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Modelling A&E process times using Queuing Theory

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Introduction

- The presentation is in two parts:
  - Is it possible to model A&E waiting times using queuing theory?
  - Are Government targets for A&E waiting times being distorted?

Modelling

- The waiting time for a patient in A&E should be easily modelled using a queue
  - The patient arrives
  - The patient waits for the treatment to become available
  - The patient is treated (processed)
  - The patient either leaves the system entirely or joins another queue for further treatment

Modelling

- However, there are two problems with creating these queues
- Firstly there are many paths that a patient can take through A&E treatment and each would need to be specified
- It is also hard to determine what is a ‘process’ and what is ‘waiting’ i.e. when does one process actually end and another begin?

Modelling

- Secondly, we have the problem in getting data
  - Times that patients arrive
  - The treatment path they take
  - Times that they wait
  - Numbers of various medical staff on duty at different times
  - Process times for various treatments
- Modelling at this micro level is therefore very difficult and also highly unstable

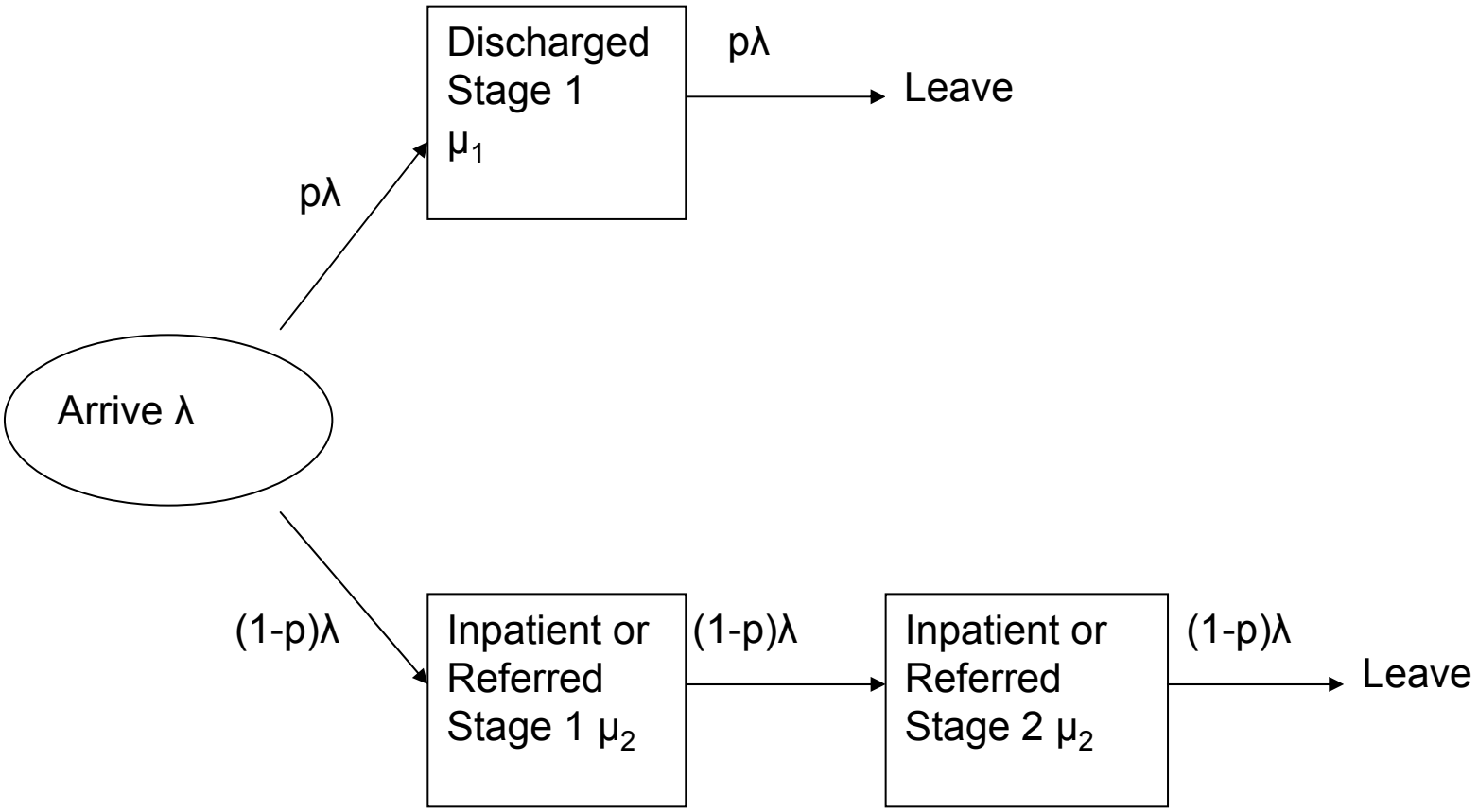
Macro Modelling

- It is far easier to look at a macro level and be concerned only with how long the patient spends in A&E
- These waiting times are used for Government targets so are recorded (unlike some of the other data we saw on the previous slide)
- We can therefore look at how a simple queue can try to model these times

Very simple model

- One way of dividing up patients is those that become in-patients and those who are discharged
- We would assume that those who are discharged would have a shorter stay in A&E
- A very simple model could therefore have two treatment paths where the definition of treatment is left open

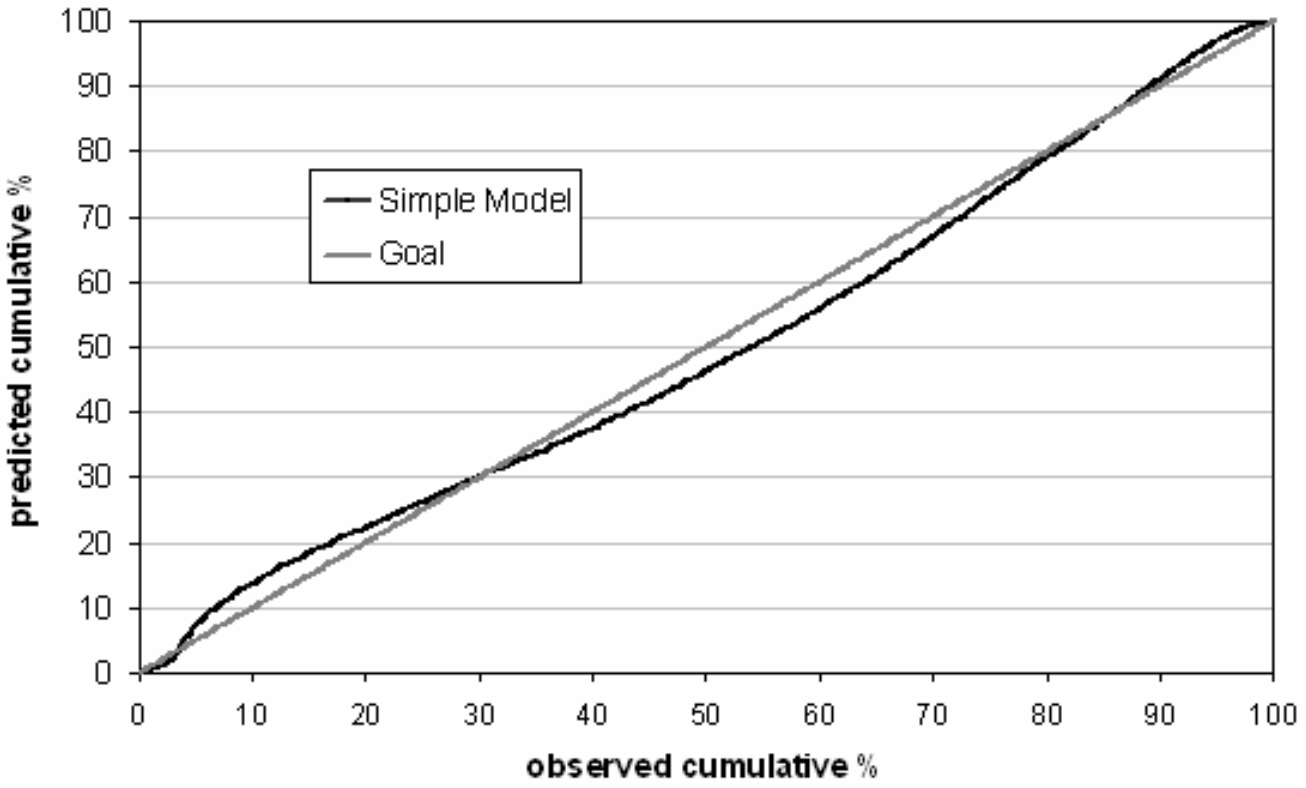
Very simple model



Very simple model

- The proportion of patients between these paths is 60% discharged and 40% referred in the model
- This is very close to the data observed
- The actual process rates were then fitted statistically and the implied completion times checked for reasonableness
- Even though this is a very simple model the fit roughly captures the distribution of completion times

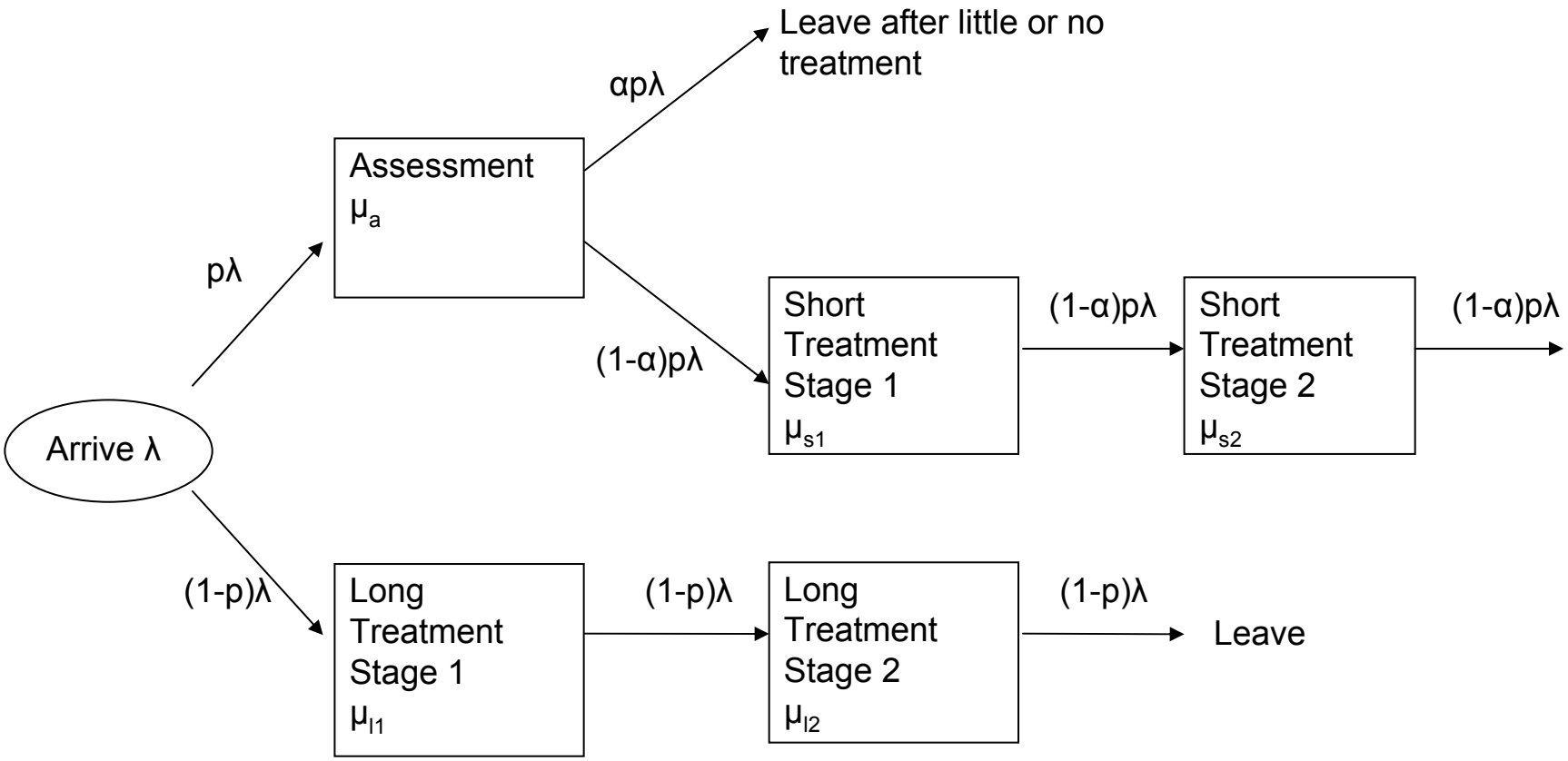
Fit of simple model



Initial Model

- We actually developed four other models of increasing complexity
- The paths created were based on the shape of the data that needed to be fitted
- However, all additions to the paths had to be justifiable in how patients are processed through A&E
- The final ‘initial’ model was thus:

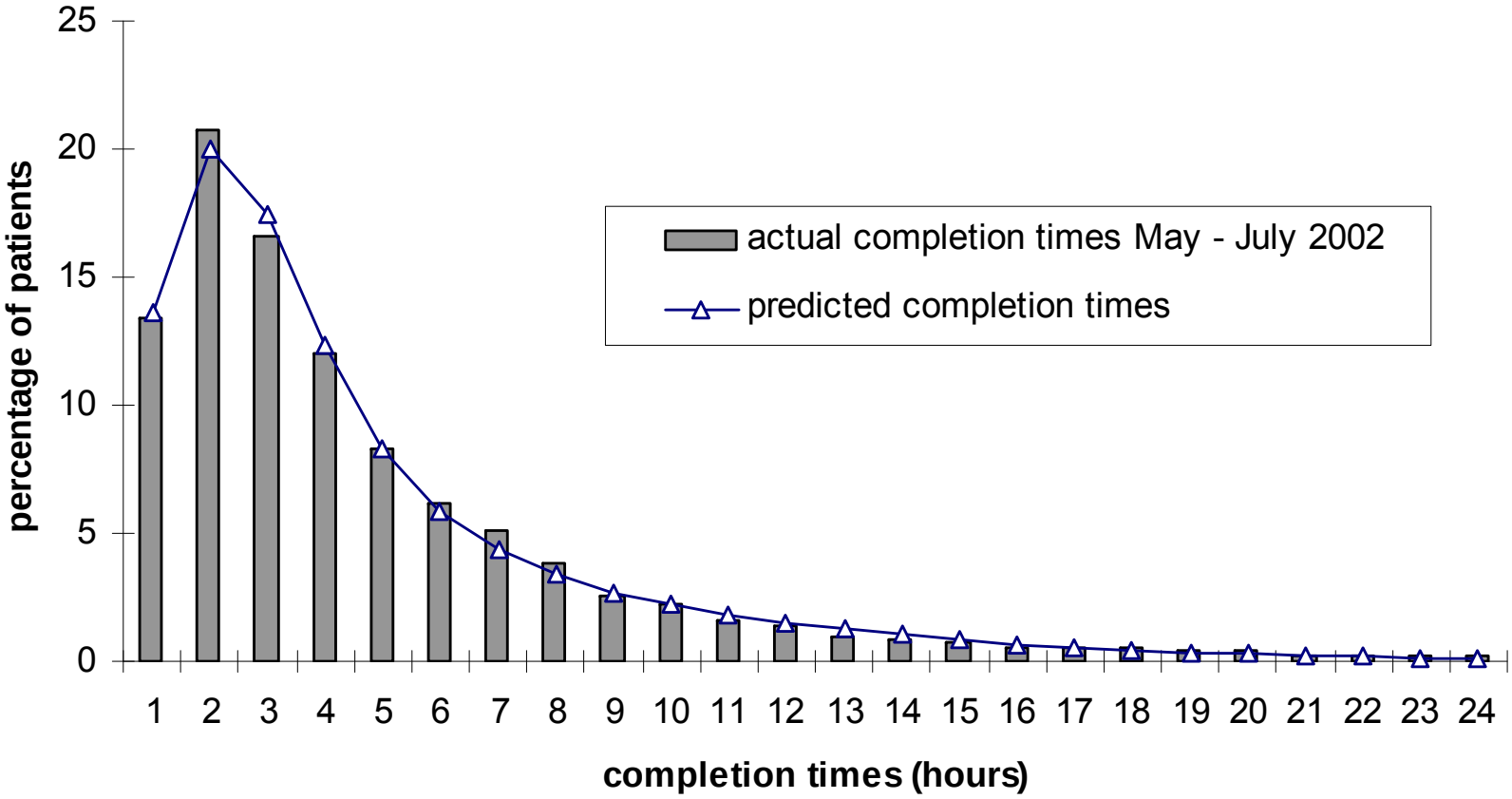
Initial Model



Initial Model

- The main changes are
  - The ‘discharged’ and ‘inpatient’ paths have been changed to ‘short treatment’ and ‘long treatment’
    - Strong correlation between the two but some minor ailments can take a long time to process
  - An assessment stage for short treatment which is similar to ‘triage’
  - Process rates for the different stages are now independent

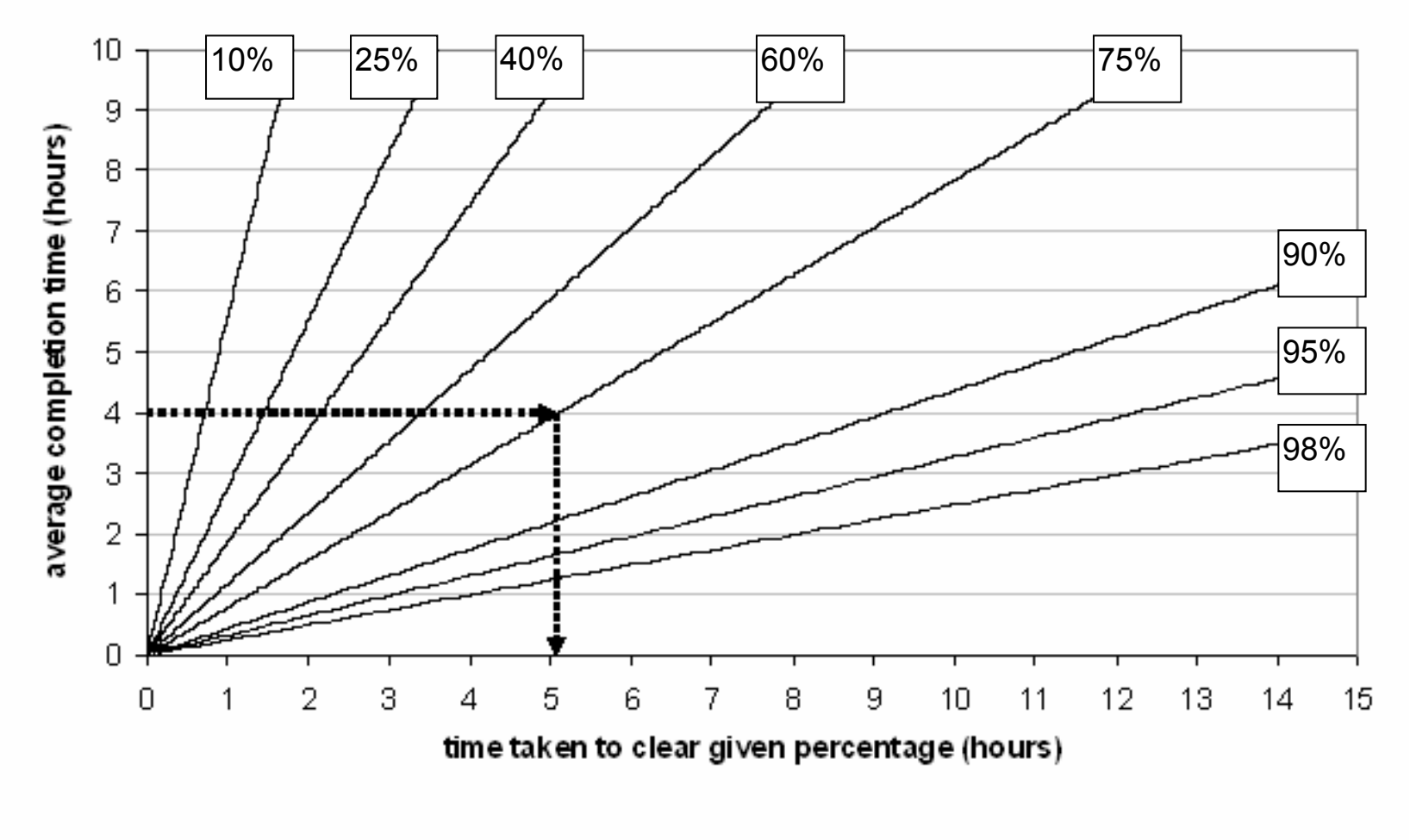
Fit of initial model to observed data



Government Targets

- The targets set by the Government are usually based on clearing a certain percentage of patients within a certain time limit
- We can relate the time taken to clear a certain percentage of patients with the average completion time by using a ‘ready reckoner’
- This is simply a plot of certain percentiles by the average completion time

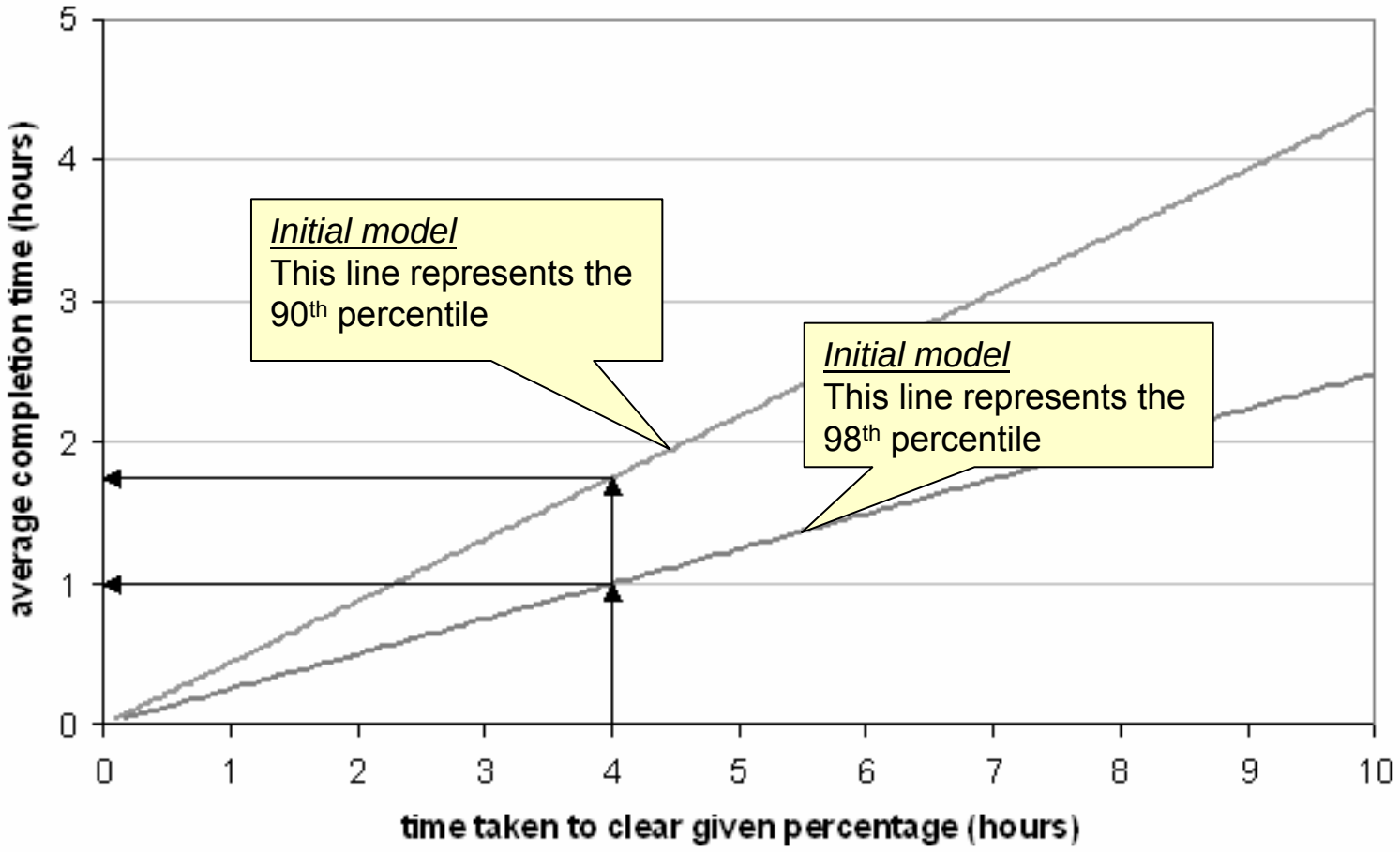
Ready reckoner for initial model



Government Targets

- The targets set by the Government are getting harder to complete
- In March 2003, 90% of patients had to be cleared within 4 hours
- The current target is 98% of patients have to be cleared within 4 hours
- Before the targets were brought in the average completion time was over 3 hours

Required average completion times of the Government targets



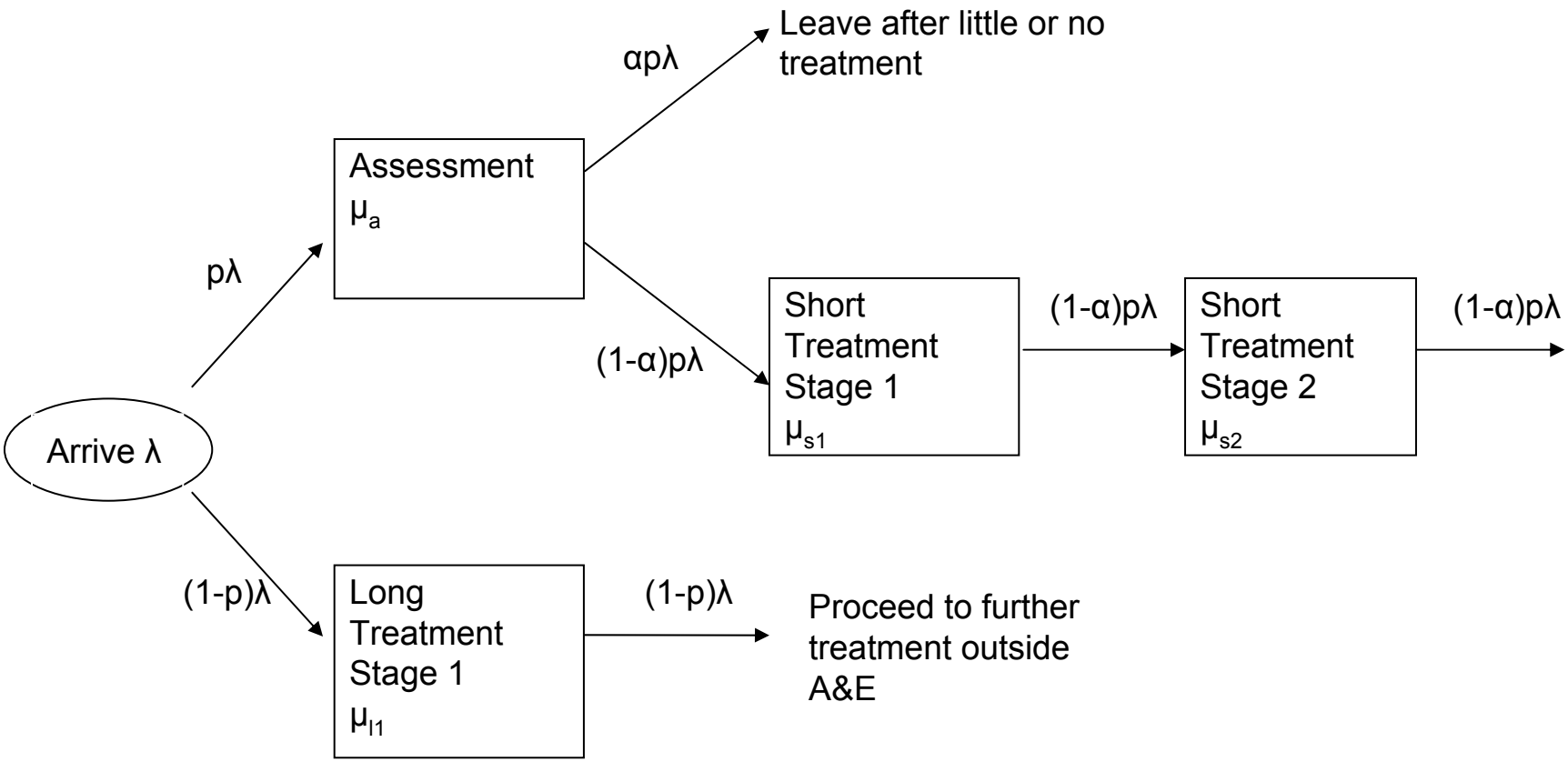
Change in definitions?

- One way to help meet targets is to re-designate a patient
- It is certainly justified in many cases to say that someone receives treatment in A&E and then completes their treatment elsewhere
- The completion time should then be when they are deemed to have left A&E
- Of course, labels can change even if this is inappropriate...

Change in definitions?

- The easiest way to model this is to change the ‘long treatment’ path by removing the second stage of treatment i.e. this stage is seen to be outside of A&E

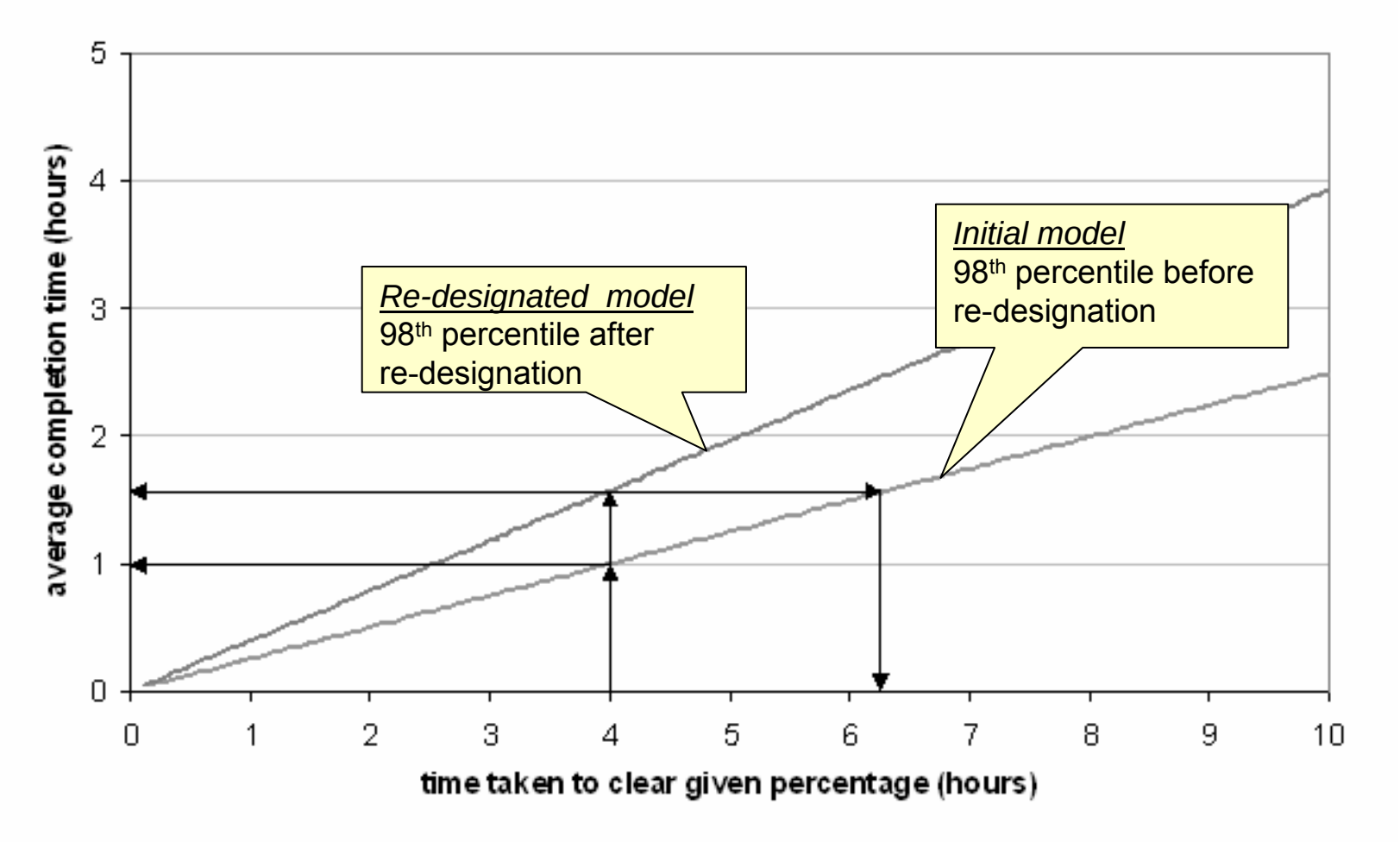
Re-designated model



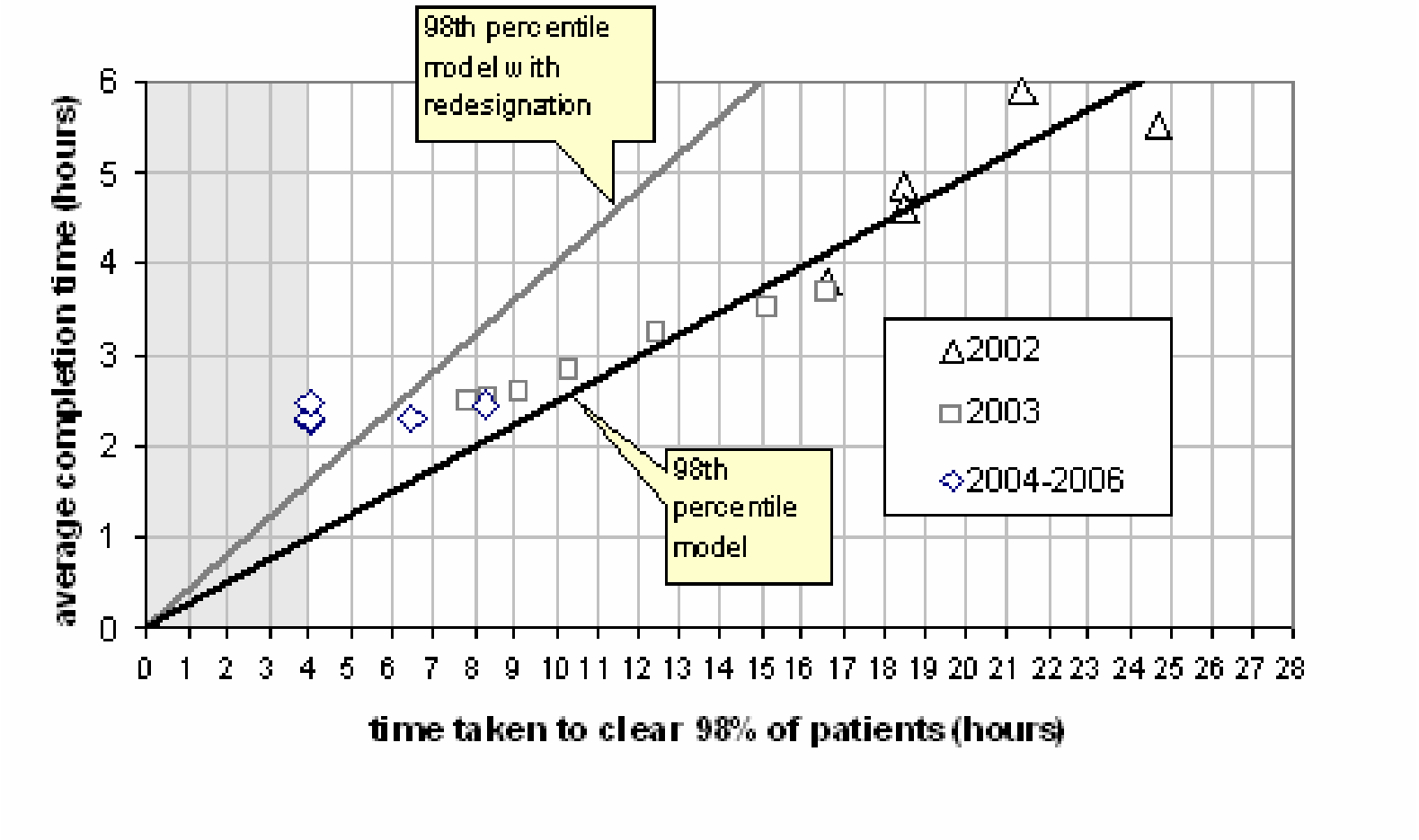
Change in average completion times

- The change in implied average completion times can be seen by comparing the ready reckoners for the two models for the 98th percentile
- This change in definition has the affect of substantially reducing the change in the real required average completion time from that needed to clear 90% of patients

98th Percentile for the two models



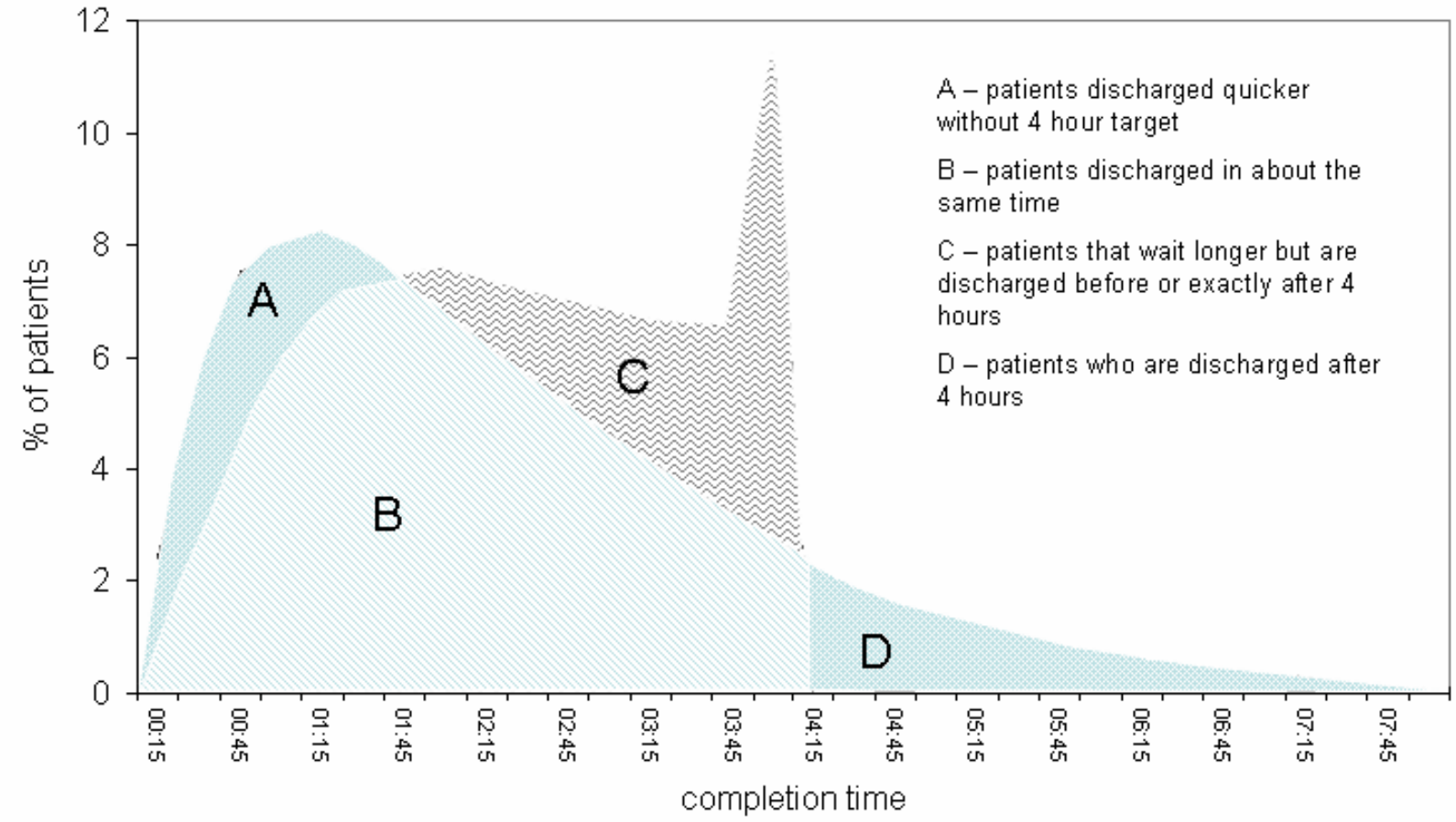
The effect of re-designation?



The effect of re-designation?

- As can be seen from the graph the data from 2002 to mid 2003 follows the initial model.
- However, from mid 2003 the time taken to process 98% of patients continues to fall while the average completion time doesn't change (in some months it is higher)

The effect of re-designation?



The effect of re-designation?

- The proceeding graph shows how much the distribution has changed
- It would appear that patients with small treatments are taking longer to be processed which could be due to resources being allocated to the 'problem' patients
- However, the new peak of completing patients just before the deadline does appear to be slightly strange

Conclusions

- The initial model, while simple, appears to have been able to model the observed monthly processing times of patients reasonably well until 2003
- With the new targets though the distribution of completion times has become very distorted
- It is unlikely that this distribution would have occurred if patients are still labelled in the original way