1: High level process flow at The Royal

Thus, the Mood and Anxiety Program at the Royal faces a difficult capacity planning challenge that includes such complications as stochastic demand, multiple resources and multiple appointments with the number of appointments varying from patient to patient. The Royal currently lacks a systematic process for scheduling its patients and no method for determining the necessary capacity to meet demand. Without proper planning, the continued need for partnership and follow-up appointments could severely delay new patients entering the system.

The CAPA system provides a series of basic guidelines to help clinics configure their resources in order to comply with the Choice and Partnership appointment requirements. (Kingsbury, York. 2013) The guidelines require a set of workforce and job planning assumptions that organizations should consider when implementing CAPA. The main assumptions are: 1) that patients require 7.5 partnership sessions, 2) that 66% of the patients that have a Choice session booked will then require partnership treatments and that 3) the number of referrals to be received per week should be equal to the number of full time equivalent (FTE's) staff performing the Partnership treatment (see Wilson et al.). We discuss these assumptions in more detail below. For now, it is important to mention that these assumptions would not be applicable to the Royal as it is providing an average of 10 partnership sessions, the percentage of patients requiring partnership sessions following the Choice appointment is around 80% and the actual demand is in fact higher than the existing level of FTE's. Additionally, the Mood and Anxiety Program has to comply with the by-law requirement in which all of its patients are to have an appointment with a psychiatrist leading to a series of follow-up appointments rather than just the partnership sessions outlined in CAPA. In the end, this makes conditions at The Royal particular and consequently a more tailored capacity planning model is required.

3 Research Question

Our research will look to answer the following question:

How does an organization such as The Mood and Anxiety Program at The Ottawa Royal Health Centre determine the necessary capacity for multiple resources (Allied Health Workers and

Psychiatrists) in order to meet performance targets with respect to wait times for first appointment and total time in the system?

From a methodological standpoint, we look to implement the Activity Based Conceptual Modeling Framework (ABCmod) and thus a further research question is:

Does the ABCmod simulation methodology bring additional benefit when seeking to build a simulation model in a setting such as the Royal?

4 Research Objectives

1. Determine the critical components needed to develop a sufficiently robust capacity plan for a Mood and Anxiety Clinic undergoing a CAPA Service Management System implementation. We will look to overcome the limitations the capacity planning tool provided with CAPA.
2. Determine the potential impact on wait times and total service time of changes in practice and adherence to standard practice in terms of the number of visits per patient.
3. Determine the adjustments/modifications the ABCmod Simulation and Modeling would need to undergo when applied in the above setting.
4. Determine the benefits and challenges of applying the ABCmod methodology.
5. Determine the key factors for a successful implementation of the most desirable capacity planning model within the Mood and Anxiety Clinic.

5 Methodology

To determine the most adequate capacity planning model for the Royal we chose to simulate the current scheduling of its psychiatrists and Allied Health Professionals using the Activity Based Conceptual Modeling Framework Methodology (ABCMod). This decision was motivated largely by the complexity of capacity planning at The Mood and Anxiety Clinic and the desire to present solutions that are realistic enough to be of practical interest to the

Royal. We considered queuing models but rejected them as too high level to be of interest. Similarly, linear programming was deemed to be a poor tool to handle the sequential nature of the appointment schedule due to the follow-up visits. Additionally, in order to obtain stakeholder validation, we needed a tool understandable to the nonprofessional. Finally, by using simulation, we are able to model and test multiple scenarios that are relevant to our research project and to the Royal.

At the last Simulation and Modeling conference, Professor Arbez presented four relevant modeling methodologies including the ABCMod (Arbez et al 2015). We considered these methodologies as the alternatives for our work. As opposed to the other methodologies, the ABCMod focuses on an activity based approach. The system under investigation is broken down into its two major components: a structural view (system elements or "entities" that perform certain functions) and a behavioural view (mainly the activities in which the entities perform the actions so that the system generates output). In the end this approach not only facilitates the modeling exercise through a comprehensive predefined format and structure but also allows a better validation process with the simulation project stakeholders. This last element had a major impact on our decision to select the ABCMod Methodology as one focus of our study is to ensure that our model presents a feasible solution for a particular capacity planning problem. By stressing the need for stakeholder feedback and validation, we aim to orient our model to reflect their needs more than a standard programing/modeling process.

This type of conceptual modeling has experienced an increased interest over the last ten years but specific applications are limited. Given this limitation, the proposed thesis will provide a case study of a conceptual modeling application and will also focus on assessing the benefits of applying this methodology in particular and evaluate how it is received by all of the stakeholders. The ABCmod methodology can thus be viewed as a tool that helps translate a simulation program into a process oriented structure which eliminates the need for the user to be 'code literate'. This translation aims to facilitate the model validation/assessment with the project stakeholders so that the overall quality of the simulation results and project recommendations can most easily align with their needs.

6 LITERATURE REVIEW

This section is divided into three main topics related to our research. We start with Capacity Planning within a CAPA Service Management Implementation. Secondly, we proceed with a review of Conceptual Modeling and the ABCMod Conceptual Modeling Framework application. Finally, we review the literature on capacity planning models with recurring appointments applied within the Health Sector. We conducted our search mainly within the SCOPUS database with the publication date left open.

The following table is a summary of our research topics, the criteria we used for selecting the articles found and any relevant search details.

Topic	Objective / Considerations
Capacity Planning within CAPA Service System Implementation	articles focusing on the capacity planning component of Mental Health Organizations implementing the CAPA Service System
Conceptual Modeling / ABCMod Conceptual Modeling Framework	Articles focusing on the implementation of Conceptual Modeling Methodologies in Simulation Projects as well as in the application of the ABCMod CM framework
Capacity Planning Models	Articles focusing on Capacity Planning models for recurring appointments and also on the application of the developed models in Health Organizations

Table 1 Literature Review Summary

6.1 CAPA related literature

In terms of Capacity Planning within the CAPA Service Management System, there are some case studies of past implementation in the literature. As mentioned earlier, CAPA does propose a very basic resource allocation model with a set of defined assumptions.

The resource allocation model proposed by CAPA is based on deterministic demand and fixed sessions of 2 hours for Choice appointments (both assumptions invalid for the Royal). In addition, the CAPA resource allocation model also assumes that the number of sessions a patient requires is fixed (whereas in our model we include 3 different patient types having a

different number of sessions). Finally, the CAPA model considers that all allied health professionals have a fixed capacity for Choice appointments. In the sum, the CAPA model leaves very little room for process and parameter variability. While it is possible to obtain an estimate of required resources based on the CAPA model, it would fail to represent the actual functioning of the Mood and Disorder Clinic at the Royal.

There are a very limited number of studies that assess this model or its validation. The existing literature related to CAPA is more focused on the methodology itself rather than how demand is satisfied. From our search in SCOPUS, only seven articles were found in which CAPA was included in the tittle or the keywords. Of these seven articles, only one addresses the capacity planning aspect of the system. Below we discuss those articles related to CAPA implementation and capacity planning within this system.

The CAPA system was developed around 2000 and implementations have been completed so far in the UK, New Zealand, Ireland, Belgium, The Netherlands, Australia and Canada. Among the relevant papers we highlight that of Naughton et al (2015), in which the treatment approach is revised and redefined as a 'modified CAPA'. The authors report a reduction in the time between the referral date and the first face to face meeting with the patient from 64 to 11 days. This was accomplished by allowing all clinicians to undertake Choice appointments. In other words, more resources were available for attending patients initially. As opposed to the pre-CAPA implementation, there were no limitations in terms of the experience level of the clinicians. It has to be mentioned that those with less experience required their patients to be seen later by a physician. In summary, wait times were decreased given that more resources were available for attending patients. The article does not mention how this change was perceived by the patients.

Wilson et al (2015) are among the few authors that have done work on the CAPA model structure. Wilson's approach focuses on assessing the CAPA assumptions. Specifically he measures the average number of treatments/patient (7.5 as per CAPA), no show rates (0%, per CAPA), percentage of patients requiring treatment (66%, ibid) and resource availability to satisfy demand (according to CAPA referral rate would not exceed the clinicians' time

availability). The study was done over a one year period in two hospitals (NHS Greater Glasgow and Clyde (NHSGGC) Child and Adolescent Mental Health Service (CAMHS)) that had recently implemented CAPA. No major difference was observed in terms of the number of appointments per patient in practice and as recommended by CAPA (7.76 vs 7.5). About a 10% difference was observed when comparing the actual number of patients requiring treatment vs the CAPA assumption (73.55 vs 66%) and, in terms of capacity, only the CAMHS was assessed and it was confirmed that this hospital would have the clinical capacity to meet demand. In the end, the major variance was in terms of the percentage of patients requiring treatment (~10%). Given that the study was based on only two hospitals, we don't believe there is enough evidence to conclude that the CAPA assumptions assessed can be generalized. Furthermore, 'no shows' were a reality at both of the studied hospitals with rates as high as 18.11%. Variances from the CAPA assumptions have also been confirmed at the Royal where the CAPA Program implementation managers require an average of 10 sessions per treatment, 80% of the patients will follow the Partnership treatment, there is an 8 to 10 % no show rate and there is an excess demand compared to the current capacity. Furthermore, within the capacity planning of CAPA it has been noted that those assumptions or 'rules of thumb' have to be treated cautiously (Kingsbury, York. 2013). The study does not examine the process CAPA recommends to determine schedules choosing to focus only on the validation of the assumptions.

Fuggle et al (2014) assessed CAPA in terms of how the service efficiency can be improved without reducing service effectiveness. Fuggle's argument is that CAPA provides the means for increasing patient flow and reducing wait times however he questions if this had any effect in terms of 'clinical effectiveness'. He proposes a method to evaluate both service and clinical outcomes. Service outcomes are related to customer satisfaction (waiting times and patient flow) while clinical outcomes relate to how clinicians are rated and how patients' goals are achieved. The article presents a study held in an inner London (UK) CAMHS (Child and Adolescent Mental Health Services) in which over a 21 month period that included three CAPA implementation phases (6 months of pre-CAPA, 9 months of CAPA implementation, and, 6 months post-CAPA) service and outcome data were collected through pragmatic mixed methods. The measurements can be categorized into three groups: client

outcomes (client satisfaction, goals achieved, and clinical improvement), service outcomes (waiting times and patient flow), and staff outcomes (beliefs about the CAPA model). The study showed that overall wait times reduced from 82 to 71 days from the pre to the post CAPA phases. The standard deviation post CAPA was significantly lower when compared to that of the Pre-CAPA phase (46.9 vs 108.1). Patient flow increased from 49 to 72 cases. In terms of customer/client satisfaction metrics, there was an overall increase in all the measurements taken. Staff perceptions were also positive in general. Finally, goals and clinician ratings were positive as well.

The article concludes that the wait time reductions and the increase in patient flow resulting from the CAPA implementation do not negatively affect the clinical effectiveness nor compromise the quality of patient (and staff) experience. They do mention though that their study was limited in terms of comparing the current satisfaction levels with those prior to CAPA. Another limitation includes the fact that parallel to the CAPA implementation there were other organizational change initiatives that could have impacted the overall results. The study does not assess the capacity planning guidelines defined within CAPA.

In terms of CAPA implementation, a study from the British Mental Health Foundation (https://www.mentalhealth.org.uk/sites/default/files/CAPA_PDF.pdf) was conducted in England in two phases. First, the authors sent surveys to national CAMHS (Child and Adolescent Mental Health Services) and then a research team visited a total of six teams that had implemented CAPA. The research team collected information through a combination of surveys and interviews (parents, children, staff and families). The study assessed the awareness of the personnel in terms of how familiar they were with CAPA and also at what stage their team was within the CAPA implementation. Overall the personnel were familiar with the system. In terms of the implementation, most of it was partial (about 55% of the requirements). Of the teams visited, very few had implemented job planning, booking and demand management as per CAPA guidelines. The Royal has similarly only partially implemented CAPA.

As pointed out earlier in Naughton et al, the study also observed that less experienced clinicians face challenges conducting Choice appointments. While wait times were reduced in terms of the first appointment (Choice in this case), there were issues when transferring families from their initial appointment to the Partnership treatment. This was in part due to inadequate capacity planning and resource utilization.

The study demonstrates that wait times (for initial appointments) are reduced and patient flow is increased. As an additional element to consider, the study mentions that capacity planning is essential for follow up and partnership appointments. This study stresses the overall structure of the system and how it is to be implemented. It does not assess or analyze the capacity planning component of the system.

The above demonstrates that while CAPA is fast becoming a preferred means of managing patient services for mental health and though it has been shown in practice to reduce wait times and improve service, there has been little attempt to develop a method to properly determine an adequate capacity plan that would allow a mental health organization to meet performance targets associated with timeliness of care. It is this gap that we attempt to fill using the ABCMod framework. Below we discuss the published works detailing this approach.

6.2 Activity Based Conceptual Modeling Framework / Conceptual Modeling Literature

The existing literature on the Activity Based Conceptual Modeling Framework (ABCmod) is mainly from Proceedings of Simulation and Modeling International Conferences. Details of these papers are provided below.

In our research, we also looked for articles related to analyzing how Conceptual Modeling methodologies should be structured and also what would be the elements to consider when applying them to simulation projects.

The first related attempts at conceptual modeling date from 1980 when Kreutzer (Kreutzer, 1980) stressed the need to have a consistent methodology that would help standardize the creation of simulation models. Kreutzer proposes a 'high level' conceptual model that would facilitate the common understanding of methods and terminology of user oriented systems. He proposes the use of encoding and structuring methods as a means of overcoming natural information processing limitations in human beings. In other words, model development should follow human cognitive structures: focused on reality abstraction, facilitate information links (refresh memory), enable information/data retrieval and storing, ordered levels of abstraction and space navigation (through the use of simulation).

Among the elements of these high level models, Kreutzer includes classes, entities and relations as part of the modeling components. He also provides a series of abstraction levels to consider within the model development. Despite Kreutzer's work, there remained plenty of progress needed towards standardizing a modeling methodology.

Louis and Arbez (2007) presented the ABCmod (Activity Based Conceptual Modeling) methodology for the first time at the San Diego Summer Computer and Simulation Conference in 2007. In this paper, they provide a general overview of the methodology and emphasize how it contributes to closing any gaps of imprecision or omission that could normally occur within the modeling process.

At a very high level, ABCMod is a representation of the structure and behavior of a 'System under investigation' (SUI). The SUI has 'consumer' entities requiring services offered by 'resources'. Consumers could wait for service in order (as a queue) or without any specific sequence (as a group). The model behavior is composed of activities and events whose occurrence is determined by 'Status Change Specifications' (SCS). Inputs are identified as a means to support the SUI representation while outputs help to illustrate the achievement of defined goals. To illustrate the ABCMod application, the article provides as examples two variations of a single repairman problem. On the Methodology section, we will further expand on the ABCMod Framework.

The article stresses the fact that the ABCmod is the element that would facilitate the presentation of the 'system under investigation' (SUI) with a disciplined non-programming environment prior to the coding phase. There is no reference to actual applications of this methodology to real life cases and consequently no details of its implications and limitations.

Three years later the same authors (Birta and Arbez, 2010) expanded on the ABCmod methodology at the Summer Computer Simulation Conference in Ottawa. They argued that this methodology could facilitate subsequent simulation program development. The modeled activities can be treated as objects within an object oriented programming structure. As a result, they presented the ABSmod/J package (Activity Based Simulation Modeling with Java) which corresponds to the methodology of creating activity based models with their corresponding Java language based simulation model. The authors indicate that this is feasible given the new perspective of the 'world view' called 'Activity-Object World View' that is an extension of the original ABCmod perspective.

One of the main reasons the authors expand on the ABCmod methodology is due to the fact that there has not been enough attention paid to these kinds of methodologies that facilitate the process of moving from a user-oriented description of the problem to the actual coding of a simulation model. They claim that the activity oriented approach should facilitate the abstraction into coding oriented elements.

In addition to the description presented in their previous paper, Arbez and Birta now include additional elements that relate the ABCmod to a Java programming structure: entities are Java classes, model behavior would also be incorporated into classes and, a time advance algorithm can be applied in order to have behavior achieved by advancing time in a logically consistent manner (events now are scheduled and sequenced). The article includes an example in which the aforementioned elements are illustrated.

There are no specific cases of the ABSmodJ application though the authors do mention that this tool has been used in academic environments. Through the presented methodology the authors provide additional tools to obtain stakeholder validation: only if they agree with the

problem description will the overall simulation model be satisfactory. An activity oriented modeling approach captures behavioral features in an easily understandable format which in the end leads to a successful project completion.

Recently some material has been published in which the different conceptual modeling approaches have been assessed. Kotiadis et al (2014) presented a general application to health care that encourages further research in the application of conceptual modeling in this field. One of the highlights of their research is the application of Checkland's Soft System Methodology (SSM) for the model development and validation of discrete event simulations. This article highlights the need to get stakeholder participation in the conceptual model (CM) development in order to get a broader view and better knowledge of the system under investigation. It aims to provide the existing need for structural guidance for group participation in CM development.

Kotiadis considered SSM to develop 'participative' and 'facilitative' conceptual models. He references Checkland to confirm that SSM can deal with unstructured problems characterized by multiple actors, multiple perspectives, conflicts of interest, major uncertainties and significant unquantifiable factors making it amenable to genuine participation.

In order to apply SSM in model development, the authors develop a framework structured in stages and sub-stages; activities; tools; and, deliverables. The stages and sub-stages set the structure of how the model is to be conceived and developed. Each would have a series of recommended activities and tools that can be used for its completion. The results or outputs of each stage are then defined as its expected deliverables. The authors also provide recommendations for the simulation project team roles in which they also state the required skills for each team member.

The article presents an application of this methodology in an obesity care system simulation study. The study deals with the increasing demand for health treatment by patients with obesity problems. Its objectives are to reduce wait times by increasing the number of physicians and, assess the required bed capacity for the additional throughput. After the

project was finalized, the authors, stakeholders provided positive feedback of the process and outputs resulting from the study.

In the end, the authors confirmed that it is beneficial to apply the SSM methodology for CM development within Discrete Event simulations. It helps to get broader views and facilitates consensus reaching. It also facilitates the overall systems and processes knowledge and increases the model's validity, credibility, utility and feasibility. Their evidence is based on the aforementioned study with which they tested their methodology. They do point out though that further research in the application of conceptual modeling in healthcare as well as in participative/facilitative CM development is needed.

The latest CM related paper comes from the Simulation and Modeling conference held in December 2015 (Arbez et al 2015). In this paper, four different conceptual modeling approaches were discussed and presented. Arbez and Birta present their approach based on their ABCmod methodology presented earlier and then compare it to that of other experts in the field (Stewart Robinson, Andreas Tolk and Gerd Wagner).

The article assesses the different perspectives on Conceptual Model definition, purpose, and benefits. There are slight differences in the way each of the above items is approached by the presenters though the differences are not likely to lead to vastly different results when applied. The article does not stress the differences but focuses on considering the integration if not consolidation of the different approaches into one. No reference nor details are provided of applications of any of the aforementioned approaches. Our work would, therefore, provide value to this stream of literature by documenting the application of CM to an applied simulation project.

6.3 Capacity Planning Models Application Literature

Compared to the two aforementioned topics, Capacity Planning has a significantly higher number of publications. Among the articles found through our search, we focused on those

related to recurring appointments. We also looked for the articles which stressed how the proposed solution or model was implemented.

Rau et al (2013) developed a model for a physical therapy clinic in Taipei. There are definite similarities to our setting in terms of follow up treatment requirements and multiple therapists and a continuous flow of new patients into the system while existing patients are still completing their treatment. Also, there is an initial assessment of all new patients (comparable to the Choice appointment at The Royal). One difference in this study though is the fact that all therapists are able to provide the same services. Another variant in Rau's paper relates to space and equipment constraints. Therapies would take place in a limited number of rooms with their corresponding equipment. The study has a detailed breakdown of the different types of therapy provided, the resources required by each of them (time, space), their frequency, and the percentage of patients requiring them. Three scenarios were then modeled: 1. Changes in the number of patients 2. Therapist pooling and 3. New patients' accommodation. For each scenario, the following performance measurements were recorded: 1. Length of stay in the system 2. Wait time 3. Number of patients and 4. Number of patients in the overtime therapy room. Simulations were run starting from a baseline case that helped to validate the model. A limitation of the model was the fixed times assigned to treatments. In summary, the simulation proved to be useful for assessing capacity planning for the therapy clinic. A further enhancement would include patient flow complexities such as no shows as well as the continuous growth in demand.

Romero et al (2013) presented a similar approach to CAPA in which services are streamlined through session integration. Authors presented a study in which the 'one-stop-shop' (OSS) concept was applied in a dermatology oncology outpatient clinic specializing in skin cancer treatment. They simulated different scenarios in which the authors varied the admissions rules and the resource allocation and capacity planning policies in order to determine the effect on the patients' throughput times. Additionally, within the study, they ran a pilot with 16 patients in order to determine the impact of the OSS ('one-stop-shop') implementation from a clinical perspective. One of the benefits of the OSS implementation is the waiting

time reduction. This is generally considered a patient satisfaction item as it also reduces the patient's uncertainty period. It is important to note that the OSS practice is not applicable to all of the clinic's patients. OSS patients will then have to share available resources with the rest of the patients. The study was structured in two phases. In the first phase, the actual capacity of the clinic was determined. The second phase consisted of running the defined scenarios. For phase one the authors used the Vissers and Beech (Vissers and Beech 2005) model to determine capacity planning. After applying this model, the authors determined that given that there was sufficient capacity to fulfil the existing demand it was feasible to have the OSS implemented. In the second phase, the authors developed the simulation model. The input parameters of the model were: patient arrival rate, service rate, patients' classification, and resource availability. The scenarios mentioned earlier were run using the Arena application. The scenarios were grouped into two categories: those with OSS implemented and those without. Overall there was a decrease in the patients' throughput times when OSS was implemented. A major challenge to the successful implementation of OSS is the need to have results from the pathology department on the same day to complete the process. This department is an external entity and worked under extraordinary conditions for the experiment run. Overall the OSS seemed to be an effective way to improve the service level for the clinic. The simulation results showed improved throughput times and patients were satisfied with the treatment obtained.

An interesting article found in the literature review is from Wu et al (2013) in which a discussion has been brought up in terms of the limitations of the existing research in developing general guidelines that can be applied to design outpatient scheduling systems. The authors summarize the aspects they consider require further research. The authors considered four aspects in their analysis: resource allocation, appointment modeling (traditional, carve-out and advanced access), patient preferences, and research methodology for outpatient scheduling. A summary of the literature mentioning the different perspectives of each of the four aspects is presented in the article. According to the authors, they did not find an optimal scheduling process that could be applied within the Chinese health care system. One of the limitations they highlight is the fact that researchers consider

cost and revenue as their goals while patients prioritize waiting times. The article also points out that there have been limited efforts in managing the uncertainty of patient demand. According to the authors, the time spent on waiting lists has been largely unexplored. The authors claim that there is not enough research designed to determine the optimal percentage of appointment time slots. To close this gap authors propose variable-sized multiple-block appointment systems developed by Fries and Marathe as cited by the authors (Fries and Marathe 1981). In this method groups of patients, identified as '*m*' within this method, are assigned to an appointment time. One of the benefits of this system is having low 'no-shows' costs. There are no details of the Chinese health system in the article so it is difficult to understand the setting the authors were using. The limitations identified do seem relevant and one could also infer from the article that there is still work to be done in terms of the application of scheduling models.

7 Intended Contribution

As has been presented there are a limited number of articles related to CAPA and ABCmod implementation. Similarly, there is very little research in terms of successful capacity planning model implementation. Our study will expand on the CAPA capacity planning component by developing a model in which we provide a more robust and quantitatively rigorous approach to capacity planning that is more tailored to the Royal and is not dependent solely on averages.

Our research also provides further guidance in terms of conceptual modeling development. Through the literature review, we observed that there is a gap between model development and implementation. We test the ABCmod methodology in order to determine how it facilitates model implementation. We take advantage of the experience at The Royal to assess stakeholders' perspectives and insights about how this methodology facilitates process modeling.

Maybe the most significant contribution from our research is a simulation capacity planning model that has been validated and tested under the CAPA service system. Given the parameters included in this model, it could be applied within other mental health organizations that are implementing the CAPA system. Additionally, it could also be extrapolated to health organizations with streamlined processes similar to those found in the literature review and those with patient management systems comparable to CAPA.

It has to be noted though that given the particularities of Mental Health and, more specifically, within a CAPA environment, we aimed in our literature review to find capacity planning models related to similar treatment / institutions but did not find anything significant in this area. The major difference with our model is the fact that patients have to go through additional sessions with two specific resources (ie, follow up sessions with a psychiatrist and partnership sessions with an Allied Health Professional). Similarly, our goal in this review was to find any material focusing on discrete event simulation or in modeling development of capacity planning models with the above mentioned characteristic of multiple sessions with an assigned resource. Our study will be among the first to include capacity planning simulation models for mental health clinics.

8 Modeling Process

To develop the capacity planning model for The Mood and Anxiety Program we used the ABCMod modeling framework. We followed this framework's sequential steps for the model development. The following is an outline of these steps and the outcome of each of them.

1. Problem statement: Confirmation of what we previously identified as our research problem.
2. System Under Investigation, SUI, description: As the name implies, within this step a description of the system to be modeled is provided. An important aspect that the

SUI includes is the model breakdown into behavior and structural components. Here we provide specific details of how the 'job planning' process within CAPA is expected to work as well as the characteristics of the patients, psychiatrists, psychologists and other assigned professionals. In this section, we also describe the different kinds of treatments and the scheduling process.

3. Goal Definition: This step involves the translation of our research objectives into the modeling methodology. The goal definition also includes additional support elements such as metrics that align with the goal achievement. This section also includes details as to how the experimentation and observation intervals are defined as well as the required inputs and expected outputs.
4. High Level Conceptual Model: Within the High Level Conceptual Model, the simplifications, the entities, the structural and behavioral views, the 'lifecycles', actions and activity constructs are outlined. This component describes all the model elements and how they relate to each other. The result of the High Level Conceptual Model is what serves as the means for discussion and validation with the project stakeholders in order to ensure that the system has been properly modeled and that it would lend itself to the questions they want answered.
5. Detailed Conceptual model: This includes pseudocode that sets the stage for translation of the model into a programming language. In this regard, the ABCMod framework has subsequent methodology ABCModJ in which the model is coded in the Java Language. As the development of a simulation program in a particular language is not within the scope of our research we will just present the elements that would need to be considered for further studies.
6. As an appendix within the ABCMod Framework, a 'Data Models' section is included in which all the values, equations and or functions of the model parameters are discussed.

8.1 Modeling Problem Statement

Our modeling premise is that the Mood and Anxiety Program at The Royal needs to have a robust capacity planning approach that will facilitate the CAPA system implementation through the best possible scheduling of its personnel. Similarly, the Program needs to assess its current capacity in order to determine the service level it can provide.

At the time of this research, the Royal was considering how to incorporate CAPA within the constraints of its capabilities. In other words, it was not only about implementing CAPA but also about how to maintain all those activities they deemed essential to the care they provide. As an example, certain psychiatrists provide additional treatment to their patients on top of those required by CAPA, mainly by providing patients with a higher number of sessions than those normally required by CAPA. This and other particularities of The Royal clearly impact the number of patients seen and therefore the extent of the impact of these particularities on patient wait times needs to be determined (as will be done in our study - more details provided within the Experimentation section).

8.2 System under Investigation Details

The 'System Under Investigation, SUI' encompasses all the processes and relevant elements that are to be modeled. From a general simulation and modeling perspective, we are here identifying which are the elements within our system that require intervention/treatment (aka 'customers'), what would be the elements providing this intervention (aka 'resources') and how and when this intervention is to be provided.
In our case these are:

- Professional personnel: the psychiatrists and all the allied health professionals
- Patients: broken down by type of treatment and length of treatment
- Treatments: The Mood and Disorder program provides three main types of treatment

8.2.1 Patients at The Royal Mood and Anxiety Program

Although there's a wide range of different patients who require service at the Mood and Anxiety Program, they can still be categorized into three main groups based upon treatment length and variability (i.e., the number of sessions a treatment requires):

- Typical: these patients follow the standard treatment length.
- Short term patients: these patients follow a shorter length of treatment compared to the typical; the variation in length is relatively high.
- Long term patients: these patients follow a longer length of treatment compared to the typical. As with the short term patients, the variation in length is relatively high.

8.2.2 Personnel at The Royal

Treatments at The Royal are provided by Psychiatrists and Allied Health Professionals (AHPs). The latter are responsible for the Choice and Partnership treatment sessions. As with Psychiatrists, their availability is established in hours per week within a specific time interval.

AHPs have different backgrounds: Psychologists, Occupational Therapists, Registered Nurses (RN), Cognitive Behaviour Therapists (CBT), and Social Workers. Clinicians at The Royal specialize in three different treatment types: Interpersonal Therapy (IPT), Cognitive Behaviour Therapy (CBT), and Occupational Therapy. In this research we focus only on the first two treatment types as Occupational Therapy is a small and fairly independent cohort. According to these specializations, AHPs are assigned to incoming patients.

Psychiatrists (also identified as MD's or Physicians within The Royal) are responsible for the Consultation (first appointment with the Psychiatrist) and Follow-Up treatment sessions. Their availability is measured in hours per week within a specific time interval in the day. Most of the psychiatrists provide the same number of sessions to each patient though some have a tendency to require additional sessions per patient.

8.2.3 Patient Process Flow at the Mood and Anxiety Program

The following is the flowchart summarizing the patient pathway with the corresponding responsible parties.

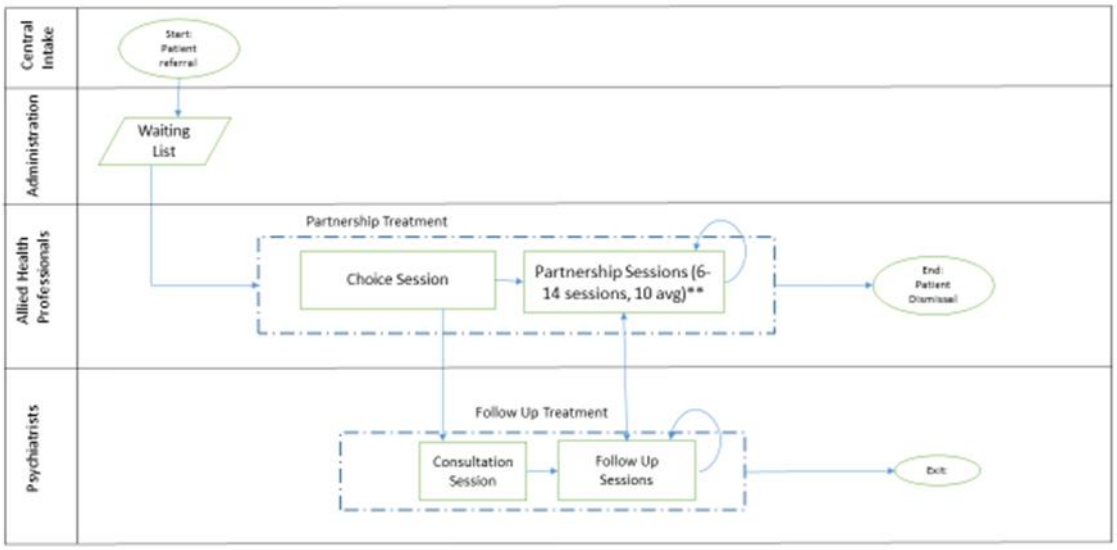


Figure 2: Patient Flowchart at The Royal

As indicated in Figure 2, The Royal receives patient referrals to its Central Intake Unit. From the Central Intake Unit, patients are referred internally to the appropriate program. The patients referred to the Mood and Anxiety Outpatient Program are managed by their own administration department. This department keeps patients on a waiting list so that they can be scheduled on a first-come-first-served basis. Every week this list is revised and the administration will proceed to book appointments occurring within the next 2 to 4 weeks. Patients who are not booked will remain on the list until space becomes available.

As the Mood and Anxiety Outpatient Program is following the CAPA System, the first session booked for patients is the Choice appointment that typically requires 3.5 hours. The Royal has determined that approximately 80% of patients will continue with the Partnership and Follow Up treatments following the Choice appointment. The next session after Choice is called the "Consultation" and is conducted by a Psychiatrist and typically requires one hour.

Following CAPA, the patient treatment then continues with the "Partnership" sessions with a specific Allied Health Professional. At the Royal, there are typically more Partnership

sessions per patient than suggested by CAPA. On average patients need 10 one-hour sessions (scheduled two weeks apart) to complete their treatment.

Concurrent with the Partnership treatment, patients undertake a series of "Follow Up" sessions with the psychiatrist that consists of an average of 8 half-hour sessions (though some psychiatrists will see their patients more often).

Once the patient finishes the Partnership and Follow Up treatments, he or she is discharged back to their referring Family Physician. In some rare occasions, there is also the possibility of the patient being referred back to the Mood and Anxiety Outpatient program for further treatment.

8.3 Project Goal

In line with our research objectives, the goal of the project is to develop a simulation model that will allow the Royal to determine the maximum number of patients that can be treated at the Mood and Anxiety Program while complying with the targeted service metrics (see output) and with a specific number of Allied Health Professionals and Physicians implementing the CAPA Service System. The model can be used to determine the impact of changing demand, adjusting capacity, of adjusting how capacity is used (such as the breakdown between Choice and Partnership time for each clinician) as well adjusting current practice in treatment (such as the total number of sessions per treatment).

8.3.1 Parameters

The parameters are the variables that will be adjusted in order to analyze the impact on the performance metrics. Below we will modify the psychiatrists, allied health professionals and patients characteristics.

8.3.1.1 **Psychiatrists and Allied Health Professionals (Resources)**

The following professionals will be considered to build the parameters of the model: Interpersonal Therapists (numAH_IPT); Cognitive Behaviour Therapists (numAH_CBT); and, Psychiatrists (num_Psy) where the first two are different types of Allied Health Professionals as mentioned earlier. We have used the ABCMod naming convention with "num" meaning the number of the corresponding professional followed by an underscore and the initials of the professional in question. Thus AH_IPT, for example, is Allied Health Interpersonal Therapy professionals while num_Psy is the number of psychiatrists.

For the Allied Health Professionals (AHPs), the model will have two parameters that determine the amount of time they are available for Choice versus Partnership appointments. These parameters are:

- choiceCapacity: we will use an array that contains the time within the weekdays in which the Allied Health Professionals are available to complete Choice Sessions (an example is shown below).
- partnershipCapacity: similar to the Choice case above, this array contains the time within the weekdays in which the Allied Health Professionals are available to complete Partnership Sessions. The following table presents an example of these details for both partnership and choice availability.

CBT DETAILS, SCHEDULE	1 means choice													
	2 means partnership													
		Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday
		0	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00
R_CBT_01	1	0	0	1	1	1	1	0	2	2	2	2	2	0
R_CBT_02	2	0	0	1	1	1	1	0	2	2	2	2	2	0
R_CBT_03	3	0	0	1	1	1	1	0	2	2	2	2	2	0
R_CBT_04	4	0	0	1	1	1	1	2	2	2	2	2	2	0
R_CBT_05	5	0	0	1	1	1	1	2	2	2	2	2	2	0
R_CBT_06	6	0	0	0	0	0	0	2	2	0	0	0	0	0
R_CBT_07	7	0	0	0	0	0	0	2	2	0	0	0	0	0
R_CBT_08	8	0	0	0	0	0	0	2	0	0	0	0	0	0
R_CBT_09	9	0	0	0	0	0	0	2	0	0	0	0	0	0
R_CBT_10	10	0	0	0	0	0	0	2	0	0	0	0	0	0
		Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday
		0	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00
R_IPT_01	1	0	0	1	1	1	1	0	2	2	2	0	0	0
R_IPT_02	2	0	0	1	1	1	1	0	2	2	0	0	0	0
R_IPT_03	3	0	0	0	0	0	0	0	0	0	0	0	0	0
R_IPT_04	4	0	0	0	0	0	0	0	0	0	0	0	0	0
R_IPT_05	5	0	0	0	0	0	0	0	0	0	0	0	0	0
R_IPT_06	6	0	0	0	0	0	0	0	0	0	0	0	0	0
R_IPT_07	7	0	0	0	0	0	0	0	0	0	0	0	0	0
R_IPT_08	8	0	0	0	0	0	0	0	0	0	0	0	0	0
R_IPT_09	9	0	0	0	0	0	0	0	0	0	0	0	0	0
R_IPT_10	10	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2. Example of Allied Health Professionals availability parameters

For the Psychiatrists, the model has three parameters that determine the psychiatrist's availability for consultation sessions, for follow up treatment sessions and the typical number of sessions per patient for that psychiatrist. These parameters are:

- consultationCapacity: this array contains the time within the weekdays that the Psychiatrists are available to complete Consultation Sessions (an example is shown below).
- followupCapacity: this array contains the time within the weekdays that the Psychiatrists are available to complete Follow-Up Sessions.
- additionalSessions: this set contains the number of additional sessions each psychiatrist will provide *on top of* those required by the treatment provided.

Table 3 provides an example of the psychiatrists' consultation, follow-up capacity and additional sessions required:

		1 means consultation											
		2 means follow-up											
			Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday
additional sessions		Start time	0	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
0	R_MD_01	1	0	1	1	1	1	0	2	2	2	2	2
0	R_MD_02	2	0	1	1	1	1	0	2	2	2	2	2
2	R_MD_03	3	0	1	1	1	1	0	2	2	2	2	2
2	R_MD_04	4	0	1	1	1	1	0	2	2	2	2	2
2	R_MD_05	5	0	1	1	1	1	0	2	2	2	2	2
2	R_MD_06	6	0	1	1	1	1	0	2	2	2	2	2
2	R_MD_07	7	0	1	1	1	1	0	2	2	2	2	2
0	R_MD_08	8	0	1	1	1	1	0	2	2	2	2	2
0	R_MD_09	9	0	1	1	1	1	0	2	2	2	2	2
0	R_MD_10	10	0	1	1	1	1	0	2	2	2	2	2
0	R_MD_11	11	0	1	1	1	1	0	2	2	2	2	2
1	R_MD_12	12	0	1	1	1	1	0	2	2	2	2	2
1	R_MD_13	13	0	1	1	1	1	0	2	2	2	2	2
1	R_MD_14	14	0	1	1	1	1	0	2	2	2	2	2
0	R_MD_15	15	0	1	1	1	1	0	2	2	2	2	2
0	R_MD_16	16	0	1	1	1	1	0	2	2	2	2	2
2	R_MD_17	17	0	1	1	1	1	0	2	2	2	2	2
2	R_MD_18	18	0	1	1	1	1	0	2	2	2	2	2
2	R_MD_19	19	0	1	1	1	1	0	2	2	2	2	2
2	R_MD_20	20	0	1	1	1	1	0	2	2	2	2	2

Table Psychiatrists Parameters

8.3.1.2 **Patients:**

As mentioned earlier, the model contains the following three patient types: Typical (TYP), Short Term (STM), and Long Term (LTM). For each patient type, we define the following parameters:

partnershipSessions: contains the number of partnership sessions for each patient type (partnershipSessions= < TYP, STM, LTM>).
followupSessions: contains the number of follow up sessions for each patient type (followupSessions= < TYP, STM, LTM>).
choiceTime: contains the length of the Choice session for each patient type (followupSessions= < TYP, STM, LTM>).

These parameters are provided in the Table 3.

Characterstic/Patient Type	typical	stm	lngtm	units
Percentage of patients	0.7	0.15	0.15	percentage
Number Partnership Sessions	10	6	14	sns
Number of Follow Up Sessions	8	8	8	sns
Choice duration	3.5	3.5	3.5	hrs
Partnership duration	1	1	1	hrs
Consulation duration	1	1	1	hrs
Follow Up duration	0.5	0.5	0.5	hrs

Table 3. Patient parameters

8.3.2 Experiment

This section describes the setting of the simulation. Details include the type of study (i.e. the simulation replication parameters), the base case scenario as well as the alternative scenarios that allow us to explore changes to the input parameters.

8.3.2.1 **Type of Study:**

We will use the simulation to provide a steady state analysis following a warm-up period. Statistics will be collected for a 720 day period with a 180 day warm up.

8.3.2.2 **Base and Alternative cases:**

The baseline scenario assumes that all psychiatrists have zero additional sessions (thus each psychiatrist has 8 follow-up sessions with each patient), all professionals' availability is fixed

and for Allied Health Professionals the ratio between partnership and choice appointments is 35 to 65 respectively.

Alternative cases: We analyze each alternative case individually and compare the results with the baseline.

- Psychiatrists' and AHPs' availability (time): 8 additional scenarios are run in which the capacity of AHPs and Psychiatrists is increased by 0.5 full time equivalent multiples (FTE) each time for a total increase of 2 FTE each. Further details of these scenarios are provided within the Results section (Scenarios 1 and 3).

- AHP's availability distribution change: We ran four scenarios in which the proportion of each AHPs available time that is allocated to Choice (versus Partnership) is varied. This distribution is changed from 65% – 35% (baseline) to 57 – 43%; 51 – 49%, 43 – 57% and 40 – 60% where the first number indicates the percentage of time dedicated to Choice and the second to Partnership. We provide the results in Scenario 3.

- Number of additional follow up sessions per treatment: We ran eight additional scenarios in which each scenario has four and six psychiatrists providing from 1 to 4 additional sessions than those established within the CAPA treatment plan. Ie 1 case with 4 psychiatrist with 1 additional session (4,1), then with 2 additional sessions (4,2) up to 4 additional sessions (4,4); we'd repeat the additional session cases considering 6 psychiatrists instead of four, so 6 with 1, 6 with 2, up to 6 with 4 additional sessions. Our eight cases can be written as 4.1,4.2,4.3,4.4,6.1,6.2,6.3 and 6.4, where the first digit is the number of psychiatrists with additional sessions and the second the number of additional sessions. We provide the details in Scenario 4.

- Choice Sessions Duration: We ran four scenarios in which Choice sessions are reduced from 3.5 to 3, 2.5, 2 and 1.5 hrs. These changes were due to the conviction of the head psychiatrist that current Choice session durations were longer than necessary. The corresponding results are shown under Scenario 2.

We provide a sensitivity analysis table to show how the variation of the above parameters affects wait times, the number of patients seen and how it relates to the established performance metrics discussed in the output section below.

8.3.3 Output

We identified the following output data as particularly relevant to the achievement of the project goal as outlined earlier. The related performance metric and expected achievement are provided next to each output. A programming naming convention has been used for each of these variables as specified by the ABCMod methodology.

patientsCompleteTreatment: Number of patients that completed their treatment at the Royal. This figure is used in order to determine how many patients complete their treatment within the 6-month target.

timetoCompleteTreatment (days): the time between the date the patient was registered and the one when he or she had his or her last treatment session (the last Follow Up session). As mentioned earlier the expected time is 180 days (6 months).

timetoChoiceSession (days): the time between the date when a patient was registered at the Royal and when he or she underwent his or her Choice session. The Royal expects this time to be less than 15 days.

timetoConsultationSession (days): the time between the date when a patient underwent his or her Choice session and when he or she underwent his or her consultation session. The Royal expects this time to be less than 15 days.

timetoPartnershipSession (days): the time between the date of the choice session and the first Partnership treatment. The Royal expects this time to be less than 15 days.

8.4 High Level Conceptual Model

As a starting point for our high level model, we define what the simplifications were, a summary of our entities and how they fit within the structure and behavior of the model, and finally, the inputs used within our model.

8.4.1 Simplifications

Below is the list of simplifications used in our model and some further details about each.

- The administration personnel booking the appointments are not included in the model. In other words, we are not modeling the management of patients prior to the Choice appointment (beyond tracking their waiting time).
- There are no cases in which a patient sees more than one psychiatrist within his or her treatment. These cases are rare as each patient is typically assigned to one psychiatrist exclusively.
- After a patient undergoes his/her Choice session, there are no cases in which a patient sees more than one clinician (allied health professional) within his or her partnership sessions. Similar to the case with the psychiatrists, patients are assigned to one allied health professional exclusively.
- Once a patient has finished his/her treatment, s/he is discharged from The Royal. If s/he needs another treatment, a new request from his/her family doctor is required and the patient is viewed as a new request.
- Psychiatrists that provide additional sessions to those provided within a typical CAPA treatment provide the same number of sessions to all of their patients. This is a rather strong assumption designed simply to recognize that there are psychiatrists who routinely provide additional sessions. We are essentially simply looking to determine the impact of deviations from the standard practice.
- The cases in which a patient calls in advance to cancel his or her appointment are not considered in this model. Again, these are not a common occurrence.

- Professionals' availability is allocated in blocks of time divided amongst the professional's various duties. For instance, mornings are dedicated for Choice appointments while afternoons for the remaining partnership sessions. For psychiatrists, Consultations take place in the morning and Follow Ups in the afternoon.
- Partnership treatments are distributed as follows: 80% are IPT while the remaining 20% are CTB. This reflects past experience at the Royal. OT treatments are not considered within the model as the demand was small.

8.4.2 **Entities**

The model entities can be grouped into resources and clients or consumers. The resources are the psychiatrists and clinicians. Given we have a number of them we can use the ABCMod naming convention for grouping them into sets. Within the ABCMod framework here is how the psychiatrists would be named:

- R.Psychiatrist: The set of Psychiatrists performing the Consultation and Follow-Up sessions. Each psychiatrist has a specific time interval in which he or she can provide the sessions s/he is assigned to. Additionally, each psychiatrist has a fixed number of the additional sessions they provide to their patients.
    - Psy1: R.Psychiatrist[Psy1]
    - Psy2: R.Psychiatrist[Psy2]
    - Psy3: R.Psychiatrist[Psy3]
    - …
    - PsyN: R.Psychiatrist[Psy20]

Similarly, this is how the Allied Health Professionals or Clinicians are identified within the ABCMod framework:

- R.Ahp: The set of Clinicians (Allied Health Professionals) performing the Choice and Partnership Sessions. Each Clinician has a specific time interval in which

he or she can provide each type of session. Additionally, each of these professionals is assigned a speciality (IPT: interpersonal therapy or CBT: cognitive behavior therapy).

- Ahp1: R.Ahp[Ahp1]
- Ahp2: R.Ahp[Ahp2]
- Ahp3: R.Ahp[Ahp3]
- …
- AhpN: R.Ahp[Ahp20]

In terms of the patients, the ABCMod uses tools to manage and classify them. The first is a queue following basic queueing theory. The corresponding naming is as follows:

- Q.Waitlist: This queue contains the list of patients registered at The Royal awaiting an appointment.

ABCMod also defines what it calls a group that identifies patients having certain characteristics. For the purpose of our model, we define:

- G.Patients: This group contains the list of patients that have started their treatment and are assigned to a specific Psychiatrist and Clinician.

Finally, the ABCMod framework uses attributes related to the number of patients in the system. For our model, each patient has attributes that define their patient type as well as the clinician and psychiatrist providing their treatment. The presentation within ABCMod would be as follows:

- iC.Patient: A consumer entity category representing the patients that require treatment at The Royal Mood and Anxiety Program. This entity category has a scope = Class. Patients would have the attribute Type that determines the number of sessions they require within their treatment. These types are: typ (typical number of sessions), stm (less than the typical number of sessions) and ltm (more than the typical

number of sessions). Additionally, this entity has two attributes that link it to both the Psychiatrist and Clinician completing their treatment.

8.4.3 **Structural View:**

This component within the ABCMod portrays the entities. As shown in Figure 3, an ellipse is used for a group, rectangles for sets, rectangles with rounded corners for queues and dots for class type entities.

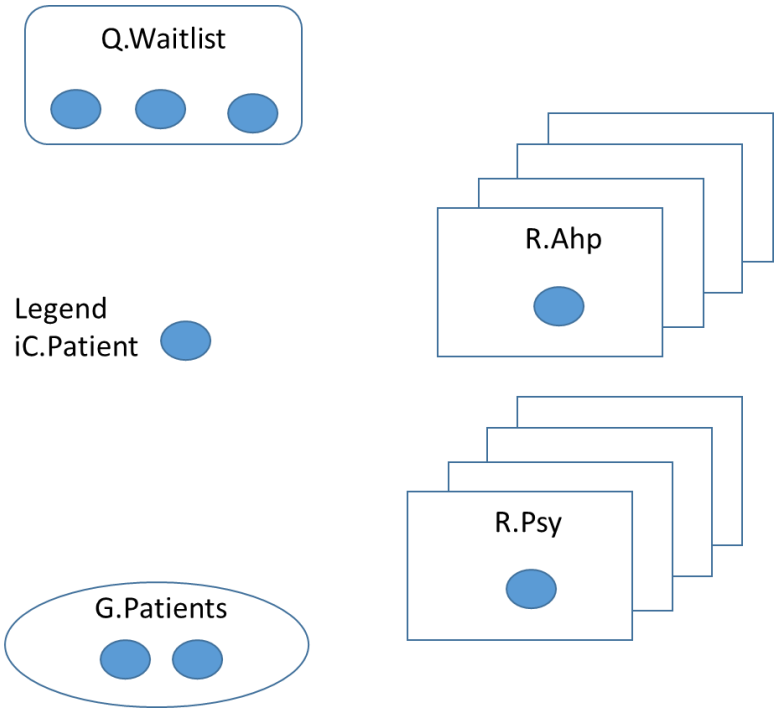


Figure 3: The Royal Structural Diagram

8.4.4 **Behavioural View:**

The behavioural view within the ABCMod reflects the modeled process flow. In order to do so, the framework divides the overall process into actions and activities and uses specific connectors depending on the sequence between them.

Figure 4 shows this view for the patient flow at The Royal. It starts with an action (a rectangle with a rounded corner) that reflects the fact that the patient has arrived. After the arrival, a

connection to another action is mapped through a circled S. This means that there is a schedule taking place in between the actions. In this case, as the following action is the scheduling of the choice appointment, this means that on a fixed interval (weekly at The Royal) these appointments are scheduled. Another schedule connection follows that represented the scheduling of the Choice session. Notice that a rectangle is used for the Choice session as this is not an action but an activity. An activity is a step within the cycle that has a defined duration.

The final activities within the flow are the Partnership, Consultation and Follow Up sessions. These have been grouped depending on the resource providing them. As the Follow Up session is the last type of session a patient should take, an exit point has been created out of this activity. Figure 4 shows how the process modeled requires many loops and is dependent upon the completion of the multiple interventions that the patients require.

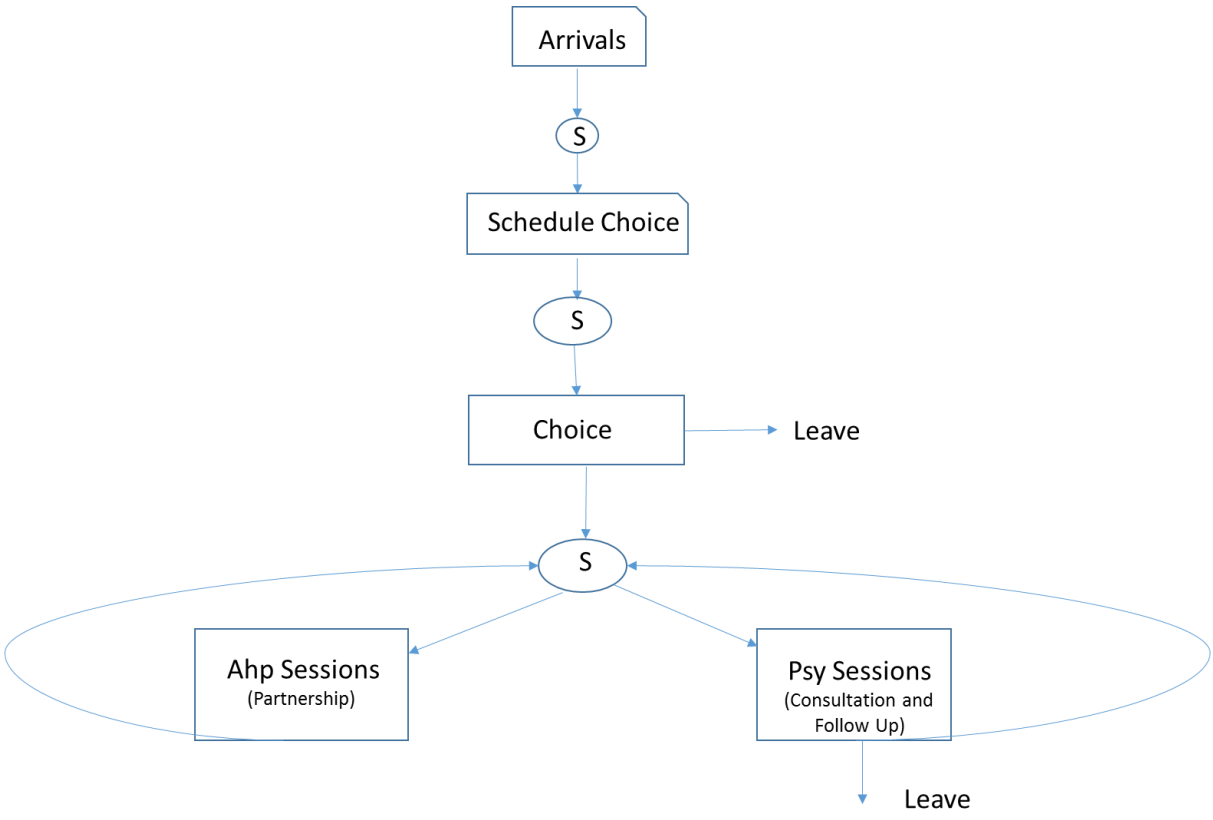


Figure 4: Patient lifecycle

8.4.5 **Action Constructs:**

In this section within the ABCMod, we provide a description of the actions identified in the previous diagrams. Below are the details as to how this is structured.

Arrivals: Patients taken from the waiting list to see a Psychiatrist and a Clinician.
Schedule: weekly process in which patients are assigned to a Clinician and Psychiatrist for the sessions within their treatment.

8.4.6 Activity Constructs:

As with the previous section, here we provide a description of the activities identified in the previous diagrams as per the ABCMod guidelines. Below are the details as to how this is structured.

Choice: initial session within a patient's treatment performed by a Clinician.
PsySessions: sessions within a patient's treatment performed by a Psychiatrist.
AhpSessions: subsequent sessions within a patient's treatment being performed by a Clinician (aka Allied Health Professional).

8.4.7 **Input**

The final section of the High Level conceptual model summarizes the inputs used within the model. We classify these into both endogenous and exogenous inputs.

Endogenous Input		
Variable	**Description**	**Values**
Duration of sessions	Length of sessions with the corresponding professional	Constant as per the data model section
Arrival	Patients released from the waiting list	RVP.Arrivals
Number of sessions	Number of sessions within each treatment	As per the patient type
Number of follow-up sessions	Number of additional sessions a psychiatrist may require	AS per the doctor number

8.5 DETAILED CONCEPTUAL MODEL:

The link between developing a simulation program and the conceptual model within the ABCMod framework is presented at the Detailed Conceptual Model level. We present a general overview of how this is structured as the development of a simulation program (as opposed to a simulation model) is not within the scope of this research. There are certain aspects within this section though that are relevant for our study and as such, we provide the details.

8.5.1 Structural Components

In this section, we provide the values that are constant within our model and those that we deem as parameters and how we vary the latter. Additionally, we present the consumer and resource characteristics as well as the output and input structure. The presentation follows the ABCMod formatting and naming convention.

Constants		
Name	**Description**	**Value**
CONSULTATION_TIME	Time required for the consultation session.	1 hour
FOLLOWUP_TIME	Time required for the follow up sessions.	30 minutes

TOTAL_Sessions	Total number of partnership and follow up sessions required by a patient	Defined by patient type.

Table 4. Model constants and their corresponding values

Parameters		
Name	**Description**	**Value**
numPsy	Total number of psychiatrists available	10 to 15
numAHP	Total number of clinicians available	10 to 15
CHOICE_TIME	Time required to complete the Choice Sessions	From 1.5 to 3.5 hours with .5 increments
numSessions	Additional number of Follow Up sessions required by certain psychiatrists	1 to 4 additional sessions for 4 and 6 psychiatrists
Ratio_CHOICE_PARTNERSHIP	Clinicians availability breakdown for Choice and Partnership sessions	5 possible combinations Choice to Partnership: 0.65-0.35; 0.57-0.43; 0.51-0.49; 0.43-0.57; 0.35-0.65

Table 5. Model parameters and their corresponding values

Consumer Class: patient

This consumer entity structure represents the patient requiring treatment at The Royal	
Attributes	**Description**
type	The type of the patient (value is one of short term, typical, large term) with assigned fixed percentages of 15, 70 and 15 respectively.
Ahp_Sessions_completed	Number of assigned sessions with a clinician that the patient has completed.
Psy_Sessions_completed	Number of assigned sessions with a psychiatrist that the patient has completed

Table 6. Consumer attributes and description as per ABCMod

Resource: Ahp	
This resource entity structure represents the clinicians performing the Choice and Partnership sessions	
Attributes	**Description**
Status	Indication if clinician is busy or idle
Session	Indication if clinician is performing a Choice or Partnership session

Table 7. Clincian Resource attributes and description as per ABCMod

Resource: Psy

This resource entity structure represents the psychiatrists performing the Consultation and Follow Up sessions	
Attributes	**Description**
Status	Indication if psychiatrist is busy or idle
Session	Indication if psychiatrist is performing a Consultation or Follow Up session

Table 8. Psychiatrist Resource attributes and description as per ABCMod

8.5.2 Behavioral Components

In this section, we describe the model outputs and inputs. Additionally, we also describe any activity or actions.

Action	
TimeSequence	< 0 >
Event SCS	Ahp_Sessions_completed ← 0 Ahp_Sessions_completed ← 0

Table 9. Action description as per ABCMod

Output	
Trajectory Sequence	
Name	**Description**
TRJ[TotalnumPatient]	Total number of patients that completed their treatment.
TRJ[totalTime]	The amount of time for a patient to complete his or her treatment.
TRJ[ChoiceTime]	The amount of time for a patient to attend his or her Choice session.
TRJ[ConsultationTime]	The amount of time for a patient to attend his or her Consultation session.
TRJ[PartnershipTime]	The amount of time for a patient to attend his or her first Partnership session.
TRJ[FollowUpTime]	The amount of time for a patient to attend his or her first follow up session.

Table 10. Output description as per ABCMod

Another important aspect of system behavior is the choice of scheduling policy.

• Patients' referrals received at the Central Intake are transfered to the Unit Administration (that of the Mood and Anxiety Program in thiscase).

• Patients are placed on a waiting list that is revised on a weekly basis in order to select, on a first come first serve basis, patients for their Choice session. This booking normally occurs 2 to 4 weeks prior to the date of the Choice session.

• After the Choice appointment confirms that the patient is qualified to continue with their treatment they are booked for their Consultation session.

• After the Consultation session, the Royal schedules the Partnership sessions. This is done on an ongoing basis after the completion of each session. Similarly, after the initial consultation, there are a series of follow up session scheduled on an ongoing basis.

• Administrative Personnel at The Royal take care so that the follow up sessions do not conflict with the partnership sessions. Follow up sessions are booked regularly between the Partnership sessions considering also that they would finalize the treatment (ie last treatment session is a Follow Up with a Psychiatrist).

• In some occasions, patients do not show to their appointments. In these cases, they need to contact The Royal to have the appointment rescheduled. Patients can also call to cancel or reschedule an appointment. In all of these cases, these patients are given priority over other patients so that they can continue with their treatment. Following one of the rules mentioned earlier, the administration personnel take care that any rescheduling does not affect the distribution of the Follow Up sessions within the Partnership ones.

Random Variate Procedures		
Name	**Description**	**Data Model**
uPatientArrival()	Returns patient inter arrival rate in hours.	t = NEGEXPO(MEAN), Where MEAN = 9

Table 11. Input description as per ABCMod

8.6 Data Models

The final section of the ABCMod Framework is the presentation of the structure and use of data within the modeling exercise.

As a side note, one of the foremost challenges faced during this project was the lack of data at The Royal. The CAPA implementation was in its initial stages, therefore, part of the data regarding system performance is still to be developed. Further along in the implementation, the Royal has identified the need for a structured system that would enable the capture of process information that could be used in a system performance management system.

8.6.1 **Patients' details:**

Most of the patient data was provided earlier within the parameters section. Additionally, it has to be taken into account that each patient requires 1 Choice and 1 Consultation session.

8.6.1.1 Partnership Sessions Breakdown**:**

Partnership sessions are one of three types: Cognitive Behaviour Therapy (CBT), Interpersonal Therapy (IPT), or Occupational Therapy (OT). For this research, OT is not considered given that the frequency is not significant. The table below summarizes the ratio of CBT vs IPT sessions required by patients.

Partnership Session Type	Proportion
Cognitive Behaviour Therapy, CBT	80%
Interpersonal Therapy, IPT	20%

Table 12. Ration between CBT and IPT sessions required by patients

8.6.1.2 Sessions Length**:**

The length of the sessions provided at the Royal is as follows:

Choice Sessions require 3.5 hours per patient.

Partnership Sessions require 1.0 hour per patient.

Consultation Sessions require 1.0 hour per patient

Follow Up Sessions require 0.5 of an hour per patient.

8.6.2 Psychiatrists and Allied Health Professionals availability data

The availability of the Allied Health Professionals is summarized in table 13.

Allied Health Professional	Hrs/week for Choice Apts.	Hrs/week for Partnership Apts.
Occupational Therapist	10.5	16.2
Psychologist 1	7	10.75
Psychologist 2	10.5	8.25
Psychologist 3	10.5	11.5
Psychologist 4	10.5	10.5
Registered Nurse 1	10.5	10
Registered Nurse 2	10.5	10.5
Social Worker 1	5.5	7.5
Social Worker 2	4.5	9.5
Social Worker 3	10.5	12.25

Table 13. Allied Health Professionals availability

The availability of the Psychiatrists is summarized in table 14.

Dr No	Hours/week for Consultation Apts.	Hours/week for Follow Up Apts.
Dr 1	2	18
Dr 2	3	26
Dr 3	1	5.5
Dr 4	1	5.5
Dr 5	3	26
Dr 6	1	5.5
Dr 7	1	3
Dr 8	1.5	13
Dr 9	1.5	13
Dr 10	3	26
Dr 11	1	15.5
Dr 12	1	5.5
Dr 13	1	5.5

Table 14. Psychiatrists availability

9 Results and Simulation analysis

As mentioned within the ABCMod experimentation section, we ran a series of scenarios in order to determine the effect of changing a number of key parameters to capacity planning at

The Royal. Prior to proceeding with the scenarios analysis, we define a baseline scenario as a point of comparison.

9.1 Baseline identification; estimated capacity at The Royal:

The baseline scenario results in simulated performance metrics similar to the current performance of The Royal. Aligned with discussions with The Royal, the current backlog is proving a serious impediment to the achievement of lower waiting times. Consistently the presented project has also confirmed this fact about the proportional relationship between the backlog and waiting times.

Table 15 below summarizes the project's parameters in the baseline scenario.

Item	Value
Number of Patients at Time 0	1000
Warmup days	180
Runtime	720
Wait time target (days)	21
Time to complete treatment target (days)	180
Exponential Interarrival rate (hrs)	9
MDs with additional sessions	0
Consultation duration (hrs)	1
Choice Duration (hrs)	3.5
MDs working per week (FTE)	7.4
AHPs working per week (FTEs)	9.6
AHPs % time allocated to Partnership	65
AHPs % time allocated to Choice	35

Table 15. Baseline figures

Table 16 provides the simulated results for the baseline scenario.

Item	Value
Number of patients that completed their treatment	530
Percentage that completed within acceptable duration	25
Average Time to Choice (days)	42
Maximum Time to Choice (days)	160
Average Time to Consultation (days)	158
Average Time to First Partnership (days)	66
Average Time to First Follow Up (days)	160
Average Time Between Follow Ups (days)	60
Average Time Between Partnshp Sessions (days)	66

Table 16. Backlog effect

Following the scheduling policy strictly, The Royal would be able to treat approximately 530 patients a year but only 25% of them would be able to complete their treatment within six months. It would take anywhere from a month and a half to five months for the first Choice to occur. Simulation results further suggest that it would take an average of 5 months before the Consultation appointment occurs. Moreover, the average time between appointments is 2 months rather than 2 weeks.

9.2 Scenario 1: Allied Health Professionals Availability Changes

It is clear that current capacity is insufficient. Thus, as a key resource within The Royal, we ran four scenarios where the AHP's availability was increased. From the baseline, we added increments of 0.5 full time equivalent (FTE). Figure 5 provides the results.

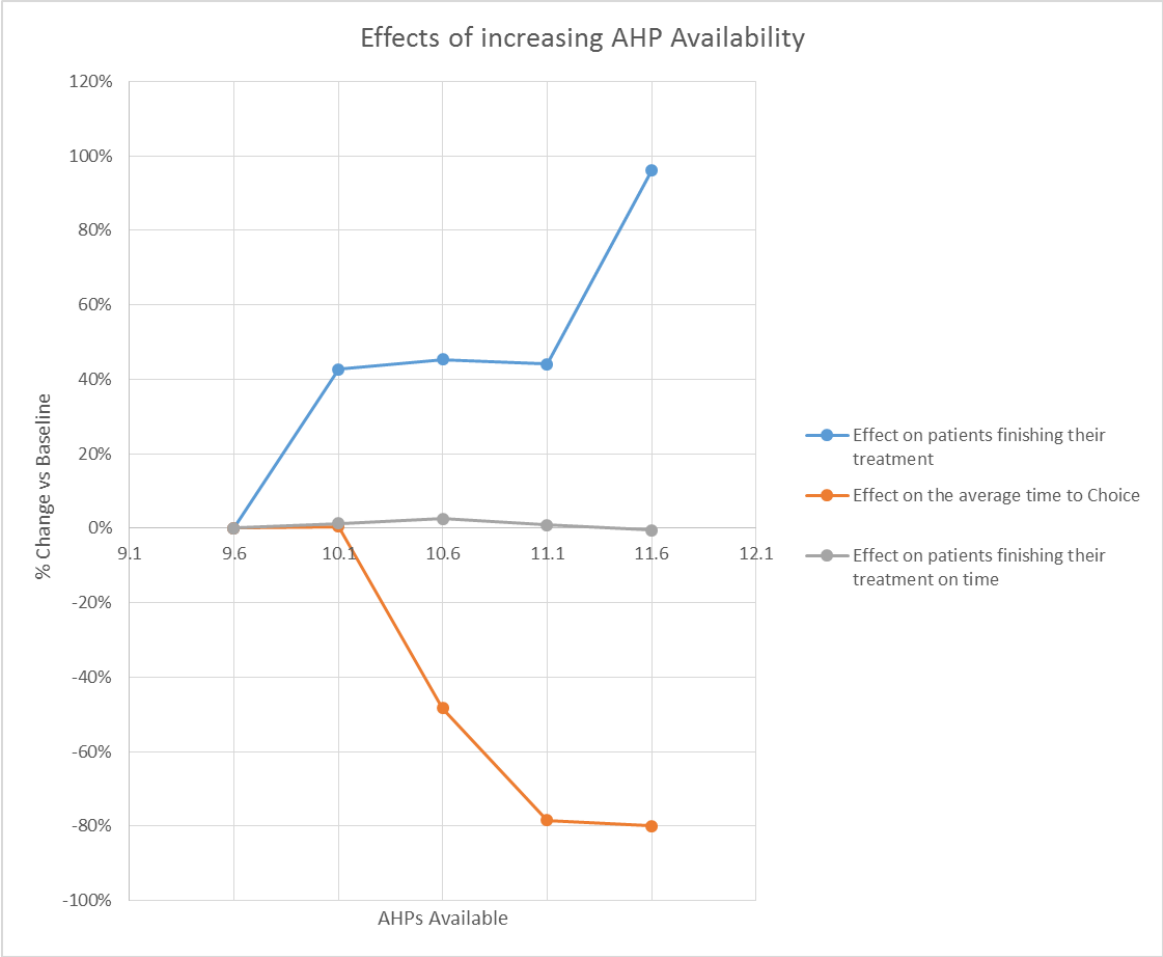


Figure 5 Allied Health Professionals availability changes

From the simulations run it is evident that the impact on the performance metrics of adding AHP capacity is far from linear. As will be discussed later, together with the addition of AHPs it is necessary to also review how their time is distributed between Partnership and Choice sessions as this has a higher impact on the number of patients treated.

A significant change is observed in terms of the number of patients finishing their treatment (particularily when 2 FTEs have been added). An interesting aspect to note is that there is no major effect in terms of completing patients' treatment on time while the total throughput increases. Most likely this can be explained by the fact that while the additional capacity is helpful, it is not sufficient to bring the wait times within the targets.

When looking at the average time to undergo a Choice appointment, it is evident that the effect of adding AHP resources results in progressive (though still not linear) time reduction.

9.3 Scenario 2: Choice duration changes

One aspect of CAPA that we discussed at length with staff at The Royal during the modeling stages was the Choice session duration. The CAPA system suggests that a Choice appointment should take 2 hours. At the Royal, two hours was deemed to be quite low. At the time of this study, the time assigned to a Choice session was 3.5 hours. We have modeled 3 additional scenarios in which we decreased the session length to 3, 2.5 and 2 hours. Results are summarized in Figure 6 below:

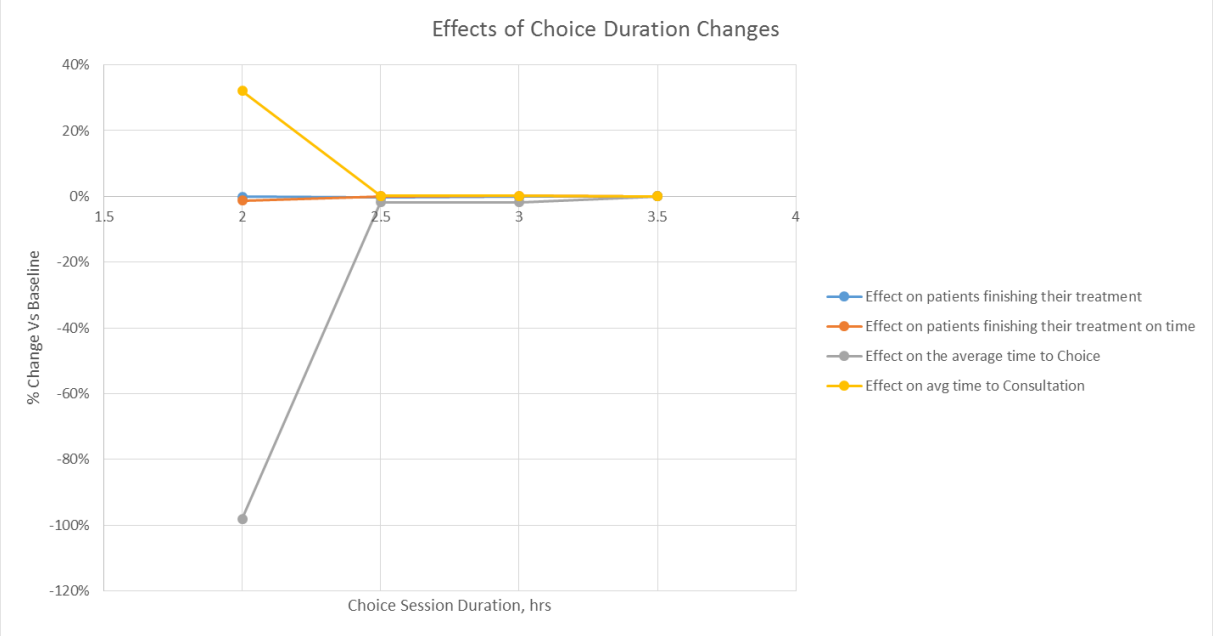


Figure 6 Choice duration changes effects

The major effect of reducing the Choice session duration occurs on both the maximum and average time to these sessions. Interestingly, as the Choice session duration is lowered, there is an increase in the time to a Consultation session. The rationale behind this effect is the fact that the reduction in the Choice session duration increases the queue of patients waiting for Consultation (as it is the appointment following Choice).

One important item to note is that the reason that we see a major effect only when the time is reduced to 2 hours is due to the fact that the Choice appointments take place in the morning, (ie from 8:00 to 12:00). Therefore, only when Choice appointments are reduced to 2 hours can more than one Choice appointment occur in a given morning.

9.4 Scenario 3: Psychiatrists availability changes

As with Allied Health Professionals, Psychiatrists have a limited number of hours available at The Royal that is clearly insufficient to meet demand. To assess the effect of the Psychiatrists availability changes, we modeled four scenarios in which their availability was increased in increments of 0.5 FTE/week, ie from 7.4 up to 9.4. Figure 7 provides the results.

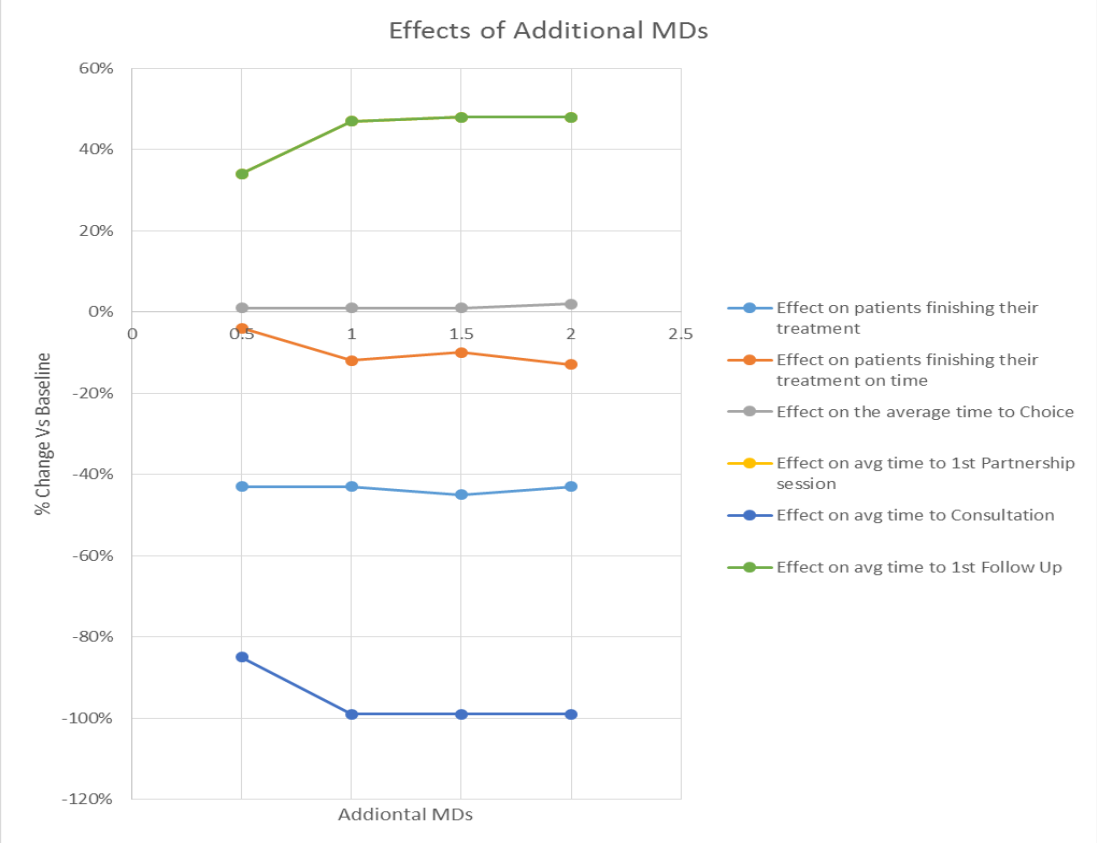


Figure 7 Psychiatrists availability changes

From the results obtained it can be seen that the combination of additional resources and a change in the Choice/Partnership ratio lead to a higher number of patients treated and overall wait time reduction.

The observed increase in patient flow, however, has an impact in the time required for patients to complete their treatment. A key component to understanding this effect is the fact that the availability of psychiatrists is broken down between Follow Up and Consultation sessions and that patients assigned to one psychiatrist will have to continue their treatment with the assigned psychiatrist. As additional psychiatrists are added, more patients make it past the Consultation thereby potentially causing blockages downstream. Thus psychiatrists can have an imbalance in terms of the completed follow up and consultation sessions. A similar case occurs with AHPs for the Choice/Partnership ratio as varying this ratio has a significant impact on performance. We will expand further on these scenario combinations in section 9.7 below.

9.5 Scenario 4: Choice Partnership allocation ratio

Given the Allied Health Professionals limited availability at The Royal, we analyzed what would be the impact of changing how they distribute their time to attend to both Choice and Partnership sessions. In the base case, the breakdown is 65% Choice and 35% Partnership. We ran three additional scenarios in which we changed the breakdown to 57 and 43 %; 51 and 49 %; and, 43 and 57 %. Within these scenarios, we adjusted the allocation to ensure that there was enough time during each shift for complete sessions. Figure 8 summarizes the results:

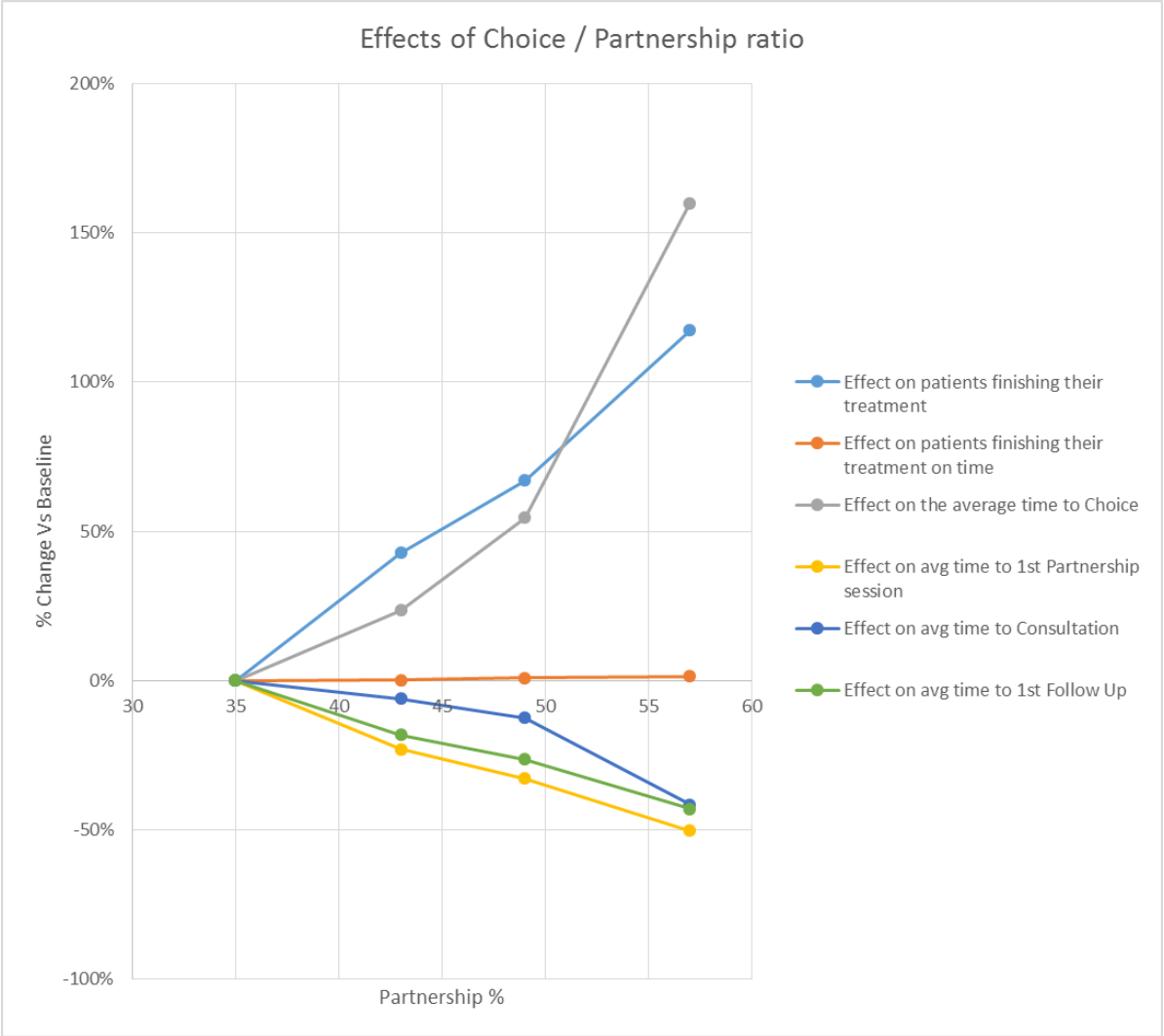


Figure 8 Choice vs Partnership allocation

From the above chart, it is clear that the number of patients treated increases proportionally to the increase in the time devoted to Partnership appointments. This comes at a cost in terms of waiting times for the patients' initial treatment though there is an increase in the overall number of patients seen. As a result, there are fewer patients coming out of the Choice session and therefore there is a reduction in the queue of patients waiting to complete a consultation session. Related to the increase in the number of patients seen, the time between Partnership and Follow Up sessions diminishes as more time is devoted to Partnership.

The above scenario seems to be the most beneficial in increasing the number of patients seen and reducing wait times. We have added two cases in which, on top of the above changes, we also increase AHPs availability by 1.3 and 2.6 obtaining the results shown in Figure 9:

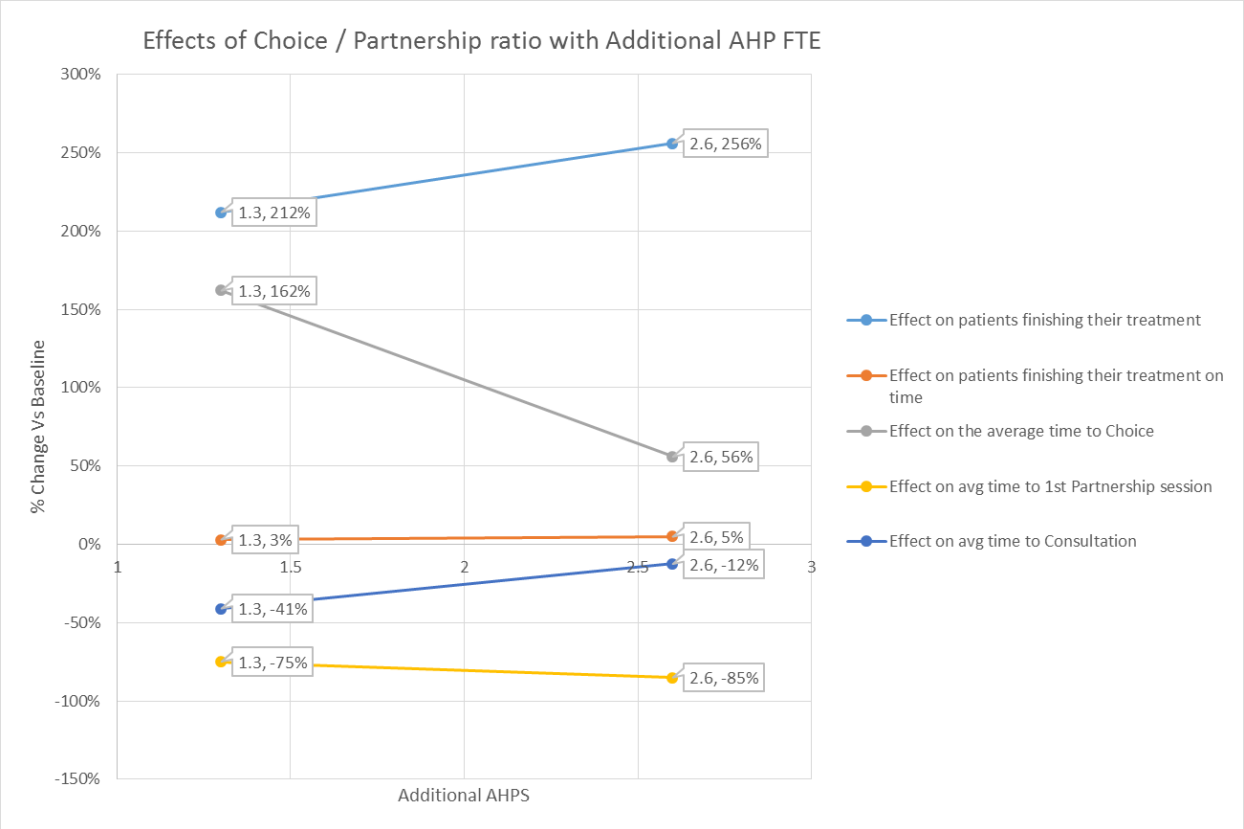


Figure 9 Choice vs Partnership relationship with added Allied Health Professionals

As shown above, the combination of the additional FTEs and a different ratio of Choice vs Partnership increases significantly the number of patients seen. It does not significantly impact the proportion of patients finishing treatment on time however it does expedite the process in general and allows The Royal to satisfy a much greater proportion of incoming demand.

We analyzed in scenario 3 the effects of increasing the psychiatrists' availability; below will analyze the combined effects of increasing their availability with the previously discussed changes to the Choice / Partnership ratio. Figure 10 below summarizes our results:

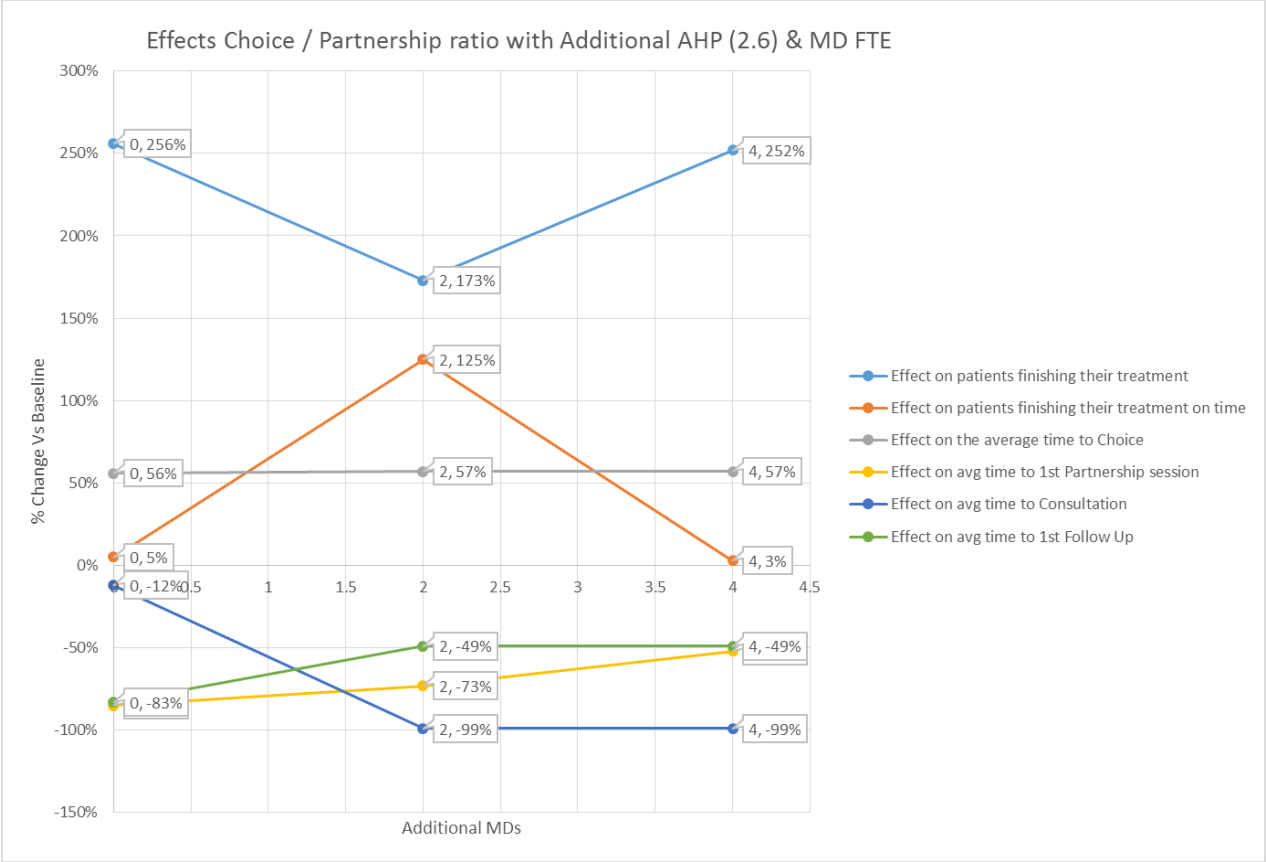


Figure 10 Choice vs Partnership relationship with added Allied Health Professionals and Psychiatrists

From the results obtained it can be seen that the combination of additional resources and a change in the Choice/Partnership ratio lead to a higher number of patients treated and overall wait time reduction.

The observed increase in patient flow, however, has an impact in the time required for patients to complete their treatment. A key component to understanding this effect is the fact that the availability of psychiatrists is broken down between Follow Up and Consultation sessions and that patients assigned to one psychiatrist will have to continue their treatment with the assigned psychiatrist. As additional psychiatrists are added, more patients make it past the Consultation thereby potentially causing blockages downstream. Thus psychiatrists can have an imbalance in terms of the completed follow up and consultation sessions. A similar case occurs with AHPs for the Choice/Partnership ratio as varying this ratio has a

significant impact on performance. We will expand further on these scenario combinations in section 9.7 below.

9.6 Scenario 5: Psychiatrists additional sessions changes

One of the realities that The Royal faces is that some psychiatrists need additional sessions to complete their treatment. Eight scenarios have been modeled in which additional sessions have been added. In the first four cases, 1 session increments are applied to four psychiatrists (ranging from 1 to 4 additional sessions). The last four scenarios have the same increment but in this case applied to six psychiatrists. The scenarios are identified with an A.B format, in which A is the number of doctors with additional sessions and B the number of additional sessions added. The results obtained are summarized in Figure 11:

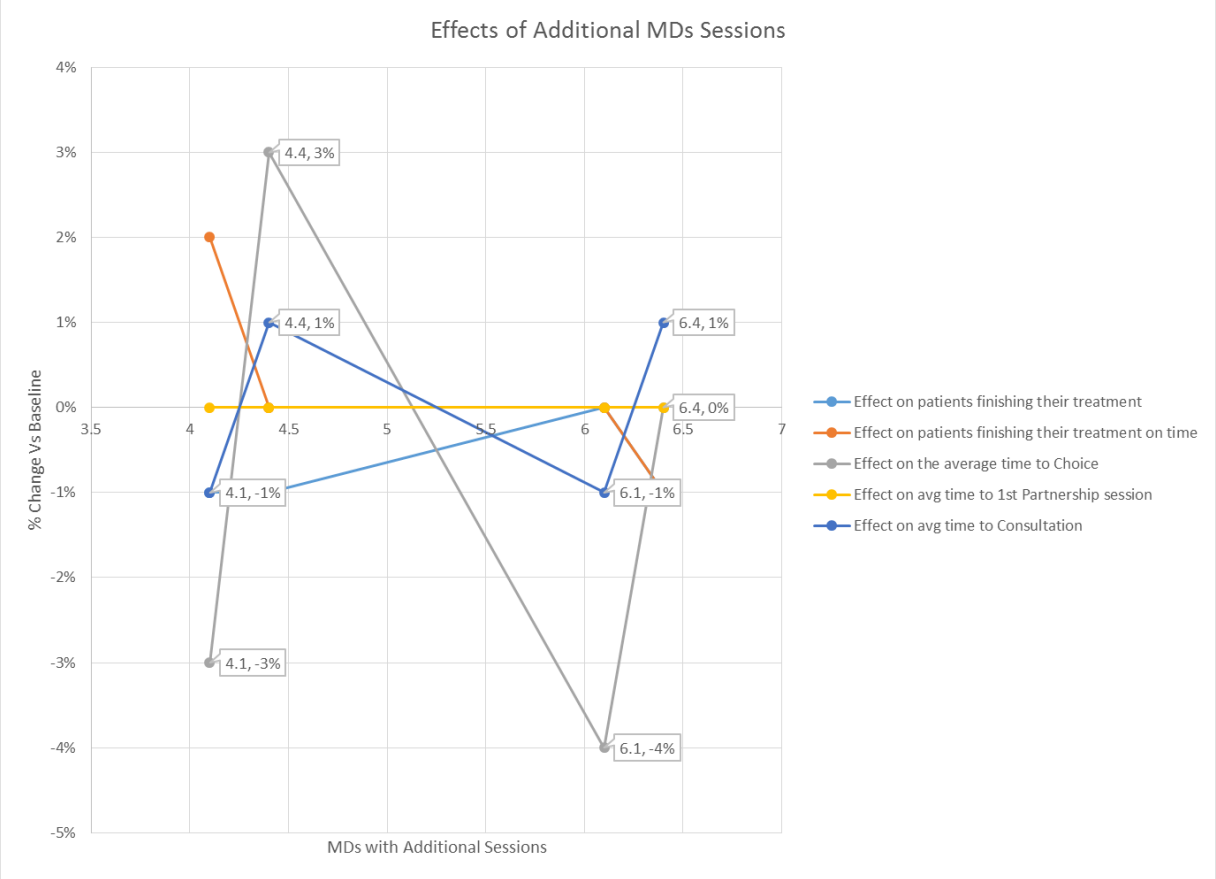


Figure 11 Additional sessions effects

As can be noted, no major impact is caused by the additional sessions other than in the time to first follow up. The main reason for this effect is due to the fact that the model distributes evenly the patient sessions so that they follow an interleave pattern. By adding follow up sessions, this number increases and therefore partnership sessions are delayed until they can be evenly scheduled with the follow-ups.

9.7 Scenario combinations and target attainment

From the results obtained above, we did a series of scenario combinations in order to determine what would be the necessary capacity that the Royal would need in order to satisfy its expected targets. As mentioned during the ABCMod the Royal expects to:

1. Have its patients finish their treatment within 6 months
2. Have an average of fewer than 15 days for the Choice session to occur after registration
3. Have an average of fewer than 15 days for the Consultation to occur after the Choice appointment
4. Have an average of fewer than 15 days for the first partnership session to occur after the Consultation session.

Considering these metrics an initial analysis was done in which the Allied Health Professions (Clinicians) availability was almost doubled and the percentage of their workweek devoted to Partnership was increased to 65% with the rest of the time (35%) being devoted to Choice. The psychiatrists' availability was also increased to the point that it was also doubled. Figure 12 summarizes the results.

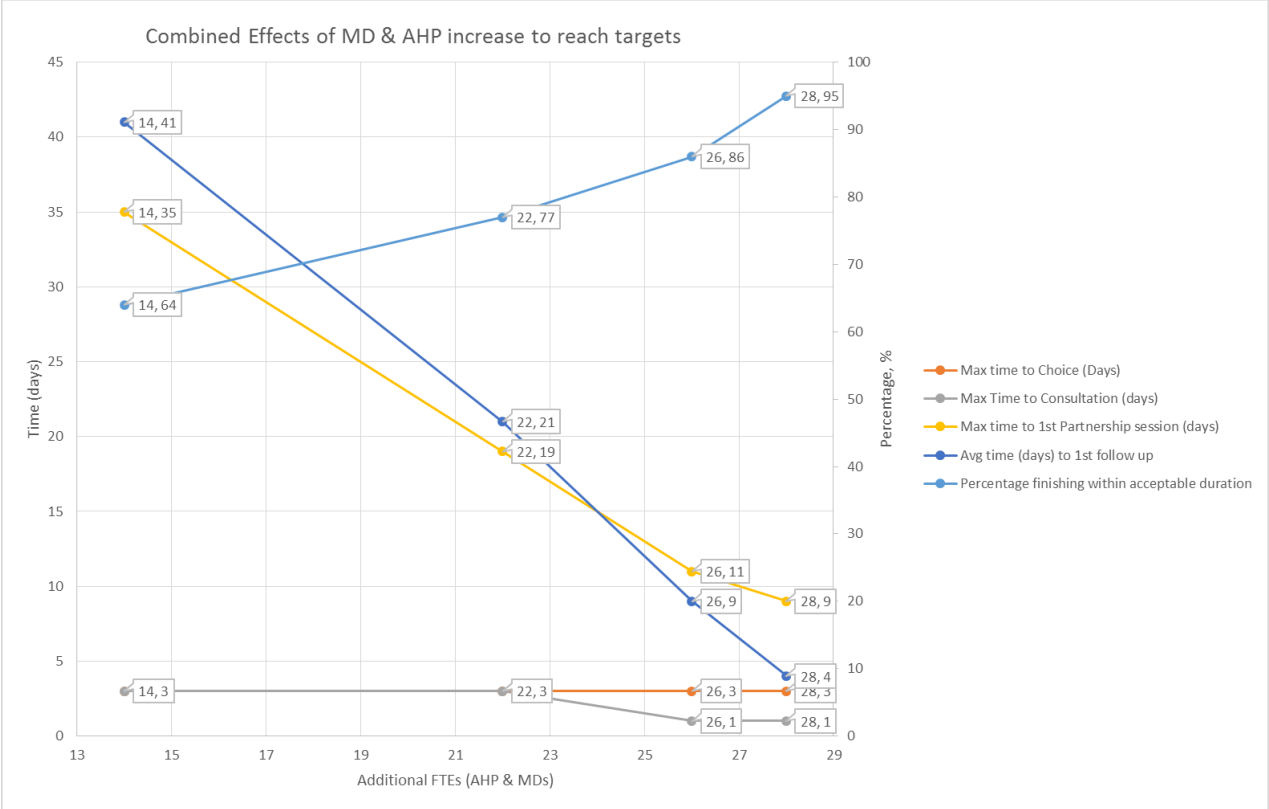
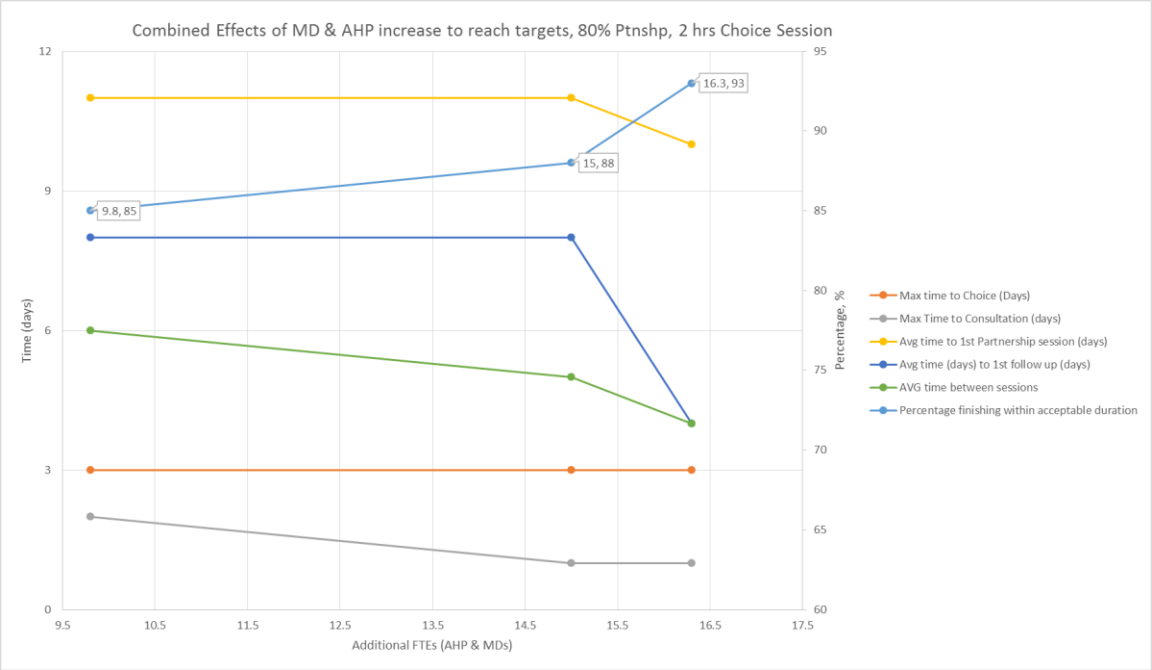


Figure 12 Combined effects of Clinicians and Psychiatrists availability to achieve The Royal targets

As observed in Figure 12, it would be completely feasible for The Royal to achieve its targets if it was to double its capacity while maintaining the current 65 – 35 ratio between Partnership and Choice sessions availability. Given the major impact that this scenario would have in terms of personnel costs and the significant effort required for recruitment, we explored other alternatives as shown below.

The case that we further considered was the one in which the Choice session length is reduced. The reason why we selected this option was that there was some discussion at The Royal as to whether the current length of time was excessive. One of the arguments supporting this premise relates to the fact that in addition to the Choice session, patients are also seen by a psychiatrist during the Consultation. Additionally, this is one particularity that The Royal has which is not standard within the CAPA service system.

Based on our initial results we noticed that changing the Clinicians time distribution had a major impact on the overall results. Thus in the final scenario combination, we adjust this ratio from 65-35 to 80-20 (partnership vs choice clinicians availability). We also added an additional variation to our experiment in which we changed the number of Interpersonal Therapists, IPT, and Cognitive Behaviour Therapists, CBT, (as mentioned within the ABCMod Data models section, 80% of the patients at The Royal would require a dedicated treatment from a CBT while the remainder 20 % from a IPT). The results are shown in Figure 13 below:



From Chart 9 it can be clearly seen that with this combination the targets are met with a fewer number of resources. The last two cases show a significant improvement over the base case and are only slightly off the target. The Royal could eventually consider these cases as part of their implementation plan. An important aspect to note is that the number of IPT Clinicians at the Royal is maintained at 4 in order to reach targets. The main learning from these experiments though is that the 80 to 20 ratio of Partnership to Choice availability is essential for target achievement and better time utilization.

10 Findings, Implications, Conclusions

10.1 Main Findings

Based on the simulation results obtained, The Royal will need to address its current capacity in order to meet its performance targets given its intentions to implement the CAPA Service System. If The Royal implements CAPA, it would be able to treat an average of 530 patients given current practices and capacity; approximately half of the number of patient referrals they receive per year. Furthermore, only about 130 of those patients would be able to finish as per their established target of six months. Additionally, the average time between sessions will take significantly longer than their expected target of 15 days.

In order for The Royal to achieve its targets within the CAPA system, it would have to increase its Allied Health Professionals/Clinicians and Psychiatrists availability for patient appointment booking. The Royal would need a minimum of 3.6 additional full-time equivalent (FTE) Psychiatrists and 6.4 additional FTE for AHPs. Additionally, 80% of the Clinicians' time should be devoted to Partnership appointments with only the remaining 20% devoted to Choice sessions and Choice appointments will need to be reduced to 2 hours. This is a significant departure from current practice.

A particularity at The Royal that is contrary to the CAPA recommendations is the fact that certain psychiatrists require additional sessions to complete their patients' treatment. From the scenarios, it was observed that this was not a significant factor on the overall performance. As discussed, this is due mainly to patients having, in general, a higher number of sessions with AHPs and as all patients sessions are processed in an interleaved sequence, in most cases the psychiatrists sessions balance those of the clinicians. The major impact on The Royal targets relates to the Clinicians availability.

In terms of the methodology followed during this research, it was found that the ABCMod conceptual modeling stage facilitated the interaction with the stakeholders at The Royal. The modeling breakdown suggested by the ABCMod, mainly in terms of the output,

parameters and input definitions as well as in the process mapping, proved extremely useful during the meetings held at The Royal for clarifying objectives and expectations. It also facilitated agreements on any constraints, assumptions or limitations within the simulation process.

10.2 Policy Implications

Based on the presented findings, The Royal might need to restructure how it allocates its Allied Health Professionals' and Psychiatrists' time. As this is not a unilateral decision, further discussion around this matter would need to take place in order to reach consensus between all parties involved. Additionally, The Royal needs to build a case for funding for additional professional personnel support. If The Royal is to maintain its service performance targets, the need for additional resources is evident.

Finally, within the CAPA implementation process, The Royal might need to have a system in place that would continuously track its performance metrics. These metrics should not only be related to waiting and treatment times but also to the level of patient satisfaction. If CAPA is to change the way patients are treated, it would be convenient to assure that the required service level is maintained.

10.3 Limitations

The major limitations faced within this research were related to data availability. This is due to the fact that the CAPA implementation was still in the planning stages at the time when this research was done. Given this situation, our analysis was focused on the simulation of potential scenarios that would help The Royal to assess potential implications of the CAPA implementation.

Given the data constraints faced, certain of our scenarios were based on assumptions that could be considered as simplifications of the current processes at The Royal. For instance, in attempting to model the effect of certain psychiatrists having additional sessions, we decided to make this number constant for all patients (all the patients assigned to a psychiatrist that normally provides additional sessions have the same number of these extra sessions). We understand that this might vary from the actual process (which is still to be

mapped/modeled at The Royal). However, it provided us with insights in terms of the effects of an overall increase in the number of treatment sessions provided by psychiatrists.

It is also worth mentioning that there is not an established scheduling policy process at The Royal. The Royal does have a series of practices that are generally followed but this is a manual process that may vary depending upon the professional. One aspect that might also be noted is that our research was focused mainly on simulation modeling. As noted in the Future Research section, the extension of our study to an optimization project could enhance the proposed results.

10.4 Research Conclusions

Research Questions: We consider that this thesis provided the answer to our research questions mentioned earlier. In regards to the determination of the necessary capacity at The Royal for a successful CAPA implementation together with target compliance, we have provided details in terms of the additional full-time equivalent needed (ie, 6.4 Clinicians and 3.4 Psychiatrists) and determined how the Clinicians availability is to be distributed (specifically 80% of the time to be devoted to Partnership sessions and the remainder 20% to Choice Sessions).

We also consider that our second research question, in which we were to determine how the ABCMod modeling framework needs to be adapted to answer our first question was also answered. Going through the conceptual modeling components of the ABCMod framework we were able to identify the elements that had to be structured in our model in order to determine the required capacity at The Royal. Aligned with our research objectives, using the format suggested within the ABCMod, we presented this framework's modeling components at our stakeholder meetings at The Royal. This allowed us to validate our process understanding and the expected output. The ABCMod framework allowed us to easily validate our model inputs, parameters and outputs with our stakeholders. It was not within the scope of this research to compare this framework with other conceptual modeling methodologies but we are certain that the ABCMod needed little adaptation to function well in this setting.

Research Objectives: In terms of our research objectives, we consider that we were able to achieve them. To start we can confirm that through the different simulation runs we determined the elements that need to be taken into account to develop a feasible if not optimal capacity plan for The Royal given its CAPA implementation. As mention earlier, our research was not focused on optimization. However, we did run multiple scenarios in which we varied the elements that were affecting The Royal's ability to meets its targets and were able to develop a capacity planning model with which we could develop proposals to meet them. Furthermore, related to our first objective, we were also able to develop a model with which we overcame the limitations that the CAPA system has for capacity planning. As repeatedly mentioned, the assumptions behind the CAPA capacity planning framework do not fit The Royal. Moreover, the methodology is entirely based on averages and provides no means to adjust the assumptions. Our model provides much more flexibility to any organization using CAPA as it not only allows for the adjustment of the assumptions but also can incorporate variability in service provision and a 'what-if' scenario analysis tool for future changes.

An additional objective we wanted to achieve was to assess the effect of the additional sessions certain psychiatrists require to complete their treatment. We noticed that given the existing capacity constraints at The Royal, the effect of these additional sessions was not significant. This with the caveat stated in the Limitations sections in which we indicated that our focus here was to assess the effect of the increase in the psychiatrists' treatment length. We also mentioned that in most cases a patient would have a higher number of sessions with a clinician than with a psychiatrist. Therefore, if there is an increase in the number of sessions with a psychiatrist this is unlikely to significantly increase the total treatment time. Much more critical to the achievement of the targets is the number of sessions with the clinicians.

We also set two additional objectives related to the ABCMod framework application. To start we wanted to determine if there were any modifications or adjustments that would be needed when applied to our simulation and modeling project at The Royal given the CAPA implementation. We do not consider that major modifications are needed given that we were able to develop a solid model following this framework. We did use, though, standard

process mapping tools such as a swim lane flowchart that are not traditionally part of the ABCMod framework. In this regard, we consider that these tools do have an advantage over those within the ABCMod perhaps because they are used more extensively and tend to be more familiar to relevant stakeholders. As mentioned in the Literature Review section, there are very few examples of successful applications of the ABCMod methodology to a real instance of capacity planning. In this sense, we have filled a gap in the literature by providing evidence of the usefulness of this methodology for an organization.

Our second ABCMod objective related to communication with stakeholders. As mentioned earlier, we did use additional tools on top of those within the ABCMod Framework to facilitate our discussions with The Royal. We presented to the project stakeholders the ABCMod diagrams and the feedback received, in general, was positive. However, it was still necessary to use the swim lanes flowchart for ease of understanding as some of the conceptual modeling proved too abstract. In summary, the ABCMod was adequate for our modeling exercise and was improved with the use of standard and more general process mapping tools.

Our last objective was the determination of the success factors for the implementation of our capacity planning model for an institution similar to The Royal. In this case, we consider that our model would be applicable to cases in which there are patients (or consumers within a more generic modeling environment) that require multiple interventions from two different professionals (or resources, if we were to generalize). Our case included four different types of interventions, each with a specific length and frequency. From here our model could be further applied to similar cases as long as each professional is providing up to two different services. Our model would require minor modifications if this distribution is to be changed. Another success factor identified in our model is how one of the resource's availability is distributed. This would be another feature that could be extrapolated and applied under similar conditions. Certainly, other mental health hospitals implementing the CAPA system would be able to easily adjust our model to fit their specific institution. We are confident it would provide more robust results than the capacity planning model currently provided with the CAPA system software.

10.5 Future Studies

This research can be extended by further exploring the application of the ABCMod framework. Our work did not explore the structuring of the model into a pseudo code language that can be translated into a simulation program. This study could be extended with the completion of this stage and even further to the ABCModJ that corresponds to the development of the simulation model in the Java programming language. However, it is unclear whether this would add significant value compared to the implementation in Arena used in this research.

In addition, this research could be extended to the development of an optimization model. This could be achieved either through the use of the ABCModJ mentioned earlier or built upon from our model developed in Arena. Arena has an optimization module in which the optimization parameters based on our model would need to be defined. Depending on the extension of the performance control system The Royal implements, our model could be further enhanced by having the output of this system as an input to our model. By updating our model on a consistent basis with more recent data related to processing times, arrival patterns, booking requests, etc The Royal would be able to provide up to date capacity planning requirements, including specific resources needs. In the end, this stage could potentially overcome one of the limitations mentioned earlier regarding data availability and continuous improvement.

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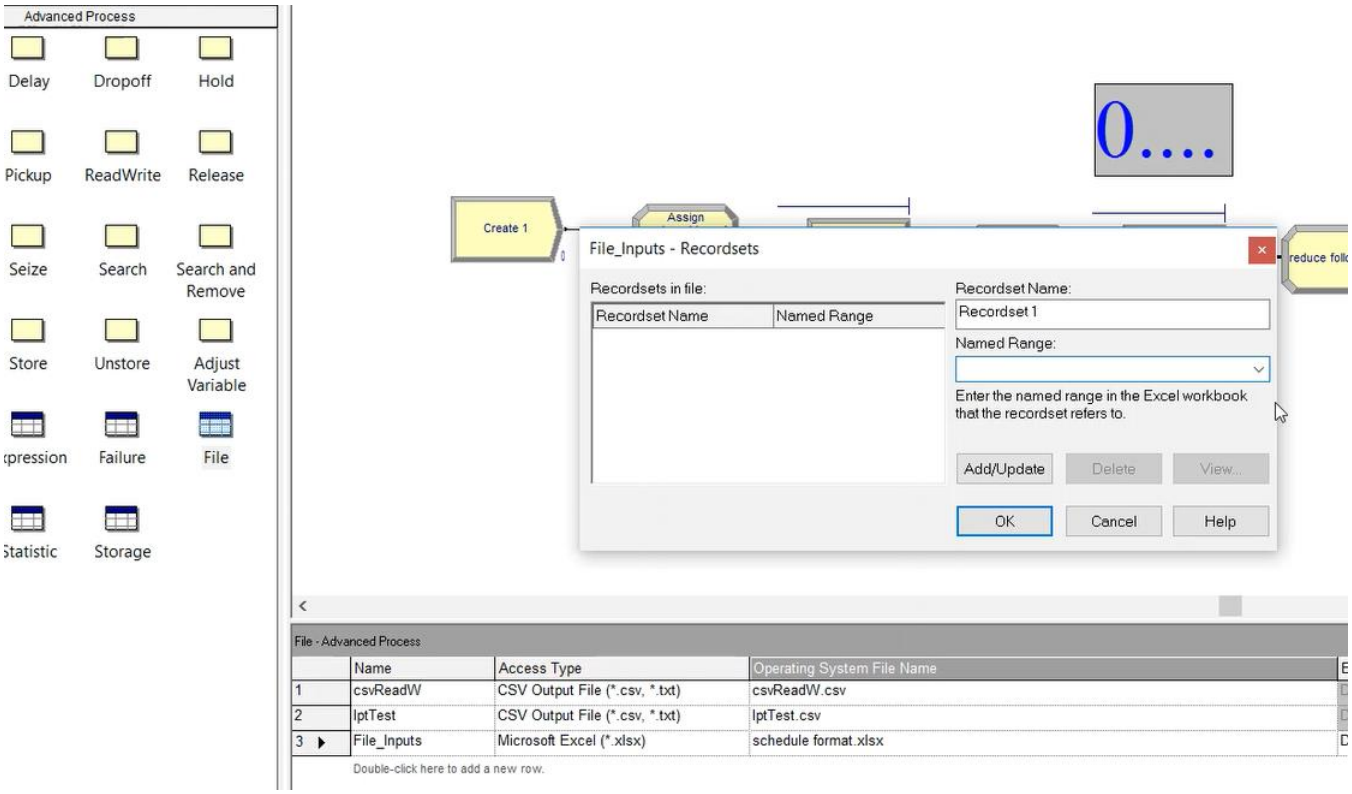
APPENDIX

ARENA Modeling Process Details

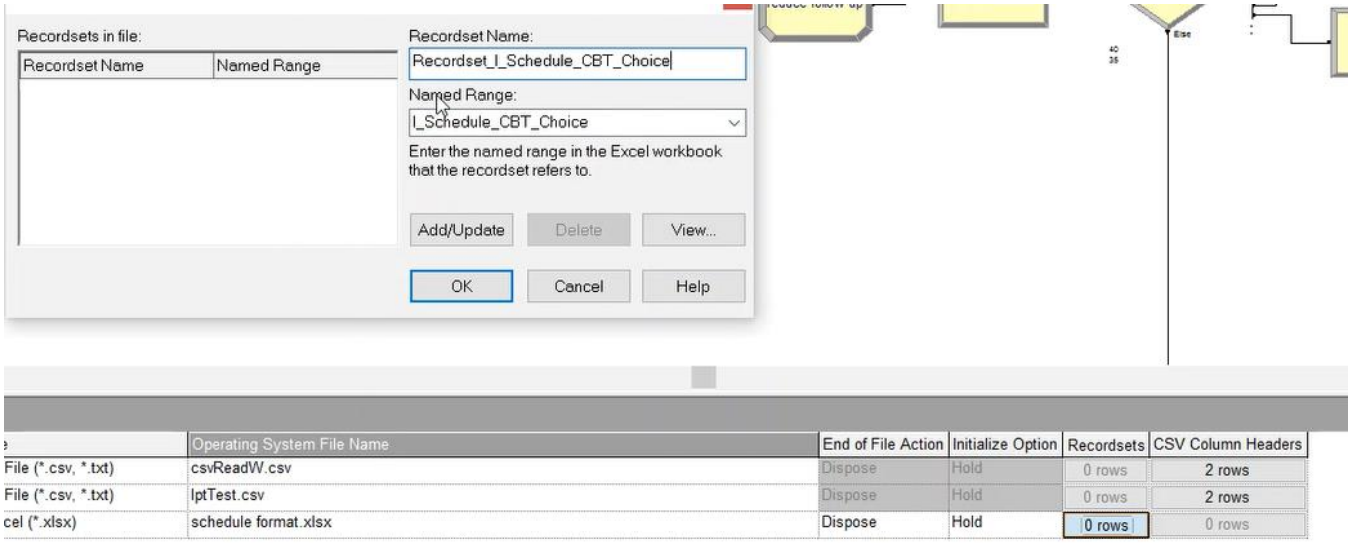
Using Excel Files

To start a file in Excel needs to be created. Within this file is important that information is kept in ranges properly named.

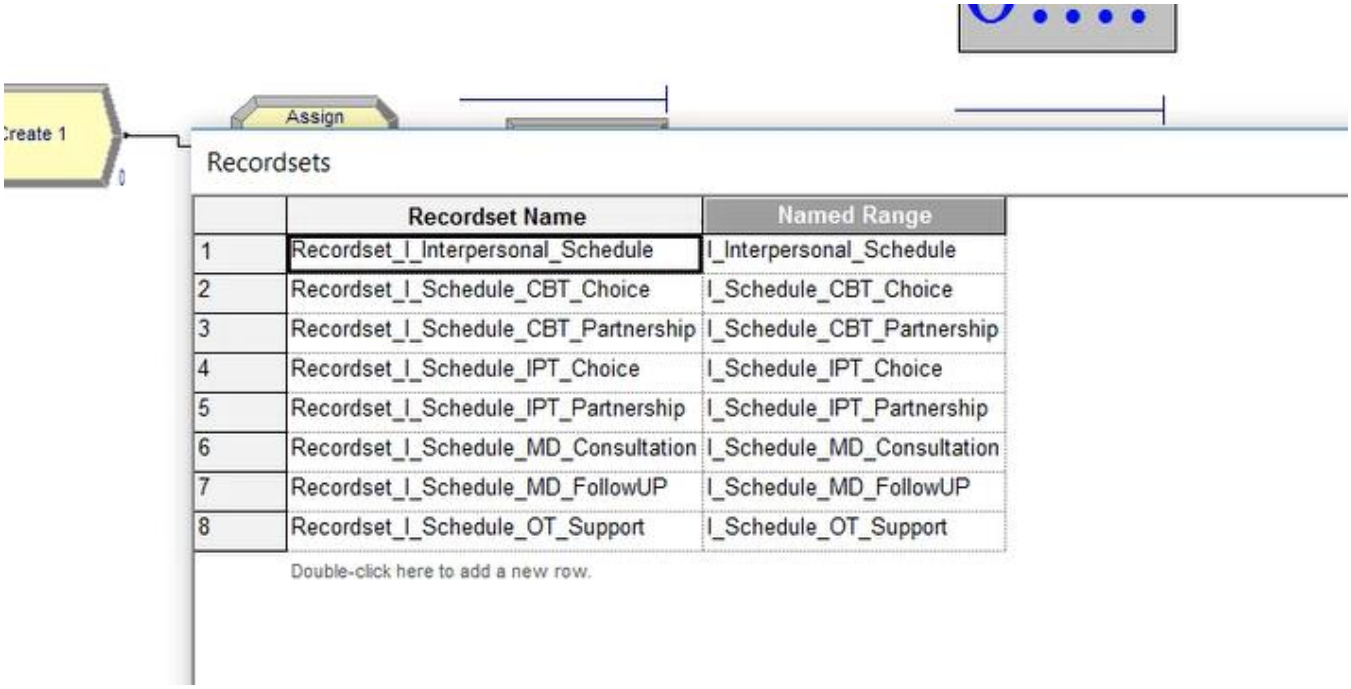
These ranges will be then referenced in Excel by going into the Advanced Process File module; notice the option to indicate it's an Excel file and at the same time the corresponding file's name



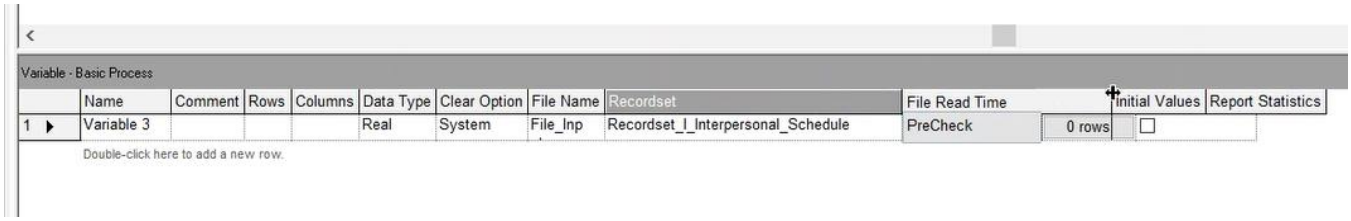
From here the recordsets are added. The Recordsets will have the name of the range that will be used; it's recommended to use the same name as that of the range:



Recordsets can be added one by one or via 'spreadsheet' where basically there'd be a copy / paste of the ranges that are to be used:

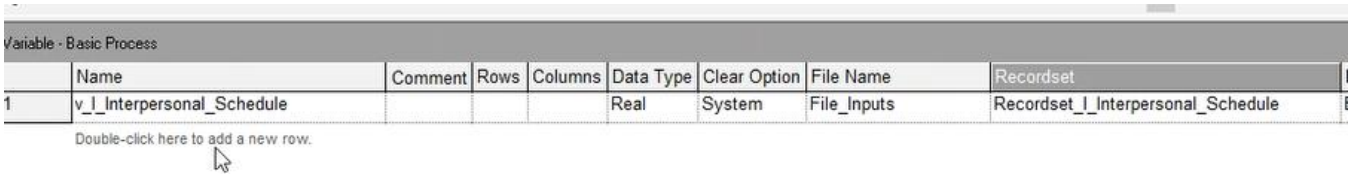


Now the Recordsets will be imported into VARIABLES: We go to Basic Process and Select Variable. Variables will be referenced to the Recordset previously created:

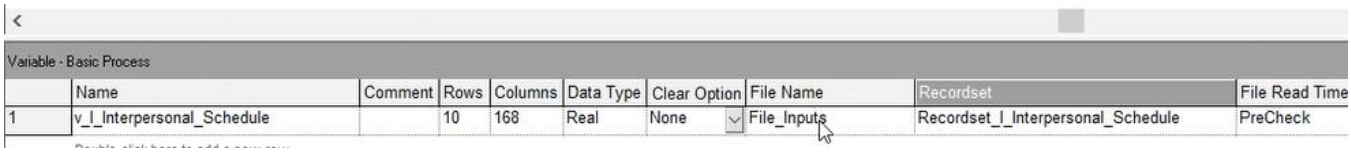


It is important to note that the "File Read Time" has been setup to PreCheck which is what's recommended to do when working with schedules.

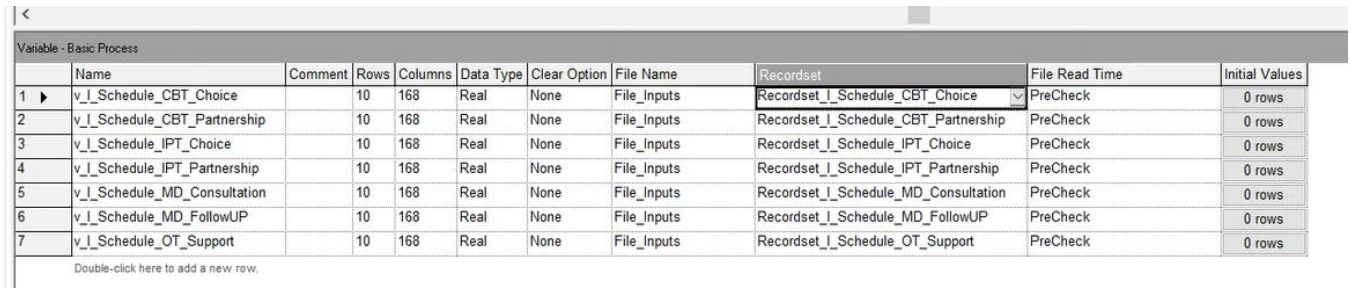
Notice that the variable will be named consistently with the Recordset:



Notice also that the variable will have as many rows and columns as the range in question does.



The variables can also be copied directly from an Excel file:



The copy and paste functions work without issues between Arena and Excel. Notice again how the variables correspond to a Recordset.

IMPORTING EXPRESSIONS:

There's a "trick" in Arena when importing 'expressions', below are the details of the input files for the patients:

		typical	stm	lngtm	units
1	Percentage of patients	0.7	0.15	0.15	percentage
2	Number Partnership Sessions	10	6	14	sns
3	Number of Follow Up Sessions	8	8	8	sns
4	Choice duration	3.5	3.5	3.5	hrs
5	Partnership duration	1	1	1	hrs
6	Consulation duration	1	1	1	hrs
7	Follow Up duration	TRIA(0.45,0.5,0.55)	TRIA(0.45,0.5,0.55)	TRIA(0.45,0.5,0.55)	hrs
8	no shows	0.1	0.1	0.1	percentage

As opposed to what we did with the resource details, we need to modify them prior to inputting them in Arena: The case with the above table is that there is a mix of numbers and expressions, therefore the numbers would need to be turned into expressions so that Arena considers all of them as such:

	typical	stm	lngtm	units
Percentage of patients	UNIF(0,0)+0.7	UNIF(0,0)+0.85	UNIF(0,0)+1	percentage
Number Partnership Sessions	UNIF(0,0)+10	UNIF(0,0)+6	UNIF(0,0)+14	sns
Number of Follow Up Sessions	UNIF(0,0)+8	UNIF(0,0)+8	UNIF(0,0)+8	sns
Choice duration	UNIF(0,0)+3.5	UNIF(0,0)+3.5	UNIF(0,0)+3.5	hrs
Partnership duration	UNIF(0,0)+1	UNIF(0,0)+1	UNIF(0,0)+1	hrs
Consulation duration	UNIF(0,0)+1	UNIF(0,0)+1	UNIF(0,0)+1	hrs
Follow Up duration	UNIF(0,0)+TRIA(0.45,0.5,0.55)	UNIF(0,0)+TRIA(0.45,0.5,0.55)	UNIF(0,0)+TRIA(0.45,0.5,0.55)	hrs
no shows	UNIF(0,0)+0.1	UNIF(0,0)+0.1	UNIF(0,0)+0.1	percentage

As you many notice a uniform 0,0 distribution has been added to the original values in order to keep them and do make sure there are no issues when Arena reads the mix of expressions and numbers.

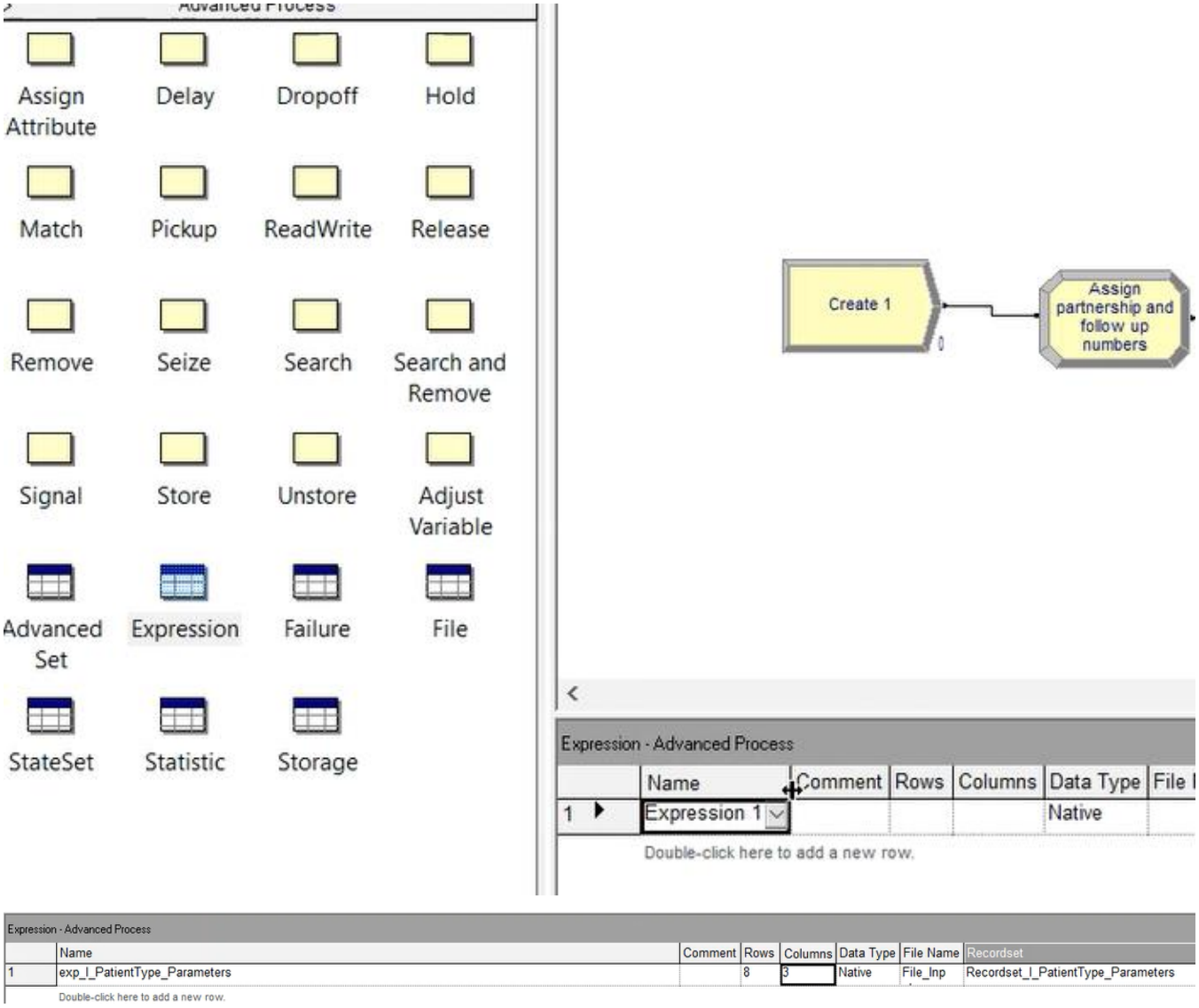
A new range is created for the above numbers and consequently a new recordset is to be created in Arena

Recordsets

	Recordset Name	Named Range
1	Recordset_I_Schedule_CBT_Choice	I_Schedule_CBT_Choice
2	Recordset_I_Schedule_CBT_Partnership	I_Schedule_CBT_Partnership
3	Recordset_I_Schedule_IPT_Choice	I_Schedule_IPT_Choice
4	Recordset_I_Schedule_IPT_Partnership	I_Schedule_IPT_Partnership
5	Recordset_I_Schedule_MD_Consultation	I_Schedule_MD_Consultation
6	Recordset_I_Schedule_MD_FollowUP	I_Schedule_MD_FollowUP
7	Recordset_I_Schedule_OT_Support	I_Schedule_OT_Support
8	Recordset_I_PatientType_Parameters	I_PatientType_Parameters

Double-click here to add a new row.

As we defined such as expressions then we'd need to add them accordingly within the Advanced Process Menu:



BEGIN SIMULATION FROM PRECHECK

As the model will not be using schedules, variables will be then changed to Begin Simulation. Notice also that there's a variable for days between sessions that has been added.

Variable - Basic Process

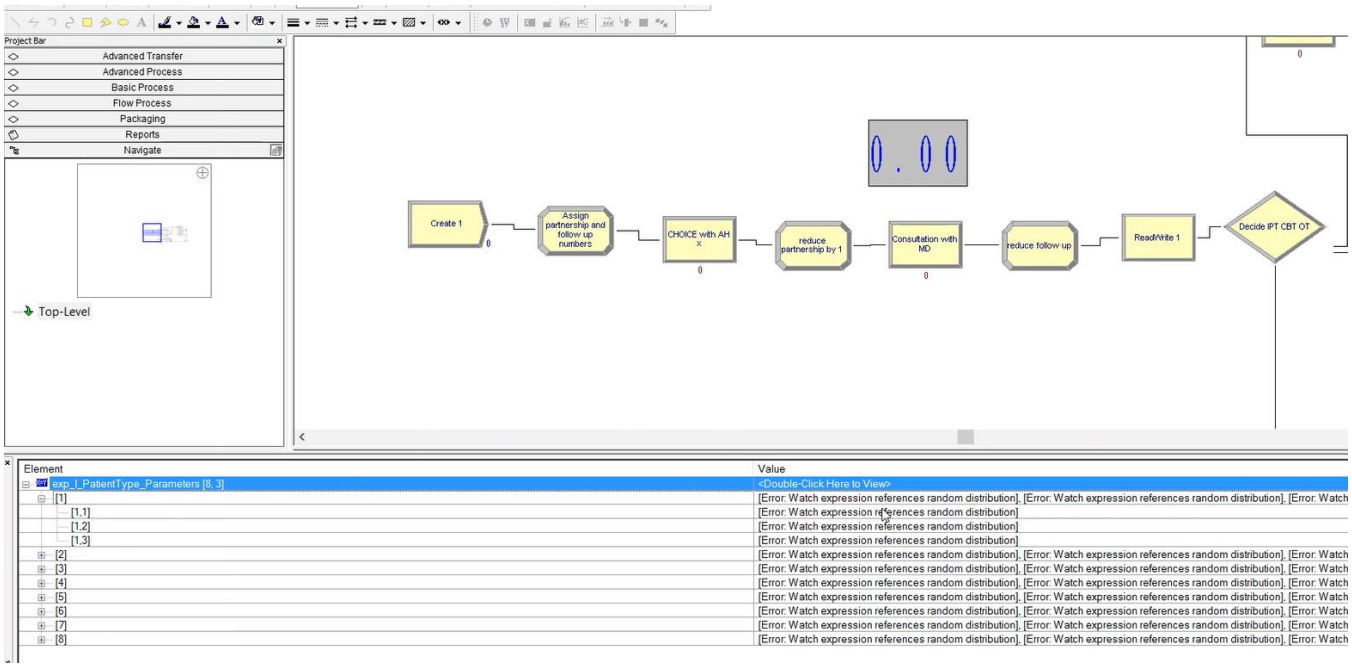
	Name	Comment	Rows	Columns	Data Type	Clear Option	File Name	Recordset	File Read Time	Initial Values
1	v_I_Schedule_CBT_Choice		10	168	Real	None	File_Inputs	Recordset_I_Schedule_CBT_Choice	BeginSimulation	0 rows
2	v_I_Schedule_CBT_Partnership		10	168	Real	None	File_Inputs	Recordset_I_Schedule_CBT_Partnership	BeginSimulation	0 rows
3	v_I_Schedule_IPT_Choice		10	168	Real	None	File_Inputs	Recordset_I_Schedule_IPT_Choice	BeginSimulation	0 rows
4	v_I_Schedule_IPT_Partnership		10	168	Real	None	File_Inputs	Recordset_I_Schedule_IPT_Partnership	BeginSimulation	0 rows
5	v_I_Schedule_MD_Consultation		10	168	Real	None	File_Inputs	Recordset_I_Schedule_MD_Consultation	BeginSimulation	0 rows
6	v_I_Schedule_MD_FollowUP		10	168	Real	None	File_Inputs	Recordset_I_Schedule_MD_FollowUP	BeginSimulation	0 rows
7	v_I_Schedule_OT_Support		10	168	Real	None	File_Inputs	Recordset_I_Schedule_OT_Support	BeginSimulation	0 rows
8	v_I_DaysBetweenSessions		6	1	Real	None	File_Inputs	Recordset_I_DaysBetweenSessions	BeginSimulation	0 rows

Double-click here to add a new row.

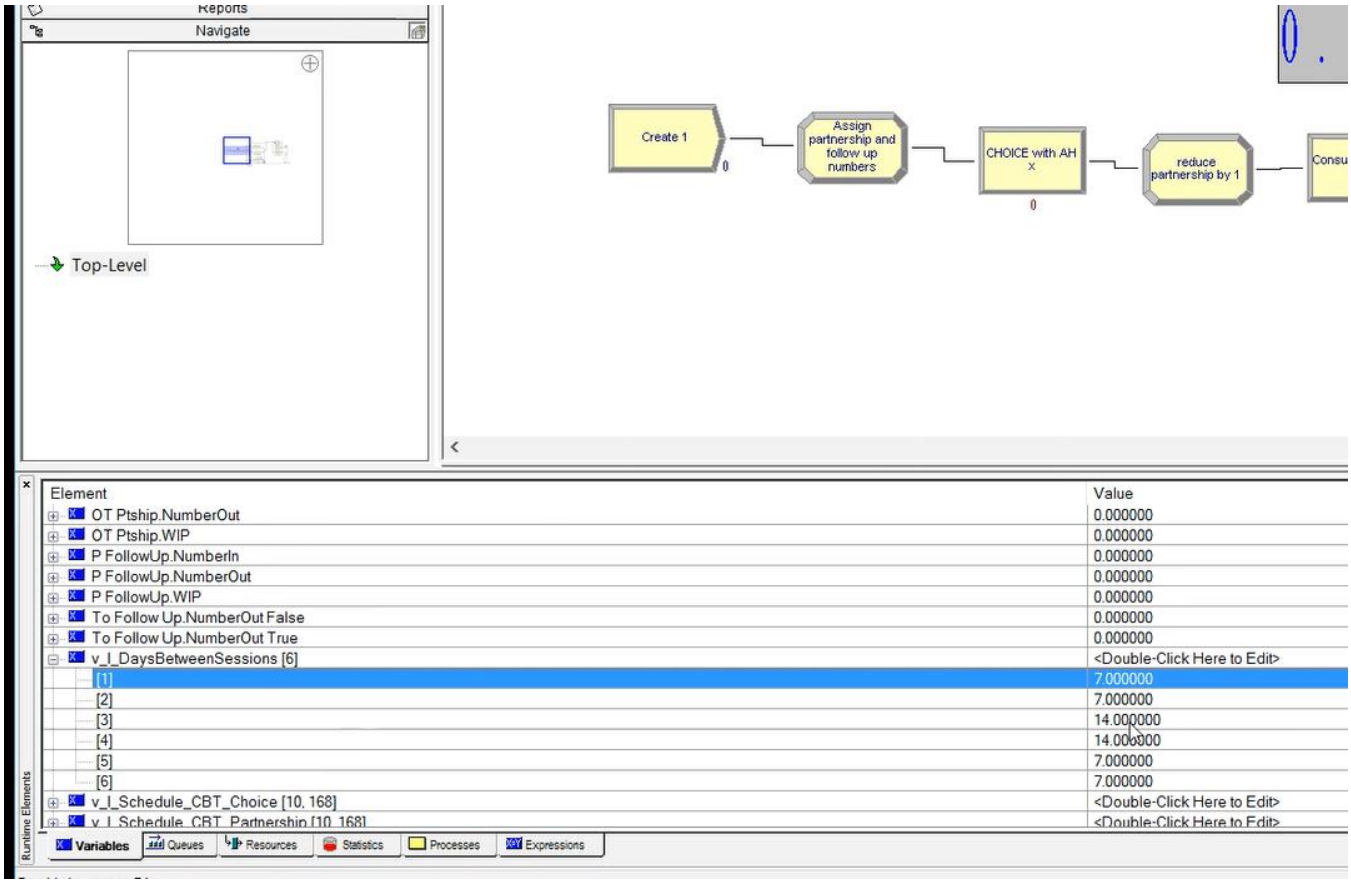
NOTE: when there's only one column there's no need to type 1, it's recommended instead to leave the field blank!

You can now check you parameters sin Arena:

The expressions:



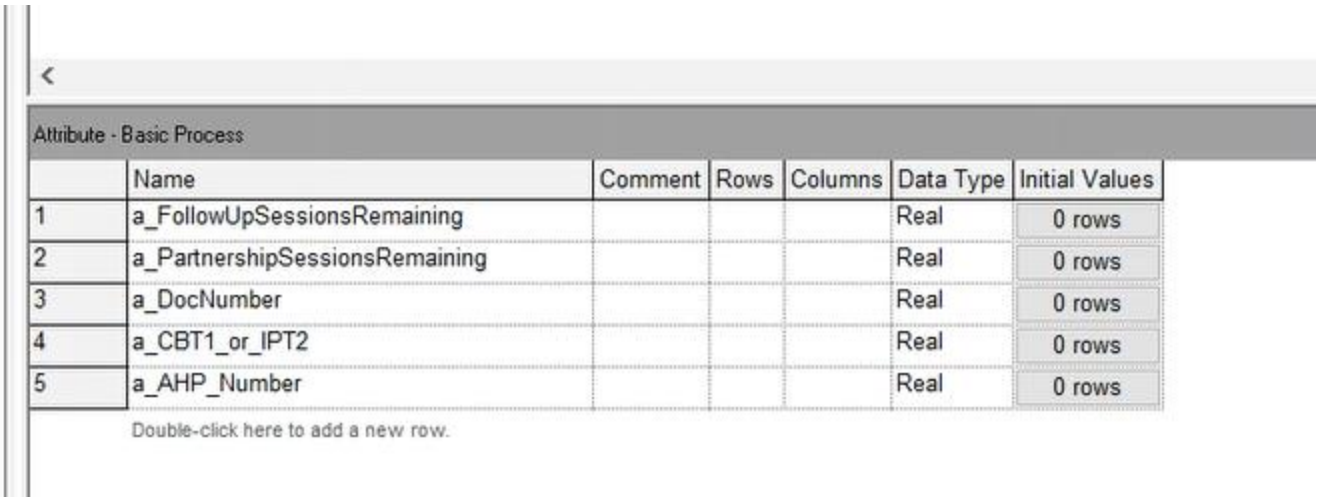
We'll now check the variables tab:



Notice values shown are those from the days between sessions range as it'd be expected.

Model ATTRIBUTES

Following is the list of attributes; note that there'd be only one attribute for the cbt or ipt. Basically the idea is for it to be either 1 or 2 and the number to be indicated by the AHP number (there's no need to have a "0" value attribute for those that are not assigned to either an ipt or cbt).

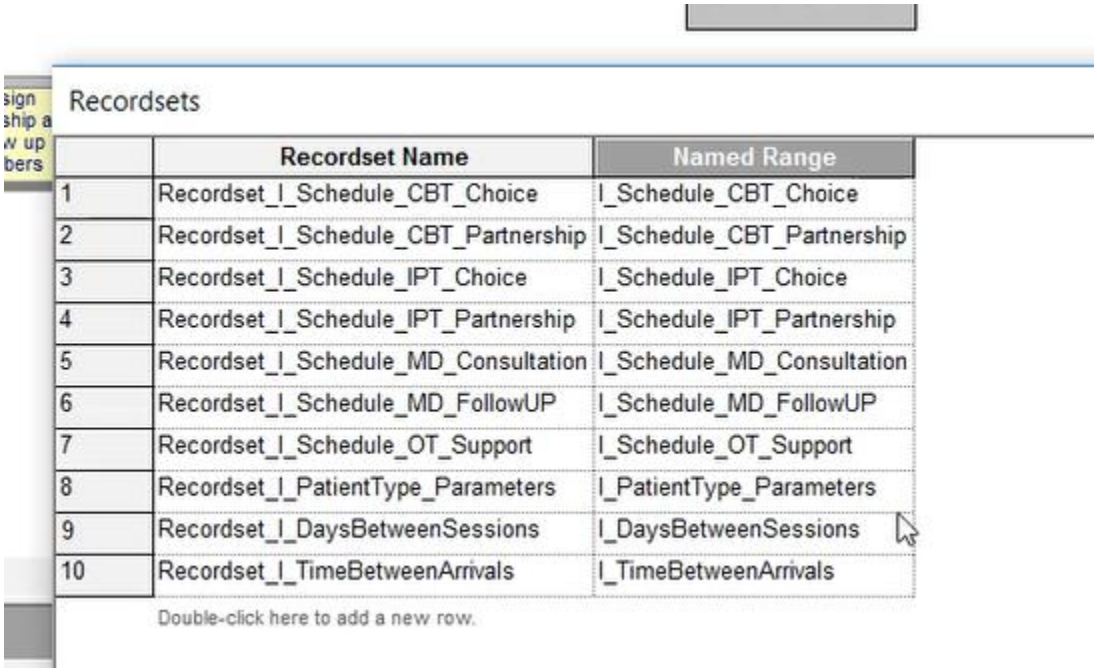


Attribute - Basic Process

	Name	Comment	Rows	Columns	Data Type	Initial Values
1	a_FollowUpSessionsRemaining				Real	0 rows
2	a_PartnershipSessionsRemaining				Real	0 rows
3	a_DocNumber				Real	0 rows
4	a_CBT1_or_IPT2				Real	0 rows
5	a_AHP_Number				Real	0 rows

Double-click here to add a new row.

Will add a variable for the arrival rate of patients (always from the same file input, just adding a row for the corresponding recordset):



Recordsets

	Recordset Name	Named Range
1	Recordset_I_Schedule_CBT_Choice	I_Schedule_CBT_Choice
2	Recordset_I_Schedule_CBT_Partnership	I_Schedule_CBT_Partnership
3	Recordset_I_Schedule_IPT_Choice	I_Schedule_IPT_Choice
4	Recordset_I_Schedule_IPT_Partnership	I_Schedule_IPT_Partnership
5	Recordset_I_Schedule_MD_Consultation	I_Schedule_MD_Consultation
6	Recordset_I_Schedule_MD_FollowUP	I_Schedule_MD_FollowUP
7	Recordset_I_Schedule_OT_Support	I_Schedule_OT_Support
8	Recordset_I_PatientType_Parameters	I_PatientType_Parameters
9	Recordset_I_DaysBetweenSessions	I_DaysBetweenSessions
10	Recordset_I_TimeBetweenArrivals	I_TimeBetweenArrivals

Double-click here to add a new row.

Adding the corresponding variable:

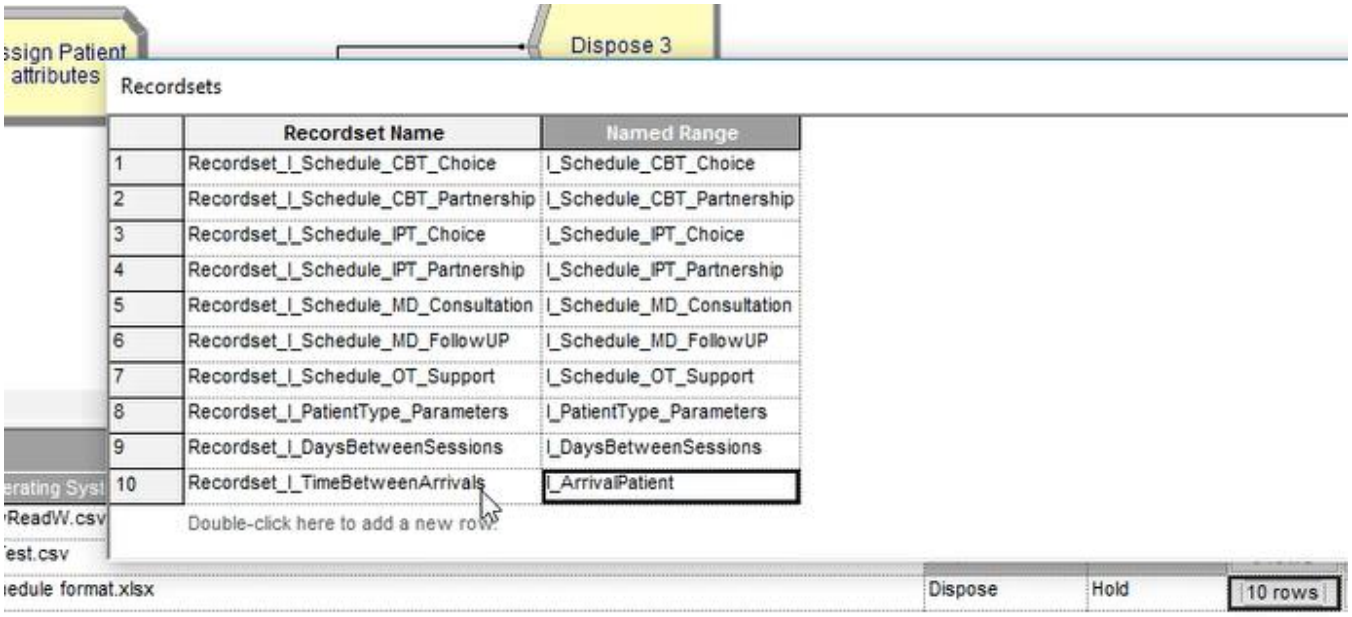
Variable - Basic Process

	Name	Comment	Rows	Columns	Data Type	Clear Option	File Name	Recordset	File Read Time	Initial Values	Report Statistics
1	v_I_Schedule_CBT_Choice		10	168	Real	None	File_Inputs	Recordset_I_Schedule_CBT_Choice	BeginSimulation	0 rows	
2	v_I_Schedule_CBT_Partnership		10	168	Real	None	File_Inputs	Recordset_I_Schedule_CBT_Partnership	BeginSimulation	0 rows	
3	v_I_Schedule_IPT_Choice		10	168	Real	None	File_Inputs	Recordset_I_Schedule_IPT_Choice	BeginSimulation	0 rows	
4	v_I_Schedule_IPT_Partnership		10	168	Real	None	File_Inputs	Recordset_I_Schedule_IPT_Partnership	BeginSimulation	0 rows	
5	v_I_Schedule_MD_Consultation		10	168	Real	None	File_Inputs	Recordset_I_Schedule_MD_Consultation	BeginSimulation	0 rows	
6	v_I_Schedule_MD_FollowUP		10	168	Real	None	File_Inputs	Recordset_I_Schedule_MD_FollowUP	BeginSimulation	0 rows	
7	v_I_Schedule_OT_Support		10	168	Real	None	File_Inputs	Recordset_I_Schedule_OT_Support	BeginSimulation	0 rows	
8	v_I_DaysBetweenSessions		6		Real	None	File_Inputs	Recordset_I_DaysBetweenSessions	BeginSimulation	0 rows	
9	v_I_TimeBetweenArrivals				Real	None	File_Inputs	Recordset_I_TimeBetweenArrivals	BeginSimulation	0 rows	

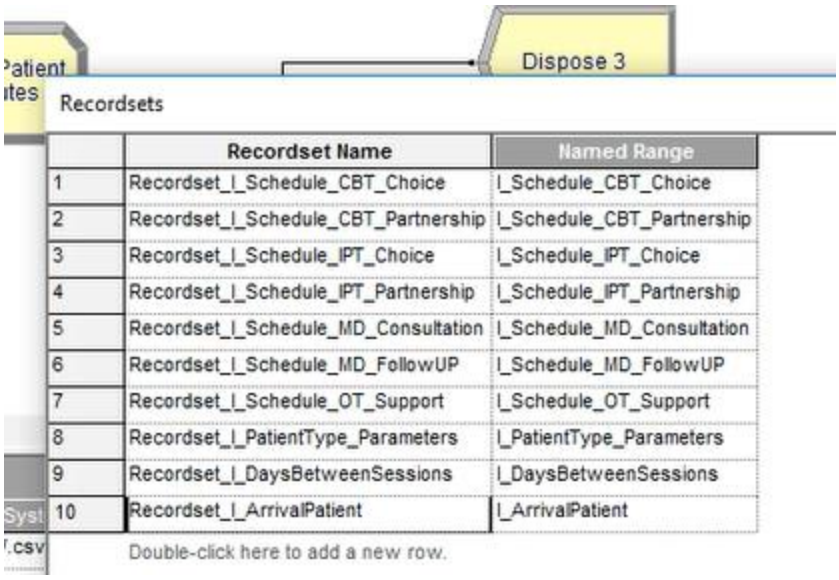
Double-click here to add a new row.

Fixing the patients arrival info:

Initial data:

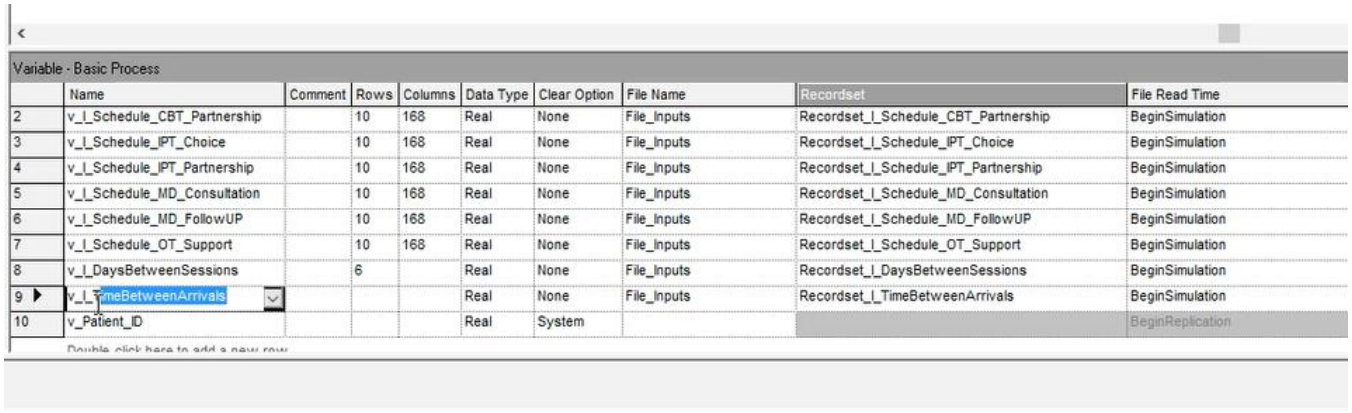


Modified:

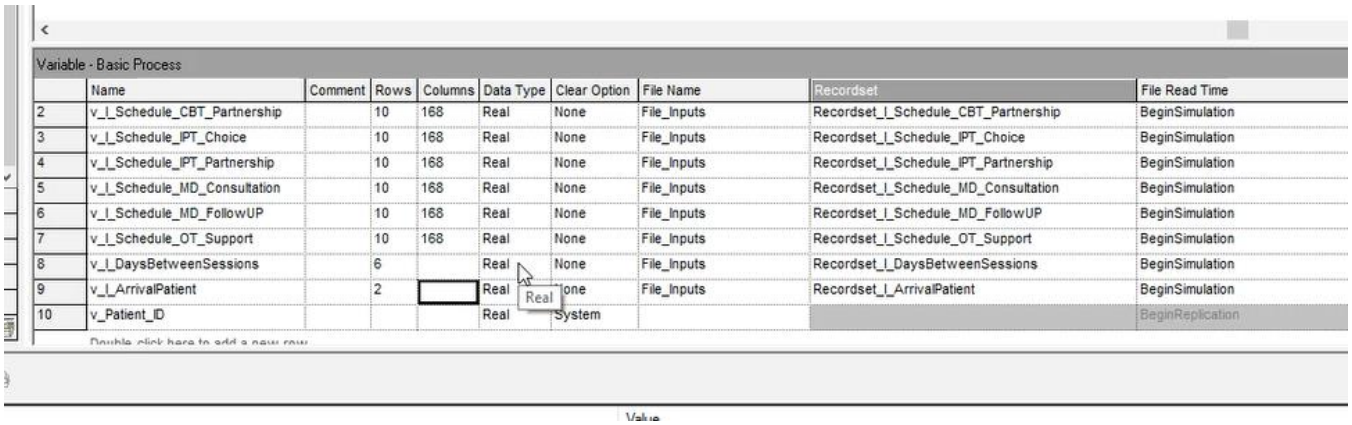


To change the corresponding variable:

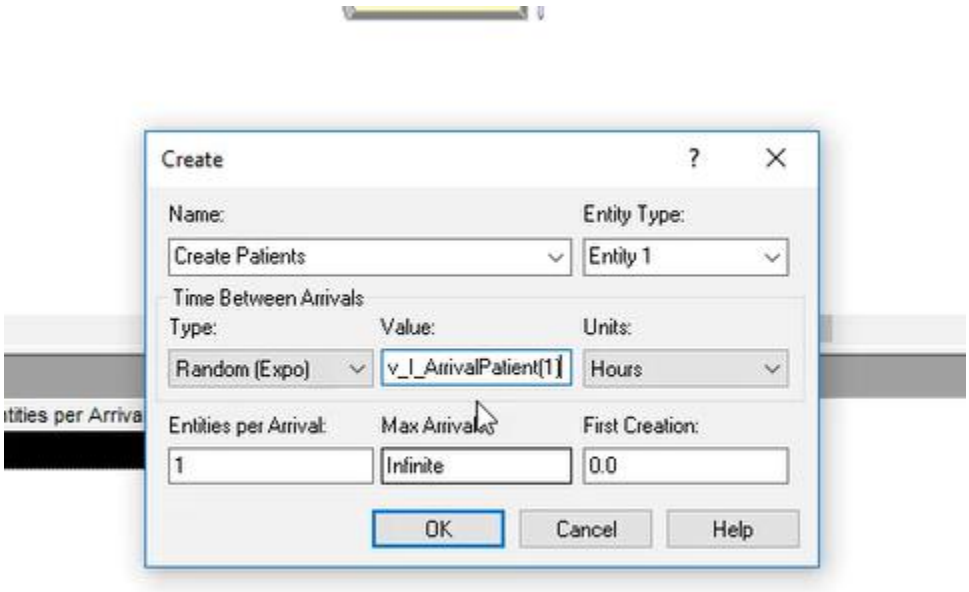
Initial,



Modified, notice change in rows and in recordset



This info is now to be used in the create patients module:

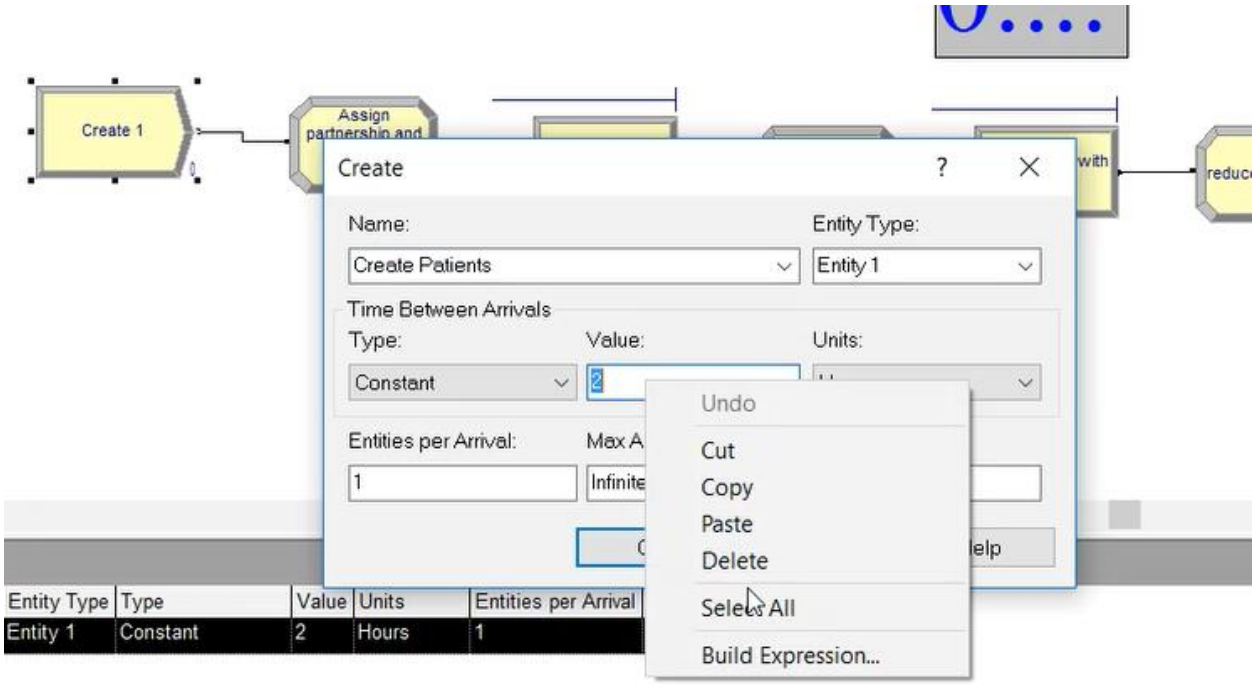


Notice is making reference to the variable row 1

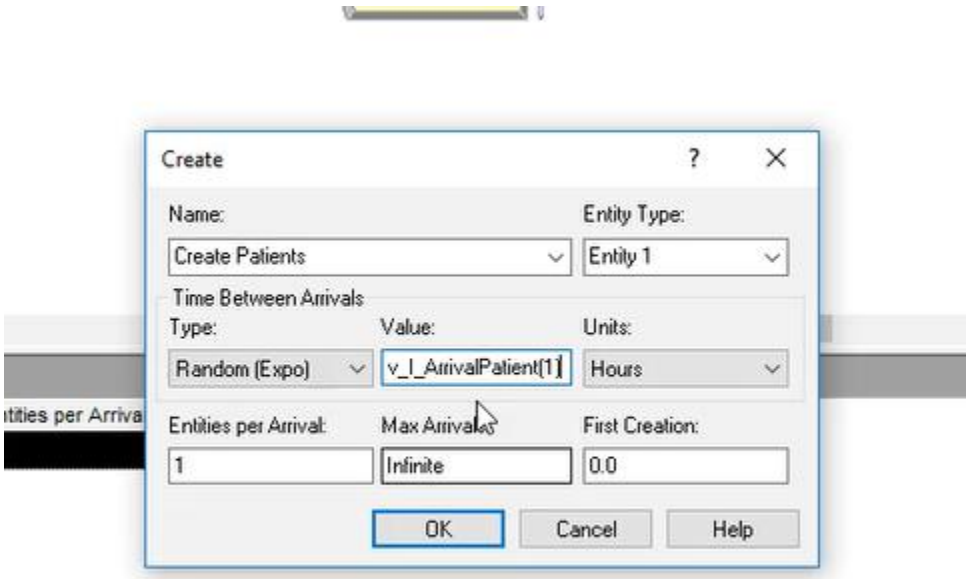
Arrivals (avg t between, entire calendar week, hrs)	9	hrs
% Going to CBT (the rest is IPT)	0.8	%

Create Patients

Patients will be created through the Create module:



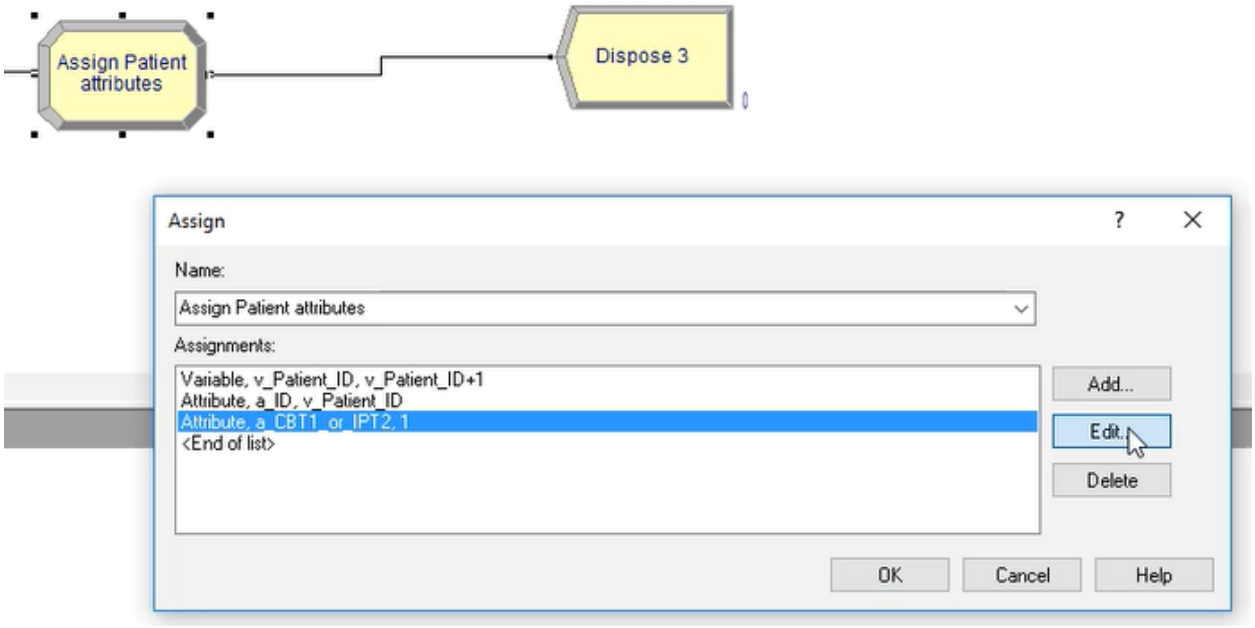
As mentioned in the last part of the working with excel files document, info is now to be defined based on the corresponding variable:



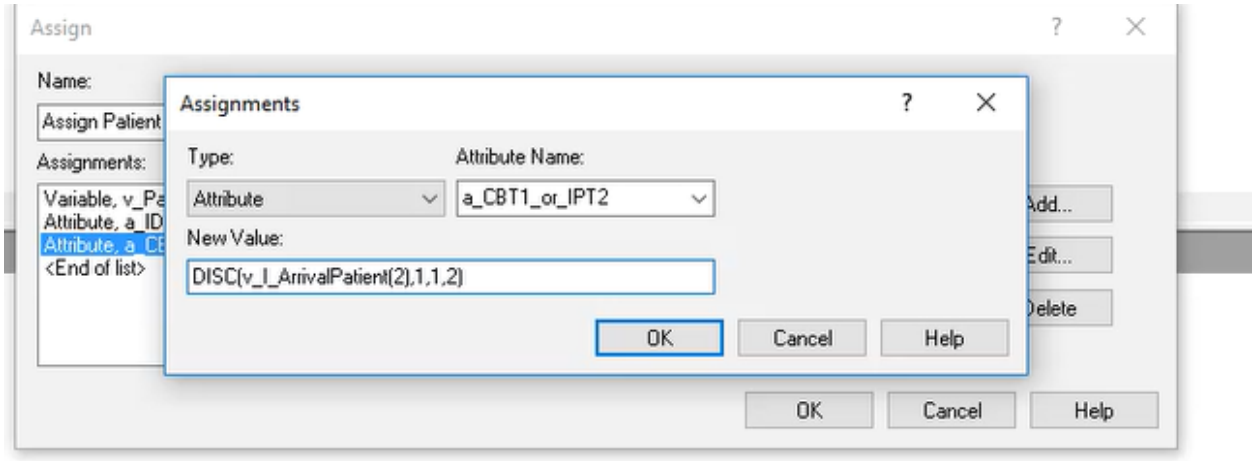
In this case it can be noted that we have defined an exponential arrival with the value from the variable ArrivalPatient, row 1

Determining Patient Type:

We're now going to define the Patient type, this will be done within the assign module:



In this case we will also use the arrivalpatient variable, but the row 2 as it'd be expected



In this case a discrete probability is used so that for the first part, ie row 2 (80%), the value will be 1 (which corresponds to CBT). The rest, cumulative 1, will be of type 2 (which corresponds to IPT).

Similarly will do so for the patient types, we defined percentages as:

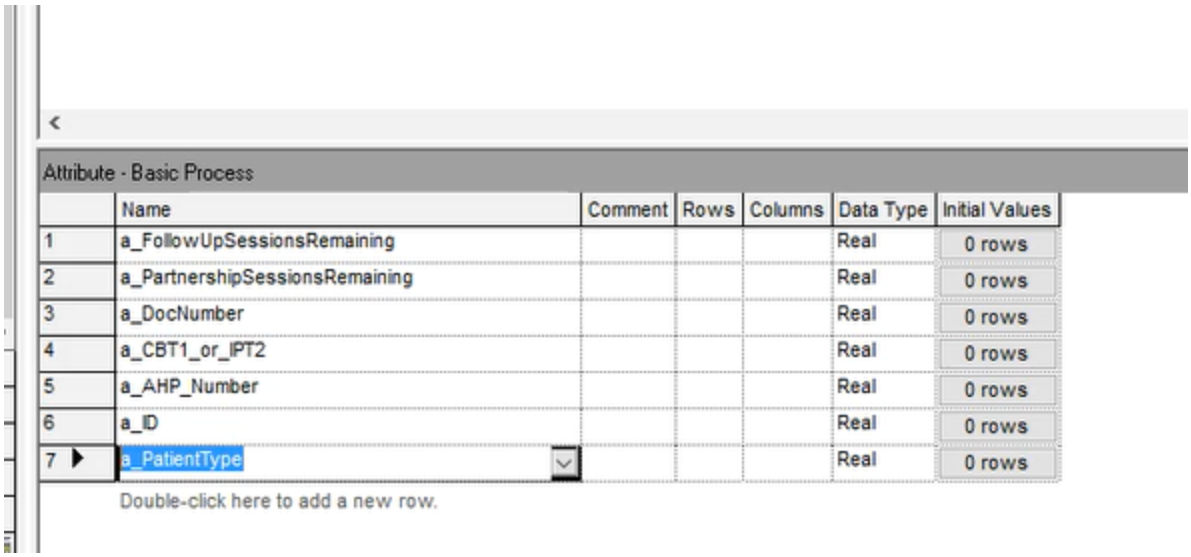
	typical	stm	lngtm	units
Percentage of patients	0.7	0.15	0.15	percentage

Using the discrete probability the expressions would be adjusted to:

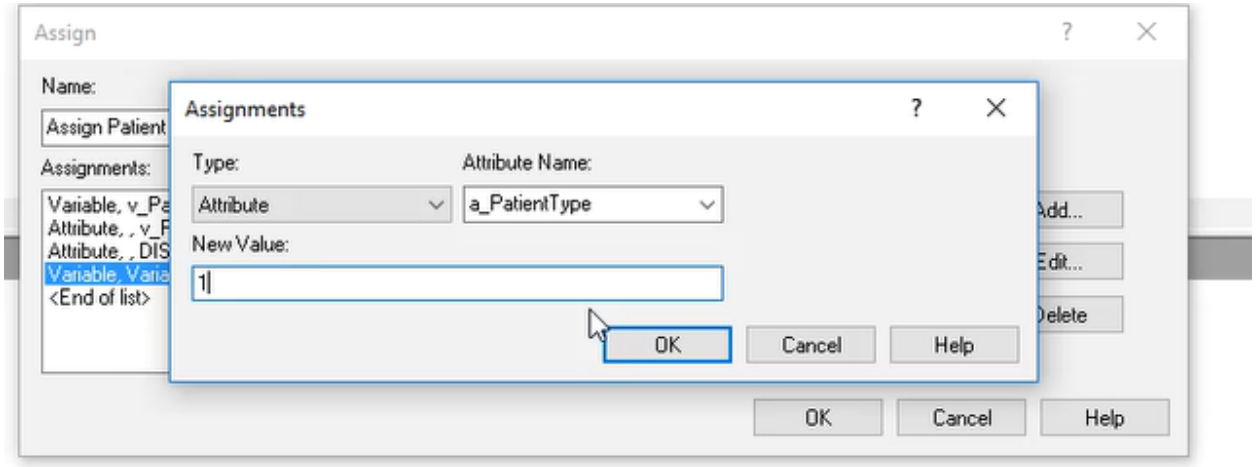
	typical	stm	lngtm	units
Percentage of patients	UNIF(0,0)+0.7	UNIF(0,0)+0.85	UNIF(0,0)+1	percentage

Remember that as we mentioned in the working with Excel File, the real numbers parameters were adjusted with the unif(0,0) distribution so that there would not be issues with the data processing.

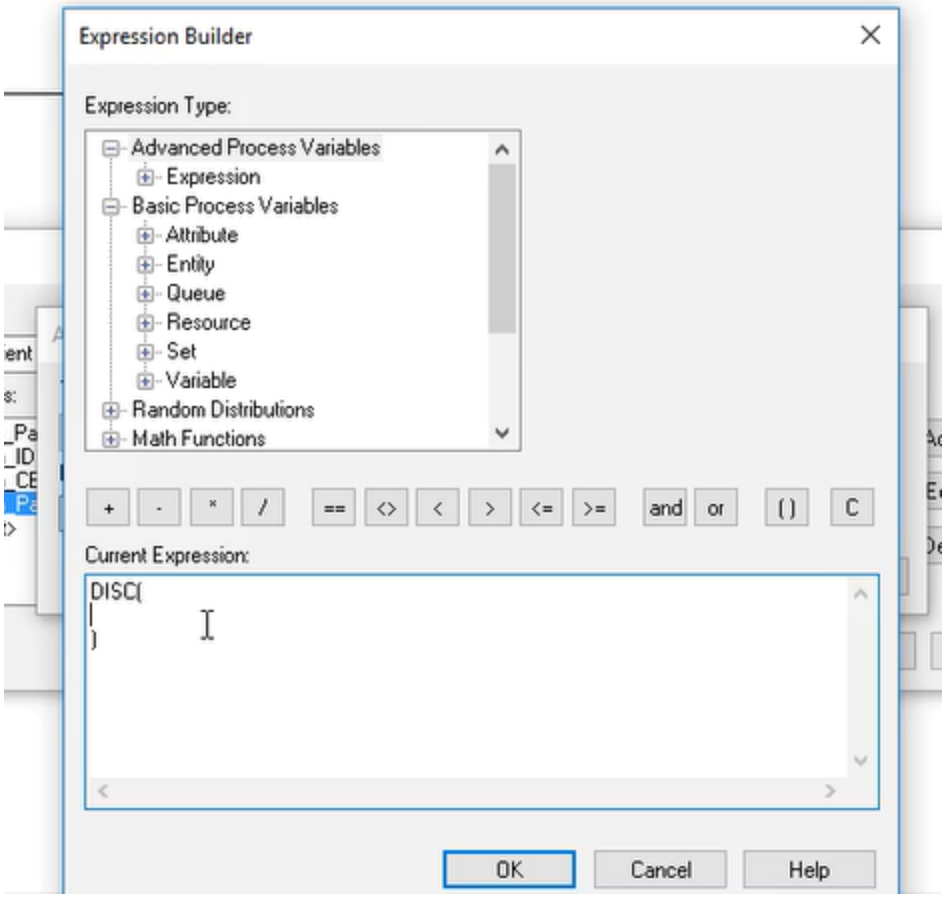
So now we're going to create a new attribute for the patient type:



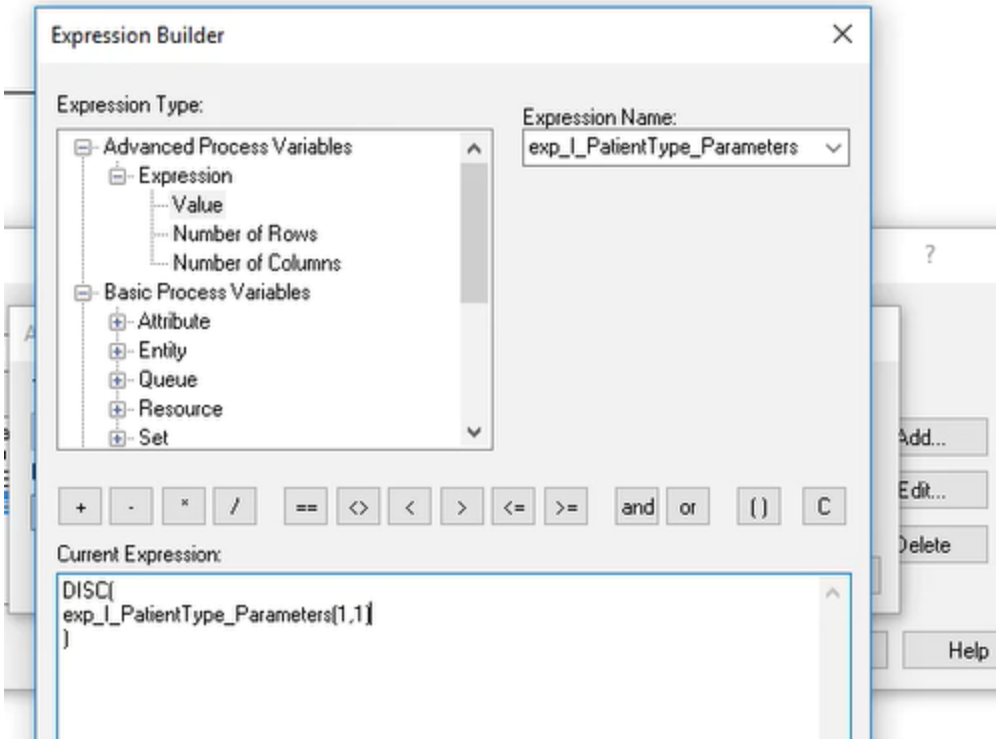
This will need to be assigned



We will now build the expression which will include the corresponding logic:



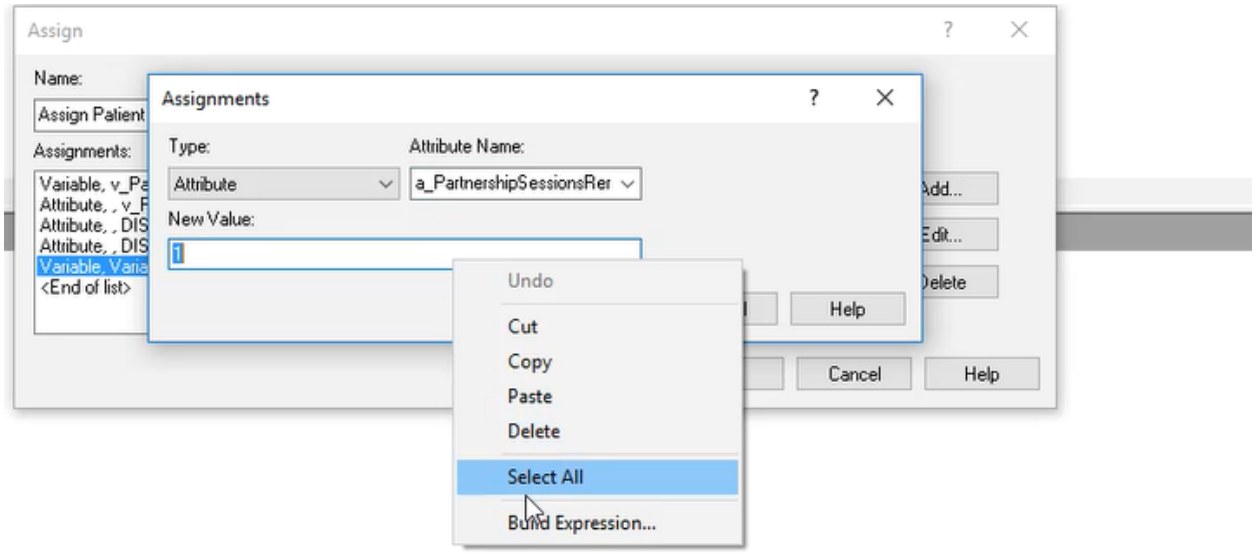
So we use expression, value and it'd be based on the patient type parameters:



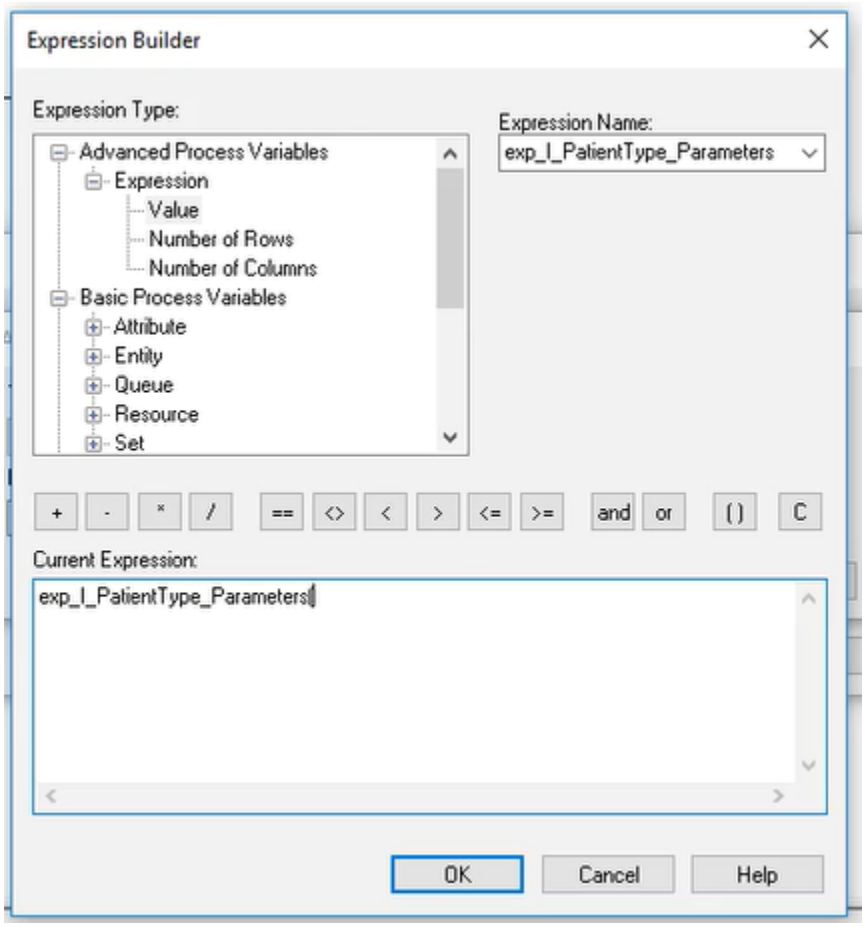
In this case the discrete distribution will be such that 70% will be type one, the discrete indicates so; likewise, it'd do so for the 15% of each of the other patient types. Syntaxis is based on the column number as it was done in the previous attribute and also using a discrete distribution. Note that the patients will now be identified as 1, 2, and 3. This will be used later on as a reference to other parameters that correspond to a specific patient type (attributes included).

Partnership sessions remaining:

An additional attribute will be assigned for the patient



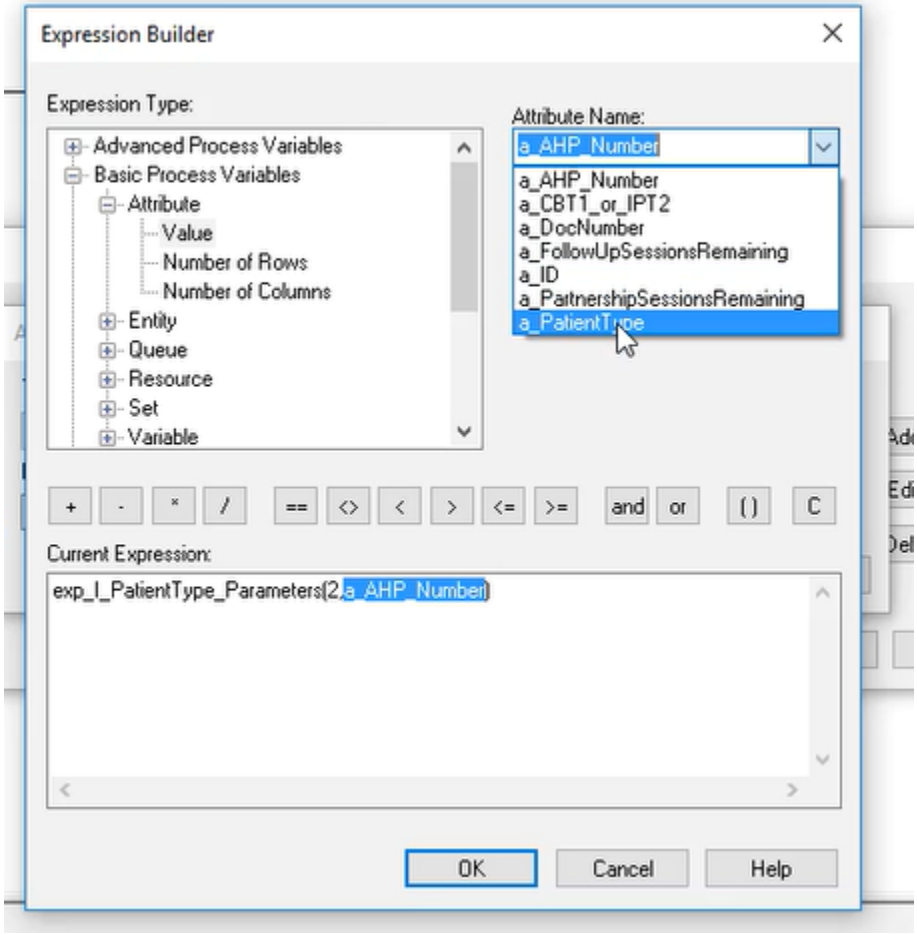
A new expression will be built (build expression / expression type / expression / value...)



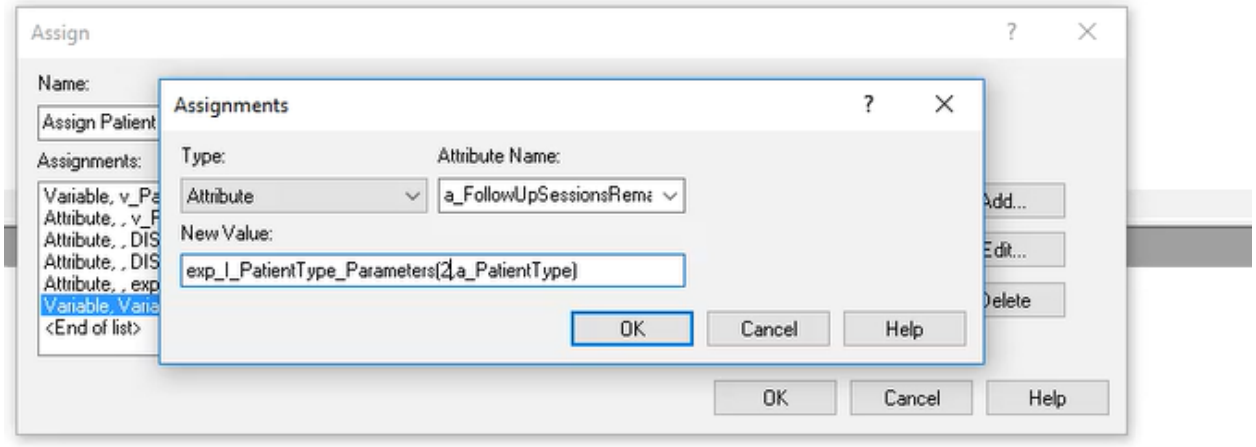
Notice that the expression will now reference the row within the range, 2 in this case:

row		typical	stm	lngtm	units
1	Percentage of patients	0.7	0.15	0.15	percentage
2	Number Partnership Sessions	10	6	14	sns

The column number will be now the attribute created just before this one. This one can be pulled from the build expression menu, just selecting it under the existing attributes.



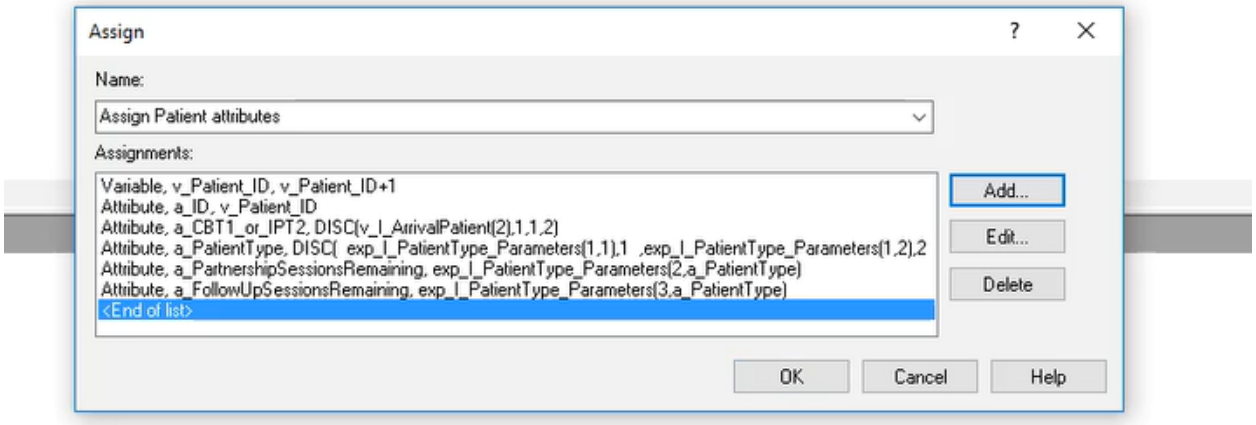
In a very similar manner the number of follow up sessions remaining can be created:



Basically we copied the previous expression for partnership sessions (with the obvious addition of the new attribute, follow up sessions in this case). The difference now is that follow up sessions are on row 3.

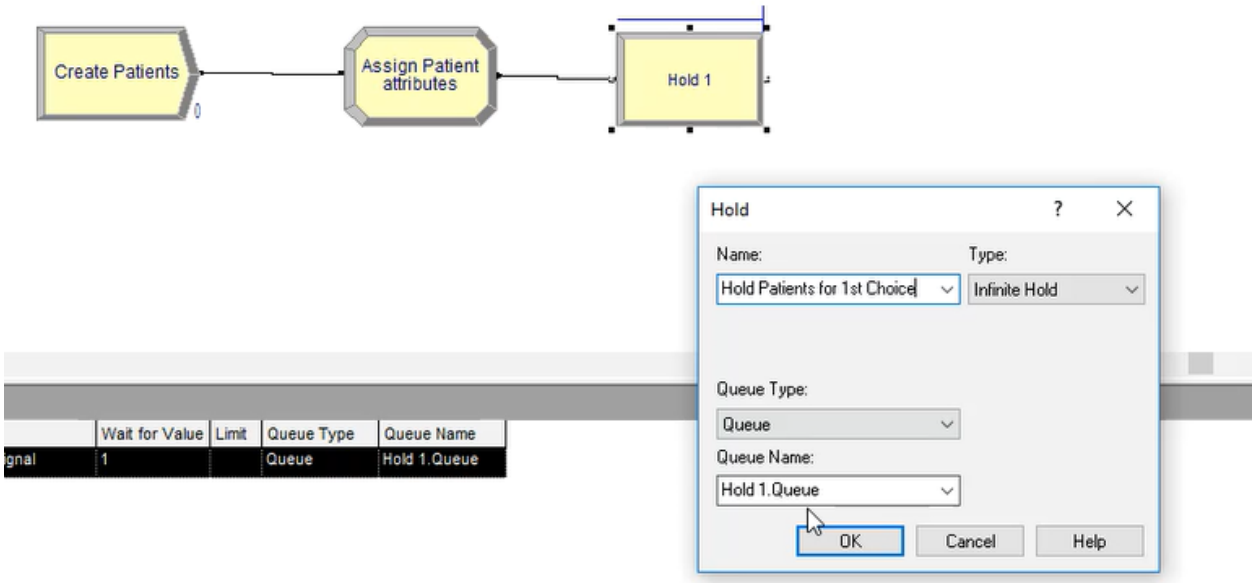
row		typical	stm	lngtm	units
1	Percentage of patients	0.7	0.15	0.15	percentage
2	Number Partnership Sessions	10	6	14	sns
3	Number of Follow Up Sessions	8	8	8	sns

The remaining parameters within this range will not be used for now (they'd be used when working in the sessions themselves). This are the attributes defined so far:



Patients On Hold

Patients will be put on infinite hold as they are to be chosen from MD's and AHPs



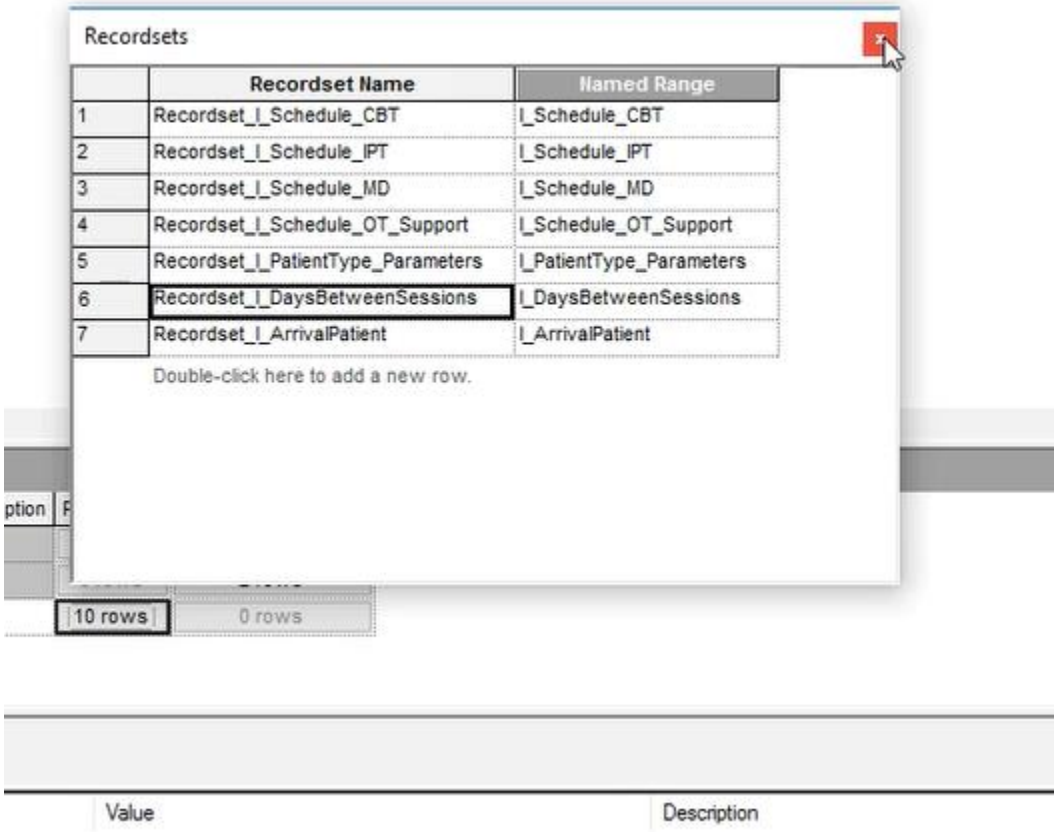
Creation of the 'Smart' Agents:

First we will adjust the schedule so that we have only one range of CBTs. Availability will be modified accordingly such that 1 is for choice and 2 for partnership.

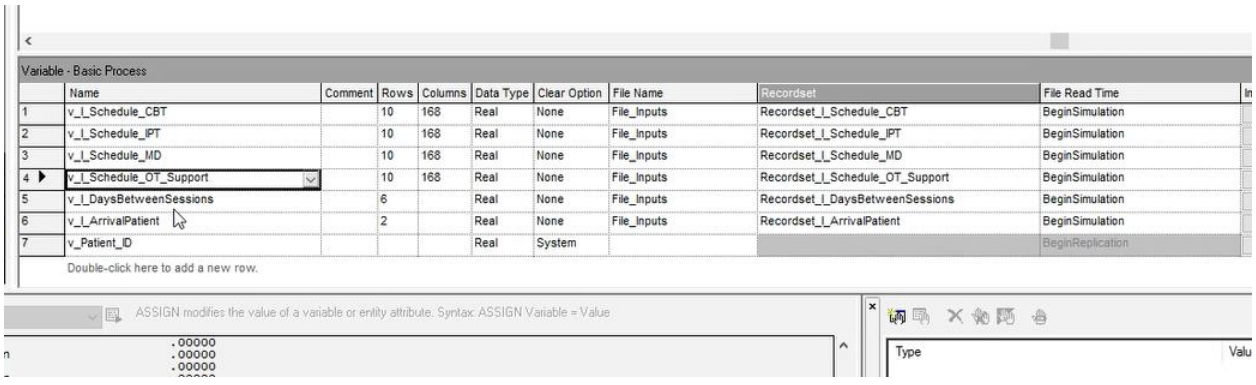
CBT DETAILS, SCHEDULE	1 means choice 2 means partnership															
		Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday
		0	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00
R_CBT_01	1	0	0	0	0	0	0	0	0	1	1	1	1	0	2	2
R_CBT_02	2	0	0	0	0	0	0	0	0	1	1	1	1	0	2	2
R_CBT_03	3	0	0	0	0	0	0	0	0	1	1	1	1	0	2	2
R_CBT_04	4	0	0	0	0	0	0	0	0	1	1	1	1	0	2	2
R_CBT_05	5	0	0	0	0	0	0	0	0	1	1	1	1	0	2	2
R_CBT_06	6	0	0	0	0	0	0	0	0	1	1	1	1	0	2	2
R_CBT_07	7	0	0	0	0	0	0	0	0	1	1	1	1	0	2	2
R_CBT_08	8	0	0	0	0	0	0	0	0	1	1	1	1	0	2	2
R_CBT_09	9	0	0	0	0	0	0	0	0	1	1	1	1	0	2	2

This was also replicated for doctors/psychiatrists. Ranges had to be renamed/deleted ie revised.

Recordsets were adjusted

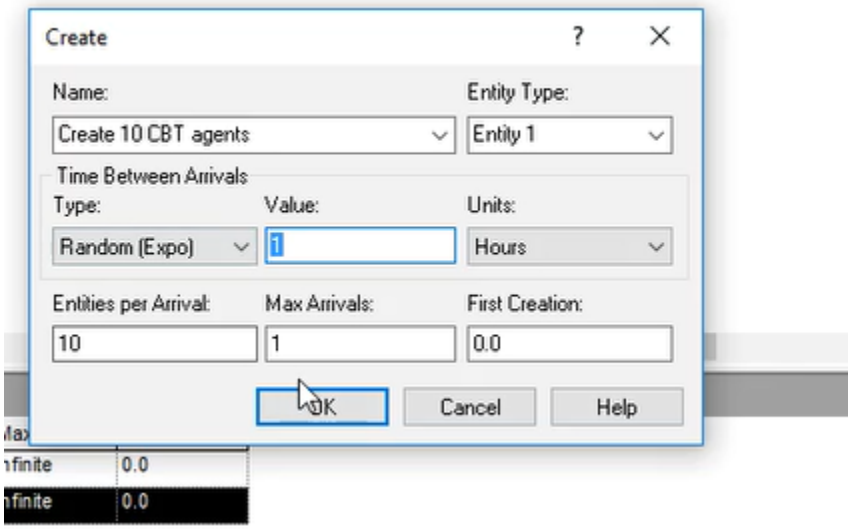


Now the variables:

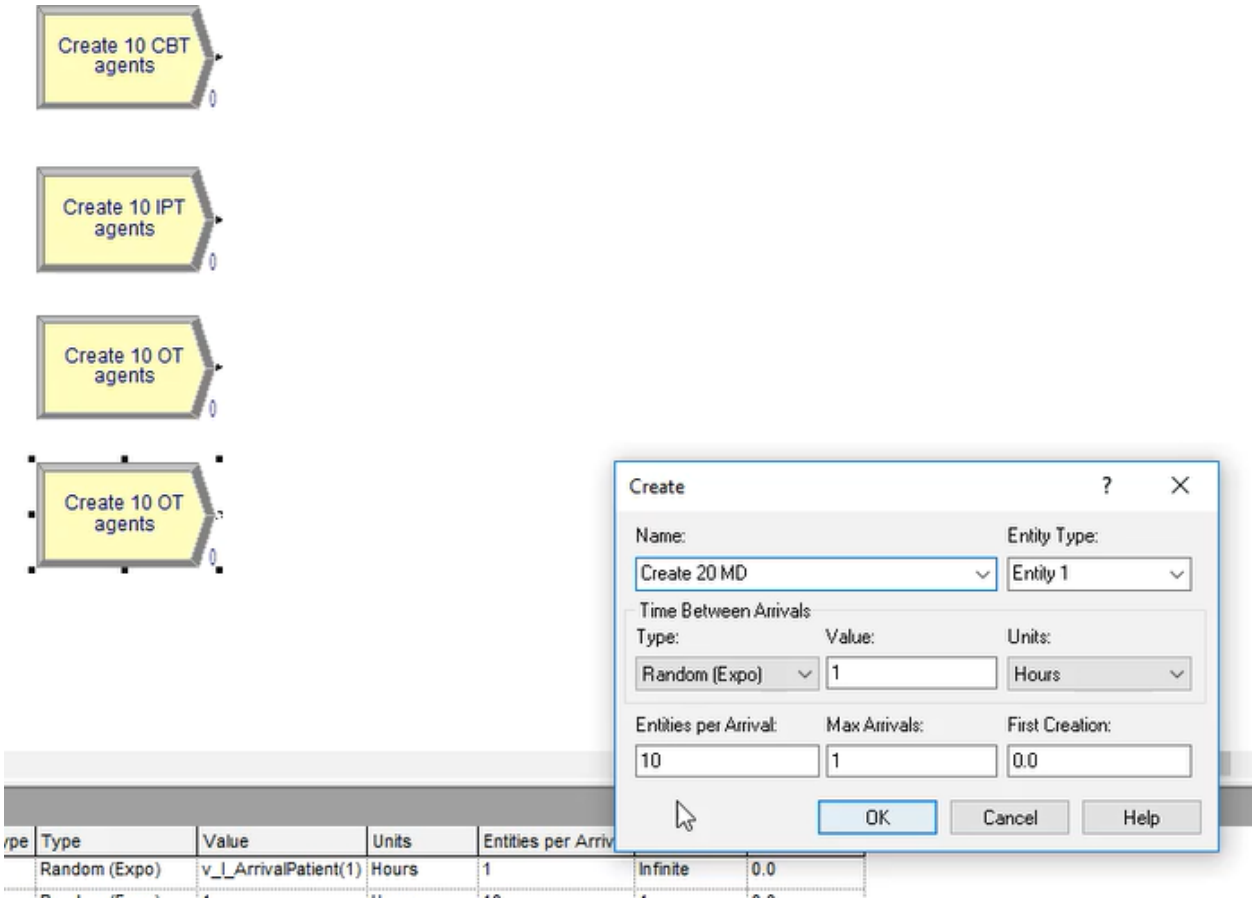


Agents creation

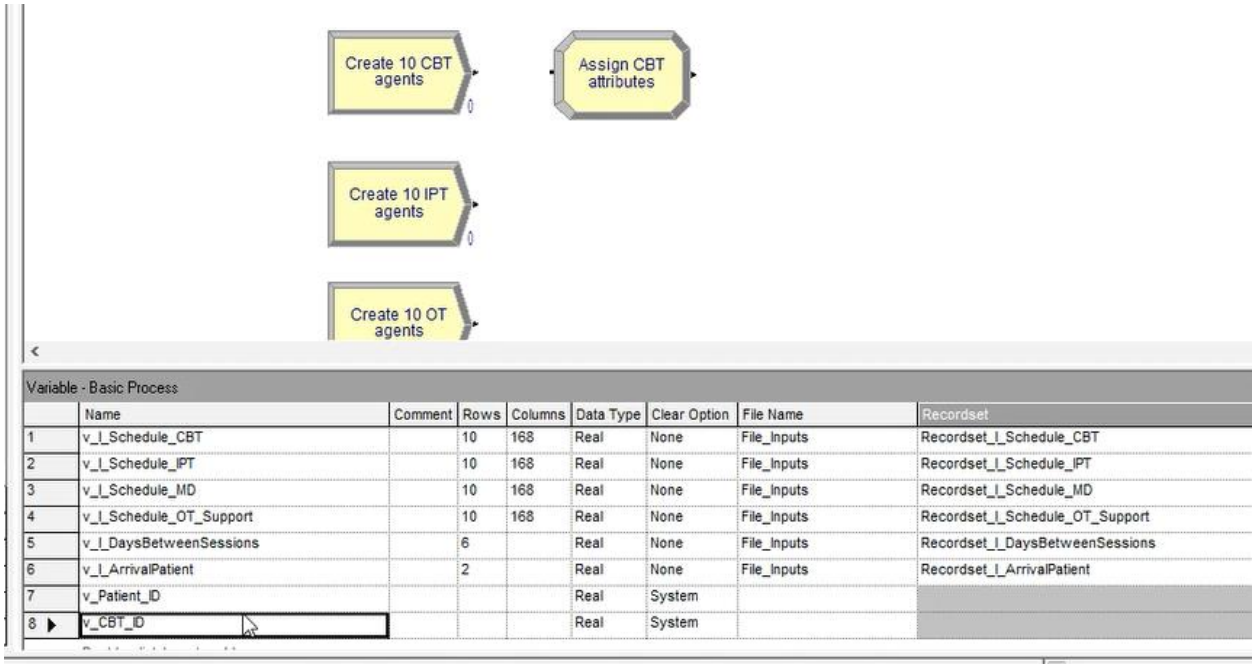
so back to the creation process notice how all the 10 CBT agents are created all at once and only once.



Process will then be repeated for the rest of agents:

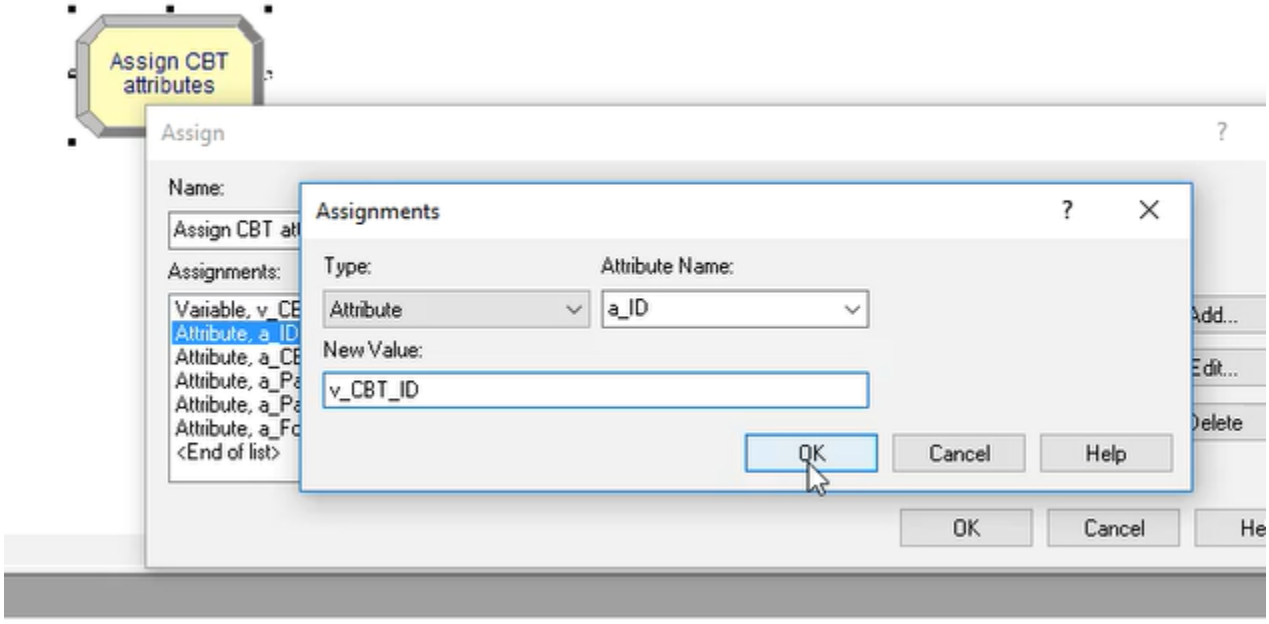


As with the customers an assign module will be needed, notice a variable will be also created for the corresponding agents:

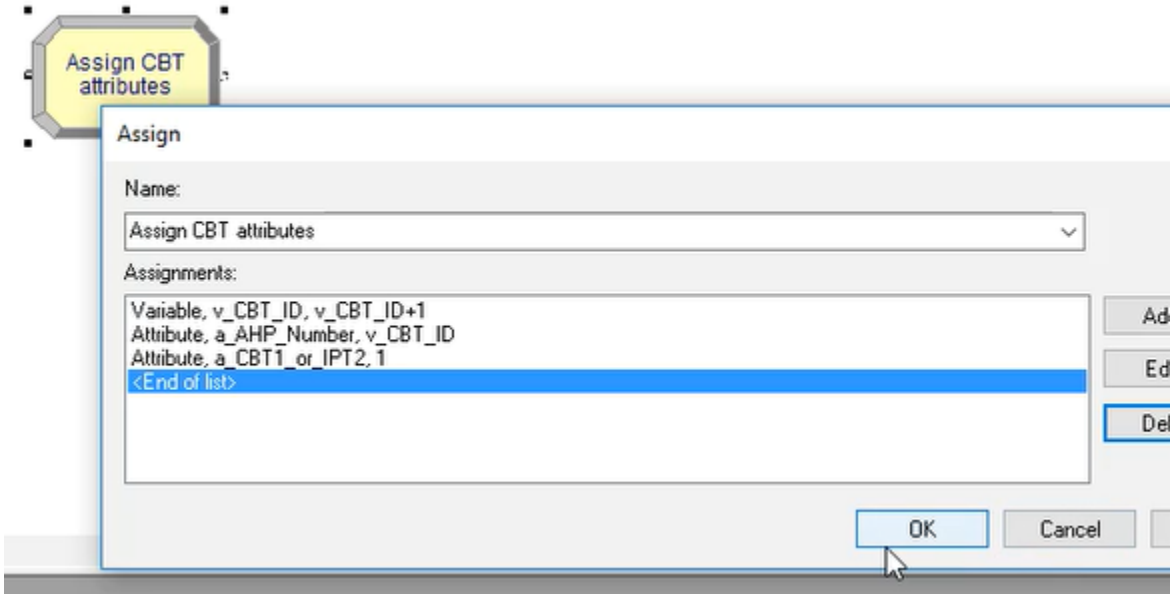


	Name	Comment	Rows	Columns	Data Type	Clear Option	File Name	Recordset
1	v_I_Schedule_CBT		10	168	Real	None	File_Inputs	Recordset_I_Schedule_CBT
2	v_I_Schedule_IPT		10	168	Real	None	File_Inputs	Recordset_I_Schedule_IPT
3	v_I_Schedule_MD		10	168	Real	None	File_Inputs	Recordset_I_Schedule_MD
4	v_I_Schedule_OT_Support		10	168	Real	None	File_Inputs	Recordset_I_Schedule_OT_Support
5	v_I_DaysBetweenSessions		6		Real	None	File_Inputs	Recordset_I_DaysBetweenSessions
6	v_I_ArrivalPatient		2		Real	None	File_Inputs	Recordset_I_ArrivalPatient
7	v_Patient_ID				Real	System		
8	v_CBT_ID				Real	System		

The corresponding variable is used to identify each professional; these are indicated in the assign module.

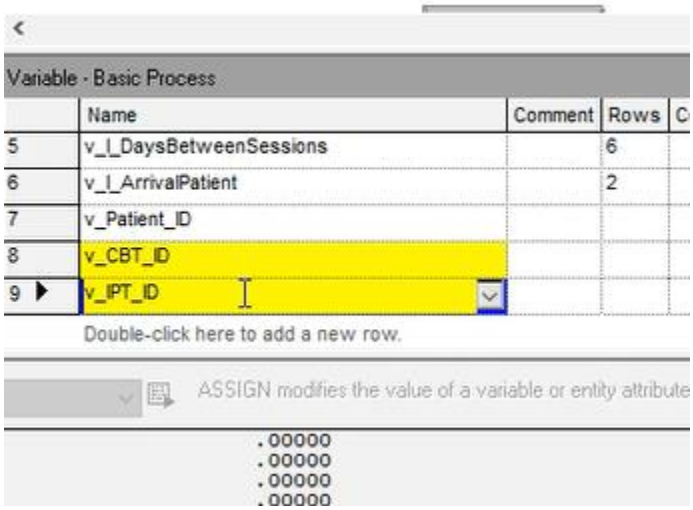


When streamlined these are the attributes:

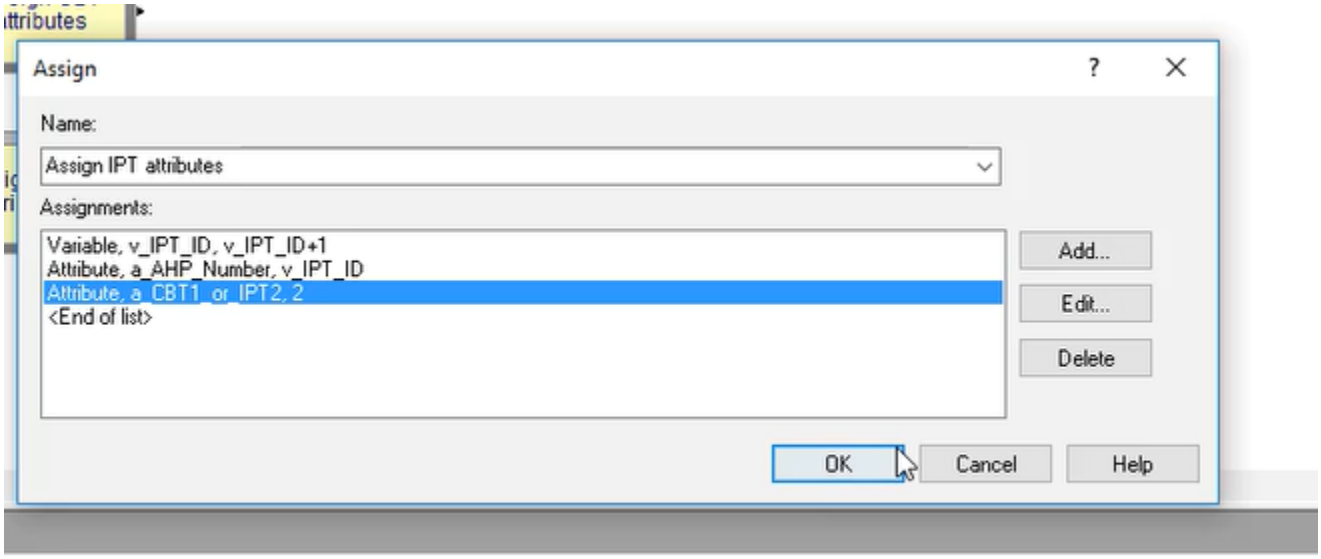


Notice there's the cbt variable, the ahp number is equal to the v cbt and the cbt attribute is fixed to 1.

When creating the IPTs also a corresponding variable is to be created:

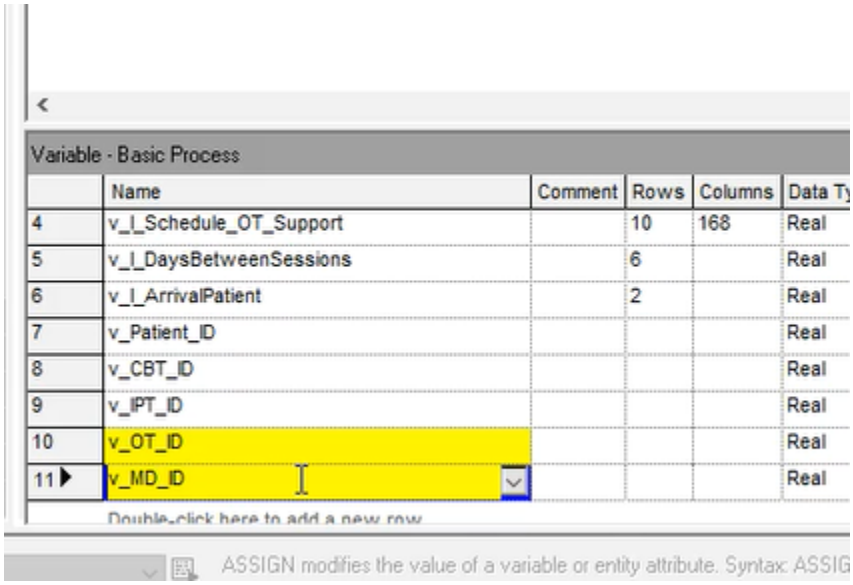


And this is how the IPT module would look like:

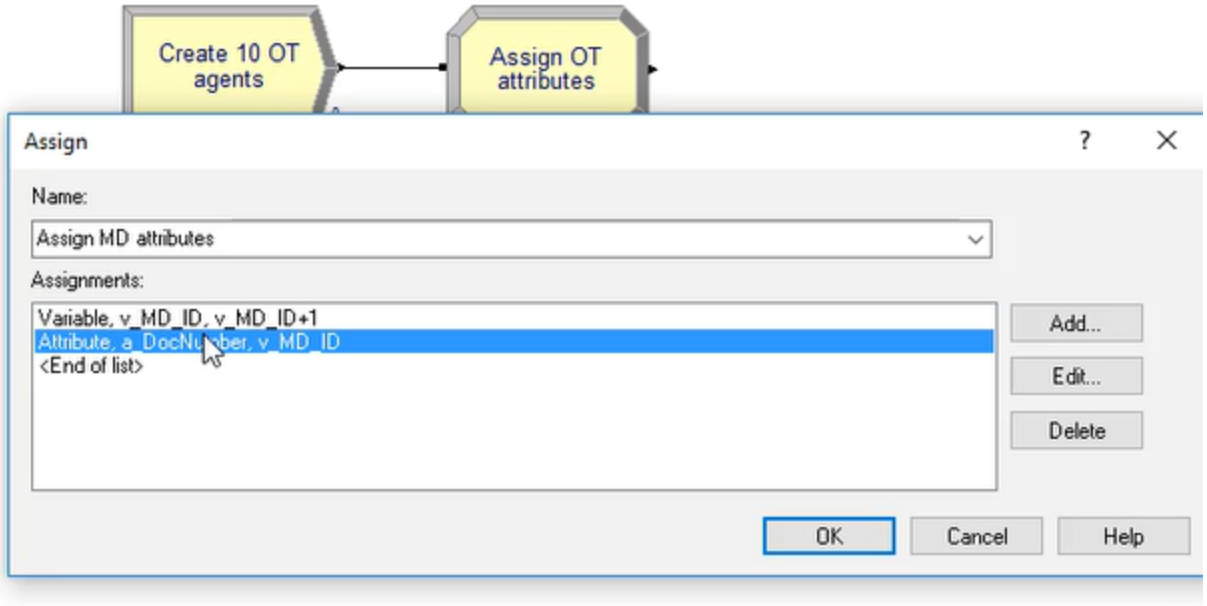


Notice how the ipt variable is used now and the ipt code2 is also set.

Additional variables are now created for the MD's and OTs.



This is how the md's look like



Notice the corresponding variable used, v md ie.

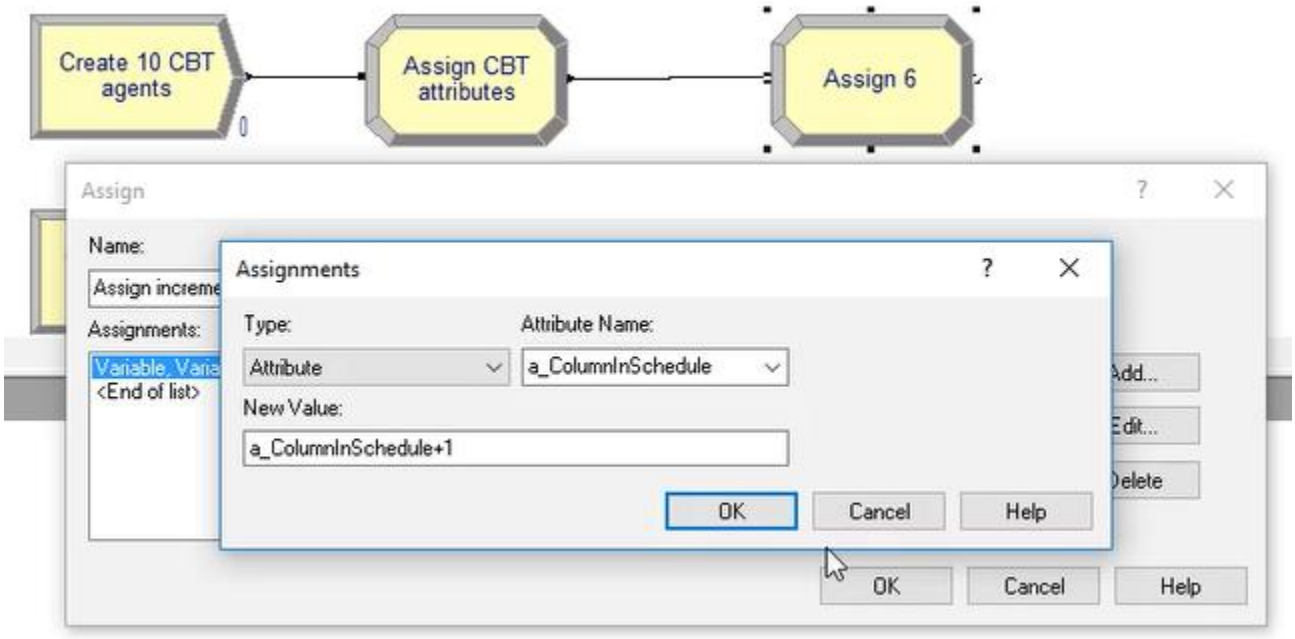
Determining when to work (agents ie):

The logic should be such that the model would go over the schedule until it finds a time when the professional is working:

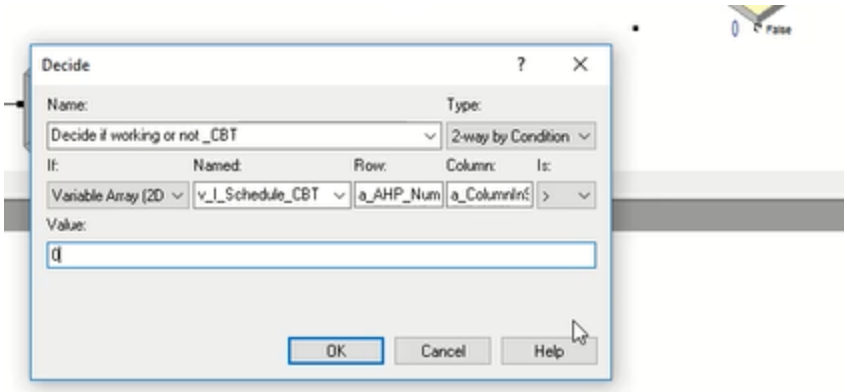
CBT DETAILS, SCHEDULE	1 means choice								
	2 means partnership								
		Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday
		0	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00
R_CBT_01	1	0	0	0	0	0	0	0	0	1
R_CBT_02	2	0	0	0	0	0	0	0	0	1
R_CBT_03	3	0	0	0	0	0	0	0	0	1
R_CBT_04	4	0	0	0	0	0	0	0	0	1
R_CBT_05	5	0	0	0	0	0	0	0	0	1
R_CBT_06	6	0	0	0	0	0	0	0	0	1
R_CBT_07	7	0	0	0	0	0	0	0	0	1

Given that this is determined by the column in the schedule an attribute for this value will be created:

Through a new assign module this value will be incremented:

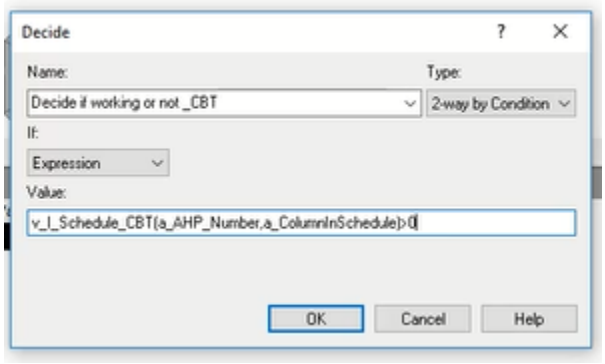


The column number attribute has been added, now you need to check if the agent is working or not. This implies that the cell (row, column) will be tested. Notice the row is the AHPnumber and the column the attribute we just defined.

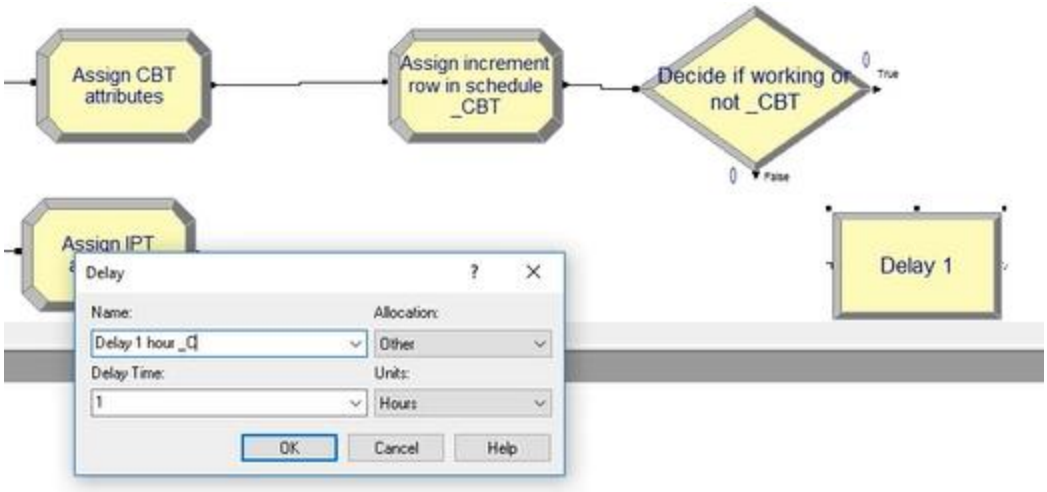


In this case the cell is tested to see if > 0 as that's when we know it's working. See how the above format gives the option to enter both the row and the column.

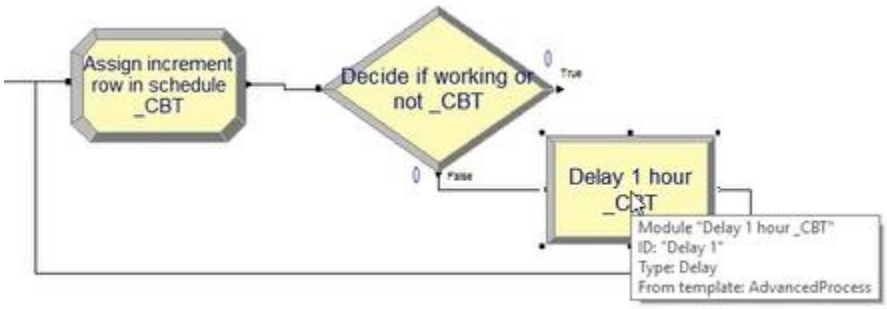
You can also indicate the above condition building and expression from the variable itself:



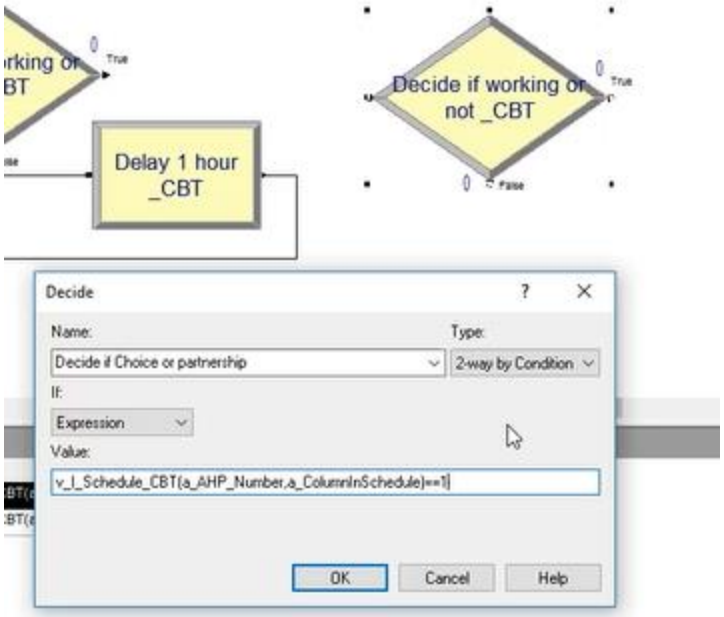
Now we'll have to wait until the agent is ready to work so we need to add a 1 hour delay within the loop:



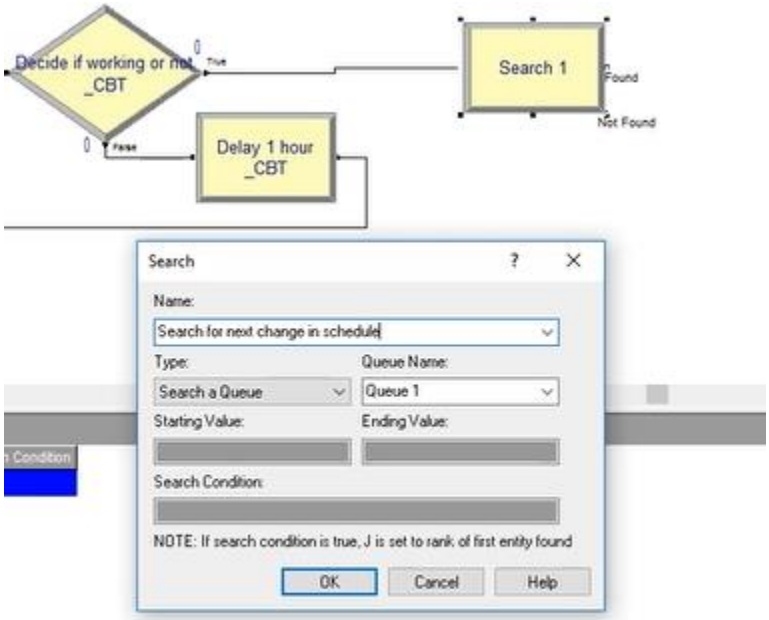
After every delayed hour we'd go to the column increment (which represents a step in time of 1 hour)



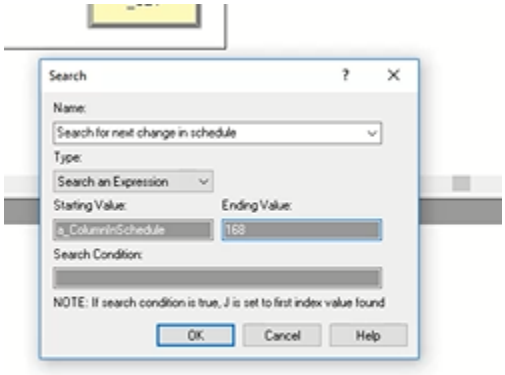
If working you'd need to determine if it's choice or partnership, syntax is similar to the one indicated in the working or not decide module, here we'd care if it's 1 or not (2 in this case)



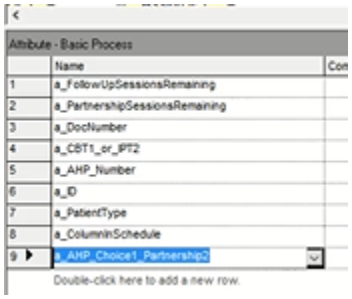
Prior to the working decision though it's necessary to determine if the agent would have enough time to complete the treatment. This will be done through a Search module, which we will call "search for a change in schedule"



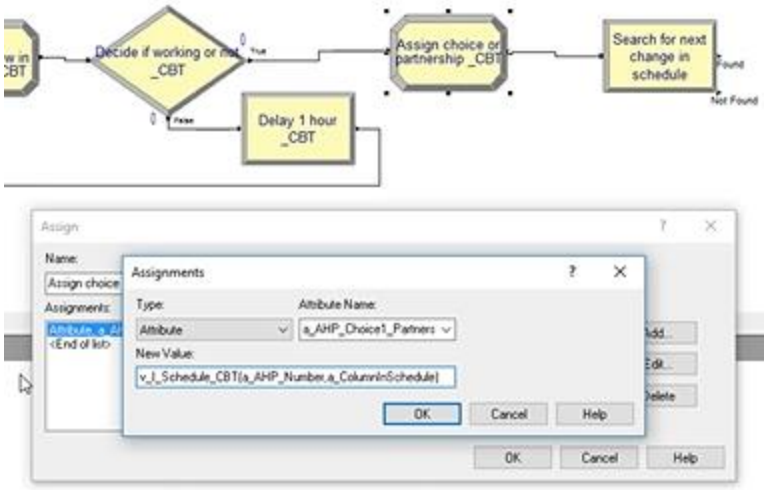
The search module operates within a range, in this case the starting point will be the column in schedule and the last one which is 168, as that is the number of columns the ranges have.



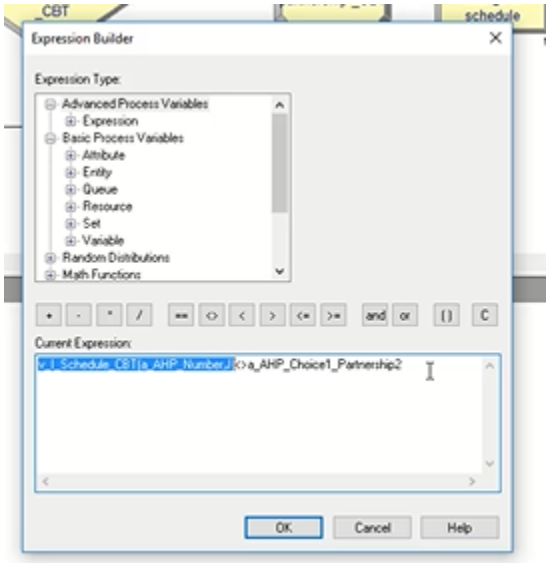
For the search condition we need a new attribute, in this case it will be one that determines whether the AHP is doing either Choice or Partnership



This will be assigned by storing the actual value on the schedule (a 1 or a 2 given the identification agreed earlier in the modeling for Chce or Ptnshp respectively).



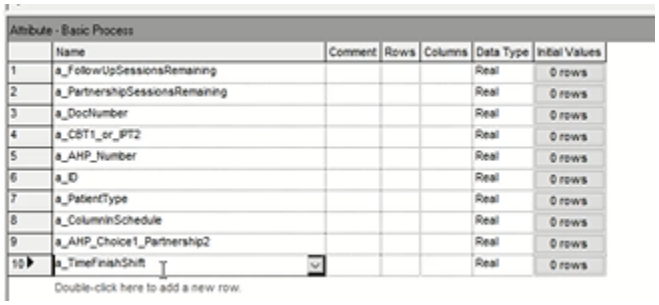
So now back to the search we create the expression that looks for a value in the schedule that is different from the choice or partnership attribute recently define as this will be the point that marks when the agent is finishing his 'shift' to do this kind of treatment:



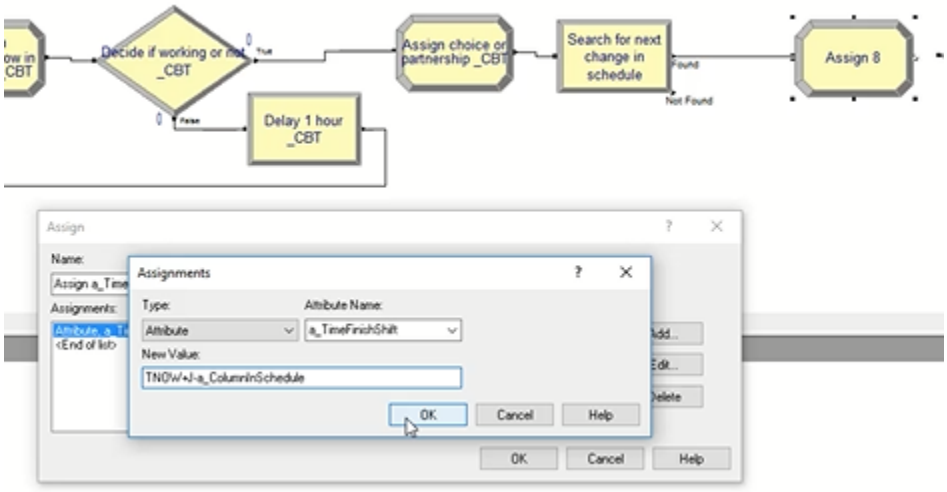
Notice here that the term J appears which is the pivot arena uses for searching, ie this value in this case would move up in the column range until it finds a different value as stated previously.

		1 means consultation										
		2 means follow-up										
			Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday
additional sessions		Start time	0	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00
0	R_MD_01	1	0	1	1	1	1	0	2	2	2	2
0	R_MD_02	2	0	1	1	1	1	0	2	2	2	2
2	R_MD_03	3	0	1	1	1	1	0	2	2	2	2
2	R_MD_04	4	0	1	1	1	1	0	2	2	2	2
2	R_MD_05	5	0	1	1	1	1	0	2	2	2	2
2	R_MD_06	6	0	1	1	1	1	0	2	2	2	2
2	R_MD_07	7	0	1	1	1	1	0	2	2	2	2

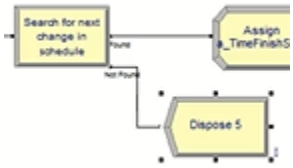
There'd be another attribute in which the time when the shift is finished will be captured:



This attribute requires the use of the J value found in the search such that the operation will be: TNOW + J – column-in-schedule:

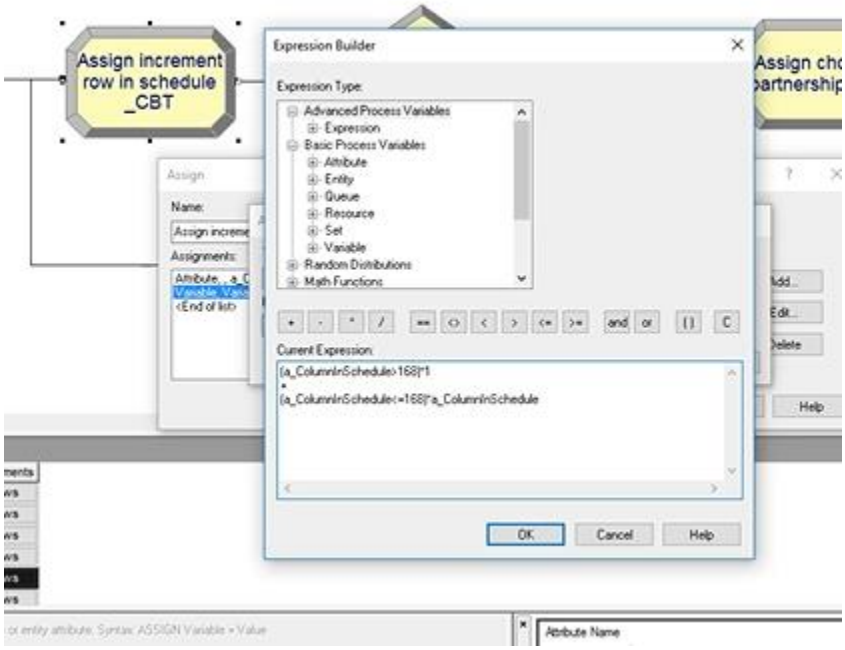


The search needs also an option when it does not find the required value. We'd start with a dispose.



One thing to keep in mind is that the current schedule runs for the 168 columns so this could affect the search above. This implies that we'd need to change the increment in the schedule column.

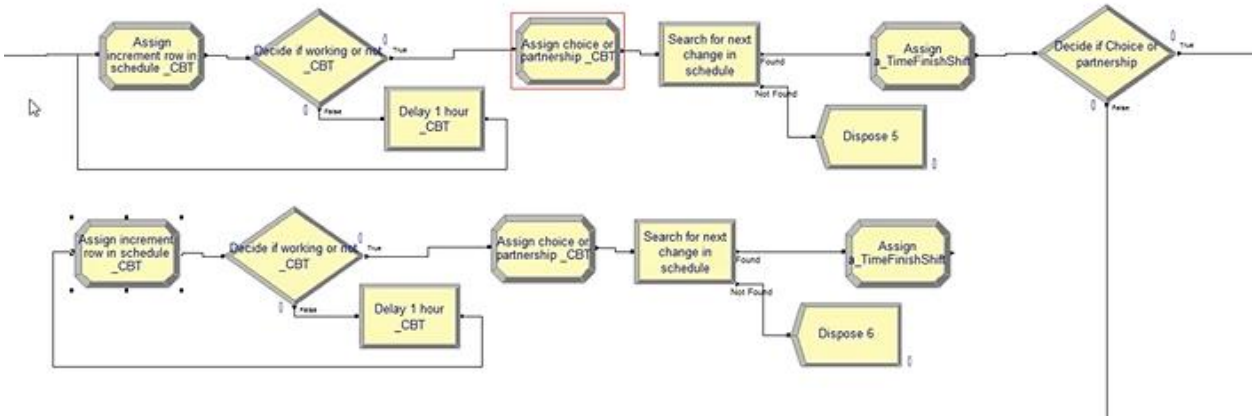
In this case, what we'd do is return back to 1 if the column is higher than 168; and if it's less or equal to 168 it'd keep the same value:



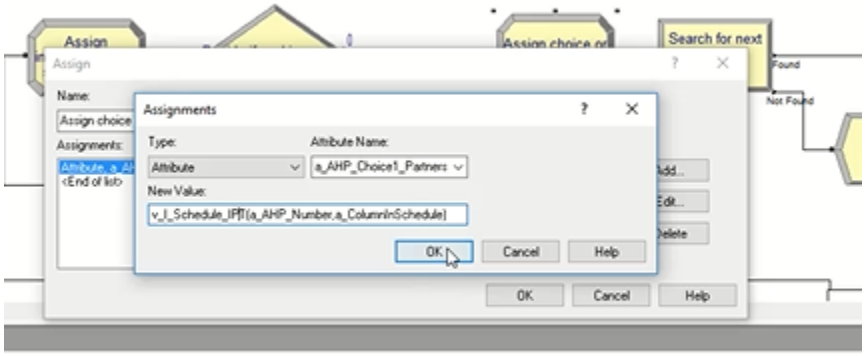
Notice that the above expressions are equivalent to if, so that if the condition it's true, it defaults to 1. When false is 0. Therefore you see that there's a multiplier * which will lead to the desired value (ie the value you're interested in if true).

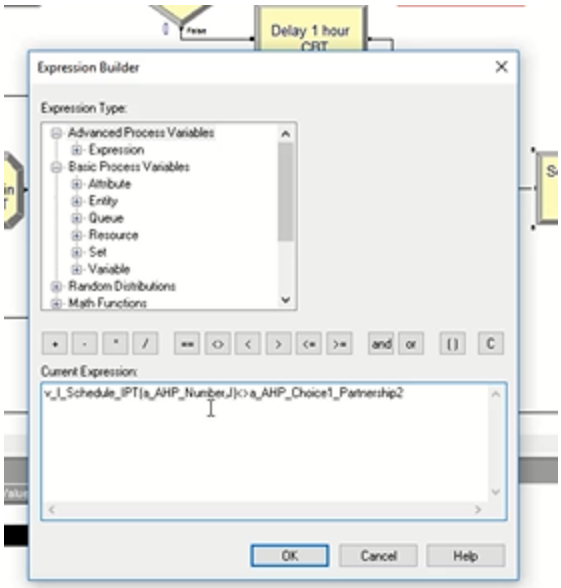
IPTs and MDs modeling:

As the logic will be the same for all the professionals we can start by replicating what has been done for the IPTs and MDs.



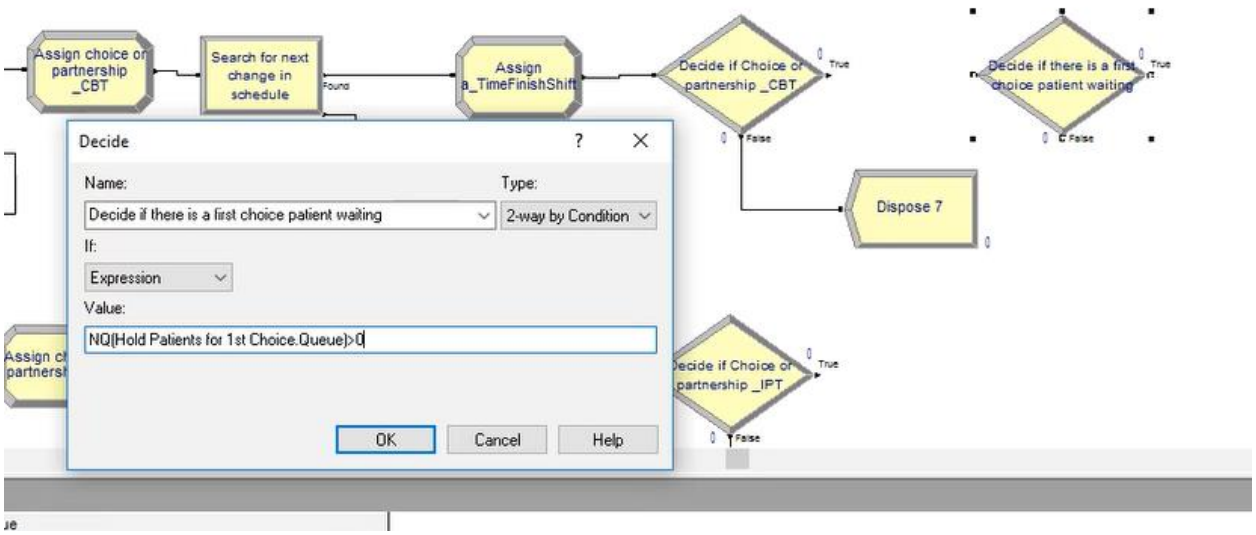
Obviously names should be changed to IPT, what is important to mention is that the logic itself won't change unless it relates to variables or so that are tied to the ranges linked to the IPTs:





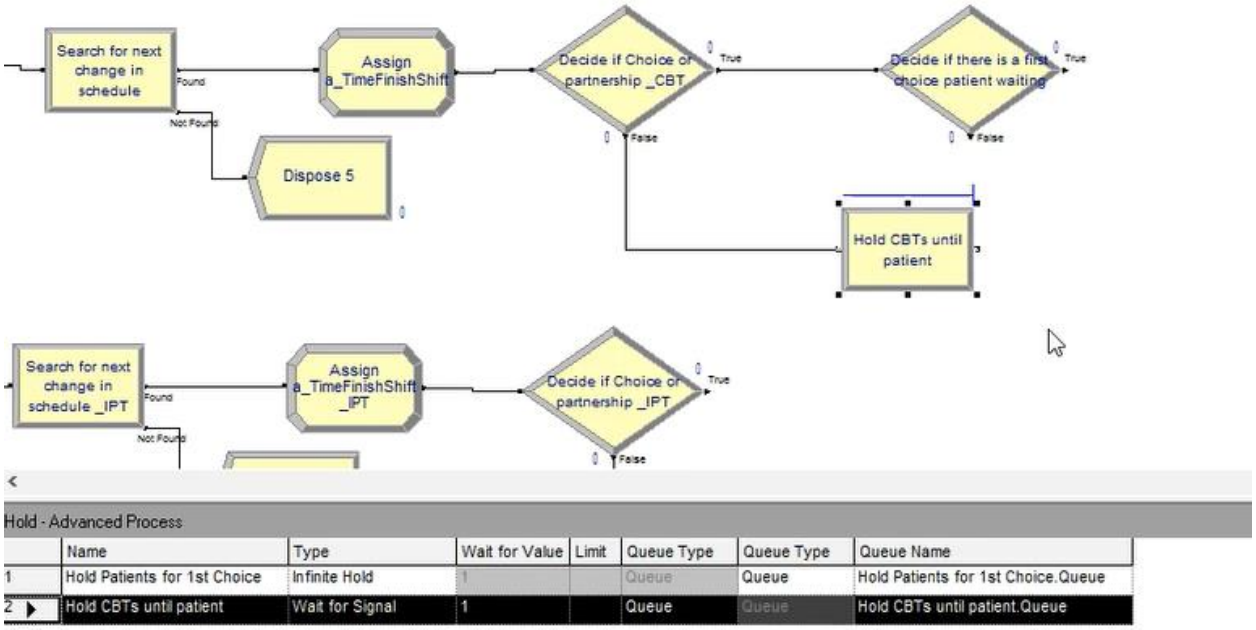
Selecting patients:

Will check to see if there's a patient waiting



It's checking on the hold from the patients stream.

For now we'll use a hold for the agent until there's a patient waiting. NOTE: this will change in the future.



Hold - Advanced Process

	Name	Type	Wait for Value	Limit	Queue Type	Queue Type	Queue Name
1	Hold Patients for 1st Choice	Infinite Hold	1		Queue	Queue	Hold Patients for 1st Choice.Queue
2	Hold CBTs until patient	Wait for Signal	1		Queue	Queue	Hold CBTs until patient.Queue

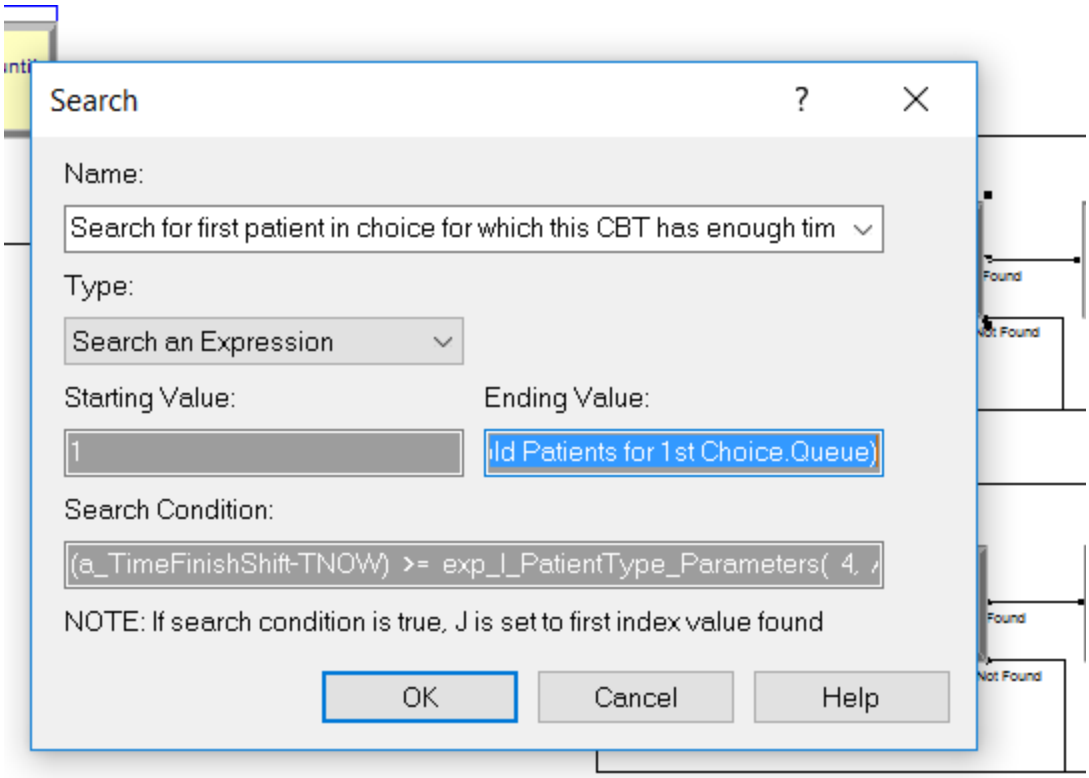
Selecting the patient:

The patient will be selected if the duration of his treatment is not longer than the time the agent is available.

So the range below would need to be reviewed based on the patient type:

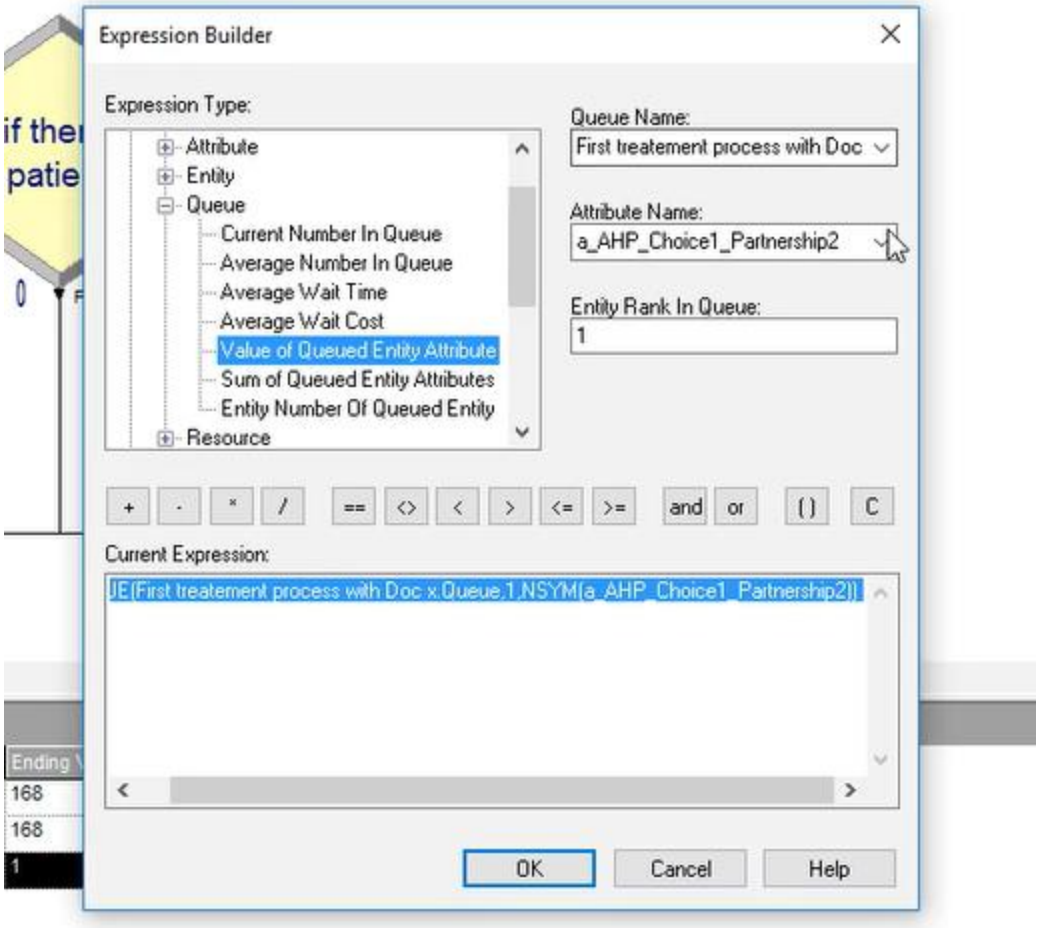
	typical	stm	lngtm
Percentage of patients	0.7	0.15	0.15
Number Partnership Sessions	10	6	14
Number of Follow Up Sessions	8	8	8
Choice duration	3.5	3.5	3.5
Partnership duration	1	1	1
Consulation duration	1	1	1
Follow Up duration	TRIA(0.45,0.5,0.55)	TRIA(0.45,0.5,0.55)	TRIA(0.45,0.5,0.55)
no shows	0.1	0.1	0.1

To do so we'd use another Search module; in this case the search goes from one up to the patients queue:

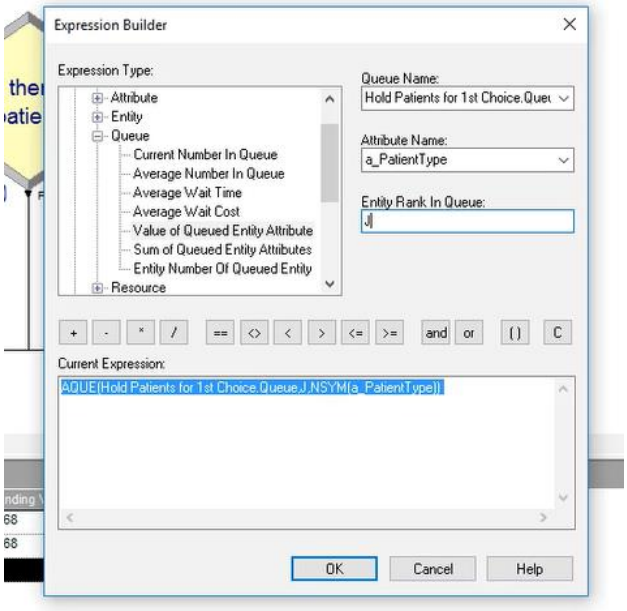


Now let's define the Search Expression:

We're interested in the que so the expression has to be related to the value of the entity in the queue:



Notice the identification of the parameters from the menu: queue name; attribute and the rank, J in this case



The above expression will then result in providing the patient type for the J patient. So now we need to look for the duration of this patient type. In this case we are looking for the value of the duration of the Choice appointment which is on Row 4:

row		typical	stm	lngtm	units
1	Percentage of patients	0.7	0.15	0.15	percentage
2	Number Partnership Sessions	10	6	14	sns
3	Number of Follow Up Sessions	8	8	8	sns
4	Choice duration	3.5	3.5	3.5	hrs
5	Partnership duration	1	1	1	hrs
6	Consulation duration	1	1	1	hrs
7	Follow Up duration	TRIA(0.45,0.5,0.55)	TRIA(0.45,0.5,0.55)	TRIA(0.45,0.5,0.55)	hrs
8	no shows	0.1	0.1	0.1	percentage

The patient type is the value we identified previously from the queue:

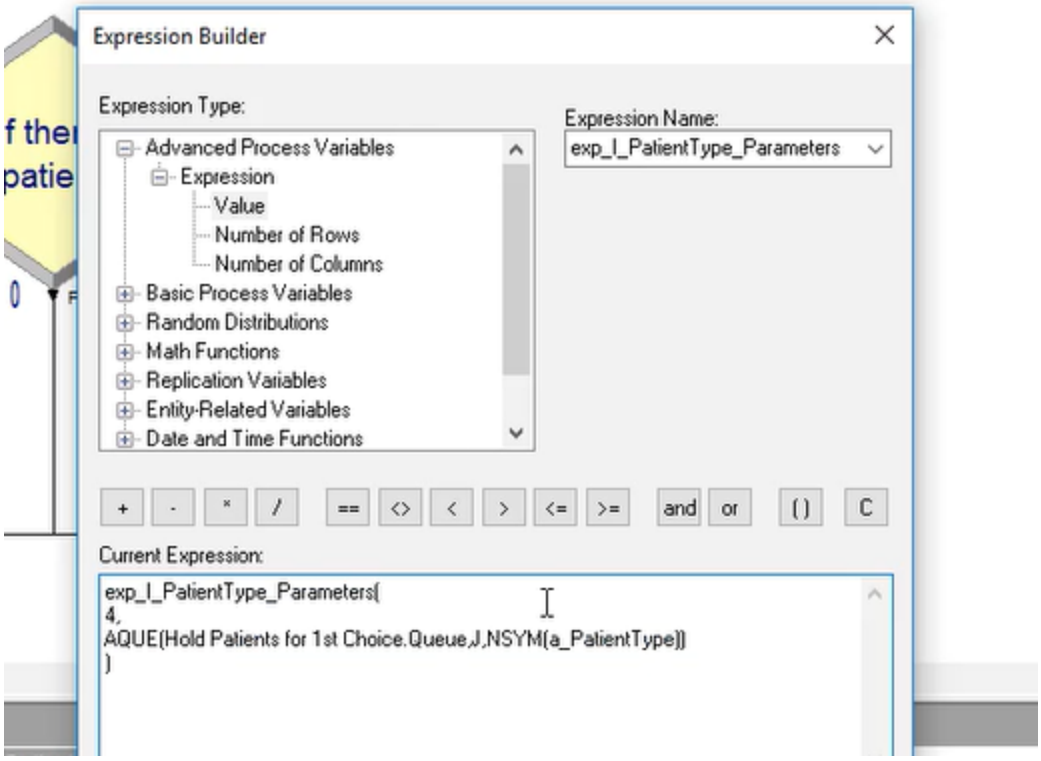
So the final expression is:

exp_I_PatientType_Parameters(

4,

AQUE(Hold Patients for 1st Choice.Queue,J,NSYM(a_PatientType))

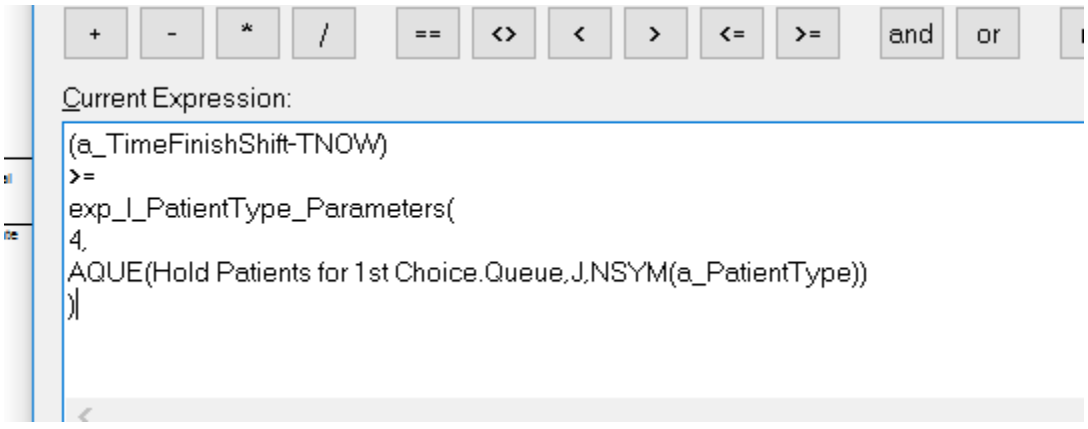
)



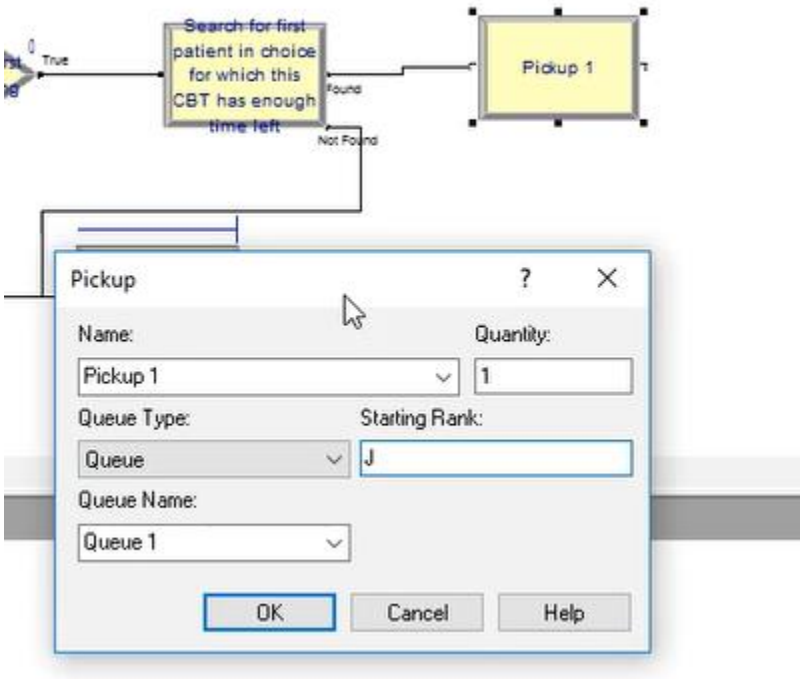
Finally this value (which is the duration) has to be compared with the time the agent has which is:

(a_TimeFinishShift-TNOW)

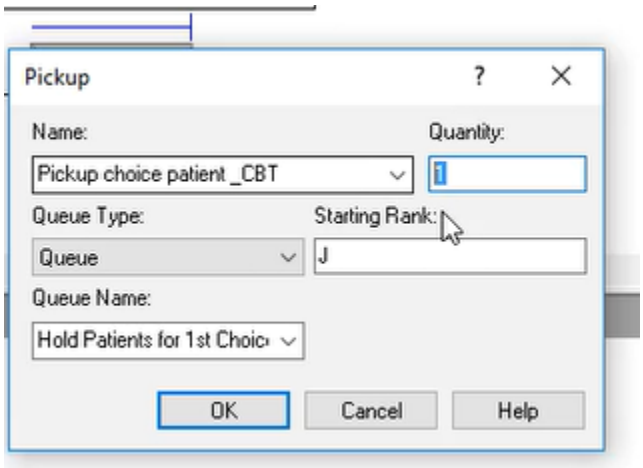
This time would have to be greater than the session duration (value identified previously:



So the search for now if it does not find a patient will go to the temporary hold built earlier. Now will use the Pick Up module in order to pick a patient from the queue.

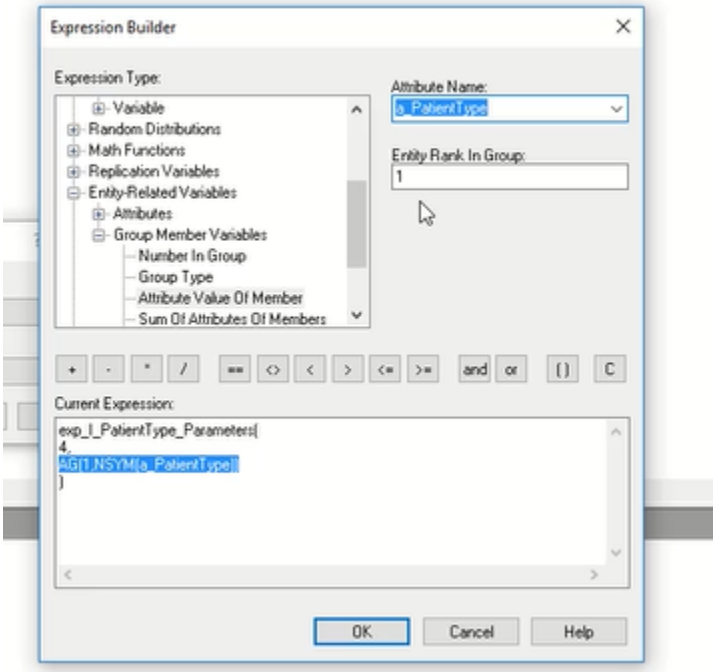


So the queue where to pickup is defined; notice is the j rank and only 1 patient:



A delay would be needed then for the Choice session; notice the time. Here it will also be in reference to the row where the value is however there is a difference now: the patient is type is selected from a GROUP. This is due to the fact that we used the PICK UP function.

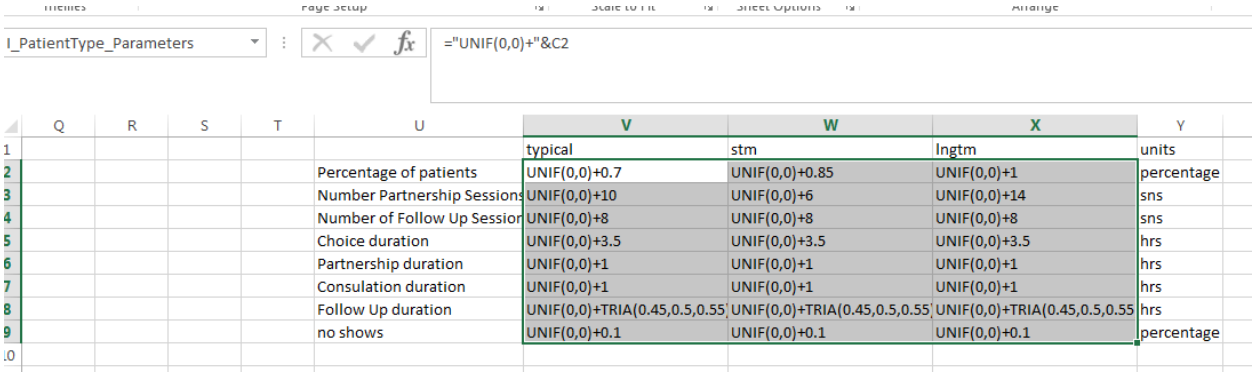
So we start building the expression, the row is # 4 as mentioned before, and now the patient type would come from 'Group Member Variables' in this case 'Attribute Value Of Member' and specifically a_PatientType. The rank is 1 as it's the 1st member picked up.



As a reminder it'd be noted that the information is coming from the I_PatientType_Parameters, ie, a range previously defined.

row		typical	stm	lngtm	units
1	Percentage of patients	0.7	0.15	0.15	percentage
2	Number Partnership Sessions	10	6	14	sns
3	Number of Follow Up Sessions	8	8	8	sns
4	Choice duration	3.5	3.5	3.5	hrs
5	Partnership duration	1	1	1	hrs
6	Consulation duration	1	1	1	hrs
7	Follow Up duration	TRIA(0.45,0.5,0.55)	TRIA(0.45,0.5,0.55)	TRIA(0.45,0.5,0.55)	hrs
8	no shows	0.1	0.1	0.1	percentage

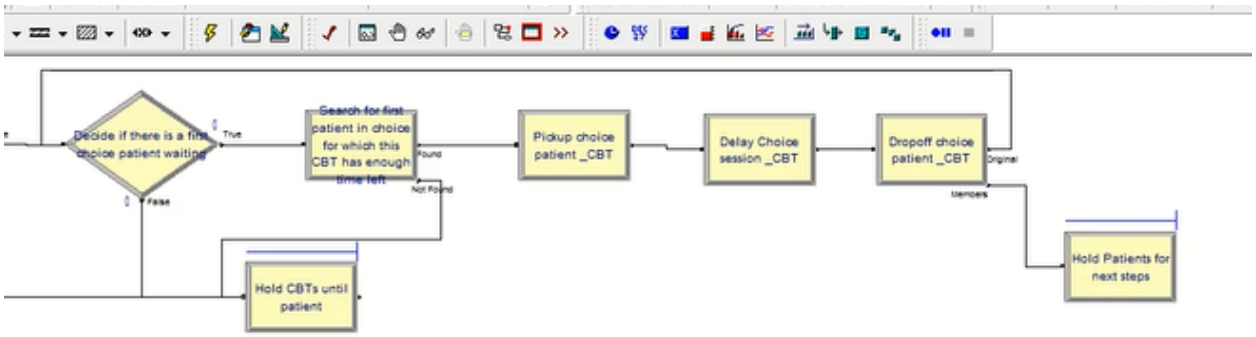
You can notice if you go into Excel how the corresponding range (the one modified) will have the referenced name.



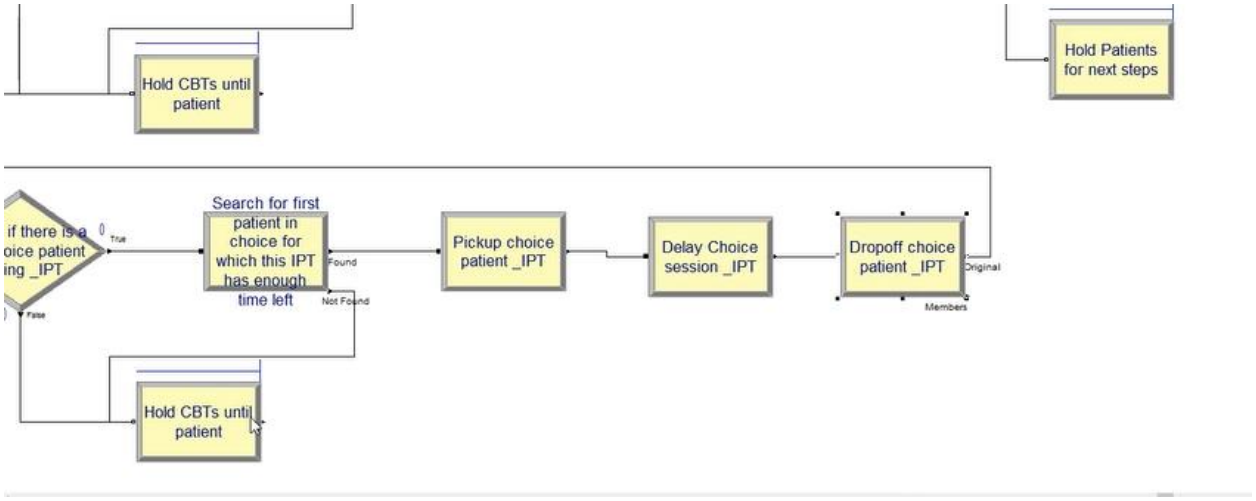
	Q	R	S	T	U	V	W	X	Y
1						typical	stm	lngtm	units
2					Percentage of patients	UNIF(0,0)+0.7	UNIF(0,0)+0.85	UNIF(0,0)+1	percentage
3					Number Partnership Sessions	UNIF(0,0)+10	UNIF(0,0)+6	UNIF(0,0)+14	sns
4					Number of Follow Up Sessior	UNIF(0,0)+8	UNIF(0,0)+8	UNIF(0,0)+8	sns
5					Choice duration	UNIF(0,0)+3.5	UNIF(0,0)+3.5	UNIF(0,0)+3.5	hrs
6					Partnership duration	UNIF(0,0)+1	UNIF(0,0)+1	UNIF(0,0)+1	hrs
7					Consulation duration	UNIF(0,0)+1	UNIF(0,0)+1	UNIF(0,0)+1	hrs
8					Follow Up duration	UNIF(0,0)+TRIA(0.45,0.5,0.55	UNIF(0,0)+TRIA(0.45,0.5,0.55	UNIF(0,0)+TRIA(0.45,0.5,0.55	hrs
9					no shows	UNIF(0,0)+0.1	UNIF(0,0)+0.1	UNIF(0,0)+0.1	percentage
10									

Now we need to 'undo' the PICKUP so we do a DROPOFF. We will leave the agent to retain his attributes.

It's important to mention that the Agent is the one doing the dropoff, he'd go back then to see if there's a patient waiting. We'd release the patient temporarily from now and "Hold it temporarily for next steps".

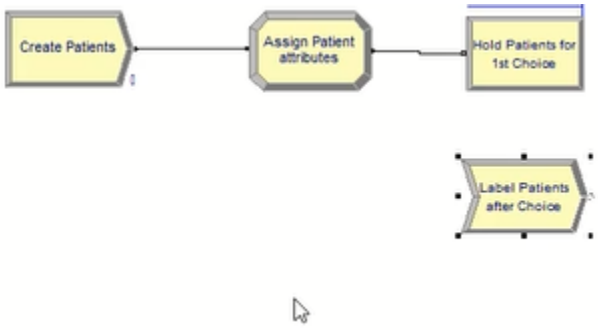


As we did earlier, we will now replicate the behavior for the IPTs (important to notice here that there are no changes in logic but only in naming of the modules):

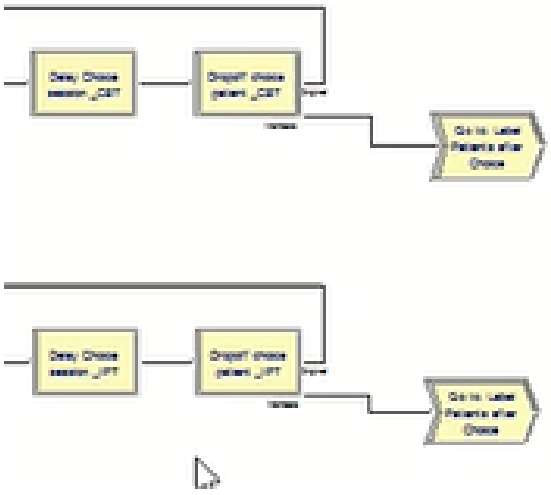


LABEL

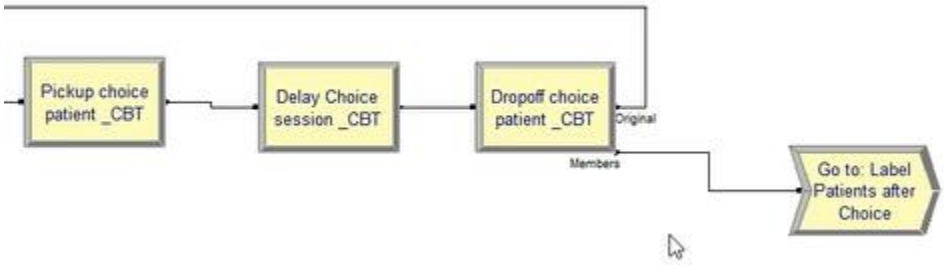
To keep consistent with the flow we'll remove the 'hold patient for next steps' from the block and add a label instead.



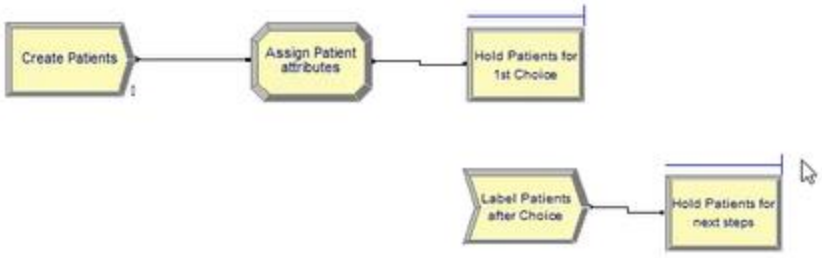
We need to create the GOTO LABEL module that would link us to the previous LABEL:



A closer look from the agent's side

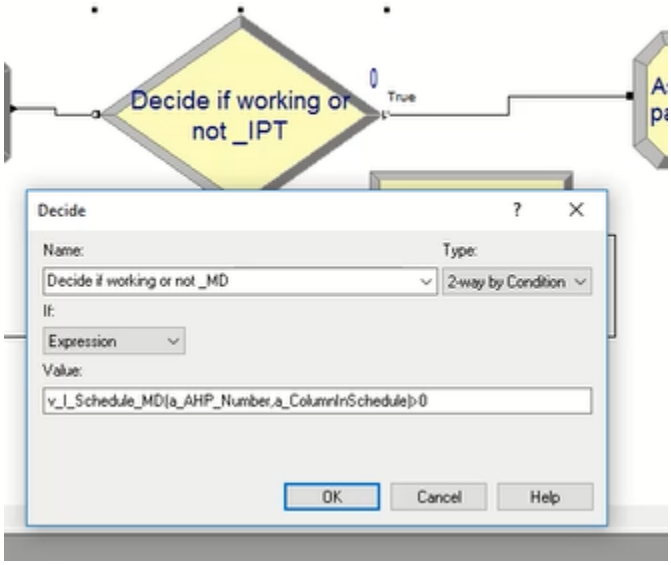


From the patient's:

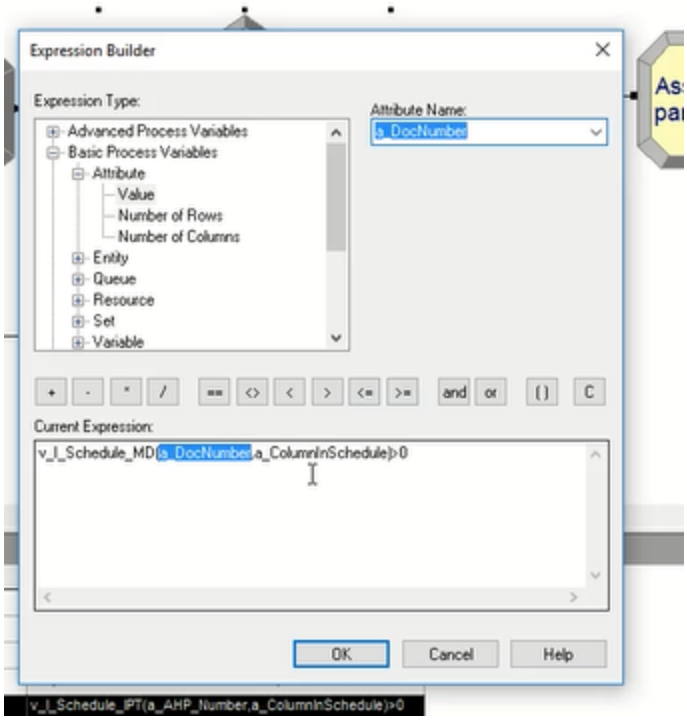


As patients got to consultation we'll update the 'next steps' details to consultation.

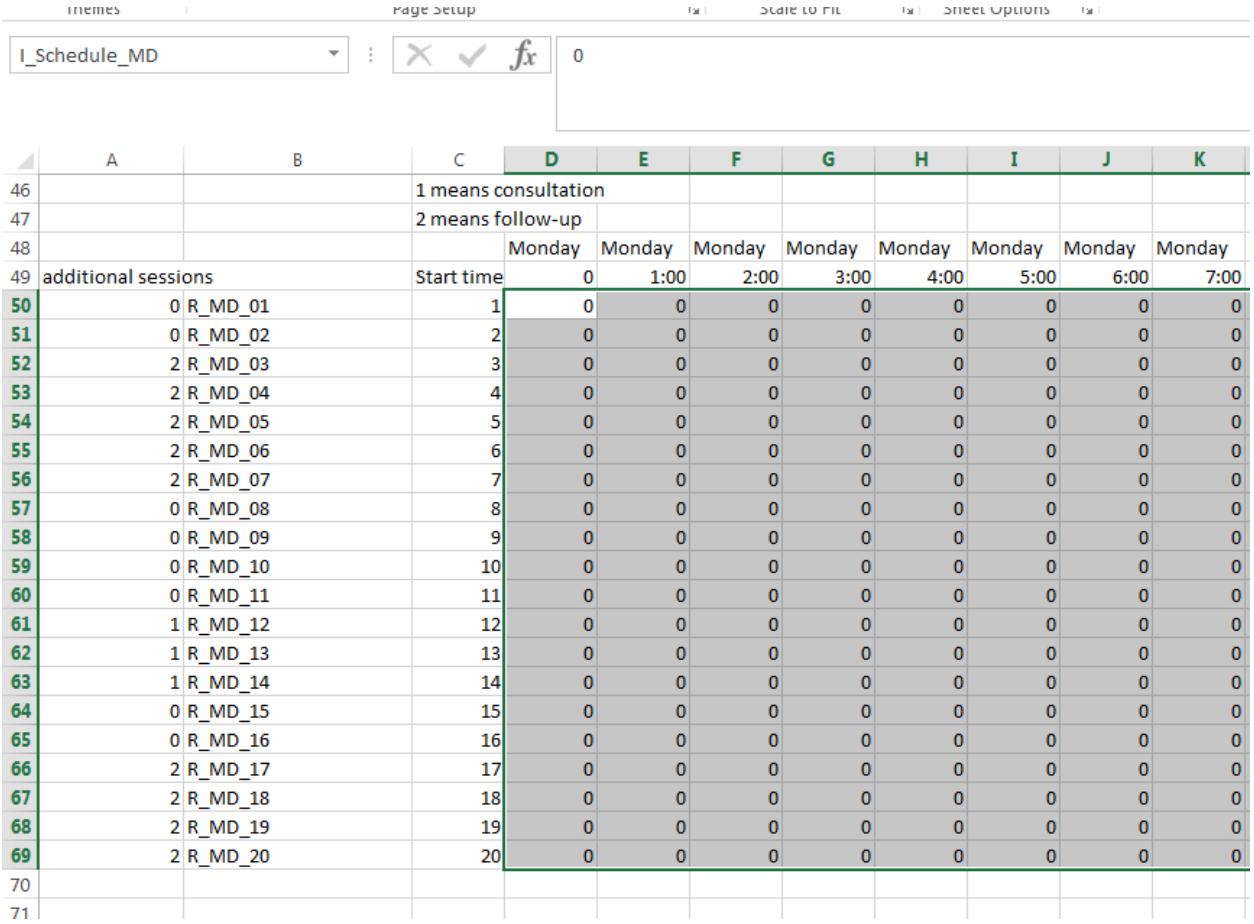
Let's now start working with the doctors, we'll use as a base the same blocks we used for ahp's and start modifying accordingly. Most only require names a bit more work on the decide if working or not:



Notice the row is different:



As it comes from a different range:

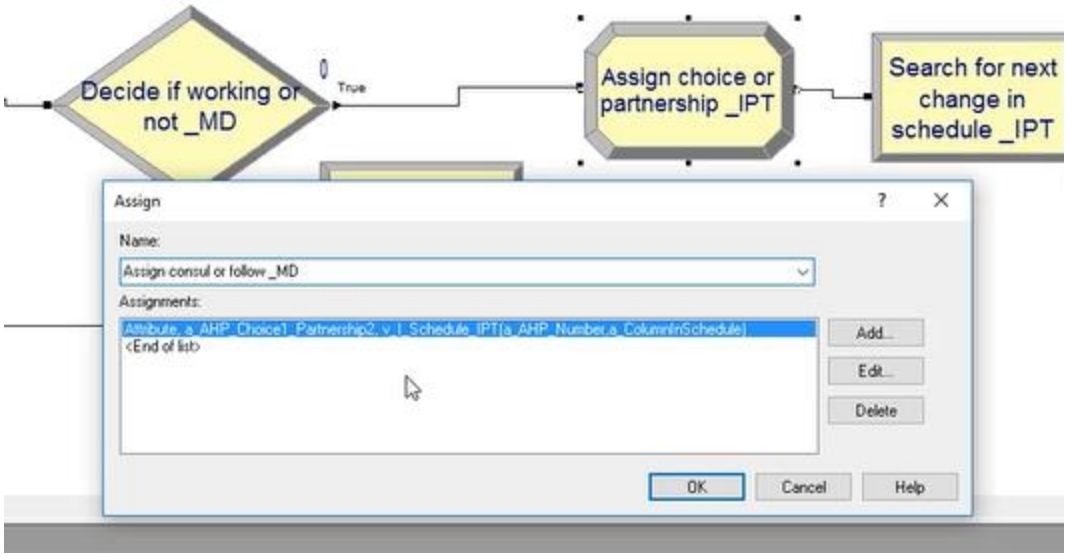


I_Schedule_MD | 0

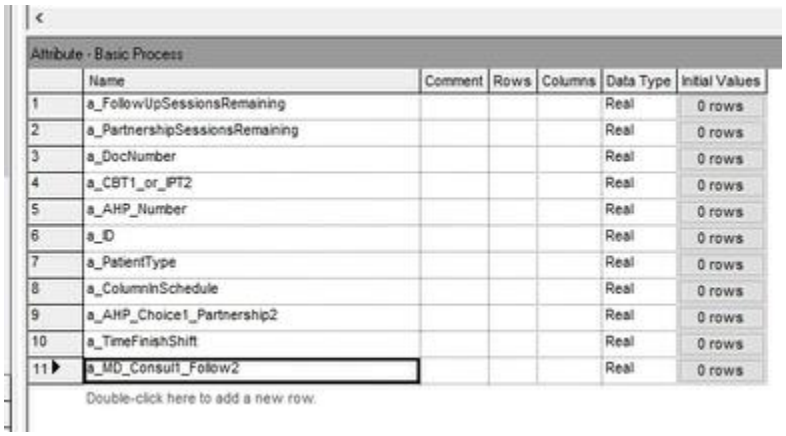
	A	B	C	D	E	F	G	H	I	J	K
46			1 means consultation								
47			2 means follow-up								
48				Monday	Monday	Monday	Monday	Monday	Monday	Monday	Monday
49	additional sessions		Start time	0	1:00	2:00	3:00	4:00	5:00	6:00	7:00
50	0	R_MD_01	1	0	0	0	0	0	0	0	0
51	0	R_MD_02	2	0	0	0	0	0	0	0	0
52	2	R_MD_03	3	0	0	0	0	0	0	0	0
53	2	R_MD_04	4	0	0	0	0	0	0	0	0
54	2	R_MD_05	5	0	0	0	0	0	0	0	0
55	2	R_MD_06	6	0	0	0	0	0	0	0	0
56	2	R_MD_07	7	0	0	0	0	0	0	0	0
57	0	R_MD_08	8	0	0	0	0	0	0	0	0
58	0	R_MD_09	9	0	0	0	0	0	0	0	0
59	0	R_MD_10	10	0	0	0	0	0	0	0	0
60	0	R_MD_11	11	0	0	0	0	0	0	0	0
61	1	R_MD_12	12	0	0	0	0	0	0	0	0
62	1	R_MD_13	13	0	0	0	0	0	0	0	0
63	1	R_MD_14	14	0	0	0	0	0	0	0	0
64	0	R_MD_15	15	0	0	0	0	0	0	0	0
65	0	R_MD_16	16	0	0	0	0	0	0	0	0
66	2	R_MD_17	17	0	0	0	0	0	0	0	0
67	2	R_MD_18	18	0	0	0	0	0	0	0	0
68	2	R_MD_19	19	0	0	0	0	0	0	0	0
69	2	R_MD_20	20	0	0	0	0	0	0	0	0
70											
71											

Column remains the same given the logic we chose for it. We are also still looking for the values to be >0 as it's what determines if working or not (see legend in above screenshot).

Consul/Ptnshp assign module needs to be changed as it does not apply:



We'll create an attribute for the consult and follow up visits:

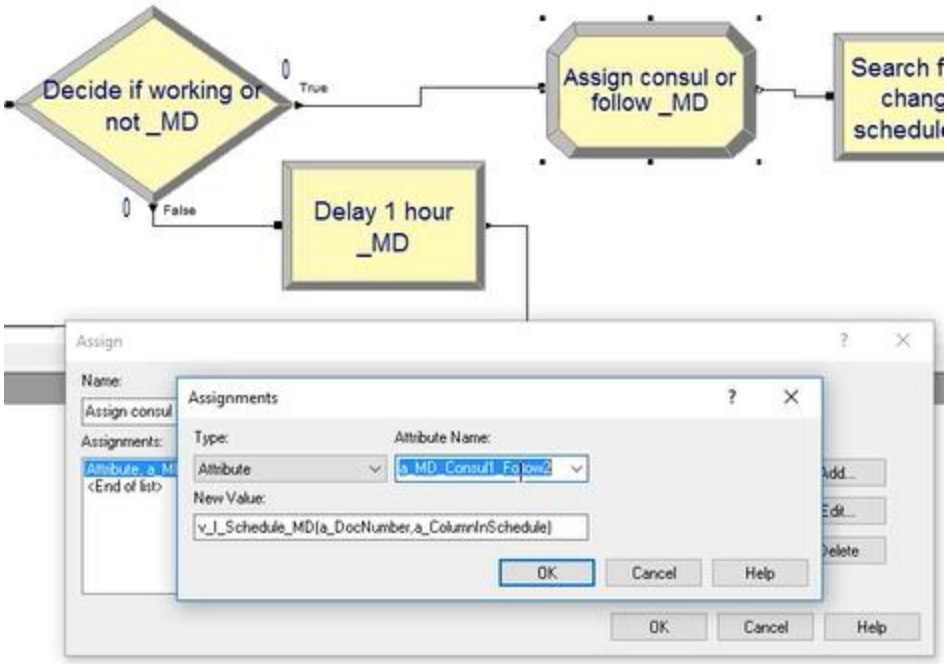


Attribute - Basic Process

	Name	Comment	Rows	Columns	Data Type	Initial Values
1	a_FollowUpSessionsRemaining				Real	0 rows
2	a_PartnershipSessionsRemaining				Real	0 rows
3	a_DocNumber				Real	0 rows
4	a_CBT1_or_IPT2				Real	0 rows
5	a_AHP_Number				Real	0 rows
6	a_ID				Real	0 rows
7	a_PatientType				Real	0 rows
8	a_ColumnInSchedule				Real	0 rows
9	a_AHP_Choice1_Partnership2				Real	0 rows
10	a_TimeFinishShift				Real	0 rows
11	a_MD_Consult_Follow2				Real	0 rows

Double-click here to add a new row.

The reference to this attribute is also changing given it corresponds to the MDs range:


Decide if working or not _MD
True
False
Assign consul or follow _MD
Search f
chang
schedul
Delay 1 hour _MD
Assign
Name:
Assign consul
Assignments:
<End of list>
Assignments
Type:
Attribute
Attribute Name:
New Value:
v_I_Schedule_MD(a_DocNumber,a_ColumnInSchedule)
OK
Cancel
Help
Add...
Edit...
Delete
OK
Cancel
Help