Panel Sizing in Oncology

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About CHOIR

- [www.CHOIR.utwente.nl](http://www.CHOIR.utwente.nl)
- Centre for Healthcare Operations Improvement and Research
- 6 PhDs in healthcare logistics
- Partnered with 23 health care provider
Outline

1. Background
2. Problem Description / Research Question
3. Panel Sizing Literature
4. Queueing Network Models
5. Numeric Results
6. Questions
Background – Patient Flow Schematic

- Monitoring for relapses is done in community by GP
- Relapsed patient return to same oncologist

New Patient Appointment → Assign FU Scheme → FU Appointment Every month → Cancer is in Remission → Patient Exits

Assign FU Scheme → FU Appointment Every 2nd month → Cancer Relapses (Identified by GP) → Patient Exits

Assign FU Scheme → FU Appointment Every 3rd month → Cancer Relapses (Identified by GP) → Patient Exits

Monitoring for relapses is done in community by GP

Cancer is in Remission → Patient Exits

Relapsed patient return to same oncologist
Background

- Patients only truly exit when they die
- Patients are a “liability” for many years
- A patient discharged today may relapse and return for further consultations in the future
Background – A Single Patient’s Resource Use

Patient PSA and Resource Use Chronology

- Treatment (BCCA)
- Biochemical Relapse
- Palliative Treatment (BCCA)

PSA Value

Radiotherapy Consults

January 2000

Months
Background – Consults for a Single Oncologist

Demand Profile for Patients Diagnosed in 2001

68 New Patients in 2001
Problem Description / Research Question

- How many “New Patients” a year can be treated at the Cancer Centre?

- How many “New Patients” a year can a single oncologist treat? (New oncologists and Established oncologists)

- How many patient should a single oncologist be accountable for?

- Scope
  - We only consider oncologist appointments, not radiotherapy or chemotherapy or other resources
Panel Sizing Literature

- **Size of a General Practitioner’s Practice**
  - How many patients can a GP be accountable for before overtime at the clinic becomes too high?

- Panel Size: The number of patients a GP is Accountable for

- Typical objective is to determine the frequency of overtime for a given panel size and patient mix

- Simplest form, modelled with a binomial distribution

- www.panelsizer.com
Panel Sizing Literature - Example

![Graph showing probability of overtime vs panel size]

- Weekly OT
- Monthly OT
- Biweekly OT

30 Apts / day
p = 0.008
Panel Sizing Literature - Extended to Oncology

- **Multiple patient types**
  - Let $i$ index the different patient types
  - With probability $p_i$ a patient needs an appointment in period $t$

- **Panel Size is a Random Variable**
  - Let $A_i(t)$ be the Panel Size for patients of type $i$

- **Two Appointment types**
  - Let $F_i(t)$ be the Follow-up Appointments in period $t$
  - Let $N_i(t)$ be the New Patient Appointments in period $t$
Panel Sizing in Oncology – General Model Idea

- Use Queueing Models to determine $A_i(t)$
- Use Panel Size Literature to determine clinic performance

Clinic Parameters
- Arrival Rate
- Offered Appointments / month
- Patient mix

Change input to obtain desired performance

QNM → Panel Size $A_i(t)$ → PSM → Clinic Performance

- Waiting Time
- Overtime
Queueing Network Models

- Patients in Active Patient Phase / Queue are $A_i(t)$
- Patients in New Patient Phase / Queue are $N_i(t)$
Queueing Network Models

- **Model 1: New oncologist**
  - Assume no patient backlog / all demand is met
  - Allow a non stationary new patient arrival rate
  - How many new patients within overtime frequency restriction?

- **Model 2: Established oncologist**
  - Finite capacity / Allow backlog
  - Assume a stationary arrival rate
  - How many new patients within waiting time restriction?
Model 1: New oncologist with excess capacity

- Poisson Arrivals with non stationary mean \( \lambda(t) \)
- Infinite Server Queues
Model 1: New oncologist with excess capacity

- Using results from (Massey and Whitt, 1993) for networks of infinite server queues with non stationary arrival rates
- Solve for $E[A_i(t)]$ and we known $A_i(t)$ is Poisson distributed
- From the Panel Size results we know $F_i(t)$ is binomial
- Overtime probability can be approximated by Poisson distribution
- Relate $\lambda(t)$ with $A_i(t)$, $F_i(t)$ and $P_{OT}(t)$
Model 2: Established oncologist with finite capacity

- Multi Class Open Queueing Network
- Limited Servers / Allow backlog
- Stationary arrival rate with mean, $\lambda_i = \lambda p_i$
Model 2: Established oncologist with finite capacity

Use the Approximate Decomposition Method

- Step 1: Aggregate the multiple patient types into a single patient type
- Step 2: Analysis a single patient type OQN
- Step 3: Disaggregate results to obtain patient type specific results

- Relate $\lambda$ with $A_i(t)$, $F_i(t)$ and $E[W]$
Numeric Results

- How many “New Patients” a year can an oncologist treat?
  - Model 1: A New Oncologist
  - Model 2: An Established Oncologist

- Model Parameters:
  - 200 follow-up appointments per month
  - Average waiting time ≤ 0.5 Months
  - Probability of OT ≤ 20%
  - Patient Mix
Find $\lambda$ such that $E[F(t)]=200$ and $E[W] \leq 0.5$

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<th>$\lambda$</th>
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<td>224</td>
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</table>

$\lambda = 6.1$
Numeric Results – Model 2: An Established Oncologist

- **Observations**
  - Offering a few extra appointments gives big waiting time gains
  - Accepting one extra new patient per month causes much longer waiting times

- **Incorporating new patient appointments**
  - 1 new patient appointments = 3 follow-up appointments
  - At steady state: $E[F(t)] + 3*E[N(t)] = 218.3$
### Numeric Results - Model 1: A New Oncologist

**Scenario 1:** No Front loading

- $\lambda(t) = 6.1$ for all $t$

**Scenario 2:** Maximize Front Loading

- Max $\sum \lambda(t)$
- Subject to:
  - $E[F(t)] + 3E[N(t)] \leq 218.3$ for all $t$
  - $6.1 \leq \lambda(t) \leq 30$ for all $t$
  - $P_{OT}(t) \leq 0.2$ for all $t$ where $\lambda(t) > 6.1$

- How can we overload the early years so steady state can be reached more quickly?

- Constrained by $P_{OT}(t) \leq 20\%$, available patients and waiting time (via steady state result)
Numeric Results - Model 1: A New Oncologist

- Scenario 1: No Front loading \((\lambda(t) = 6.1 \text{ for all } t)\)

\[
E[F(t)] + 3E[N(t)]
\]

\(\approx 14 \text{ years and only halfway to steady state}\)
Numeric Results - Model 1: A New Oncologist

- Scenario 2: Maximize Front Loading*

\[ E[F(t)] + 3E[N(t)] \]

\[ \text{Time (Months)} \]

\[ \text{Established Oncologist} \]

\[ P_{OT}(t) ≈ 20\% \]

*May not be optimal
Numeric Results – Further Study

What policy changes are possible?
- Discharging patients more quickly
- Seeing patients less often
- Different patient mix during transient

Clinic Parameters
- Arrival Rate
- Offered Appointments / month
- Patient mix

Panel Size $A_i(t)$

QNM

PSM

Clinic Performance
- Waiting Time
- Overtime

Change input to obtain desired performance

UNIVERSITY OF TWENTE.
Questions

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