A case study of implementing simulation results in emergency stroke care

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Talk Overview

- Implementation of simulation results – any evidence?
- Background to the simulation study
- Overview of the model
- Timeline of implementation
- Empirical evaluation of system changes
- Evaluation conclusions

Implementation of simulation results

This talk describes the implementation and evaluation of changes to a stroke emergency pathway following a simulation study.

What do I mean by implementation?

- **Concrete**: direct changes to the real system
- **Abstract**: learning or moving a debate forward

Implementation – the evidence

- There are lots of published case studies of simulation models
- Not many consider if results were implemented
- I don't believe this is limited to one domain, but it has been particularly well documented in healthcare by five systematic reviews between 1999 and 2011.

"we were unable to reach any conclusions on the value of modelling in health care because the evidence of implementation was so scant" Fone et al. 2003

Why is the evidence missing?

Brailsford and Vissers (2011)

- Tension between what is seen as consultancy and research
- Different timelines for implementation and academic publication

Tako, Kotiadis and Vasilakis (2010)

- Lack of stakeholder involvement in key modeling stages
- Particularly conceptual modeling

Background to the simulation study

Context: acute stroke

The rapid loss of brain function due to a disruption in the blood supply to the brain

- Ischemic stroke (80%): lack of blood flow due to a blockage
- Hemorrhagic stroke: a bleed within the brain

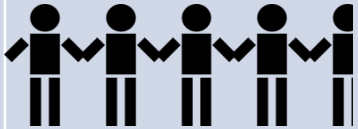
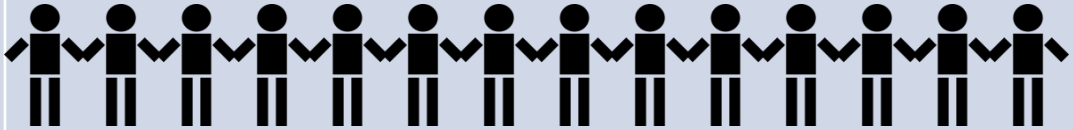
Consequences of stroke

- There are around 110,000 strokes in England per year
- One quarter of patients with stroke are dead within one month, one third by six months and one half by a year (Churlov and Donnan, 2012)
- Stroke accounts 9% of all deaths worldwide (12% in western countries)
- Many surviving patients are severely disabled

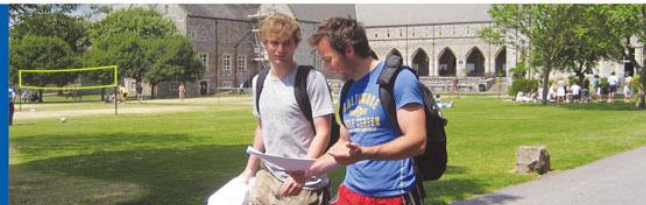
Treatment for acute ischemic stroke

- The only treatment for ischemic stroke is thrombolysis
- A clot busting drug called alteplase (recombinant tissue plasminogen activator)
- Treatment is critically time dependent (time is brain)
- Risk of symptomatic intracerebral haemorrhage (4%–7%)
- It must be administered a short period from onset or the risks begin to outweigh the benefits

Time dependent effectiveness

Treatment time	Treat to get one attributable mRS 0-1
0-90 mins	
91-180 mins	
181-270 mins	

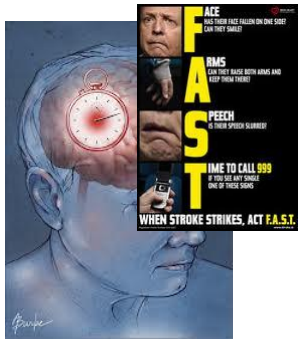
- Research has largely focussed on extension of eligibility criteria;
- Our focus: analysis of the impact of reducing in-hospital delays;

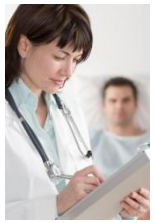


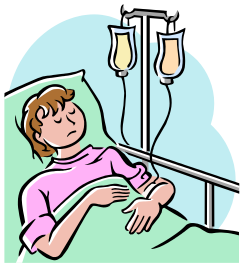
Thrombolysis: high level pathway

Arrival to treatment time (ATT)

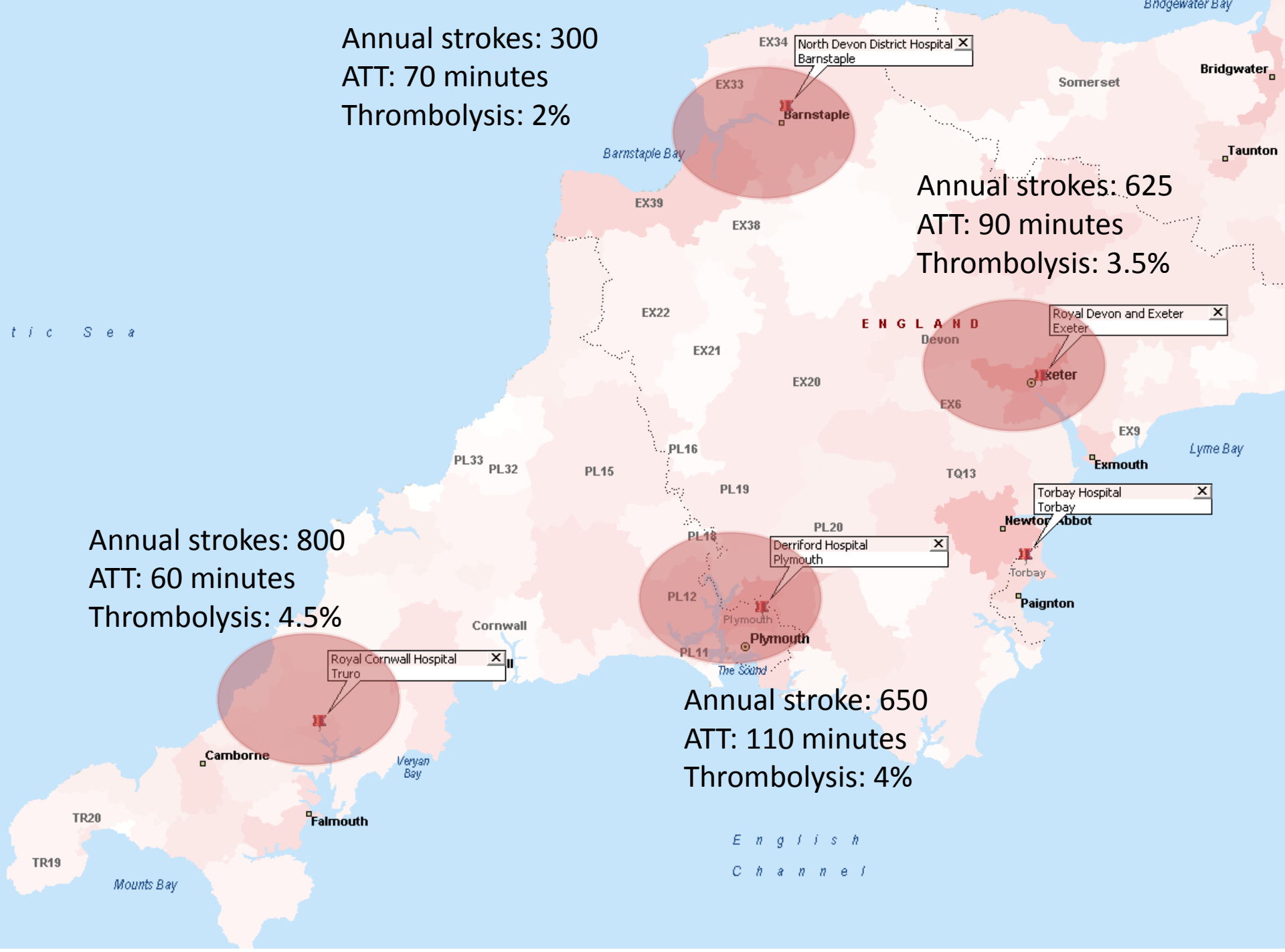
Onset → 999 call → Pre-hospital care → CT Scan → Eligibility?







Treatment


Annual strokes: 300
ATT: 70 minutes
Thrombolysis: 2%
North Devon District Hospital
Barnstaple
Barnstaple
Annual strokes: 625
ATT: 90 minutes
Thrombolysis: 3.5%
Royal Devon and Exeter
Exeter
Exeter
Annual strokes: 800
ATT: 60 minutes
Thrombolysis: 4.5%
Royal Cornwall Hospital
Truro
Annual stroke: 650
ATT: 110 minutes
Thrombolysis: 4%
Derriford Hospital
Plymouth
Plymouth
Torbay Hospital
Torbay
Torbay
Bridgwater
Somerset
Taunton
Exmouth
Paignton
Newton Abbot
Camborne
Falmouth
Cornwall
Devon
ENGLAND
Barnstaple Bay
Bridgwater Bay
Lyme Bay
Veryan Bay
Mounts Bay
The Sound
English Channel
EX34
EX33
EX39
EX38
EX22
EX21
EX20
EX6
EX9
PL33
PL32
PL15
PL16
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TQ13
TR20
TR19

The simulation project

1. What is the expected impact on the thrombolysis rate by extending the alteplase window from 3 to 4.5 hours from onset?
2. What is the clinical benefit of reducing in-hospital delays to treatment compared to extending the alteplase time window?
3. What in-hospital process changes are most effective in improving thrombolysis rates and reducing post-stroke disability?
4. Are the modelled benefits realised once implemented in the hospital?
5. Did the simulation project help implementation as expected?

Our assumptions about implementation

1. Involving the acute stroke team and emergency department in conceptual modelling will aid the uptake of recommendations

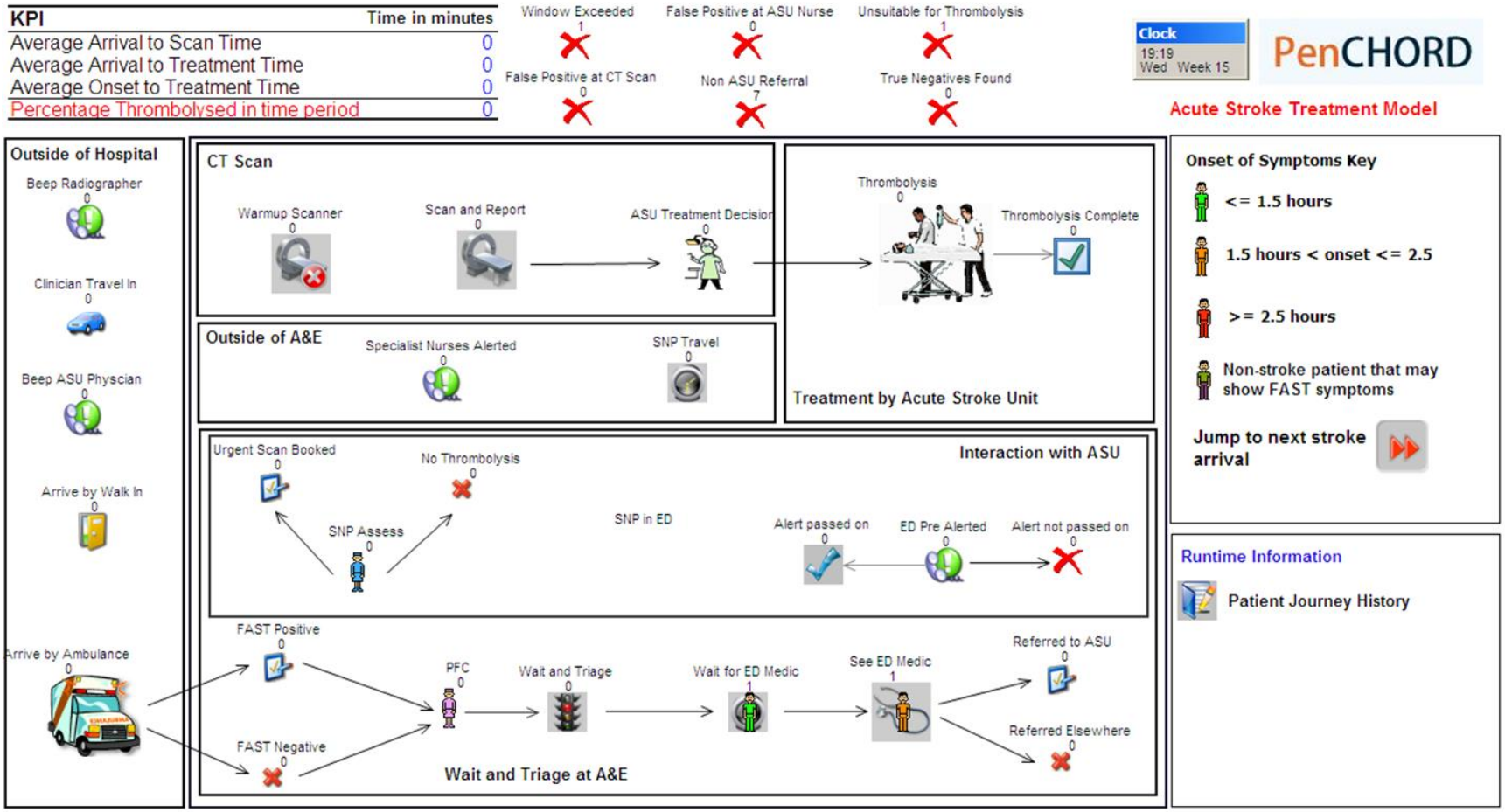
2. The use of VIS within DES engages problem stakeholders and increases the transparency of a model

3. Modelling provides structure in a debate between stakeholders with competing interests

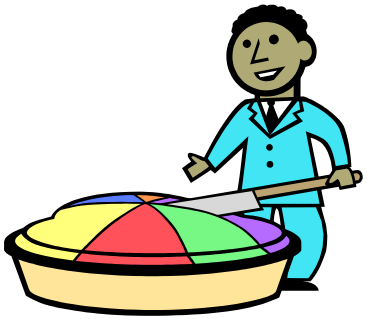
Quick overview of the model

Monks T, Pitt M, Stein K and James M.A. **Maximizing the Population Benefit from Thrombolysis in Acute Ischemic Stroke: A Modeling Study of In-Hospital Delays**. Stroke 2012; 43(10).

Methods: Discrete-event simulation



Key model outputs



Percentage of patients thrombolysed

Patients with minimal disability due to treatment

Urgent radiology workload (queue jumpers)

Key model inputs

Paramedic phone ahead (pre-alert) rate

ED triage referral rate

Thrombolysis contra-indication rate
(other than time and age)

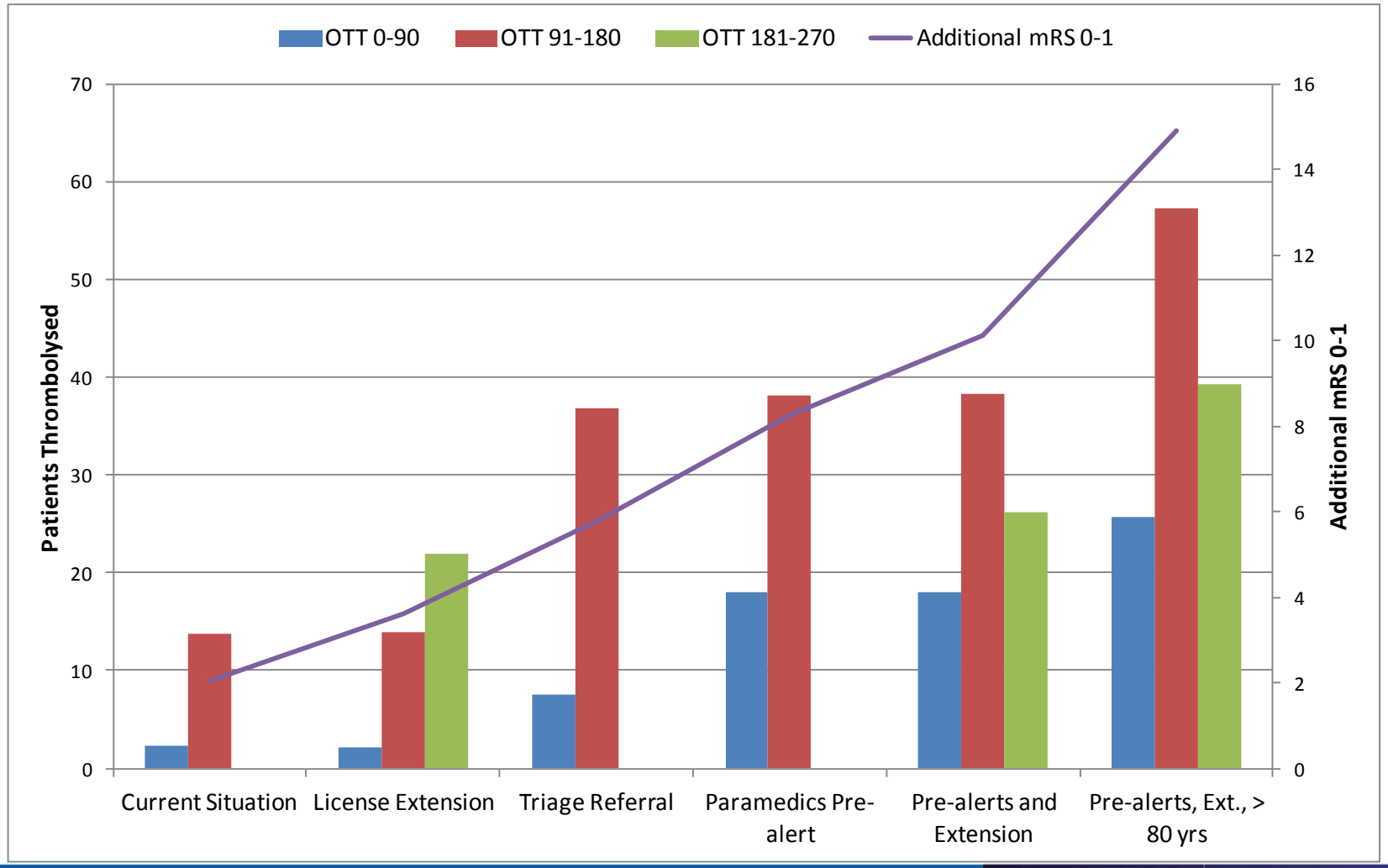
Key model simplifications

Process times independent from time remaining

Pitt, M., Monks, T., Agarwal, P., Worthington, D., Ford, G. A., Lees, K. R., Stein, K., & James, M. A. (2012). **Will Delays in Treatment Jeopardize the Population Benefit From Extending the Time Window for Stroke Thrombolysis?** Stroke, 43, 2992-2997.

ED queuing modelled as time delays

Results presented as scenarios



Model uncertainty (4.5 hr license)

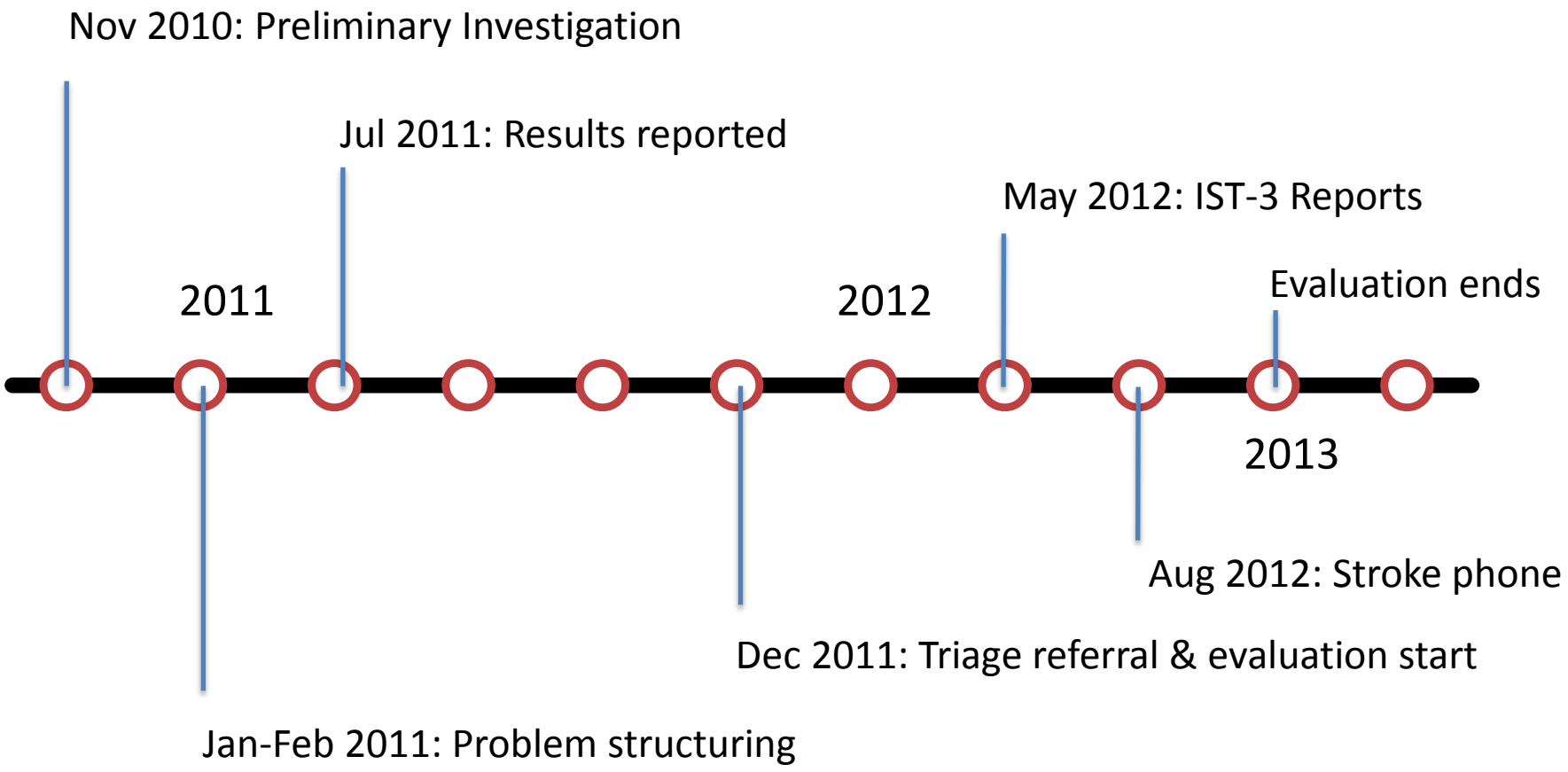
Input	Low	High
Paramedic Pre-alerts	15%	85%
Triage referrals	15%	85%
Wake-up contra-indications	Base	Base + 40%

Output	Lower bound	Upper bound
Thrombolysis rate	8%	14%
ATT	65	110
mRS 0-1	4	11

Significant interactions between pre-alert and triage referral rates.

Project timeline and narrative

Timeline of project and implementation



Preliminary Investigation (Nov 2010)

- Meeting: medical school academics, head of the emergency department (ED) and head of acute stroke team (AST)
- Quick analysis: patients potentially eligible for thrombolysis take an average of 60 minutes to be scanned.
- Head of ED led process mapping
- A possible solution was recognised as referring FAST positive patients directly to the AST as they are triaged.
- Agreement: AST would lead investigation with modeling support

Problem structuring (Jan-Feb 2011)

- Process mapping meetings with the AST (nurses and physicians)
- It became obvious that ambulance paramedics could help
- Paramedics could send a pre-alert of imminent FAST positive arrivals so resources could be in place asap
- ***Implementation***: who should be pre-alerted ED or AST?
- ***Persuasion***: included patient disability as a model output
- ***Persuasion***: included urgent scanning workload for radiology

Use of VIS (Mar-Jun 2011)

- We spent a lot of time developing the model so that it was very clear what was happening in it
- VIS was mainly used as a face validation tool with AST
- We did use it to demonstrate (VIE) the impact of early alerting on individual patients; although the AST already bought into it!
- VIS proved a powerful tool for talking to other trusts (later)

Results: reaction of ambulance trust (Sept 2011)

- Final results were disseminated to the amb trust in Sept 2011.
- The ambulance trust response was very positive!
- In particular, they commented that it was rare to get feedback on what they as paramedics could do to aid patient outcomes
- They asked us to conduct a similar project with them on pre-hospital delays
- They were keen to implement a pre-alert system in Exeter and elsewhere.

Reaction of ED (Nov 2011)

- It took five months to organise a meeting with ED;
- Presentation given by the AST lead with modeller support
- A group of ED consultant's were not interested in the operational logic of our model -> more the clinical assumptions
- This group did not believe the effectiveness data for thrombolysis and believed the risks outweighed the benefits
- We did not model the risks because overall death rates are the same in treated and untreated patients.

Reaction of ED (Nov 2011)

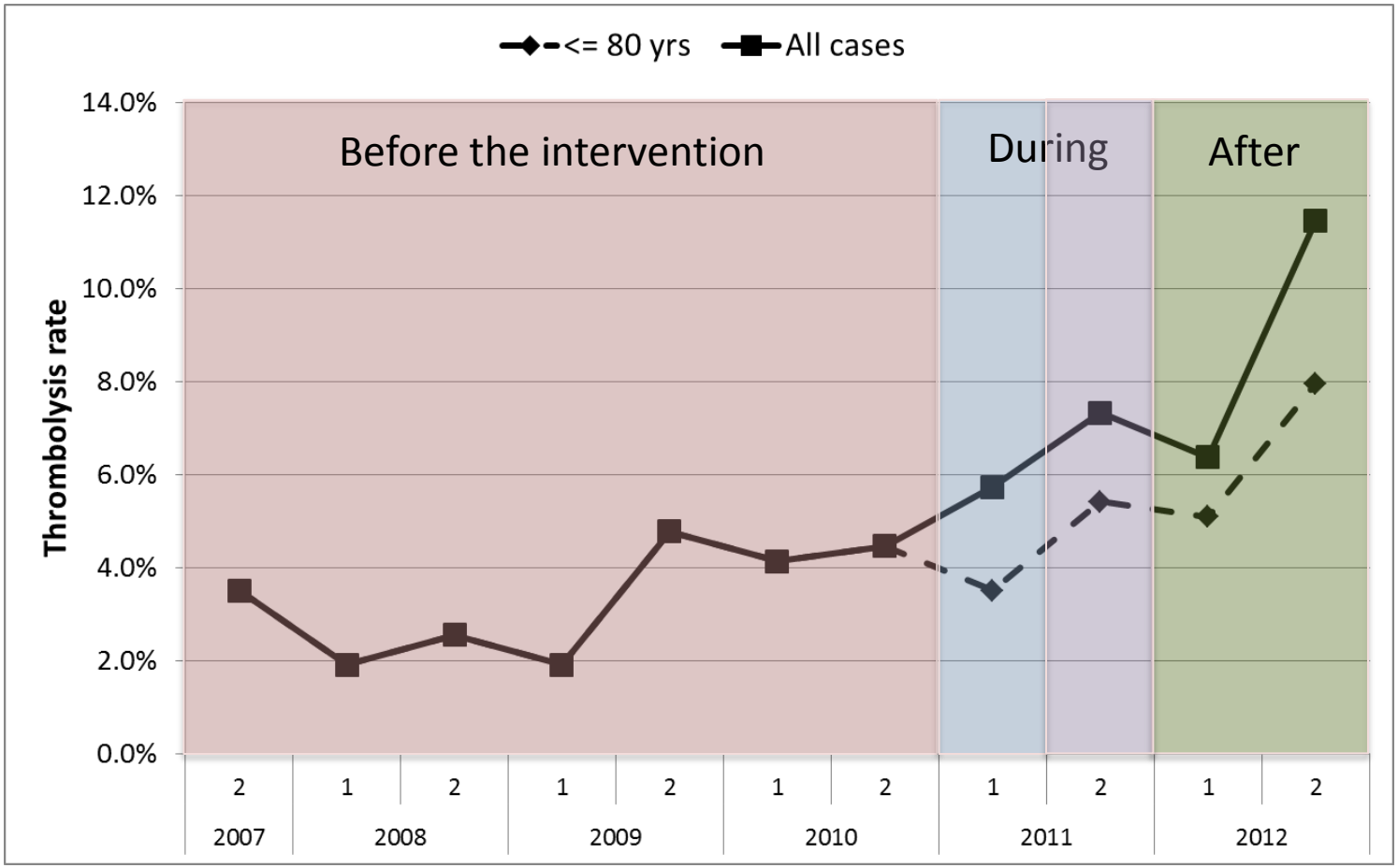
- The consultants were much more casual about process changes
  - They suggested pre-alerts should go to the AST
  - They were not concerned about overloading radiology
- Grateful for being consulted in such a manner.
  - “The usual approach is to receive an e-mail demand”
- The decision was left with the ED consultants to debate.

Implementation events

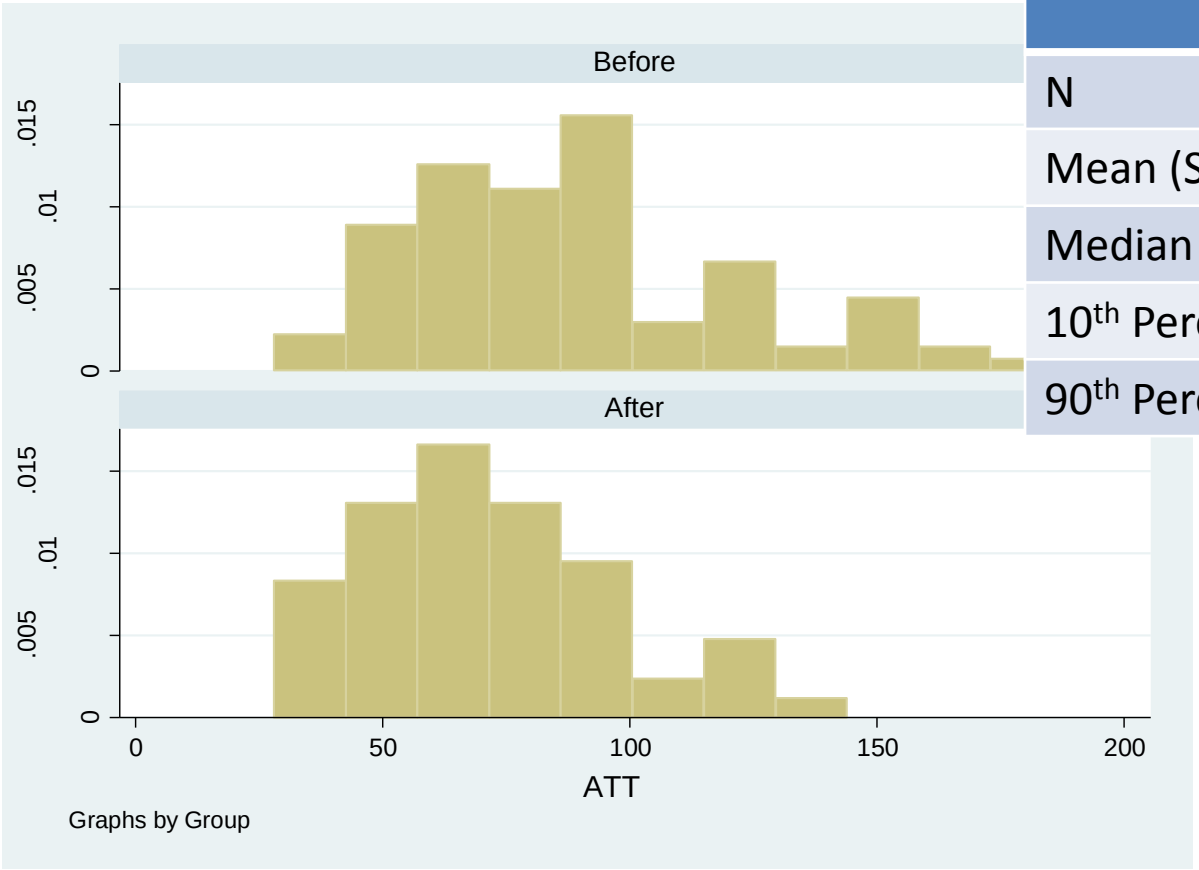
- FAST positive patients referred at triage (Dec 2011)
- Stroke phone protocol (Aug 2012)
- We ran four similar projects with different trusts during this time

Did the changes work?

Did the changes work?

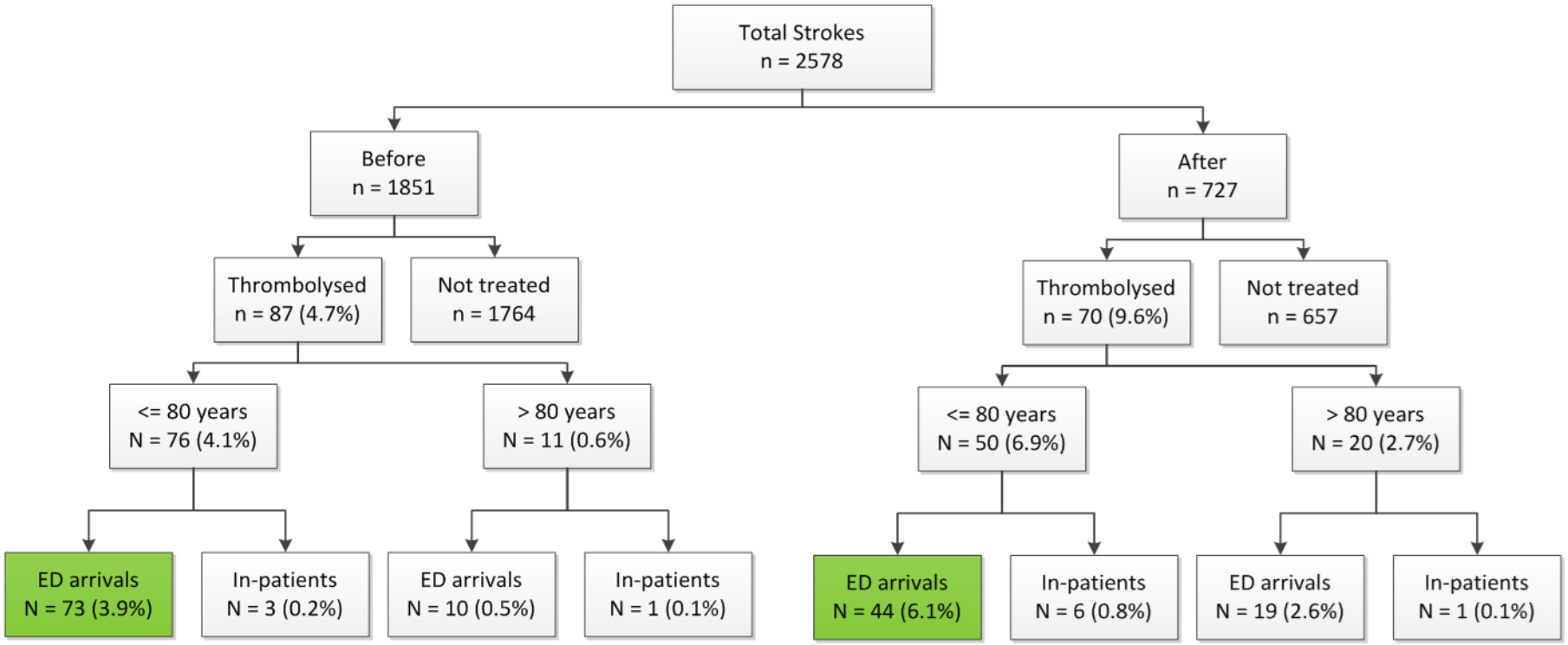


Are patients treated quicker?



	Before	After
N	93	58
Mean (SD)	90 (35)	71 (25)
Median (IQR)	85 (46)	70 (35)
10th Percentile	52	51
90th Percentile	145	105

Is there strong evidence of more thrombolysis?



Overall difference: 2.2% (95% CI 0.3-4.1%)

Difference after implementation phase two: 4%

Compliance to protocol (pre-alert rates)

- Pre-alerts didn't really kick in until Sept 2012.

Compliance After Sept 2012	N (%)	95% CI
Paramedic	52 (30%)	22-38%
ED Triage	15 (11%)	4-16%

- The figures are corrected for the average FAST sensitivity

Discussion: Our assumptions about the intervention

Stakeholder involvement

- AST and ED involved in conceptual modeling.
- ED not involved enough? Involved the wrong consultant?
- We struggled to have credibility with one group
- Decision was difficult for ED
- (My experience elsewhere suggests it is difficult even with lots of involvement throughout)

Discussion: Our assumptions about the intervention

Visual Interactive Simulation

- I have no evidence that it increased engagement
- Stakeholders were much more excited about charts of results
- Very useful for checking the process logic with nurses
- It proved very useful for engaging other trusts who were keen to improve their own thrombolysis rates.
- Less engaging due to relatively low volume of entities?

Discussion: Our assumptions about the intervention

Models help structure debates about change

- Most relevant to the discussion with ED.
- Focus on the validity of assumptions
- Encouraged expression of concerns about thrombolysis
- Uncovered the source of these concerns
- Model logic was discussed in view of implementation.

Conclusions

- Study provides some quantitative evidence of the (modest) impact of simulation in healthcare
- Unpacks our assumptions about how a modeling intervention would lead to system change
- **Involvement**: selection of participants not straightforward.
- **VIS**: Not as effective as expected, but useful for spin-offs
- **Debate:** Evidence that it helped, but not in the manner we expected!

Thanks for listening

Any questions?

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