# *Final Project Design Proposal*

Jeff Kahn, Agent Based Modeling, Spring 13

## ***An Agent Based Model of Medical ICU Release Processes***

I plan to design and implement a NetLogo model of the Intensive Care Unit (ICU) system. My goal is to explore the dynamics behind performing medical rounds in the ICU and how we might minimize patient release wait times given the constrains in the ICU setting

ICU care is costly. Many studies suggest that 11-30% of hospital costs and .4-2% of GDP result from delivering ICU care. Further, the number of beds in the ICU has increased by 26% since the 1980's.[1] In addition, the complexity of care delivered in the ICU suggests a high variability in patient throughput.

Fluctuating, uncontrolled throughput is also costly. In an interview with an ICU thrid year fellow at Northwestern Memorial Hospital (NMH), the cost of one ICU day without procedures can be anywhere from $2500-$3000. This suggests that the ICU may be an opportunistic place to analyze and re-engineer process bottlenecks. Specifically, I plan to look at how patients are released from the ICU in order to reduce costs and increase quality of care.

I will use information I have gathered from two interviews at the NMH Medical ICU (MICU) as well as observational data to understand and analyze the patient release process in the MICU. Attending rounds begin at 7 or 8 am and patients are visited based on arbitrary heuristics such as alphabetical ordering by last name or physician proximity to patient. For a patient to be released, the attending physician must observe and sign off that the patient is in good enough condition to be released to another location. The release process most often happens during attending physician rounds. Most often, the patient is released to the medical floor or a long term care facility. Appropriate considerations must be made for the intake of these patients at the receiving department once released from the ICU.

Specifically, if the patient has been released to the medical floor, the patient's record must be viewed by the intake physician on the medical floor. For transport to take place, there must be an available bed in the receiving unit. In addition, transport of the patient depends on the availability of a transporter. Long term care facilities must also be pre-arranged so the patient can be transported. However, I am not as familiar with the procedure in place to transport to a long term care facility. This requires more investigation.

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1 Halpern NA et al. Critical care medicine in the United States 1985-2000: An analysis of bed numbers, use and costs. Critical Care Medicine 1999. 32(6):1254-59

## *What Can we Learn*

This model should highlight and offer insight into how to best plan the order of patient rounds done by attending physicians. As mentioned above, it is critical to be able to release patients as safely and time efficient as possible. This both reduces cost and improves patient satisfaction. With this model, we hope to learn more about the patient release process and to identify and optimize key variables in reducing time to release.

More succinctly the guiding question is as follows: How might we reduce patient release times in the MICU by thoughtfully arranging the order in which attending physicians visit their patients. For example, we may find that attending physicians should visit patients that have been highlighted for release first. And that this operational strategy is positively or negatively related to patient release time. These insights would then guide procedural recommendations the MICU.

I plan to conclude which strategy for rounds is most effective. In addition, I plan to explore how one might decouple release from regular patient rounds and how this might affect process variability. For example, given the scenario that all patients – not just those looking to be released– will be visited, how does stratification of the type of visit (health or release) affect overall patient release time.

I plan to initially set up the model in general fashion so the results may be externally valid to other ICU or patient release operations.

## *A Guide to Implementation*

**Who are the Agents(Behaviors | Properties)**:

**1.** Attending Physicians ( Speed of Round, Conservative or liberal?, | release-patient, pick next room)
**2.** Patients (Wait time, release-type, acuity, length of stay | Release-Me!)
**3.** Patient Transporters (time-to-ready, | transport
**4.** Possibly fellows, residents and interns but I do not think they will be necessary as I have not observed them having unique characterisitics (Positive or negative effect on round speed)
**5.** Medical Floor Physician (Record Review Speed, Open Bed? | Admit patient)
**6.** Long Term Care Facilities (Open Bed? | Admit patient)

**System Parameters**
1. Number of patients or patients per day inflow
2. Cost per day (whole days 1,2,3 etc.)
3. Patient Acuity
4. Number of patient releasers
5. Number of beds

**Time-Step ( Day )**
1. Attending visits patient
2. Attending assesses patient related to acuity

3. Attending signs or doesn't sign release
4. If signed, transporter moves patient

**Measures**
1. Patient release time distribution
2. Average patient release time
3. Average cost per day
4. Average time for round
5. Bed Utilization 1- (total empty bed time / total elapsed time)
6. Patient Throughput (total patients out / # of days)

**Analysis - Using Behavior Space**
1. How changing the attending visiting behavior affects measures listed above
2. Varying transporter time to ready $\longrightarrow$ measures
3. Vary Medical Floor Physician properties $\longrightarrow$ measures

Based on these analyses, which strategy the most effective at optimizing given measures.

**Questions**
1. Time Horizon Choice - infinite or discrete?
2. Does it make sense to assume functional equivalence between medical floor and outside departments?
3.

## *Rationale for Choices*

ABM is an effective modeling choice for this application because it provides "an object to think with" as well as a heterogeneous and uncertain environment of interest. The ICU has many independent, interacting actors that engage on an individual level. We are primarily concerned with how individual agent "micro-motives" correspond to the observed "macro-behavior" in the ICU.

I plan for this model to provide insights into the underlying mechanisms of patient release times in conjunction with physician rounds. This is helpful because this model can serve as a glass box where every involved stakeholder can question the assumptions. Health care often exhibits what some call system inertia because of the necessary coordination of all involved stakeholders. I plan to be able to present my model in a few minutes inviting feedback and improvement from all stakeholders including: top management, MICU director, MICU staff, Medical Floor staff and Medical Floor Physician. The transparency and ease of understanding of the model will provide all empower all interested stakeholders to take part in process improvement.

Beyond its value in facilitating communication, the computational nature and ease of extendability will allow others to build off the model to understand tangential phenomena. This also means that the model can be improved by integrating real hospital data into the model.

Similarly, the use of machine learning methods and GIS may become important when trying to optimize the system. Machine learning may be important to select a strategy that is best suited to reduce release times. GIS could be used to help define spatial constraints in the model. For example, it may be possible to upload a floor plan of the ICU of interest and use image recognition to define spatial constraints.

Agent Based Modeling of this phenomena has several distinct advantages over alternative simulation methods. First, many model paradigms require extensive data collection and can take years to process the health data in a way suitable for simulation. In addition, health data is notorious for being difficult and lengthy to process. Second, other modeling paradigms like monte carlo simulation or discrete event optimization do not allow interested stake holders to gain insight from the model construction itself. Specifically, interested stakeholders have to rely more on the modelers to have correct assumptions. With ABM, the assumptions are clear and up for debate.

The current model to analyze the operational effectiveness of patient release is often judgement based that depends on expert judgement. While timely, expert judgement often comes  feeling and experience rather than a stated assumption. To me, it appears exceedingly clear that Agent Based Modeling will aid in the re-engineering of the patient release workflow.

*Revision History*

*Version 1.0 May 2, 2013*