Using Discrete Event Simulation to predict the need for renal replacement therapy resources

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OBJECTIVES

Barbados, like the rest of the world, has seen a rising burden of patients with End Stage Renal Disease. Healthcare worldwide is struggling with financial limitations, resulting in the 'health care crisis'. Renal Replacement Therapy (RRT) has a significant health economic impact and adds to the already existing 'crisis'. This calls for improved methods to make informed health policy decisions.
The aim is to assess the feasibility of building detailed Discrete Event Simulation models to assess the need for future RRT capacity and improve the efficiency of current RRT services.

METHODS

Discrete Event Simulation is a logical (or mathematical) model of a system where changes occur at separate points in time. Even though most changes related to RRT happen at separate points some changes occur as a continues process as well, hence a more appropriate term describing our model would be as a *mixed continuous-discrete model*[1].
The core of our simulation model is the universal RRT model as originally presented by Davies & Roderick[2]. It basically deals with the flow of patients within what we could call the 'chronic RRT-core'. It admits patients with ESRD onto RRT based on known gross incidences of patients in need of RRT. The model then simulates interaction between the three available modalities (PD, HD, TX*) based on known frequencies on transfer between the modalities. There is by nature only one-way out of the model, namely death. Hence mortality within each of the modalities determines a patient's exit.
The strengths of this model is its simplicity and universality. For example, an intervention resulting in improved survival can be easily entered into the model thereby permitting a mathematical assessment of this intervention.

*The transplant submodel is not included since we do not offer that modality at present

RESULTS

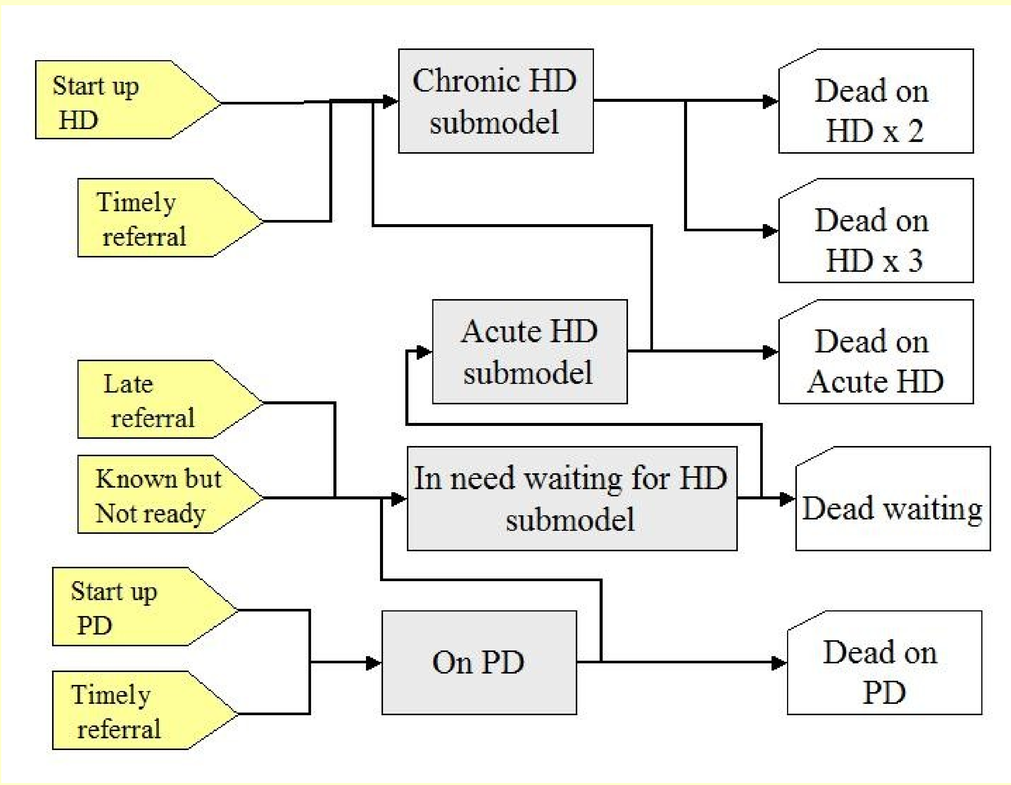
Simulation of the model was performed with 1000 replications of a 5 year period. The simulation reached a steady state with a population on RRT of approximately 300. However it also showed the possibility of peaks where the current resources would not meet demand, as seen by the fact that the average maximum is 20 patients dying while waiting for treatment [see table below].

	Average	Avg min	Avg max	Worse case scenario#
New Patients with ESRD	299.9	196	424	424
Died waiting for HD	3.5	0	20	0
Died first 3 months on HD	83.6	11	138	11
Died on Chronic HD	223.4	136	304	136
Total 5 year gain	-10.6	49	-38	277
Net yearly gain	-2.1	9.8	-7.6	55.4

 # Inversed worse case scenario is incoming maximized, death rate minimized.

With the present number of patients on dialysis and present rate of admissions, the system predicted a larger capacity than perceived by the staff. The capacity was only utilized on average to 80.2 % of its scheduled capacity.

MODEL



The simulation model was implemented using Arena® 12.0 Simulation software

CONCLUSIONS

Discrete Event Simulation of RRT can be a useful tool in helping accessing the optimal amount of resources needed and in testing the effect of planned interventions. We see a huge potential for improving already existing models and thereby their usefulness as policy decision tools.
Organizational and cultural barriers are identified as the major contributors to the non-optimal use of the RRT resource in Barbados.
Our simulation suggests a steady state of patient numbers in this programme which is reflected in our patient statistics[3].
As an added benefit the detailed models can bring applied but non vocalized rules to the surface – hopefully improving the accountability and transparency of our health care systems.

REFERENCES

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3. Mohammed EP. *The Epidemiology of ESRD in Barbados – Where are we now?* Oral presentation CANU, Caribbean Health Research Council 55th Annual Meeting: Trinidad & Tobago, April 2010

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