National Institute of Health and Care Excellence

Consultation

Chapter 41 Cost-effectiveness analyses

Emergency and acute medical care in over 16s: service delivery and organisation

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Chapter 41 Cost-effectiveness analyses

Contents

41 Cost-effectiveness analyses

41.1 Introduction

The health economic work within the guideline was undertaken in a systematic approach. Prioritised areas were analysed with increasingly complex and detailed methods in accordance with the added value such methods would bring to decision making and recommendations (taking into account data availability, number of assumptions required and so on). Where there was a clear consensus on the likelihood of cost effectiveness at any given stage of the modelling work up for a question, no further analytical economic work was undertaken.

Step 1: review of published economic evaluations. The reviews can be found in the relevant topic-specific chapters. A generic protocol was used across all topics – see Appendix A. A single flow chart was produced for the guideline's economic evaluation review – see Appendix B.

Step 2: presentation of unit costs associated with the intervention and/or downstream resource use impact (for questions where there are no published economic evaluations). These unit costs and can be found in Appendix I:.

Step 3: costing analyses based on the guideline's systematic review, including downstream resource impact. Description of costing analyses and discussion of findings can be found in the relevant chapters. They were undertaken for the topics of:

- Multi-disciplinary hospital teams (Chapter 29).
- Standardised systems for -hospital transfer (Chapter 34).

Step 4: Cost-utility analyses based on the guideline's systematic review. Cost utility analyses were conducted for the following topics:

- Timing of consultant review (Chapter 19)
  - Rapid Assessment and Treatment (RAT) in the Emergency Department (ED)
  - Extended hours for consultants in the Acute Medical Unit (AMU).
- Frequency of consultant review (Chapter 26)
  - Daily consultant review on medical wards
- Extended access to therapy (Chapter 31)
  - in the ED
  - on medical wards.

Whilst steps 1-4 allow for evaluation of the cost effectiveness of the interventions in isolation, the methods do not allow for consideration of the performance of individual service interventions within a dynamic system, where relationships and interactions of interventions within a complete pathway can be explored. Therefore, a final step is being undertaken.

Step 5: development of a hospital simulation model

Parameter inputs include those used within steps 1-4 where appropriate, alongside findings of the weekend admission (Appendix C) and medical outlier (Appendix D) reviews specifically conducted to inform the model. Further data was sourced via a district general hospital to take into account epidemiology, flow and capacity modelling of a hospital. The simulation model is being developed to explore:

- the relative importance of the interventions covered in step 4 in terms of their cost and quality-adjusted life-year (QALY) impact
- additional factors (such as medical outliers and delayed discharge).

The model seeks to capture hourly, daily, weekly and seasonal fluctuations. It evaluates waiting time in ED and the number of medical outliers and their consequences.

This report focuses on Steps 4 and 5. Methods and inputs that are common to both are reported in 41.2. Methods specific to the cohort model and simulation model are reported in sections 41.3 and 41.4 respectively. These are followed by the results of the cohort model and discussion. The simulation model is still in development and therefore we present only methods. The results will be added on completion, after stakeholder consultation.

41.1.1 Health economics sub-group

The modelling was conducted by the health economists of the guideline technical team and was directed by a subgroup of the full guideline committee comprised of volunteers. It comprised of experts in acute medicine, emergency medicine, paramedics, intensive care medicine, psychiatry and hospital clinical management. The full committee were consulted on all methods.

41.2 General methods

41.2.1 Model overview

41.2.1.1 Comparators & population

The guideline population is adults (age≥18) who have had an acute medical emergency (AME). It therefore exclude paediatric patients, maternity, trauma, surgery and people attending health services for non-urgent care. Our models focus primarily on interventions that occur in hospital to improve the flow of patients and patient outcomes:

1. RAT in the ED
2. Extended hours for consultants in AMU
3. Daily consultant review on medical wards
4. Extended access to therapy on wards
5. Extended access to therapy in the ED.

For 1 and 5 the population is people attending ED. For 2, its patients admitted to the AMU and for the others it is patients on medical wards (other than AMU).

The simulation model includes non-AME patients passing through the adult ED but the pathway for these patients is not specifically modelled after they have been processed by the ED.

41.2.1.2 Conceptual model

The health economics subgroup of the committee discussed the requirements of a simulation of a hospital that could evaluate costs, QALYs and explore the variation of performance over time.

Generally, the models were designed on the basis that

- Workload and case-mix (age and NEWS) is determined by season and day of the week and hour of the day. NEWS (National Early Warning Score) is a measure of acuity that uses 7 physiological parameters to determine a score ranging from 0 (low acuity) to 7 or more (critically ill).
- Case-mix (age and NEWS) determines baseline mortality, movements between locations and length of stay.
- Case-mix (age and CFS) determine average long-term survival and average utility. The Clinical Frailty Scale (CFS) uses a descriptive chart illustrating activity level. The scale ranges from 1 (very fit) to 9 (terminally ill).

- Age, NEWS and CFS are correlated.
- Interventions can affect many different outcomes:
    - length of stay which is influenced by clinical need, timely diagnosis, timely access to beds and specialist staff.
    - In-hospital mortality – sometimes a reduction in mortality is a real effect leading to substantial QALYS gained but sometimes patients will be discharged earlier so that they can die in a more preferable location.
    - Intensive care referral – we consider this an indicator of adverse events, other adverse events are captured by mortality and length of stay.
    - Medical outlying – an indicator of suboptimal care, associated with risk of death, adverse event and increased length of stay.
    - Queuing in ED – an indicator of the hospital being under stress and sub-optimal care.

Typical hospital pre-admission locations:

- Emergency Department (ED).
- Ambulatory Acute Medical Unit (AAMU)– acute medicine experts provides outpatient care for AME patients during daytime.
- Clinical Decision Unit (CDU) – short stay wards provided by emergency medicine experts. Although these are technically admissions, we have made a distinction, since they are part of the emergency pathway rather than medical pathway and in the hospital data sourced, these patients were not recorded on VitalPAC, which computes NEWS.

Typical hospital admission pathways/ locations:

- Acute Medical Unit (AMU) – where undifferentiated AME patients are assessed and managed usually for up to 48 hours.
- General medical wards (GMW) – provide level 1 care to medical patients, includes specialist wards such as gastroenterology, care of the elderly.
- Intensive care unit / high dependency unit (ICU/HDU) – the intensive medicine department providing level 2 and level 3 care.
- Specialist high care units (HCU) – level 2 care such as hyper-acute stroke unit and coronary care unit.
- Rehabilitation (Rehab) wards – longer stay wards involving occupational therapy and physiotherapy.
- Medical outliers – AME patients on non-medical (surgery, gynaecology, trauma) wards.

  Non-medical pathway – Patients that are admitted under a medical consultant but subsequently take an appropriately non-medical pathway.

41.2.1.3 Reference case

We have followed the NICE reference case{National Institute for Health and Clinical Excellence, 2013 NICE2013 /id;National Institute for Health and Care Excellence, 2014 NICE2014 /id}.

The cost perspective taken is that of the NHS and personal social services. The health perspective was limited to the patients and not family members or staff.

We used a cost-effectiveness threshold of £20,000 per QALY in the base case. Between £20,000 and £30,000 per QALY the intervention could be considered cost effective if there are additional justifications. Future costs and QALYs were discounted at 3.5% per annum, and incremental analysis was conducted.

For our cohort analyses, we have not conducted probabilistic sensitivity analysis, since we have investigated uncertainty using a simulation model.

41.2.2 Comparators

41.2.2.1 RAT in the ED

In current UK practice, consultant oversight and advice is available in the ED, however, not all patients are routinely assessed with immediate consultant input. Rapid Assessment and Treatment (RAT) is where an immediate assessment by the consultant is given routinely for a subset of patients and is in addition to a subsequent (more comprehensive) assessment within the ED. The RAT assessment therefore uses additional resources in terms of consultant time and comes at an incremental cost to normal care.

In an average hospital (say, 50 medical admissions per day), a consultant would probably assess, on average, approximately 2 AME patients per hour, constituting about a third of the overall number of assessments of AME patients within ED (with the remainder focused on other presentations for example, minor injury and major trauma). If RAT assessment was in place, a consultant could potentially see 4 patients in an hour.

The likely rota arrangements which may be implemented to provide early consultant assessment within the ED are contingent on many factors, such as the numbers of patients, acuity of patients, time of day, day of week, number of consultants and middle grades available on recruitment and relative proportions of consultants/middle grades in a given department. Broadly speaking, an individual consultant might do 3 or 4 full (8 hour) clinical shifts in a week, a mixture of early (for example, 8am - 4pm), mid (for example, 11am – 9pm), or late (for example, 4pm - midnight). Consultants doing the RAT shift may see 16 patients in a 4 hour period. This is intensive work, probably broken down into shifts of no more than 4 hours in the busy periods.

Due to the potential variation in optimal staffing arrangement, the model costs patient contacts, and does not comment further on staffing arrangements.

- **Baseline:** no RAT consultant review of the patient within the ED.
- **Intervention:** RAT consultant review of the patient within the ED (that is, ensuring a consultant will review the majors patients on presentation), with the service available from 8am-midnight every day.
- **Specification of staff time:** the intervention involves 15 minutes of 1 medical consultant per major patient arriving in service hours. The baseline involves no staff costs, since we assume that all other staff costs are common to both scenarios.
- **Cost of staff time:** where the person arrives in ED within service hours, the cost of staff time is dependent on whether arrival is within normal working hours or in premium time. Where the patient arrives outside of service hours, the patient does not have the intervention and no staff time (or cost) is attributed.
- **Population receiving the intervention:** all ED attendances in majors arriving during the service hours.

The average full clinical assessment involves approximately 15 minutes of clinical contact time (range of 10 – 30 minutes) with a further non-clinical contact time (notes write-up and result checking) of 15 minutes. A RAT assessment is shorter, that is, 10 minutes for clinical assessment plus 5 minutes for write-up and organisation of investigations.

It was not felt necessary to stratify time spent with the patient by acuity. However, notably, very sick patients with NEWS above 6 will go to resuscitation, so are unlikely to have a RATing style assessment. Less sick patients will go to minors where RATing does not take place.

The specification of the modelled comparison is summarised in the above text box.

41.2.2.2 Extended hours for consultants

On AMU there should be a maximum of 45 patient contacts in a 12 hour day or 35 during an 8 hour day per consultant (please see Table 1 below, taken from the RCP acute care toolkit){Royal College of Physicians, 2015 RCP2015 /id}. This equates to approximately 15 minutes per patient on average, however, for some patients the assessment may be longer (that is, 30 minutes). Generally, consultant assessment usually takes place between 8am and 8pm; however, the precise timings are variable between providers.

Table 1: Recommended number of consultants for AMU based on number of patient contacts{Royal College of Physicians, 2015 RCP2015 /id}

Number of beds on AMU	Admissions in 24 hours	Patient contacts 8am-8pm	Number of consultant FTE required between 8am-8pm
≤30	≤25	≤55	1-1.5
30-50	25-44	55-89	1.5-2
51-70	45-60	90-135	2-3
>70	>60	>135	>3

(a) Table has been copied for indicative purposes, for full details please refer directly to the source.
(b) 1 FTE = 1 Full time Equivalent consultant = 1 consultant working for 12 hours (may be augmented with overlapping shifts).

Typically consultants would undertake overlapping shifts to provide such care (that is, from 8am - 5pm and 11am – 9pm or 12pm – 10pm). Due to the potential variation in optimal staffing arrangement, the model costs patient contacts and does not assume any particular staffing arrangement.

The specification of the comparison is summarised in the below text box.

- **Baseline:** consultant assessment in AMU between hours of 8am - 6pm. This should allow assessment within 14 hours as standard.
- **Intervention:** consultant assessment available in AMU between hours of 8am - 10pm (this allows most patients to be assessed within 4 hours of being on AMU).
- **Specification of staff time:** the intervention and baseline involves 20 minutes of 1 medical consultant's time per patient arriving in service hours.
- **Cost of staff time:** Where the person is admitted within service hours, the cost of staff time is dependent on whether time of admission to AMU is within normal working hours or in premium time. Where the patient arrives outside of service hours, the patient is not seen by the consultant and the cost of a consultant assessment is not incurred.
- **Population receiving intervention:** all patients admitted to AMU within the service hours receive a consultant assessment that day.

41.2.2.3 Daily consultant review on medical wards

Throughout this chapter, we use the term general medical ward (GMW) to denote wards for medical patients that are not the AMU and are not high care or intensive care. These include wards that are dedicated to specific medical specialties, as well as ones that have a more generic medical population. On a GMW, a patient would be reviewed daily (weekdays) by ward staff but not necessarily with a consultant present. Nonetheless, there may be consultant input via 'board round' oversight rather than through direct bedside review. The additional ward rounds at the weekend would mean additional workload for junior doctors and a nurse, who support the consultant.

Daily review would increase the consultant's familiarity with the patient and promote continuity. This would reduce the time it takes to do the review.

The specification of the comparison is summarised in the below text box.

- **Baseline:** a consultant undertakes a ward round **twice a week** (in normal working hours, that is, non-premium time). A junior doctor will take a ward round on the other 3 weekdays. At the weekend, there is no ward round.
- **Intervention:** a consultant undertakes a ward round once **daily** (to take place in normal working hours that is, non-premium time and on weekends, that is, in premium time). Two junior doctors and 1 nurse accompany the consultant on ward rounds – this represents an incremental cost only at the weekend.
- **Specification of staff time:** the review is assumed to take 15 minutes per patient for an initial assessment and 10 minutes for each daily review, at baseline. For the intervention, the initial assessment takes 15 minutes, the first review takes 10 minutes and subsequent reviews take 5 minutes per patient. We include junior doctor and nurse time for those consultant reviews taking place at the weekend.
- **Cost of staff time:** consultant review occurs within normal working hours on weekdays and in premium time on the weekend. The intervention always occurs within normal working hours for junior doctors. For nurse time, additional pay enhancements are given for Saturday and Sunday work.
- **Population:** all admitted patients on medical wards (excluding AMU and high care wards).

41.2.2.4 Extended access to therapy

Hospitals generally have a dedicated physiotherapy and occupational therapy (PT/OT) service for acutely ill patients. The primary role of the therapist is to assess and improve the patient's mobility/functioning, to make sure they are safe to go home and to avoid unnecessarily prolonged hospital stay. The therapists sometimes get involved in some of the social work function, for example, calling around to try to arrange emergency placements.

A REACT team typically consists of an OT, PT and an OT/PT support worker who cover the ED and AMU. The presence of a dedicated service on the wards and for outlying patients is more variable. In some hospitals, each medical ward will have a dedicated PT and OT, who would work Monday to Friday, 9am-5pm. At weekends, a number of patients on the ward would be highlighted for weekend input, but generally, there is very much a reduced service.

The initial assessment in ED typically takes between 30 minutes to 1 hour, with the time increased where discharge is planned. Up-skilling of both physiotherapists and occupational therapists mean that basic assessment and referral can be done by either staff member.

Once assessed, a management plan is drawn up. Typically, the patient will be reassessed once admitted on the ward (approximately 40 minutes of reassessment time) and then have 20 – 40 minutes of follow up reassessment and action of the management plan for each subsequent day on the ward. Ward based management plans are enacted by various members of the team dependent on the patient and their needs. We assume that any 1 member from a team of a physiotherapist (1 whole-time equivalent [WTE]) an assistant (0.5 WTE) or ward nurse (0.2 WTE) could be involved in any given session.

During the ward stay, the occupational therapist's time spent on each patient will be variable, and predominantly used preparing the patient for discharge. This activity is varied and important but we have not costed this as part of the intervention, on the assumption that this activity would have to take place anyway.

The impact of extended PT/OT services is heavily reliant on the service provided in the community. The typical delay to discharge varies but is often due to capacity of care agencies at a weekend. In addition, the home environment of the patient might be unsuitable for early discharge without several adaptations.

The specification of the modelled comparison is summarised in the below text box.

- **Baseline:** access to PT/OT (service available 9am - 5pm weekdays, that is, in normal working hours).
- **Intervention:** extended access to PT/OT (available 9am - 8pm including weekends).
- **Specification of staff time:** a PT/OT assessment takes 45 minutes with 1 member of the referral team in attendance (a weighted average cost of 2 qualified OT/PT professionals and 0.5 assistant is used). On medical wards, daily PT sessions of 30 minutes are given, with 1 member of the management team in attendance (a weighted average cost of a team member from a team of a physiotherapist (1WTE) an assistant (0.5 WTE) or ward nurse (0.2 WTE) is applied).
- **Cost of staff time:** for assessment in the ED, the ED arrival time{Health & Social Care Information Centre, 2011 HES2011 /id} was used to establish whether the intervention occurs outside of normal working hours. All physiotherapy session on the ward are assumed to take place inside normal working hours, unless occurring on Saturday or Sunday.
- **Population:** within ED, PT/OT referral is assumed to be indicated in those with low NEWS scores (0,1). PT/OT referral is only indicated for patients having a CFS score of 3, 4, 5 or 6. Patients with CFS score of 1 or 2 are unlikely to require a PT/OT referral, whilst those with a CFS score of 7 and above are likely to have special PT/OT arrangements in place in both baseline and intervention. For patients on medical wards, PT/OT is assumed to be indicated for all patients with CFS 3 and above.

41.2.3 Patient characteristics

An acute medical emergency can arise from a multitude of conditions and contains a wide number of diagnostic groups. Within each diagnostic group, the severity of the condition, the long-term prognosis and associated expected resource use can also widely differ. For this reason, it was felt most appropriate to stratify by age and by commonly used indicators of acuity and frailty, which could be applied across the population. Therefore, for purposes of identification of appropriate subgroups to receive specific interventions and to assist determination of long term survival and quality of life, the modelling work stratifies the AME population using the National Early Warning Score (NEWS){Royal College of Physicians, 2015 RCP2015A /id} and Clinical Frailty Scale (CFS){Rockwood, 2005 ROCKWOOD2005 /id}.

For both models, we determined the age distribution from the Queen Alexandra Hospital – see Appendix E. We did this separately for admitted patients and patients discharged from the ED.

Admitted patients

For the cohort model, the case mix (CFS and NEWS) by age of admitted patients was determined using a UK audit of 2990 patients attending Acute Medical Units (AMUs) – SAMBA 2013{Subbe, 2015 SUBBE2015 /id} – see Table 2 and Table 3. At the time, this was the most recent year of the annual audit that was available for bespoke analysis. The audit used a modified version of NEWS that omitted responsiveness (AVPU scale - alert, voice, pain, unresponsive).

For the simulation model, the case mix of age and NEWS were determined by data from the Queen Alexandra Hospital – see Appendix E. In the absence of specific CFS data, a CFS distribution was assumed for each age-NEWS group (0, 1-4, 5-6, 7+), using the SAMBA 2013 data. The Portsmouth data allowed calculation of the full NEWS score and 'NEWS minus AVPU'. Therefore, at admission, we allocated each patient both a NEWS score and 'NEWS minus AVPU' score; a CFS score was then randomly allocated based on age and 'NEWS minus AVPU'.

Patients discharged from the Emergency Department

We ascribed a CFS score to patients, using the age-CFS distribution in SAMBA 2013 – see Table 2. The patients being discharged from ED were less frail on average than those patients who were admitted to hospital since they were considerably younger.

We did not have NEWS data for patients discharged from the ED and therefore we assumed that the NEWS-CFS distribution by age was the same as for admitted patients, again using SAMBA 2013 – see Table 2. Hence, NEWS in ED was on average lower for patients discharged from ED, since they were considerably younger on average.

Table 2: CFS distribution of admitted patients by age{Subbe, 2015 SUBBE2015 /id}

Age group	Clinical Frailty Score (CFS)									
	1	2	3	4	5	6	7	8	9	All
<18	10	2	1	1	-	-	-			14
18-25	76	34	5	3	1	2	2			123
25-34	104	80	16	6	1	-	1			208
35-44	75	79	36	16	4	-	3			213
45-54	88	126	69	26	10	9	12	1	2	343
55-64	57	96	92	49	25	26	14	4	6	369
65-74	44	97	140	86	51	65	34	4	8	529
75-84	20	55	157	144	106	116	54	14	14	680
85-94	4	20	61	82	81	125	58	25	5	461
95+	-	-	4	6	6	13	17	5		51
All	478	589	581	419	285	356	478	53	35	2991

Table 3: NEWS distribution (%) of admitted patients by clinical frailty score {Subbe, 2015 SUBBE2015 /id}

	NEWS minus AVPU									
CFS	0	1	2	3	4	5	6	7-10	11+	Total %
1	46	28	11	4	3	3	1	2	0	16
2	44	24	13	8	5	2	2	2	0	20
3	36	24	16	10	4	3	2	4	0	19
4	27	23	17	10	6	6	3	6	0	14
5	27	20	19	9	9	5	5	6	0	10
6	29	18	17	10	5	7	5	8	0	12
7	19	17	13	15	6	8	4	18	1	7
8	17	9	9	6	15	9	11	15	8	2
9	14	26	14	6	6	6	6	15	9	1
Total %	35	23	15	9	5	4	3	6	1	100

41.2.4 Baseline event rates

The simulation model uses data from a single large district general hospital (DGH), the Queen Alexandra Hospital, Portsmouth – see Appendix E.

The cohort model uses a mixture of national sources including the Office for National Statistics (ONS) supplemented with data from the Queen Alexandra Hospital.

For baseline survival at 30 days and beyond – see 41.2.6.

41.2.4.1 Timing and number of AME presentations

For the cohort model, we take English A&E attendance data from Hospital Episode Statistics (HES){Health & Social Care Information Centre, 2011 HES2011 /id} to estimate time and day of arrival distributions at ED - Table 4.

For the simulation model, we use data from the Queen Alexandra Hospital, Portsmouth – see Appendix E. These presentations were also stratified by time of day, day of week and season. There was also data on the number and source of direct admissions (those not passing through the ED).

Table 4: Number of A&E attendances by hour of arrival, 2014-15

Arrival time (hour)	Average length of stay in ED (minutes)	Number of patients (on arrival)	% (at time of arrival)	% (at time of departure)(a)
0-1	276	436,553	2.23%	0.00%
01-02	204	305,969	1.56%	3.24%
02-03	203	252,102	1.29%	2.55%
03-04	203	220,818	1.13%	0.00%
04-05	202	200,216	1.02%	3.80%
05-06	201	189,594	0.97%	1.29%
06-07	185	206,957	1.06%	1.13%
07-08	152	327,941	1.68%	1.02%
08-09	123	773,230	3.95%	1.00%
09-10	123	1,243,704	6.36%	2.74%
10-11	132	1,373,822	7.02%	3.95%
11-12	144	1,400,793	7.16%	6.36%
12-13	146	1,319,049	6.74%	7.02%
13-14	145	1,288,975	6.59%	7.16%
14-15	141	1,248,402	6.38%	6.74%
15-16	140	1,207,856	6.18%	6.59%
16-17	141	1,208,970	6.18%	6.38%
17-18	146	1,164,460	5.95%	6.18%
18-19	148	1,195,982	6.12%	6.18%
19-20	153	1,111,388	5.68%	5.95%
20-21	163	960,047	4.91%	6.12%
21-22	175	787,070	4.02%	5.68%
22-23	186	633,602	3.24%	4.91%
23-24	196	499,281	2.55%	4.02%
	Mean (154)	Total (19,556,781)		

(a) Calculated by adding the mean duration of stay onto the arrival time.

41.2.4.2 Admissions from ED

For the proportion of ED presentations arriving by ambulance, 30.5% was taken from national data{Meacock, 2016 MEACOCK2016 /id}.

For the cohort model, admissions rates were derived from a sample of 5 hospitals (n=412,500){National Institute for Health and Care Excellence, 2014 NICE2014A /id}:

- Admission rate for patients arriving by ambulance, 42.6%.
- Admission rate overall for all ED attendances, 28.9%.
- Proportion of admissions that arrived by ambulance, 39.1%.

In the model, we made the simplifying assumption that those arriving by ambulance were dealt with in majors.

For the simulation model, admission rates were from the Queen Alexandra Hospital, Portsmouth, and they were stratified by age group, time of day, day of week and season – see Appendix E.

41.2.4.3 ED mortality and length of stay

For both models, mortality in the ED was taken from Hospital Episode Statistics and was 20,388/19,556,781 (0.1%){Health & Social Care Information Centre, 2015 HSCIC2015A /id}.

ED length of stay features only in the simulation model; these data came from the Queen Alexandra Hospital, Portsmouth, and they were stratified by discharge destination (CDU, Ward, AAMU, discharge) – see Appendix E. The mean length of stay was 157 minutes (2.6 hours).

41.2.4.4 Inpatient mortality and length of stay

For the cohort model, inpatient mortality (5.8%) and average length of stay (6.4 days) were calculated by a NICE analyst in a bespoke analysis of HES data restricted to medical treatment specialty in the first finished consultant episode, adults and emergencies and excluding day cases.

Table 5: In-hospital mortality and length of stay

	Queen Alexandra hospital, Portsmouth (Appendix41C)	England (HES)	England (HES)	United Kingdom (SAMBA)	England (HES-ONS) – 41.2.6.2
Years	2010-2016	2010-2015	2014-2015	2013	2013-14
N	148,637	13,999,919	2,958,602	2,990	3,576,663
Mean length of stay (days)	7.5	6.5	6.4		6.4
Probability of death in hospital	6.7%	6.0%	5.8%		
Age profile					
18-44	14.5%*		16.3%	18.7%*	18.6%
45-64	24.0%		23.2%	23.8%	25.3%
65-74	18.9%		18.0%	17.7%	17.7%
75-84	23.9%		23.5%	22.7%	21.8%
85+	18.6%		18.9%	17.1%	16.6%

** Includes some patients aged 16-17.*

For the simulation model, these data came from the Queen Alexandra Hospital, Portsmouth, and they were stratified by age, NEWS and current hospital location – see Appendix E. Length of stay was also stratified by next location. The probability that admitted patients die in AMU (1,039/110,995=0.9%) or GMW (6,194/97,521=6.4%) was also used in the cohort model.

41.2.4.5 Referral to intensive care and other movements within the hospital

The simulation model distinguishes between the following parts of the hospital:

- Emergency department (ED)
- Clinical decision unit (CDU)
- Ambulatory acute medical unit (AAMU)
- Acute medical unit (AMU)
- General medical wards (GMW)
- Intensive care unit / high dependency unit (ICU/HDU)
- Specialist high care units (HCUs)
- Medical outliers.
- Non-medical pathway.

Data on movements between these locations was from the Queen Alexandra Hospital, Portsmouth – see Appendix E. This was mainly used in the simulation model only. The probability that admitted patients go to the ICU/HDU from AMU (339/110,995=0.3%) and from GMW (866/97,521=0.9%) was also used in the cohort model.

41.2.4.6 Discharge

Data on discharge destination and time of discharge was from the Queen Alexandra Hospital, Portsmouth – see Appendix E. This data is not used in the cohort model.

41.2.5 Relative treatment effects

Treatment effectiveness estimates derived from the relevant clinical review were of low applicability or derived from studies with low quality. In addition, there was no evidence for many important outcomes. Therefore, treatment effects were formally elicited from the guideline's health economics subgroup.

The elicitation exercise involved:

- There was an initial discussion of the published estimates by the whole committee.
- This was followed by a survey monkey questionnaire whereby each subgroup member independently cited their own estimates of important outcomes (taking into account the published evidence, discussion and their own experience).
- These individual estimates were brought back for discussion by the subgroup to reach a consensus on the point estimates and uncertainty ranges.
- These estimates were then discussed and finalised by the full committee.

In general, these estimates were considerably more conservative than estimates in the literature, reflecting the committee's view that these studies have limited applicability and that they are heavily influenced by the baseline service structure.

In the elicitation exercise experts were asked:

- For which outcomes there will be a treatment effect?
- Specification of the population on whom the treatment effect should be applied?
- To give a percentage change for each outcome of interest, with a lower and upper bound to test within a sensitivity analysis.
- To assist interpretation, baseline risks and absolute differences were presented as well as relative risks.

The final values of treatment effect for each intervention can be found in Table 6. The interventions were not thought to have a significant effect on readmissions, reflecting the evidence reviewed.

Table 6: Treatment effects (relative risks/weights) compared with baseline - lower estimate, mid-point, upper estimate

	RAT in ED	Extended hours for consultant in AMU	Daily consultant review on medical wards	Extended access to therapy in the ED	Extended access to therapy on medical wards
Mortality within ED	1, **1**, 0.99 [A]	n/a	n/a	n/a	n/a
Mortality within AMU	n/a	1, **0.99**, 0.985 [D]	n/a	n/a	n/a
Mortality within GMW	n/a	n/a	1, **0.99**, 0.985[G]	n/a	n/a
Admissions to hospital	1.01, **0.95**, 0.9 [B]	n/a	n/a	0.993, **0.986**, 0.972 [J]	n/a
ICU/HDU referral from AMU	n/a	1, **0.95**, 0.9 [E]	n/a	n/a	n/a
ICU/HDU referral from GMW	n/a	n/a	1, **0.929**, 0.857 [H]	n/a	n/a
Length of stay ED	0.873, **0.904**, 0.936 [C]	n/a	n/a	n/a	n/a
Length of stay GMW	n/a	n/a	1, **0.989**, 0.978 [I]	n/a	0.971, **0.941**, 0.912 [K]
Utility for first 12 months for patients age≥65 and CFS≥3	n/a	n/a	n/a	n/a	1, **1.01**, 1.02 [L]
Length of stay in AMU	n/a	See [F]	n/a	n/a	n/a

In the cohort model, treatment effects are being applied to a whole cohort whereas in the simulation model the treatment effect is more targeted. In some cases, additional calculations needed to be made to enable the treatment effect elicited from the committee subgroup to be applied correctly in the model. These are explained in more detail below.

Length of stay reductions were estimated as absolute average stays reductions (for example, 1 day less). This was applied as a relative reduction in stay to all relevant patients, since some patients might have less than a full day's stay even before the treatment effect has been applied – hence the effects in Table 6 are expressed as relative risks. For example, 0.84 represents a 16% reduction in length of stay – see Appendix F for details.

41.2.5.1 RAT in the ED

[A] – Mortality within ED

Mortality within ED is mostly prevalent in resuscitation patients who do not normally come through RAT. The RAT intervention affects majors patients only and therefore there was unlikely to be a substantial mortality effect. However, a small decrease in mortality of 1 in 100 (RR=0.99) has been included for the optimistic treatment effect analysis. This treatment effect is applied to ED mortality only. The probability of dying in the ED was found to be 0.1%. Therefore, applying the treatment effect of 0.99 reduces this probability to 0.099%. With this treatment effect applied, for every 100,000 patients that go through the ED you would expect to prevent one death.

[B] – Admissions

A midpoint of 1 in 20 patients avoiding admission was agreed (RR=0.95). It was agreed that the range around the effect size should include the possibility of increasing admissions. The admissions avoided would be those where patients are admitted to AMU and subsequently discharged with a short length of stay.

[C] – ED length of stay

The presence of RATing would reduce the time to decision of admission or discharge. However, it was discussed that admitted patients might not see their overall length of stay change dependent on bed availability. This should be captured in the capacity of the model. 26.0% of patients in ED receive RAT, which was majors equating to 30.5% of ED patients - 41.2.4.2 multiplied by 85.4% arriving in service hours from the Portsmouth data). These patients would see an average decrease in time to decision of around 15 minutes (20-10 minute range). For our average length of stay of 157 minutes (41.2.4.3), this equates to treatment effect of 0.904 with an upper and lower range of 0.873- 0.936. As the main benefit of this treatment effect is to improve hospital flow it was omitted from the cohort model, as the impact of hospital flow is not captured.

41.2.5.2 Extended hours for consultants in AMU

[D] – Within AMU mortality

There would only be a small number of preventable deaths, as many deaths will be patients who are on end of life pathways. It was proposed that 1 in 100 (RR=0.99) reduction in mortality would be realistic. The effect will be applied to all AMU patients. This treatment effect is applied to AMU mortality only. The probability of dying in the AMU was found to be 0.94% in the Portsmouth hospital data analysis. Therefore, applying the risk ratio of 0.99 reduces this probability to 0.93%. With this treatment effect applied, for every 10,000 patients that go through the AMU you would expect to prevent one death.

[E] – Adverse events (admissions to ICU/HDU directly from AMU)

The treatment effect will only be applied to those that enter the AMU during extended hours 6pm – 10pm weekday, 8am – 10pm weekend). It was agreed that for these patients, of those that would have been referred to ICU/HDU, 1 in 20 would be avoided.

[F] – Length of stay in AMU (earlier discharge)

It was decided to break this down into 2 parts:

1. Some patients who arrive during extended hours can be discharged a day earlier as a consequence of being seen earlier.

   - 1 in 15 of all such patients could avoid an overnight stay (1 in 30 in the conservative analysis and 1 in 10 in the optimistic analysis)

   - Those that benefit are under age 65 and are being discharged the next day to usual residence may.

2. Some patients who can be discharged hours earlier due to earlier testing/cancelled unnecessary tests.

   - Patients who are admitted to AMU during extended hours, are under age 65 and are being discharged the next day to usual residence will have reduced length of stay if they are not discharged a day earlier, as above.

   - 1 hour reduction (0.5 in the conservative analysis and 2 in the optimistic analysis).

41.2.5.3 Daily consultant review on medical wards

All these treatment effects apply to everyone who receives the intervention, therefore no adjustments need to be made to the MS Excel cohort model:

[G] – Mortality within GMW

It was felt that daily consultant reviews would prevent only a small number of deaths on the GMW. It was proposed that 1 in 100 (0.99) reduction in mortality would be realistic. The effect was applied to all GMW patients. This treatment effect is applied to GMW mortality only. The probability of dying in the GMW was found to be 6.35% in the Portsmouth data analysis (41.2.4.4). Therefore, applying the treatment effect of 0.99 reduces this probability to 6.29%. With this treatment effect applied, for every 10,000 patients that go through the AMU you would expect to prevent 6 deaths.

[H] – Adverse events (admission to ICU/HDU directly from GMW)

The consensus was that 1 in 14 referrals to ICU/HDU would be avoided (1 in 7 in the optimistic treatment effects sensitivity analysis and 0 in the conservative treatment effects analysis).

[I] – Length of stay on GMW

It was agreed that there would be a 1-day reduction in length of stay for 1 in 10 patients (24 * 0.1 = 2.4 hours) in the base case and 1 in 5 patients for the optimistic treatment effects sensitivity analysis. There would be a partial effect in the control arm where consultant review takes place 2 days a week, therefore the net effect was 2.4 * (5/7) = 1.7 hours.

41.2.5.4 Extended access to therapy in the ED

[J] – Admissions

The committee expected 1-2 admissions to be avoided per day for a hospital with 250 ED presentations per day. This is the equivalent of preventing 4-8 admissions per 1000 ED attendances. In the base case, it was assumed that 4 admissions would be averted (8 in the optimistic treatment effects analysis and 2 in the conservative analysis).

The patients benefiting would be those with a CFS 3-6, NEWS 0-1, and who would have had a short length of stay.

Patients avoiding admission continue to sample their post-discharge outcomes as if they were admitted patients. This is done to avoid an effect on post-discharge outcomes by avoiding admission not intended by the intervention scenario.

41.2.5.5 Extended access to therapy on medical wards

[K] –Length of stay

It was agreed that patients on the GMW with CFS ≥3, age over 65 and being discharged would see a stay reduction of 1 day on average (0.5 to 1.5 days in sensitivity analyses).

[L] – Quality of life

It was agreed that there would be an increase of 1% in quality of life for patients on the GMW with CFS ≥3, age over 65 and being discharged to their usual place of residence from the GMW that would last for 1 year.

41.2.6 Life expectancy

Where interventions prolong life, it is good practice for economic evaluations to use a lifetime horizon. To calculate QALYs using a lifetime horizon requires estimation of survival beyond discharge from hospital.

41.2.6.1 Literature review

No study included within the guideline reviews reported survival rates for an undifferentiated AME population beyond 30 days.

A systematic search was conducted with the aim of finding long-term survival outcomes for a generic population. We were specifically interested in survival numbers/rates, survival curves or standardised mortality ratios (SMRs). An SMR is equal to the number of deaths in an AME population divided by deaths in the general population with the same age/sex distribution.

The search retrieved 1187 records. Titles and abstracts were sifted with the following exclusions:

- Publication date prior to 2006 (a 10 year publication cut off).
- Studies where population was not from North America, Australia or Europe.
- Studies with no indication from abstract or title that the population has had an acute event/emergency (that is, simply focused on chronic management).
- Studies looking at very specific subpopulations of 1 condition, that is, after a specific surgery, with a particular complication.
- Studies that had follow-up of less than 1 year.

From the search, only 1 paper was retrieved that reported long term survival of a generic AME population group{Safwenberg, 2008 SAFWENBERG2008 /id}. A search on Google Scholar, PubMed and the journal's website for all citing papers retrieved a further 14 English language results, only 1 of which reported relevant outcomes for a non-condition specific medical emergency population{Gunnarsdottir, 2006 GUNNARSDOTTIR2006 /id;Gunnarsdottir, 2006 GUNNARSDOTTIR2006A /id}.

The first study, a Swedish retrospective cohort study reported standardised mortality ratios for a population of non-surgical patients admitted after visiting the ED (n =6,263){Safwenberg, 2008 SAFWENBERG2008 /id}. Data was collected between 1995 and 1996, with follow up 10 years (median 9.6 years). The mean age of the cohort was 62.6. The main causes of death (SMR) were related to seizures (2.62), intoxications (2.51), asthma-like symptoms (1.84), hyperglycaemia (1.67) and chest pain (1.2). Authors note that reference population has lower than typical mortality for Sweden. The reported in-hospital mortality rate was 5.20%.

The second study, an Icelandic retrospective 6 year cohort study, reports standardised mortality ratios of a population of patients attending ED (n =19,259), with findings stratified by age and sex{Gunnarsdottir, 2006 GUNNARSDOTTIR2006 /id;Gunnarsdottir, 2006 GUNNARSDOTTIR2006A /id}. The hazard ratio calculated for the age group 80 to 84 was 1.33; however, for younger ages the hazard ratio was considerably higher. Data was collected between 1995 and 2001, with follow up at death or at study end for enrolled patients. The main causes of death (percent of all causes of death) were related to malignant neoplasm (32%), ischaemic heart disease (21%), cerebrovascular disease (10%) and chronic lower respiratory disease (5%).

To calculate survival curves we chose to use the SMRs from the Icelandic study since they were based on a larger cohort and were age group-specific, and therefore survival can be tailored more distinctly to case-mix and individual patients within the simulation model– see Table 7. Iceland has longer life expectancy than England therefore, we would expect crude mortality rates to be lower but it is not clear whether the SMRs would be an under or over-estimate.

Table 7: Aggregated standardised mortality ratios after an AME from Gunnarsdottir et al (2012) n=19,259

Age group	Observed deaths	Expected deaths for general population (Iceland)	SMR
18 to 44	94	23.9	3.94
45 to 64	325	106.0	3.07
65 to 74	439	214.2	2.05
75 to 84	693	486.3	1.43
85 to 104	554	296.3	1.87

41.2.6.2 Analysis of 90-day mortality using HES linked to ONS mortality

NHS digital has published linked HES-ONS mortality data aggregated by primary diagnosis (3 character ICD10). This reports mortality at 30, 60 and 90 days post admission for admitted patients in 1617 diagnostic categories:

http://content.digital.nhs.uk/article/2677/Linked-HES-ONS-mortality-data

The most recent year published is 2013-2014:

http://content.digital.nhs.uk/catalogue/PUB16081

We used this published data to calculate standardised mortality ratios (SMRs) for the first 90 days after admission for an adult AME by taking the following steps:

1. Removed diagnostic categories where emergency<50% or adult<50%.
2. Removed diagnostic categories which are non-medical (for details see below).
3. Added up number of deaths at each time point across the categories (a).
4. Extracted the age-sex profile of each included category.
    a. Had to assume sex split was the same for each age group (within a diagnostic category).
5. Calculated the expected deaths from ONS England life table for each age-sex group{Office for National Statistics, 2016 ONS2016 /id}.
6. Added up number of expected deaths across all categories and all age-sex groups (b).

7. Calculated the standardised mortality ratio SMR=a/b and 95% confidence intervals{Goldblatt, 1990 GOLDBLATT1990 /id}.

To remove diagnostic categories that would not normally be dealt with through the adult medical pathway (trauma, surgery, gynaecology/obstetrics, paediatrics and psychiatry) – step 2 - 3 physicians from the guideline's health economic subgroup went through the remaining diagnostic codes and marked them as being either i) likely to be medical, ii) unlikely to be medical or iii) uncertain / combination. There was complete agreement for 500 categories, a majority decision for 57 categories and 13 remained uncertain. It was decided to use a priori in the model; the SMRs based on diagnostic categories where there was complete agreement or a majority (Table 8) but we computed them separately for comparison (Table 9).

Table 8: Standardised mortality ratios used in base case

	Expected	Observed	Expected	Observed	SMR	Lower 95% limit	Upper 95% limit
0-30 days	5,309	159,988	0.17%	5.12%	30.14	29.99	30.29
31-60 days	5,251	66,707	0.17%	2.14%	12.70	12.61	12.80
61-90 days	5,194	46,748	0.17%	1.50%	9.00	8.92	9.08

Table 9: SMRs, by level of consensus around diagnostic inclusion

	Agreed	Majority	Uncertain	Agreed+ majority (see Table 8)
0-30 days	31.0	20.9	17.7	30.1
30-60 days	12.6	13.4	13.0	12.7
60-90 days	8.9	10.4	9.6	9.0

Table 10: Cohorts used to calculate SMRs

	Finished admission episodes	Deaths 30 days	Deaths 60 days	Deaths 90 days	Mean length of stay (excluding day cases)	Emergency	Age<17	Male	Day case
Agreed	2,744,455	5.5%	7.7%	9.2%	6.5	85%	8%	49%	9%
Majority	383,212	2.6%	4.2%	5.5%	5.1	77%	10%	49%	18%
Uncertain	528,697	2.0%	3.5%	4.5%	4.9	77%	9%	38%	19%
Agreed+ Majority - base case	3,127,667	5.1%	7.2%	8.7%	6.4	84%	8%	49%	10%

The cohorts include some elective episodes and children and therefore this method certainly under-estimates the crude death rates of adults having an AME (Table 10). Whether it biases the SMRs is not clear – the inclusion of elective patients will under-estimate them but the inclusion of children might over-estimate them. Despite this, the mean stay was almost identical to what we have found by other means (Table 5).

The 'uncertain' cohort was somewhat different to the base case (Table 10) in that there were proportionately fewer men, fewer emergencies and more day cases. This contributed to lower crude mortality. SMRs were comparable apart from the first 30 days, where they were substantially lower for the 'uncertain' cohort (Table 9). By far the largest diagnostic category in the 'uncertain' cohort was 'abdominal or pelvic pain' – these patients could take either a medical or a surgical/gynaecological pathway, depending on local hospital and patient factors. The 'uncertain' cohort was left out of the SMRs used in the model but including them would have made little difference, given the relatively small cohort size.

41.2.6.3 Calculating survival curves

A typical cohort model might use the mean age of the population and calculate life-years (mean survival) accordingly. However, for a patient level simulation, the expected life expectancy of an individual patient respective to their age (and case-mix) is required. In our models, therefore, expected life years and QALYs were modelled for each age between 18 and 100.

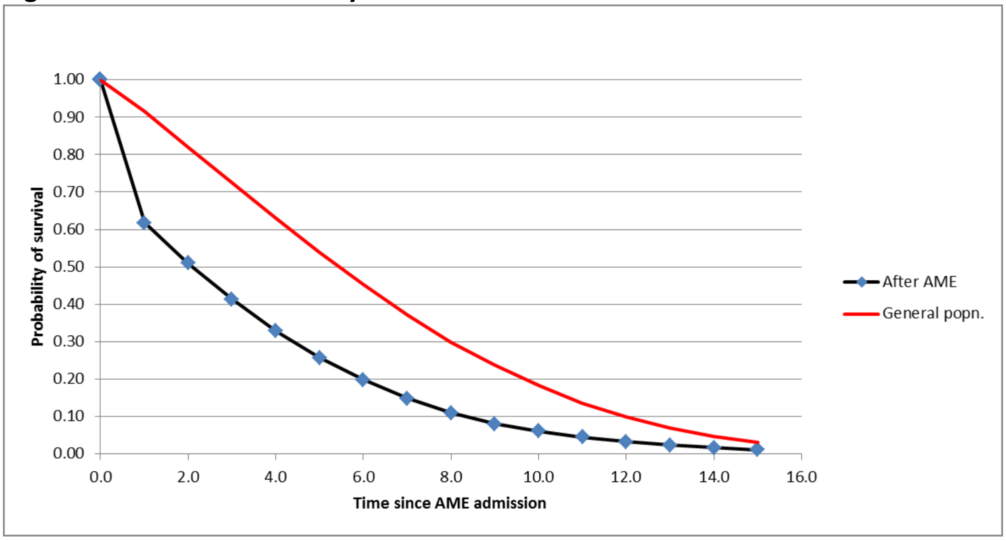
In the cohort models, life years and QALYs found for each specific age were then weighted by the age distribution of the population to find the expected average QALY for the cohort. Similarly, in the simulation model, the QALYs accrued by each patient are aggregated to find an average for the population.

Our approach was to produce survival curves for each age by multiplying together mortality rates taken from national life tables for England{Office for National Statistics, 2016 ONS2016 /id} with standardised mortality ratios (SMRs) for AME patients.

For all patients we used the SMRs in Table 8 for the first 90 days and then thereafter the age-specific SMRs in Table 7. To verify this approach we compared the 30-day mortality from our baseline model, 4.0%, with a published estimated for England based on 12.7 million ED attendances between April 2013 and February 2014, 4.3%{meacock2016}. We considered this to be reasonably close.

Figure 1 shows an example survival curve for a person aged 85 after an AME using this method compared with the general population of the same age. We calculate life-years as the area under the curve.

Figure 1: Survival of an 85-year-old after admission for an AME



41.2.6.4 Capturing frailty

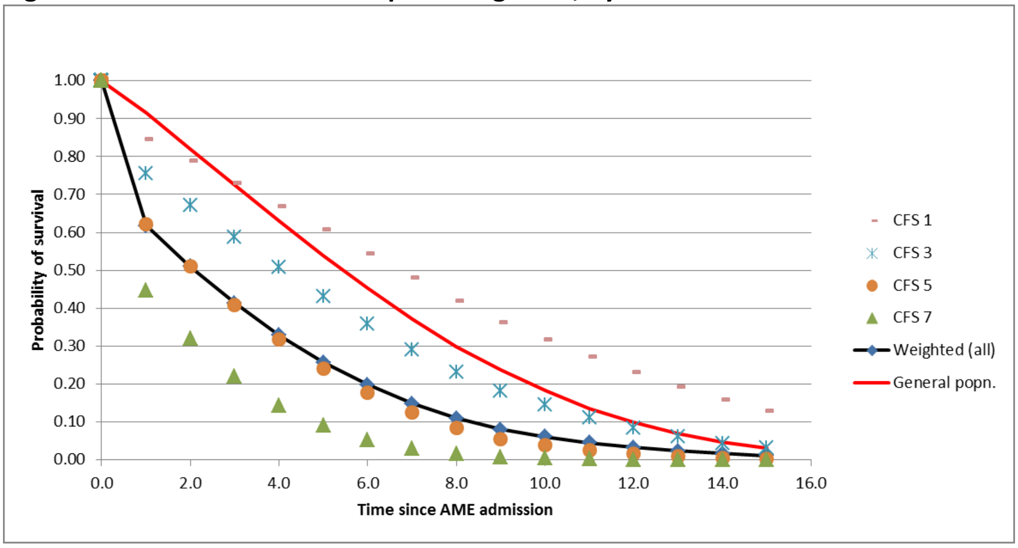
Figure 1 shows estimated survival for the cohort as a whole but some of the interventions we are evaluating are targeted at the frail elderly. The survival for these patients will be poorer than that for a similar cohort who are not frail. To avoid over-estimating QALYs gained, we attempted to estimate survival curves that were both age-specific and frailty-specific. As noted above, we have used the Clinical Frailty Score, since this has been used in the Society for Acute Medicine's benchmarking audits – see 41.2.3. Rockwood and colleagues{Rockwood, 2005 ROCKWOOD2005 /id} analysed survival for a sample of 2305 elderly patients who participated in the second stage of the Canadian Study of Health and Aging (CSHA). They were aged over 65 (mean age 85). They estimated a mortality hazard ratio of 1.3 for each increment on the CFS (note that they also showed Kaplan-Meir curves for the cohort as a whole but we could not use these directly since, follow-up was only for 5 years and when we fitted curves to them, the best fit was the exponential function, which did not seem plausible for the longer-term, especially for the lower frailty scores).

We used the hazard ratio to estimate, for each patient age 65 and above, a survival curve that is both age and CFS-specific as follows:

- We have calculated a survival curve for all patients at a specific age (for example, Figure 1).
- We define each point on the survival curve as being a weighted average of the survival curves for each of the individual CFS scores.
- For the weights, the proportion of patients in each CFS score group at that age, we use the SAMBA 2013 (see Table 2).
- Using the hazard rate of 1.3, if we know the mortality for CFS1 then we also know it for the other CFS groups.
- At each point of the survival curve, given the specific set of weights and the hazard ratio of 1.3 there is a unique mortality for CFS1 that is consistent with the mortality for that age as a whole. We solved this for each point using the Goalseek tool in MS Excel.
- By joining up the CFS1 survival for each point gives a survival curve for CFS1, and so on for the other CFS score groups.

As an illustration, Figure 2 shows a set of survival curves for a person aged 85 after being admitted with an AME and for selected CFS scores. The CFS5 survival curve is similar the weighted average, since 5 is the median CFS at this age.

Figure 2: Survival curves for a person aged 85, by CFS



41.2.6.5 Application of mortality treatment effect

To assess the treatment effects on mortality in the cohort model, we estimated impact on 30 day mortality of each intervention (41.2.5) and then re-calculated the survival curve for each age and adding up the life-years.

To assess the treatment effects on mortality in the simulation model, we took a slightly different approach. There was a mortality risk in each location within the hospital. These location-specific risks were modified according to the treatment effect (41.2.5). Post-discharge the patients had a risk of death for the first 30 days that was specific to their age and CFS score – this was estimated by subtracting age-specific in-hospital mortality from the 30-day mortality. For the period beyond 30 days, each individual had a life expectancy, again related to his or her age and CFS score, using the method described above but omitting the first 30 days.

41.2.7 Utilities

41.2.7.1 Identification of relevant evidence

Three systematic searches were conducted to find appropriate utilities to populate the model. The first was conducted for a general AME population and returned 662 titles, of which 12 papers were found to be suitable for review{Agborsangaya, 2013 AGBORSANGAYA2013 /id;Courtney, 2009 COURTNEY2009 /id;Vedio, 2000 VEDIO2000 /id;Eriksen, 1998 ERIKSEN1998 /id;Hutchinson, 2015 HUTCHINSON2015 /id;Hutchinson, 2013 HUTCHINSON2013 /id;Saukkonen, 2006 SAUKKONEN2006 /id;Goodacre, 2012 GOODACRE2012 /id;Round, 2004 ROUND2004 /id;Sacanella, 2011 SACANELLA2011 /id;Vainiola, 2011 VAINIOLA2011 /id;Ara, 2011 ARA2011 /id}. The second search conducted aimed at finding any utilities reported for a population stratified by clinical frailty score. Of the 6 titles returned, 1 paper was reviewed for relevance{Bagshaw, 2014 BAGSHAW2014 /id}. The third search conducted aimed to find any utilities reported for a population stratified by NEWS, no titles were returned.

Of the 13 studies identified for relevance:

- Six studies were excluded due to poor applicability or quality that is, inappropriate quality of life measure employed{Eriksen, 1998 ERIKSEN1998 /id;Hutchinson, 2015 HUTCHINSON2015 /id;Hutchinson, 2013 HUTCHINSON2013 /id;Saukkonen, 2006 SAUKKONEN2006 /id;Courtney, 2009 COURTNEY2009 /id;Vedio, 2000 VEDIO2000 /id}.
- Two studies were conducted in the UK, both reporting EuroQol 5-Dimensions (EQ5D):
    - Goodacre et al. 2012 reports on quality of life experienced 30 days after admission by admitted patients who arrived by ambulance{Goodacre, 2012 GOODACRE2012 /id}.
    - Round et al. 2004 reports quality of life at presentation and at 6 months for patients aged 70 and over who have experienced acute care{Round, 2004 ROUND2004 /id}.
- Two European studies report quality of life specifically for patients who have had an ICU admission, both reporting the EQ5D:
    - Sacanella et al. 2011 (Spain) reports on patients experiencing a medical condition and ICU aged 65 and over at the study start, discharge and 12 months{Sacanella, 2011 SACANELLA2011 /id}.
    - Vainiola et al. 2011 (Finland) reports quality of life for emergency patients admitted to ICU/HDU at 6 and 12 months post treatment, stratifying by age{Vainiola, 2011 VAINIOLA2011 /id}.
- Three studies could be considered for longer term quality of life, all reporting use of EQ5D:
    - Bagshaw et al. 2014 (USA) reports quality of life experienced by people who had a critical care admission and stratifies by clinical frailty score{Bagshaw, 2014 BAGSHAW2014 /id}.
    - Ara and Brazier. 2011 (UK) report condition specific quality of life, stratified by age, using health surveys{Ara, 2011 ARA2011 /id}.
    - Agborsangaya et al. 2013 (Canada) report quality of life experienced by people with a chronic condition within the last 12 months{Agborsangaya, 2013 AGBORSANGAYA2013 /id}. This study was selectively excluded in light of similar evidence for a UK population{Ara, 2011 ARA2011 /id}.

The reviewed quality of life papers are also summarised in Table 11 with rationale for inclusion and exclusion.

1 **Table 11: Summary of utility evidence**

Study	Country	Population	Year of data	Quality of life meausre	Follow up	Sample size	Stratification of findings	Inclusion?
AGBORSANGAYA2013{Agborsangaya, 2013 AGBORSANGAYA2013 /id}	Canada	Random sample from a community population with 16 common self-reported chronic conditions	NR	EQ5D	health over last 12 months	4946	By condition, level of multi-morbidity, age, gender	Selectively excluded in light of Ara 2011
ARA2011{Ara, 2011 ARA2011 /id}	UK	General population - Health Survey for England	2003-6	EQ-5D	Cross-sectional study	41,174	Presence/absence of a chronic condition	**Inclusion for long term quality of life**
BAGSHAW2014{Bagshaw, 2014 BAGSHAW2014 /id}	USA	Critical care patients age >=50	2010	EQ5D VAS and SF12	6 months and 12 months	421	By clinical frailty score and age	**Inclusion for long term quality of life**
COURTNEY2009{Courtney, 2009 COURTNEY2009 /id}	Australia	Patients with an acute medical admission age≥65 with at least one risk factor for readmission	2004 to 2006	SF12	4, 12 and 24 weeks	128	NR	Excluded due to utility measure employed
ERIKSEN1998{Eriksen, 1998 ERIKSEN1998 /id}	Norway	Admitted patients	1993	Experts determined score	6 weeks	479	NR	Excluded due to utility measure employed
GOODACRE2012{Goodacre, 2012 GOODACRE2012 /id}	UK	Admitted to hospital by ambulance	2007 to 2008	EQ5D	30 days after admission	3028	by age, gender, condition	**Inclusion for post-acute phase**
HUTCHINSON2013{Hutchinson,	Australia	Patients with comorbid chronic condition	2007 to 2009	AQOL	questionnaire shortly after first visit	210		Excluded due to utility measure employed

Study	Country	Population	Year of data	Quality of life measure	Follow up	Sample size	Stratification of findings	Inclusion?
2013 HUTCHINSON2013 /id}								
HUTCHINSON2015{Hutchinson, 2015 HUTCHINSON2015 /id}	Australia	Patients with chronic condition at high risk of emergency admission	2007-2012	AQOL	questionnaire shortly after first visit	1999		Excluded due to utility measure employed
ROUND2004{Round, 2004 ROUND2004 /id}	UK	Patients with age>= 70 and experiencing acute care	prospective cohort - 1999-2000	SF36 and EQ5D	Time zero, 6 months post admission	367 at time zero, 254 at 6 mo	community versus district general hospital	**Inclusion for subgroup of patients over 70.**
SACANELLA2011{Sacanella, 2011 SACANELLA2011 /id}	Spain	Patients with age>= 65 admitted to ICU with medical condition	NR	EQ5D	Time zero, discharge, 12 months	112	For ages 65-74 and 75 +	Selective exclusion in light of Bagshaw et al. which stratifies by CFS
SAUKKONEN2006{Saukkonen, 2006 SAUKKONEN2006 /id}	Finland	Medical ICU patients	2002-2004	15 D	6 months post ICU admission	1167	ED versus non ED patients going to MICU	Exclude due to QoL measure employed
VAINIOLA2011{Vainiola, 2011 VAINIOLA2011 /id}	Finland	Emergency patients admitted to ICU/HDU	2003 and 2004	EQ5D and 15D	6 and 12 months post treatment	937	By presentation	Selective exclusion in light of Bagshaw et al. which stratifies by CFS
VEDIO2000 Vedio, 2000 VEDIO200	UK	Patients discharged from ICU	1994-5	SF36	6 months	115	Medical / surgical admissions	Excluded because of outcome measure

Study	Country	Population	Year of data	Quality of life meausre	Follow up	Sample size	Stratification of findings	Inclusion?
0 /id								

41.2.7.2 Quality of life after an AME

Utility values of those surviving 30 days post admission were taken from a UK study of patients recently admitted to hospital with a medical emergency{Goodacre, 2012 GOODACRE2012 /id}. The study uses responses to a EQ5D self-completed questionnaire. They report a utility of 0.45 (SD of 0.36) for the whole cohort where a utility of zero was given to non-survivors. Utilities of survivors only for application in the model were calculated and a breakdown by age is given in Table 12.

Table 12: Health utility estimates 30 days post admission stratified by age{Goodacre, 2012 GOODACRE2012 /id}

Age	N	N dead	Mean[(a)]	SD[(a)]	Median[(a)]	Mean of survivors (adjusted)[(b)]
Under 30	110	2	0.65	0.38	0.59	**0.66**
30-39	121	4	0.58	0.37	0.69	**0.60**
40-49	204	4	0.53	0.40	0.69	**0.54**
50-59	277	19	0.47	0.36	0.59	**0.50**
60 -69	509	69	0.45	0.37	0.52	**0.52**
70-79	773	137	0.43	0.35	0.52	**0.52**
80-89	813	219	0.4	0.34	0.52	**0.55**
90 or above	204	82	0.29	0.3	0.25	**0.48**
Total	3028	541	0.45	0.36	0.52	**0.55**

(a) These include non-survivors who have utility of 0.
(b) This mean has been adjusted by removing non-survivors.

Utility values of those surviving 6 months post admission are reported by a UK prospective cohort study of patients aged over 70 with an acute illness requiring hospital admission{Round, 2004 ROUND2004 /id}. The study uses responses to a EQ5D self-completed questionnaire. The findings are reported by either those attending a district general hospital or attending a community hospital. The utilities are reported for the study start point and a mean change score for 6 months is given in Table 13.

Table 13: Health utility estimates over six months{Round, 2004 ROUND2004 /id}

Population	n.	Male %	Median age	Median EuroQol 5D weighted health index at presentation	Mean change EuroQol 5D weighted health index at 6 months
District general hospital	118	53%	81 (76 to 85 IQR)	0.36 (95%CI: 0.07 to 0.69)	0.21 (95%CI: 0.14 to 0.28)
Community hospital	136	46%	83 (78 to 88 IQR)	0.26 (95%CI: 0.005 to 0.69)	0.16 (95%CI: 0.08 to 0.24)

The populations and findings from the 2 UK studies{Goodacre, 2012 GOODACRE2012 /id;Round, 2004 ROUND2004 /id} appear comparable. Taking data from Goodacre et al. 2012{Goodacre, 2012 GOODACRE2012 /id}, the weighted utility for patients 70 and over was 0.53 (at 30 days). Taking mid points of age categories, the mean age for this group was 81. Round et al{Round, 2004 ROUND2004

/id} who studied patients aged 70 and over who were admitted with an acute illness, whose condition could have been fully treated in either a district general or community hospital. They found a mean utility of 0.36 at the start of the study (timing was undefined) and 0.57 at 6 months post admission. The median age of participants was 81.

A US study reports utility values for a population of critically ill patients, stratifying by clinical frailty score{Bagshaw, 2014 BAGSHAW2014 /id}. This study reported EuroQol visual analogue scale scores for each of 2 groups based on clinical frailty scores: 1 group with a score from 1 to 4 and the other group with a score greater than 4, representing the most frail group. We noted that those who have a CFS score > 3 have a utility 21% lower than the utility of those who were considered non-frail.

Table 14: Utilities by Clinical Frailty Scale score at 6 months{Bagshaw, 2014 BAGSHAW2014 /id}

	CFS score	
	1-4 Non-frail	**5-9 Frail**
Mean age	66 (SD ±10)	69 (SD ±10)
At 6months		
n =	195	67
Utility	0.65 (SD ±19)	0.52 (SD ±22)
At 12 months		
n =	170	59
Utility	0.68 (SD ±18)	0.54 (SD ±23)

41.2.7.3 Quality of life by age for people with chronic condition

Ara and Brazier{Ara, 2011 ARA2011 /id} report expected utilities stratified by age group and common health conditions for a UK population (Table 15). Utilities for a patient population without a history of any health condition are reported for comparison.

Table 15: Quality of life by age for the general population – with and without a history of a health condition. Ara and Brazier{Ara, 2011 ARA2011 /id}.

Age Band (years)	N	mean	95% CI of mean	n	mean	95% CI of mean
	History of health condition			No history of health condition		
	n = 41147			n=22449		
<30	8083	0.9383	(0.935,0.941)	6269	0.9633	(0.960,0.965)
30 to ≤ 35	3608	0.9145	(0.907,0.921)	2555	0.9564	(0.951,0.961)
35 to ≤ 40	4020	0.9069	(0.900,0.913)	2675	0.9544	(0.950,0.958)
40 to ≤ 45	3746	0.8824	(0.872,0.891)	2376	0.9513	(0.946,0.956)
45 to ≤ 50	3294	0.8639	(0.852,0.875)	1892	0.943	(0.936,0.949)
50 to ≤ 55	3156	0.8344	(0.824,0.843)	1555	0.9345	(0.927,0.941)
55 to ≤ 60	3285	0.8222	(0.811,0.833)	1400	0.9296	(0.914,0.944)
60 to ≤ 65	2739	0.8072	(0.793,0.821)	1017	0.9373	(0.928,0.946)
65 to ≤ 70	2993	0.8041	(0.790,0.817)	992	0.9331	(0.921,0.944)
70 to ≤ 75	2501	0.779	(0.766,0.791)	741	0.9219	(0.909,0.934)
75 to ≤ 80	1895	0.7533	(0.739,0.767)	522	0.8965	(0.881,0.911)
80 to ≤ 85	1199	0.6985	(0.677,0.719)	301	0.8844	(0.866,0.902)
>85	655	0.6497	(0.624,0.675)	154	0.8191	(0.784,0.853)

41.2.7.4 Application of utility data in the baseline scenario

Three studies were used to estimate baseline quality of life.

- Goodacre et al. 2012{Goodacre, 2012 GOODACRE2012 /id} reports applicable and complete data for quality of life experienced 30 days after admission by patients arriving by ambulance, however, the study did not report change in quality of life overtime.
- Bagshaw et al. 2014{Bagshaw, 2014 BAGSHAW2014 /id} indicates the difference in utility between frail and non-frail patients.
- Ara and Brazier 2011{Ara, 2011 ARA2011 /id} provide utilities by age group for people with chronic conditions.

Ara and Brazier{Ara, 2011 ARA2011 /id} report condition specific quality of life, stratified by age, using health surveys in a UK population. These represent upper estimates of long-term utility after an AME. We use these for utility for non-frail patients. Using this data, quality of life declines over time as the patient gets older. The committee were aware that for some patients, quality of life declines significantly after an AME, whereas others return to their usual quality of life. It is assumed in the model that those who are considered frail (CFS≥5) will have no utility improvement after an AME. Those who are not frail will have their utility linearly improve to the average age-specific quality of life described in Ara and Brazier{Ara, 2011 ARA2011 /id} for an individual with a health condition 1 year post AME.

Taking the above into account, the baseline utility used in the model is age dependent and informed by the proportion of that age group that are considered frail upon admission:

- Depending on the individual's age, a utility value is taken from Goodacre et al, as described in Table 12.
- As this value represents the average utility for both frail and non-frail, it is then adjusted based on the assumption that those who are frail have a quality of life 23% lower than those who are not frail, as described in Bagshaw et al.
- If the individual is not frail then their quality of life will increase at a linear rate until 1 year when it reaches the age-specific quality of life of the general population, with a health condition, as described in Table 16.
- As the patient gets older, their quality of life changes in line with the values presented in Ara and Brazier but with the smoothing applied.
- If the patient is frail, it is assumed that their quality of life will remain unchanged for the remainder of their life.

This approach is illustrated in if the individual is not frail then their quality of life will increase at a linear rate until 1 year when it reaches the age-specific quality of life of the general population with a health condition, as described in Table 16.

Table 16: Utility over time in the baseline scenario for patient age 80

Frailty (%)	Non-Frail CFS 1-4 (58%)	Frail CFS 5+ (42%)	Weighted average (a)
Presentation	0.600	0.476	0.547
30 days	0.610	0.476	0.553
90 days	0.620	0.476	0.559
6 months	0.630	0.476	0.565
1 year	0.723	0.476	0.618
2 years	0.718	0.476	0.615
5 years	0.716	0.476	0.587
10 years	0.701	0.476	0.563

(a) [utility (non-frail) x (% non-frail)] +[(utility (frail) x (% frail)] = weighted average

41.2.7.5 Application of the quality of life treatment effect

The treatment effect for extended access to physiotherapy and occupational therapy was elicited from the experts of the committee's health economics subgroup. These were multipliers and were applied for 1 year only in the base case analysis and for 5 years in a sensitivity analysis.

41.2.7.6 Quality of life within hospital

The models do not take into account incremental quality of life within the hospital period explicitly. There was no evidence for in-hospital quality of life improvement for the interventions we looked at and a modest gain in quality of life over the course of an admission would have a negligible impact on the long-term QALYs. To avoid over-estimating the benefits of reduced length of stay, we assumed the same utility in hospital as post-discharge up to 90 days.

41.2.8 Resource use and costs

Costs of the different types of resource use, such as staff time, are taken from standard NHS sources.

41.2.8.1 Intervention (Staff) costs

Table 17gives details of the staff time in the interventions, as decided by the Guideline's health economics subgroup.

Table 17: Staff time

Description	Baseline	Intervention
RAT in the ED		
Time spent with patient	This service is currently not provided	15 minutes
Staff member(s) involved		1 consultant
AMU consultant review		
Time spent with patient	20 minutes	
Staff member(s) involved	1 consultant	
Consultant review on medical wards		
Consultant reviews per patient per week	2	7
How long will each review take?	15 minutes - first review 10 minutes - subsequent	15 minutes – first review 10 minutes - second review 5 minutes - subsequent reviews
Staff member(s) involved	1 consultant	1 consultant AND 2 junior doctors* and 1 nurse*
Therapy in the ED		
Time spent with patient	45 minutes	
Staff member(s) involved	occupational or physiotherapist (80% of the time) assistant (20% of the time)	
Therapy on medical wards		
Time spent with patient	30 minutes review every day	
Staff member(s) involved	occupational or physiotherapist (59% of the time) assistant (12% of the time) ward nurse (29% of the time)	

** Costed only at the weekend because it's considered that they would be present for ward rounds in the week for both scenarios.*

The unit cost of staff were reported by the Personal and Social Services Research Unit{Curtis, 2015 CURTIS2015 /id}. These costs were adjusted to reflect on-call salary enhancements and whether the work was in premium or non-premium time. Standard NHS contract policy documents were consulted to determine any additional cost associated with out of hours and premium time, inclusive of enhancements to salary due to rota and on-call arrangements{NHS Employers, 2009 NHSE2009 /id;NHS Employers, 2011 NHSE2011 /id;NHS Employers, 2016 AFC2016 /id;NHS Employers, 2016 NHSE /id}. Since most of the interventions involve extending services further in to unsocial hours, it is important to capture the incremental costs associated with these hours. The full break down of these costs is shown in Table 18 and Table 19.

Table 18: annual wage costs used in the models

Member of staff	Band/level	On-call salary enhancement	Wages	Wages (with on-call salary enhancement)
Hospital physiotherapist	6	3.00%	£31,351	£31,978
Hospital occupational therapist	6	3.00%	£31,351	£31,978
Hospital support worker	4	3.00%	£21,413	£21,841
Nurse	6	3.00%	£32,114	£32,756
Consultant	Medical	5.00%	£87,499	£90,124
Foundation Doctor Year 1	Foundation Doctor Year 1	4.00%	£26,350	£26,350
StR CT1	StR CT1	4.00%	£26,350	£26,350

Table 19: overhead costs associated with staff time

Member of staff	Oncost: superannuation and national insurance	Qualification and ongoing training	Staff (direct) overhead (PSSRU 2016)	Non staff (indirect) overhead (PSSRU 2016)	Capital	Sum of additional costs
Hospital physiotherapist	£7,235	£5,995	£9,427	£16,789	£4,672	£36,883
Hospital occupational therapist	£7,235	£5,995	£9,427	£16,789	£4,672	£36,883
Hospital support worker	£4,587	£0	£6,353	£11,315	£4,104	£21,772
Nurse	£7,439	£11,251	£9,663	£17,210	£3,065	£41,189
Consultant	£22,427	£58,533	£26,777	£47,689	£5,295	£138,294
Foundation Doctor Year 1	£5,765	£24,295	£6,752	£12,026	£4,228	£47,301
StR CT1	£5,765	£24,295	£6,752	£12,026	£4,228	£47,301

Table 20: Cost of staff time

	Hours worked per annum (PSSRU 2016)	Premium wage enhancement	Cost per hour – non-premium	Cost per hour – premium	Premium time
Consultant	1838	33% increase	£138	£159	Weekends and 7pm-7am
Junior doctor (registrar ST1)	2133	37% increase	£59	Not used in model	9pm-7am daily
Junior doctor (foundation year 1)	2037	37% increase	£38	Not used in model	
Therapist (band 6)	1603	30% increase (60% for Sundays)	£48	£55 (Sunday £63)	Weekends and 6am-8pm
Therapy assistant (band 4)	1592	37% increase (74% for Sundays)	£30	£37 (Sunday £41)	
Ward nurse (Band 6)	1573	30% increase (60% for Sundays)	£48	£55 (Sunday £63)	

41.2.8.2 Pathway and downstream costs

The models analysed the subsequent impact on hospital costs associated with the interventions. Table 21 below details the unit costs used.

Table 21: Unit costs of health care

	Model	Unit cost	Source & notes
Hospital bed day - all inpatient wards except ICU/HDU)	Cohort model & simulation model	£296	NHS Reference costs{Department of Health, 2014 NHSREFCOSTS2014 /id} For non-elective excess bed days: (Total cost of bed days / number of bed days) = £999,936,997 / 3,380,432
ICU/HDU attendance	Cohort model	£5,207	NHS Reference costs{Department of Health, 2014 NHSREFCOSTS2014 /id} Weighted average of: (cost of an ICU/HDU bed day for given service code) x (average length of stay for given service code) for NHS reference cost service codes: CCU01, CCU03, CCU05, CCU09, CCU10, CCU11, CCU90, CCU91.
ICU/HDU bed day	Simulation model	£1,262	NHS Reference costs{Department of Health, 2014 NHSREFCOSTS2014 /id}
ED attendance	Cohort model & simulation model	£114	NHS Reference costs{Department of Health, 2014 NHSREFCOSTS2014 /id} ED – not admitted Weighted average cost of the following service codes: T01NA, T02NA, T03NA, T04NA
Post-discharge cost	Cohort model & simulation model	£2,107	PSSRU{Curtis, 2015 CURTIS2015 /id}
Short stay admission	Cohort model	£588	Non-elective short stay NHS Reference costs{Department of Health, 2014 NHSREFCOSTS2014 /id}
CDU visit	Simulation model	£192	NHS Reference costs{Department of Health, 2014 NHSREFCOSTS2014 /id} ED – admitted
AAMU visit	Simulation model	£158	NHS Reference costs{Department of Health, 2014 NHSREFCOSTS2014 /id} General medicine - outpatient

For post-discharge costs, we used the 3-month costs for patients followed up after being admitted to an AMU. In the base case analysis, we did not include other costs in extra months of life, since only disease-specific costs should be included in the NICE reference case. However, in a sensitivity analysis we included age-specific annual NHS costs calculated by the Nuffield Trust{Robineau, 2016 ROBINEAU2016 /id;Bardsley, 2010 BARDSLEY2010 /id}.

41.2.9 Cost-effectiveness

The widely used cost-effectiveness metric is the incremental cost-effectiveness ratio (ICER). This is calculated by dividing the difference in costs associated with 2 alternatives by the difference in QALYs. The decision rule then applied is that if the ICER falls below a given cost per QALY threshold then the result is considered cost-effective. If both costs are lower and QALYs are higher, then the option is said to dominate and an ICER is not calculated.

$$ICER = \frac{Costs(B) - Costs(A)}{QALYs(B) - QALYs(A)}$$

Where: Costs(A) = total costs for option A; QALYs(A) = total QALYs for option A

Cost-effective if:

- ICER < Threshold

When there are more than 2 alternative comparators, options must be ranked in order of increasing cost then options ruled out by dominance or extended dominance before calculating ICERs excluding these options. An option is said to be dominated and ruled out if another intervention is less costly and more effective. An option is said to be extendedly dominated if a combination of 2 other options would prove to be less costly and more effective.

It is also possible, for a particular cost-effectiveness threshold, to re-express cost-effectiveness results in term of net monetary benefit (NMB). This is calculated by multiplying the total QALYs for a comparator by the threshold cost per QALY value (for example, £20,000) and then subtracting the total costs (formula below). The decision rule then applied is that the comparator with the highest NMB is the most cost-effective option at the specified threshold. It provides the highest number of QALYs at an acceptable cost.

$$Net\ Monetary\ Benefit\ (X) = \left(QALYs(X) \times \lambda\right) - Costs(X)$$

Where: λ = threshold (£20,000 per QALY gained)

Cost-effective if:

- Highest net benefit

Both methods of determining cost-effectiveness will identify exactly the same optimal strategy. For ease of computation, NMB is used in this analysis to identify the optimal strategy.

Results are also presented graphically where total costs and total QALYs for each diagnostic strategy are shown. Comparisons not ruled out by dominance or extended dominance are joined by a line on the graph where the slope represents the incremental cost-effectiveness ratio.

41.2.9.1 Interpreting the results

NICE's report 'Social value judgements: principles for the development of NICE guidance'{National Institute for Health and Clinical Excellence, 2008 NICE2008 /id} sets out the principles that committees should consider when judging whether an intervention offers good value for money. In general, an intervention was considered cost-effective if either of the following criteria applied (given that the estimate was considered plausible):

- The intervention dominated other relevant strategies (that is, it was both less costly in terms of resource use and more clinically effective compared with all the other relevant alternative strategies), or
- The intervention costs less than £20,000 per quality-adjusted life-year (QALY) gained compared with the next best strategy.

Where we compare several interventions, we use the NMB to rank the strategies based on their relative cost-effectiveness. The highest NMB identifies the optimal strategy at a willingness to pay of £20,000 per QALY gained.

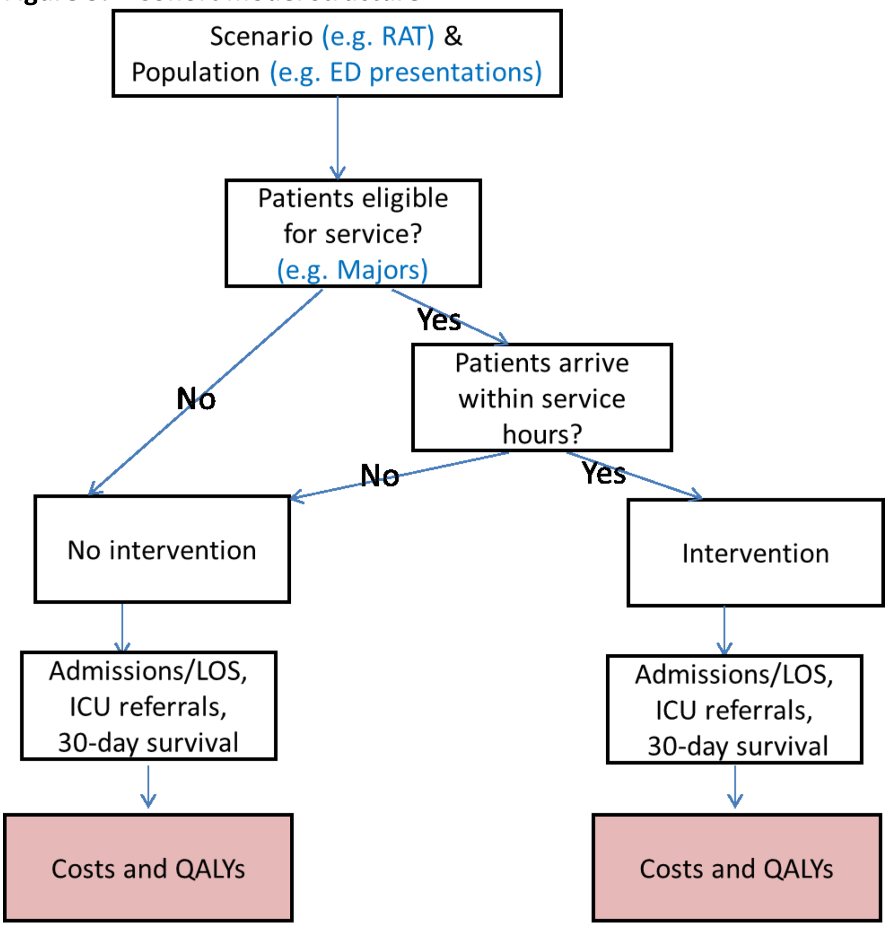
41.3 Cohort model methods

41.3.1 Approach to modelling

The model has a simple structure (**Figure 3**) but the calculations are stratified by age. For each scenario, the model runs first with a cohort of 18-year-old patients and then re-runs the analysis for every age up to 100 years old, increasing age by increments of one year each time. Each time, the model calculates the costs and QALYs for a cohort of 1,000 patients going through. At the end, the model weights the results for each age cohort based on the relevant age distribution.

The results of each scenario are compared to the Baseline scenario where none of the interventions takes place.

Figure 3: Cohort model structure



41.3.2 Interventions that take place in the emergency department

This section covers how the model calculates costs and QALYs for the following interventions:

- RAT in the ED
- Extended access to therapy in the ED

First, the model retrieves the case-mix (NEWS minus AVPU, CFS) of patients for a given age. Further details on how case mix is determined can be found in section 41.2.3. In the case of RAT, it depends on whether they come through majors.

Based on the case-mix, a proportion of patients will receive the intervention. Further details on the selection criteria for each intervention can be found in section 41.2.2. Two outcomes are determined by case-mix and by the proportion of patients receiving the intervention (see 41.2.5):

- Admission.
- 30-day survival (for RAT in the optimistic treatment effects sensitivity analysis).

The costs are calculated based on the number of patients who receive the intervention, the number of admissions and the number of survivors at 30 days. Details on costs can be found in section 41.2.7.6.

Lifetime QALYs are calculated for each age for those patients surviving 30 days. Hence, the QALYs depend on age, frailty and the proportion surviving at 30 days. Since mortality is unchanged by these 2 interventions, there is no improvement in QALYs in the base case. Further details on how survival and quality of life are determined can be found in section 41.2.6 and 41.2.7 respectively.

41.3.3 Interventions that take place in hospital wards

This section covers how the model calculates costs and QALYs for the following interventions:

- Daily consultant review on medical wards.
- Extended hours consultants in AMU.
- Extended access to therapy on medical wards.

The model calculates the impact on total costs and QALYs for a cohort of 1000 patients going through a particular ward (GMW or AMU, depending on which intervention is being analysed).

First, the model retrieves the case-mix (NEWS minus AVPU, CFS) of patients for a given age. Further details on how case mix is determined can be found in section 41.2.3.

Based on the case-mix, a proportion of patients will receive the intervention. In the case of extended hours for consultants in AMU, it will also depend on how many patients arrive during service hours. Further details on the selection criteria for each intervention can be found in 41.2.2.

Four outcomes are determined by case-mix, by the intervention and by the proportion of patients receiving the intervention (see 41.2.5):

- Length of hospital stay.
- Number of ICU/HDU referrals.
- 30-day survival.
- Quality of life up to 1 year.

The costs are calculated based on the number of patients who receive the intervention, the length of stay, the number of ICU/HDU referrals and the number of survivors. Details on costs can be found in section 41.2.7.6.

Lifetime QALYs are calculated for each age for those patients surviving 30 days. Hence, the QALYs depend on age, frailty and the proportion surviving at 30 days. For the therapy intervention, an additional quality of life benefit is added to those who receive the intervention and survive. Further details on how survival and quality of life are determined can be found in section 41.2.6 and 41.2.7 respectively.

41.3.4 Inputs

The inputs have been described in 41.2. Table 22 shows the proportion of patients who were eligible for each intervention.

Table 22: Proportion of patients who receive the intervention in the Cohort model

Description	Baseline	Intervention	Source
RAT			
emergency attendances eligible for service (major patients only)	This service is currently not provided	30.5%	Meacock 2016{Meacock, 2016 MEACOCK2016 /id}
emergency attendances arriving within intervention service hours (8:00 – midnight, everyday)		89%	HES 2014-15{Health & Social Care Information Centre, 2015 HSCIC2015A /id}
AMU consultant review			
AMU patients eligible for this review	100%		
patients arriving during current service hours	54%		HES 2014-15{Health & Social Care Information Centre, 2015 HSCIC2015A /id}
patients arriving within extended service hours (18:00 – 22:00)	0%	24%	HES 2014-15{Health & Social Care Information Centre, 2015 HSCIC2015A /id}
Consultant review on medical wards			
GMW patients eligible for this review	100%		
Therapy in the ED			
emergency attendances eligible for service (CFS score of 3,4,5 or 6)	21%		SAMBA 2013{Subbe, 2015 SUBBE2015 /id}
emergency attendances arriving within intervention service hours	38%	75%	HES 2014-15{Health & Social Care Information Centre, 2015 HSCIC2015A /id}
Therapy on medical wards			
GMW attendances eligible for service (CFS score of 3 or greater)	67%		SAMBA 2013{Subbe, 2015 SUBBE2015 /id}

The cost of the intervention depended on the number of patients receiving the intervention during premium time – see Table 23.

Table 23: Proportion of time the intervention is in premium hours

Description	Baseline	Intervention
RAT in the ED		
Consultants (weekends and 7pm-7am)	NA	40%
AMU consultant review		
Consultants (weekends and 7pm-7am)	39%	45%
Consultant review on medical wards		
Consultants (weekends and 7pm-7am)	0%	21%
Junior doctors (9pm-7am daily)	NA	0%
Nurses (weekends and 6am-8pm)	NA	100%
Therapy in the ED		
Therapists (weekends and 6am-8pm)	0%	39%

Description	Baseline	Intervention
Therapy on medical wards		
Therapists/nurses (weekends and 6am-8pm)	0%	29%

41.3.5 Sensitivity analysis

Each analysis was repeated as follows:

Table 24: sensitivity analyses for cohort model

Sensitivity analysis	Description
SA1: Optimistic treatment effects	The analysis was re-run using the most favourable conditions for the intervention treatment effects.
SA2: Conservative treatment effects	The analysis was re-run using the least favourable conditions for the intervention treatment effects.
SA3: Long term costs	Include the non-AME related healthcare costs associated with lifetime survival
SA4: improve post-AME survival	The age-specific standardised mortality ratios were applied as usual but there was no additional excess mortality in the first 90 days. This improves survival and therefore increases the cost effectiveness of interventions that avert in-hospital deaths.
SA5: improve quality of life	The quality of life of an individual who is frail returns to pre-AME levels. This improvement in quality of life improves the cost effectiveness of interventions that avert deaths.
SA6: simultaneously improve quality of life and survival	This sensitivity analysis improves survival and quality of life simultaneously, as described in SA4 and SA5.
SA7: Lower intervention costs	Consultant wages were reduced by 25% and other staff were a grade lower than in the base case. There is a lower frequency of on-call working.
SA8: Higher intervention costs	Consultant wages were increased by 25% and other staff were a grade lower than in the base case. There is a highr frequency of on-call working.

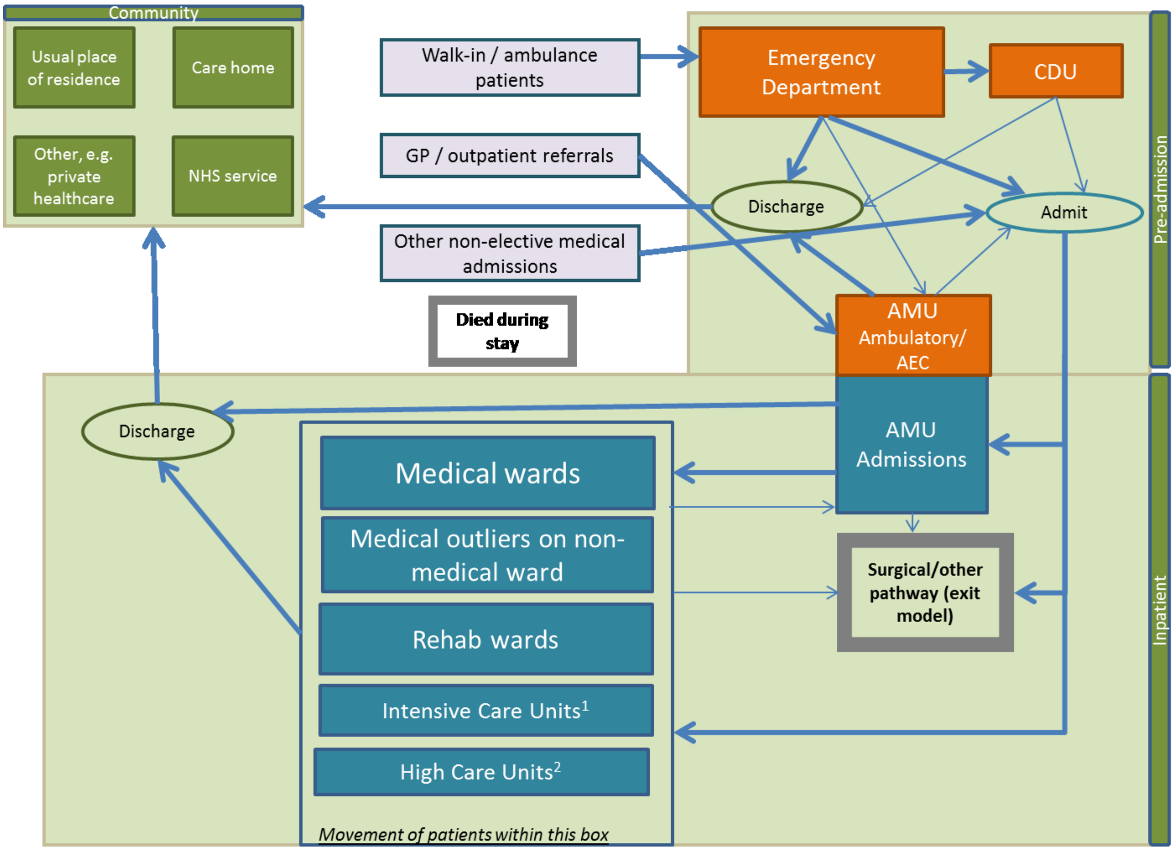
41.4 Simulation model methods

41.4.1 Approach to modelling

A discrete event simulation model was built using a “determine event first then time” approach within Simul8 professional{Barton, 2004 BARTON2004 /id;Brennan, 2006 BRENNAN2006 /id;Karnon, 2012 KARNON2012 /id}. Simul8 allows the interaction of simulated patients with resources (beds) within the hospital. Since resources are limited, the model records queueing of patients and occupancy of resources.

The model captures the results for patients in 1 year running of simulated hospital for emergency patients. The model runs for a total of 4 years; 2 year warm up period to populate the simulated hospital, 1 year results collection year and 1 year cool down period to allow patients with a large length of stay that entered during the results collection year to exit the simulated hospital. After 10 months of the 1 year cool down period, resource constraints are lifted to allow the free movement and exit of the model of any patients who entered during the collection year but are still in the hospital at this time. To account for the few patients still in the hospital at the end of the cool down year, we calculated in Excel, QALYs and costs based on their case-mix and added them to the Simul8 totals.

Figure 4: Flow of patients through the model



[1]High Dependency Unit, Intensive Care Unit
[2]Hyper-acute Stroke Unit, Coronary Care Unit, Renal high care, Respiratory high care

Figure 4 shows the different locations in the model and the flow of patients between them. The model is split into 3 distinct areas; preadmission, admitted wards and the community. In addition to the flows indicated by arrows, at any location, some patients will die and there are movements between the different ward locations, for example, a patient could move from a medical ward to ICU/HDU back to a medical ward and then on to a rehabilitation ward.

The following areas are modelled:

- Hospital pre-admission locations
  - Emergency Department (ED)
  - Ambulatory Acute Medical Unit – acute medicine experts provides outpatient care for AME patients during daytime.
  - Clinical Decision Unit – short stay wards provided by emergency medicine experts. Although these are technically admissions, we have made a distinction, since they are part of the emergency pathway rather than medical pathway and patients were not recorded on VitalPAC, which computes NEWS.
- Hospital admission locations
  - Acute Medical Unit (AMU) – where undifferentiated AME patients are assessed and managed usually for up to 24 hours.
  - General medical wards (GMW) – provide level 1 care to medical patients, includes specialist wards such as gastroenterology, care of the elderly.
  - Intensive care unit / high dependency unit (ICU/HDU) – the intensive medicine department providing level 2 and level 3 care.

  - Specialist high care units (HCU) – level 2 care in the hyper-acute stroke unit, coronary care unit, respiratory high care unit and renal high care unit.
  - Rehab wards – long stay wards.
  - Medical outliers – AME patients on non-medical (surgery, gynaecology, trauma) wards.
  - Non-medical pathway – Patients that are admitted under a medical consultant but subsequently take a non-medical pathway.

Patients join the model at the point that they present to the hospital with an acute medical problem. Patients presenting at the emergency department (ED) with a non-medical problem (trauma, gynaecology, surgery or mental health) are also simulated but leave the model at the point they leave the ED. Other patients start on a medical pathway but subsequently leave the model when there pathway changes to a non-medical one. Medical patients leave the model at the point that they are discharged from the hospital.

All patients (medical and non-medical) presenting within the observation year are allocated life-years, QALYs and post-discharge costs at the point that they leave the model.

The model compared the following scenarios:

- Baseline.
- RAT in the ED.
  - Base case and optimistic sensitivity analysis.
- Extended hours for consultants on AMU.
  - Base case and conservative sensitivity analysis.
- Daily consultant review on medical wards.
  - Base case and optimistic sensitivity analysis.
- Extended access to therapy in the ED.
  - Base case and optimistic sensitivity analysis.
- Extended access to therapy on medical wards.
  - Base case and conservative sensitivity analysis.
- Earlier access to new care home.
  - Five day decrease in length of stay.
  - One day decrease in length of stay.

The model was run many times for each scenario. For each run, Simul8 outputs the following to a spreadsheet, sub-grouped by age group and current NEWS:

- Number of presentations.
- Number of admissions.
- In-hospital deaths.
- Costs (discounted and undiscounted).
- QALYs (discounted and undiscounted).

Simul8 also outputs the following sub-grouped by location:

- Total number of stays.
- Average length of stay.
- Total discharges.
- Stay costs.
- Intervention costs.
- Average bed occupancy.

- Percentage of 4 hour breeches (ED only).

41.4.1.1 Differences between the simulation model and the cohort model

By modelling hospital flow in the simulation model, we are able to estimate the incidence of medical outliers and the consequences for costs and health outcomes that are not assessed in the cohort model (41.3). The simulation model evaluates the same interventions as the cohort model. It is also being used to estimate the benefits of reducing delayed transfers of care for patients being transferred to a care home.

The cohort model can therefore be seen as the impact on costs and health outcomes if there were no changes to hospital flow arising from the interventions. This may be the case in some hospitals if they have few medical outliers.

By modelling individual patients, the simulation model can model some of the effects more precisely; since the effects can be applied directly to the transition probabilities (see 41.2.5). In addition, by modelling individual patients, the simulation model can better deal with the correlation between different patient characteristics.

For some of the comparisons, the cohort model contained intervention costs in the baseline as well as in the intervention arm. For the simulation model, only the incremental intervention costs were included in the intervention scenarios and no intervention costs were included in the baseline scenario, on the assumption that they are incorporated within bed-day costs. The impact on cost effectiveness should be the same but it allowed the simulation model to have only a single Baseline scenario.

For the cohort models, results were reported per 1000 patients, whereas for the simulation model results are reported based on a single large DGH. Three different cohorts were used in the cohort analyses depending on the analysis (ED patients, AMU patients and GMW patients). For the simulation model, the population includes everyone presenting at ED plus direct non-elective medical admissions plus direct referrals to the ambulatory AMU. Hence mean QALYs and mean costs will reflect the cohort. However, this difference in approach should not affect the cost effectiveness result, such as the magnitude of the incremental cost per QALY gained.

The simulation model does utilise mode data that is specific to one hospital rather than national data (41.4.4) but that hospital was broadly similar to the national average in most respects (Appendix E).

During construction, the cohort model has been useful in checking the validity of the output of the (more complex) simulation model (see 41.4.8).

The run time of the simulation model has limited the number of sensitivity analyses that can be performed. Therefore, the cohort model has been useful in exploring the robustness of the model results (see 41.4.7).

41.4.2 Labels, workstations and procedures

A description of labels, workstations and procedures can be found in Appendix G.

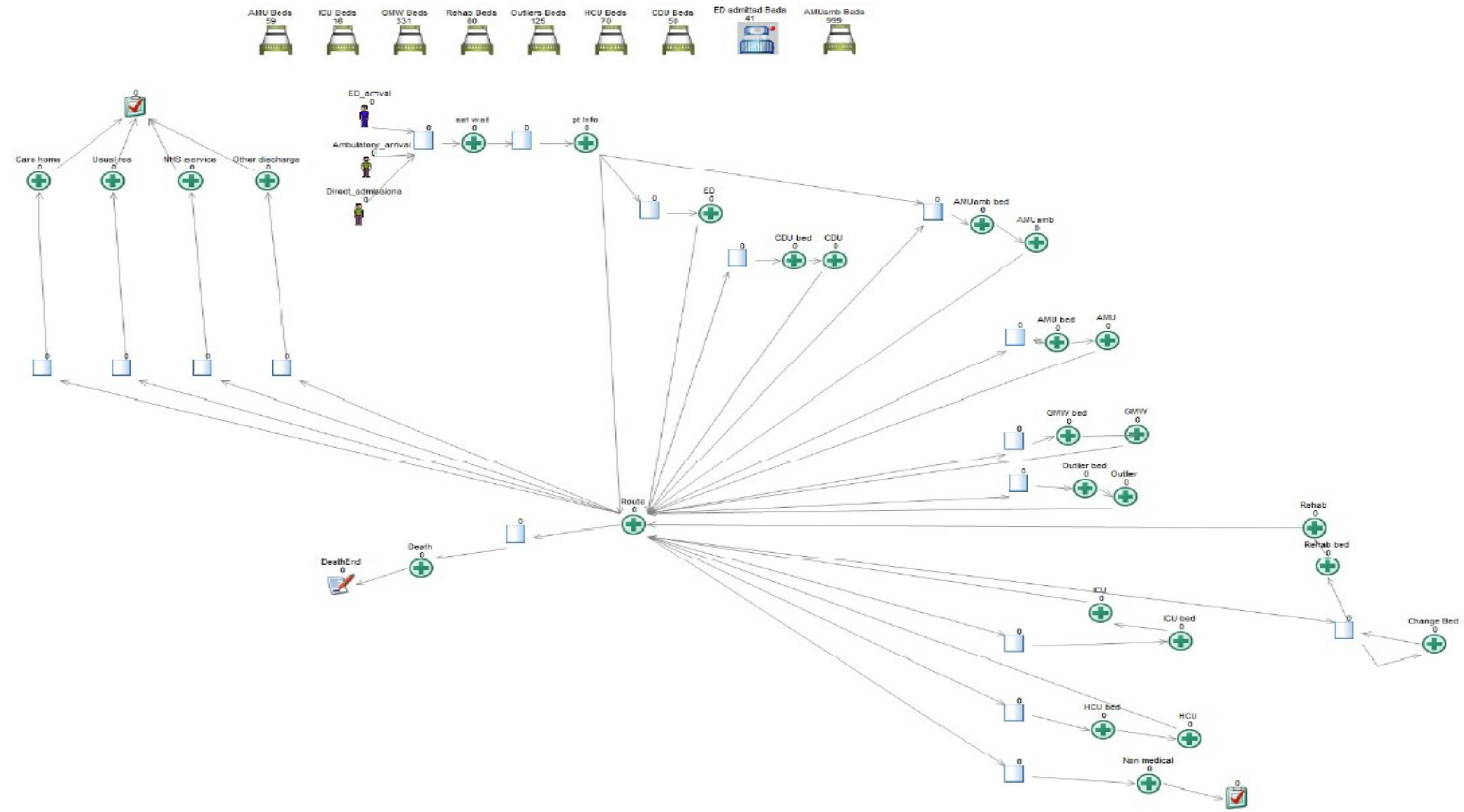
Labels are patient-level variables that define the characteristics and history of a patient as they move throughout the model. Labels are attached to individual patients and are used for the following:

- as indicators of case-mix (age, NEWS, CFS),
- to record where the patient is and where they are going next,
- to record model outcomes for the individual patient, such as costs and QALYs.

In addition to labels, the model also uses global values, which are used by the entire cohort as an input or output. Examples of global variables include: one to indicate which quarter of the year the simulation is currently in and another to record the total number of admissions.

'Workstations' are used to do the work of different locations of the pathway; this includes assigning patient characteristics and routing patients around the model. The workstations can be seen in the model as objects that process individual patients as they move throughout the simulation. Within the objects, multiple calculations and processes can be implemented. The calculations and processes of each location within the model are represented by a queue and 2 workstations (**Error! Reference ource not found.**).

Figure 5: Simul8 model



The image shows a snapshot of the model at the start. The numbers at the very top indicate the number of beds currently unoccupied. The numbers by each workstation or queue indicate the number of patients currently in that location.

The queue allows patients to wait for movement into a new location and trigger decision rules after a certain time waiting. For example, simulated patients enter and wait in a queue to enter the rehabilitation ward until there is available capacity. The first of 2 workstations changes the resource used by the simulated patient, representing change of beds, and creates the block causing the wait time within the queue when there is no available capacity. The second workstation calls on the different procedures to calculate the simulated patient's next location in their pathway, their length of stay in their current location and change in NEWS over the course of the stay in that current location). Workstations are also used for other processes within the model, such as assigning patient characteristics and routing simulated patients around the model. A description of each workstation can be seen in Table 75.

The simulation model uses 'resources' to represent beds. There are a constrained number of beds for each location to represent the capacity of that location. Patients pick up resources on entry to a location and drop the resource only when they are able to pick up a new resource for their next location.

The simulation model calls on 'procedures' for identical work in each area of the model. Procedures increase efficiency within the model by avoiding repeated coding in multiple areas of the model. Procedures can be used where the same block of calculations are required but only the location is different, such as calculating the length of stay. Procedures are used for setting patient characteristics, routing patients throughout the pathway, calculating patient length of stay in each location of the model, working with resources, calling on decision rules, calculating post-hospital outcomes and recording results.

41.4.3 Number of model runs

The simulation model uses numerous random numbers for probability calculations and samples from distributions for processes such as arrival times and length of stay. As a result, multiple runs need to be carried out to take into account random variation in sampling. Using the built in run calculator, Simul8 estimated a total number of 600 runs needed would be required to estimate the number of medical outliers (a key outcome of this model) within 5% of what we would get from an infinite number of runs. However, what we are interested in is the incremental results between scenarios.

To see if we had conducted a sufficient number of runs, we re-calculated:

- The incremental number of medical outliers for an intervention scenario compared with baseline, averaged across different runs.
- This was re-computed after each run.
- This was then plotted on a graph with number of runs on the horizontal axis (see Figure 6) to see how soon the results stabilised.
- This was repeated for each scenario for the following outcomes: medical outliers, cost per patient, QALYs per patient, in-hospital deaths and incremental net benefit.

The committee agreed that, due to time and logistical constraints, above 1000 runs was arbitrarily decided to be the minimum number of runs needed. Under the time and logistical constraints, 1280 runs of each scenario were completed.

Figure 6: Plot of incremental QALYs in relation to the number of runs

Work in progress – To be added after consultation.

41.4.4 Inputs and sampling

41.4.4.1 Data

The data sources for the simulation model have been described above (41.2). Much of the data comes from a bespoke analysis of data from a large DGH, the Queen Alexandra Hospital, Portsmouth (Appendix E). The bed numbers were estimated as part of the bespoke analysis. However, the bed numbers used in the simulation were moderated to achieve a representative simulation of the hospital and processes not provided within the data analysis (see 41.4.6). GMW beds were adjusted until the model produced an average number of outliers within 1 year close to the 1800 seen in the data analysis. Once calibrated to achieve the correct number of outliers, the bed numbers and more detailed baseline results, including bed occupancy in the AMU and GMW, were discussed with the health economic subgroup as a sense check. ED trollies are the first constrained resource within the model. In times of pressure, the hospital flow will back up all the way to the queue for ED trollies. Therefore, the queue into the ED is the final choke point within the model. The ED queue can be affected by the flow of patients at other points within the hospital. The final bed numbers used can be found in Table 25.

Table 25: Bed/trolley numbers in the model

Resource	Provision	Source
General Medical Ward (GMW)	331	Calculated through calibration of outlier numbers in the baseline scenario (see 41.4.5)
Emergency Department (ED) trolleys	41	Estimated from Queen Alexandra Hospital data from the data collection period
Acute Medical Unit (AMU)	59	
Intensive Care Units (ICU)	16	
Rehab	80	
Medical outlier	125	Expert opinion
High Care Units (HCU)	70	Calibrated so that there was not excessive queuing
Clinical Decision Units (CDU)	Not limited in the model	
Ambulatory AMU		

A review of the effects of weekend admission on mortality was conducted (Appendix C). It is difficult to control for case-mix in this area. The studies that included ED presentations in addition to admissions suggested that case-mix could explain most of the observed weekend effect. Therefore, we decided not to include an explicit weekend effect, other than by varying case-mix (age and NEWS on admission) by day of week.

41.4.4.2 Sampling of probabilities

For patient movements, the model uses cumulative probabilities (see for example Table 26). Random numbers between 0 and 1 are generated to determine which route, so for the example in the table, a number of 0.6 would send the individual on to usual residence, whereas a value of 0.3 would send them to the GMW. The probabilities are stratified by: current location, age group, NEWS group and whether it is their first admitted location:

- Age groups
    - 16-44, 45-64, 65-75, 75-85, 85+
- NEWS groups
    - 0, 1-4, 5-6, 7+
    - Zero indicates normal healthy life signs. A score of 7+ indicates referral to critical care outreach.

This approach is also used to determine:

- The arrival time of patients across the week.
- Discharge time of patient across the day.
- Patient case-mix (age, NEWS, CFS).
- Change in NEWS group over the stay in each location.
- The next location in the patient pathway.

Table 26: Transition probability for patients in AMU age group 16-44, NEWS group 1-4 and it is their first admitted location

Potential next location	Probability [(a)]	Cumulative probability
GMW	0.361	0.361
Outlier	0.012	0.373
Rehab	0.0002	0.374
ICU	0.003	0.377
HCU	0.007	0.384
Non-medical path	0.011	0.395
Care home	0.0001	0.396
Usual res	0.579	0.974
NHS service	0.017	0.992
Other discharge	0.008	0.9996
Death	0.0004	1.000

(a) This data is from the analysis of data from the Queen Alexandra Hospital in Portsmouth - Appendix E. The proportion of the patients moving to Medical outlier was omitted here and those patients re-distributed to the GMW. This was so that medical outliers were only created when medical wards were at full capacity – see 41.4.5.

The model controls for the case-mix of patients within the model by using identical random number streams for comparative runs. This means that for a given run, the number and case-mix of patients is identical for each scenario. However, the course that an individual patient can take can vary considerably, depending on:

- whether they receive the intervention,
- whether changes to system performance affect their pathway (indirectly caused by the intervention), and
- random variation.

41.4.4.3 Sampling of other inputs

For some variables in the model, the model creates distributions from which to sample. For example, patient length of stay in each location is determined by sampling from a lognormal distribution created using a mean and standard deviation from the data analysis found in a lookup table that is stratified by current location, next location, current NEWS group and age group. The sampled length of stay is capped at a maximum of one year for each location, to avoid sampling long lengths of stay that would not be captured in the model run time. The patient's actual length of stay in a location in the model will differ from that which is initially sampled for them for a number of reasons:

- If their next destination is full then they might have to wait until a bed becomes available.
- If the GMW is full then they might be discharged slightly earlier (see Table 27: Decision rules built into the simulation model).
- If GMW is full they might be made a medical outlier (see Table 27: Decision rules built into the simulation model).

- If they are due to be discharged then their length of stay will be adjusted to fit the discharge time profile.
- They might receive an intervention that reduces their length of stay (Table 6).

In other instances, probability profiles have been generated using data from the bespoke analysis. Probability profiles have been used where the patient needs to sample from a bespoke distribution. Probability profiles have been used for the following:

- Time presenting to hospital.
- Preadmission length of stay.
- Discharge time.

Post-discharge mortality up to 30-days and lifetime QALYs from 30-days, each by age and CFS were calculated in MS Excel in the manner described in section 41.2.7. These are then applied to patients in the simulation model using a lookup table.

41.4.5 Medical outliers

A medical patient becomes a medical outlier when they are transferred to a surgical or other non-medical ward bed. Medical outliers are generated in the model at times of pressure within the system, when demand for medical beds exceeds supply. Medical outliers are created in line with the decision rules implemented in the model (41.4.6).

In the model, during their time as a medical outlier, patients incur the same risk of mortality and risk of transfer to ICU/HDU as observed in the Portsmouth data (Appendix E). As with other probabilities, these risks are stratified by current NEWS group, age group and next location.

On leaving the outlying ward, patients revert to the previous pathway they would have followed had they not been made a medical outlier (unless they died or they were referred to ICU/HDU). If they were in AMU waiting to go to GMW when they were made a medical outlier then they would move to GMW after their outlier stay. Whereas if they were in GMW when they were made a medical outlier then they would be discharged to their usual place of residence (if that were where they were due to go).

We conducted a literature review of the impact of medical outliers (Appendix D). The evidence was heterogeneous. Focusing on the evidence in general medical patients, there appeared to be an increase in length of hospital stay associated with being a medical outlier of 2.6 days and an increase in mortality (RR=1.3). In the model, most medical outliers are generated towards the end of a patient's stay. Therefore, the mortality occurring within the medical outlier stay and the length of that stay is largely incremental. We calibrated the average time that a person spent on an outlier ward from 5.1 days in the Portsmouth data to 2.6 days found in the literature, to avoid over-estimating the impact of reduced incidence of medical outliers.

Overall, an outlying patient on a surgical ward will have similar resource use and cost as a patient on a medical ward. The timing of care however may be slower, and there may be additional cost of consultant time due to the need to travel to the patient. However, to be conservative, we have not included this extra time in the model and have used the same bed-day cost for non-medical wards as for medical wards.

41.4.6 Decision rules for routing patients when resources are fully utilised

Decision rules were discussed and agreed with the health economic subgroup and full committee. They aim to capture what can happen to the patient pathway, in line with current good practice. The decision rules are triggered when there are blockages to the patient pathway within the simulated hospital. Once triggered, the decision rules force movements of patients, either along their pathway or moving them to an outlying (non-medical) ward when necessary and possible. The decision rules should give priority to freeing capacity at bottlenecks in the hospital pathway. The final choke point within the simulation model is the emergency department, which will see a build-up of patients once the limit on outliers has been reached and all the other wards are full.

Sometimes, when a bed becomes available, there are several people queueing for that bed. Typically, the patient waiting the longest would be prioritised. Prioritisation was not based on age, NEWS or frailty. However, for AMU beds, CDU patients take priority over ED patients, with both taking priority over ambulatory AMU patients.

The bespoke data analysis provided total ED length of stay, inclusive of clinical length of stay and any additional length of stay caused by blockages preventing movement. Without adjusting the ED length of stay input, simulated patients could sample long lengths of stay when there are no blockages in the simulated hospital and shorter lengths of stay when there are blockages. As we were unable to differentiate between clinical length of stay and length of stay caused by blockages, we used 3 hour 59 minute as the minimum length of stay a simulated patient that sampled over 4 hours could stay. Supposing 4 hours 30 minutes is sampled for a patient that is to be admitted to AMU. If AMU has a spare bed then the patient will be transferred after 3 hours 59 minutes. However, if a bed is not available then they wait until one is. If a bed is still not available at 4 hours 30 minutes, then they are switched to a medical outlier ward. This allows queues to build up in ED when the simulated hospital is under pressure.

A description of the decision rules implemented in the simulation model when full capacity is reached is shown in Table 27: Decision rules built into the simulation model. The majority of medical outliers will come from the GMW, but they can come from anywhere (second most likely is AMU and then the ED).

Table 27: Decision rules built into the simulation model

Blockage	Rule
AMU is full	1. Move the patient that has the least time remaining in the AMU, NEWS<5 and GMW as their next destination to the GMW
	2. Look in the queues for rehab or care home if anyone is waiting and holding AMU bed, move them temporarily to a GMW bed
GMW is full	1. Discharge patient early from GMW who is within 24 hours of discharge, has NEWS <5 and is not being newly discharged to care home
	2. Move patient who is between 24-72 hours of their GMW length of stay and has NEWS <5 to medical outlier
	3. Move new incoming patient to medical outlier.
ICU is full	1. Move patient from ICU to GMW if they are in last 12 hours of ICU stay and are destined to move to GMW or rehab
HCU is full	1. Move patient from HCU to GMW if they are in last 12 hours of HCU stay and are destined to move to GMW or rehab and NEWS <5
	2. New HCU patient can move to ICU but must move on when 'true ICU' patient needs bed
Rehab is full	Patient has to wait for a bed to become available.
Medical outliers has reached maximum	Queues will build up in ED as the hospital is full.

41.4.7 Sensitivity analyses

Sensitivity analyses were undertaken looking at uncertainty around the elicited treatment effects. Upper and lower ranges of the treatment effects were elicited by the committee to create optimistic and conservative treatment effects (41.2.5) to capture the uncertainty around the effects of the different interventions.

To explore the impact of delayed transfers of care, sensitivity analyses were conducted reducing the length of stay in patients moving to a care home from hospital. Length of stay was reduced by 5 days in one scenario and by 1 day in another, from a baseline of 20.6 days.

41.4.8 Model validation

The model was developed in consultation with the committee; model structure, inputs and results were presented to and discussed with the committee for clinical validation and interpretation.

The model was systematically checked by the health economist undertaking the analysis. Breakpoints were implemented each time new logic code was implemented or edited to check the code was achieving the desired effect before running results. A built in watch window was utilised to track key variables whilst the model was running. Where errors in the code occurred, Simul8's debugging process was used to step through code and identify the cause of any error.

Results were compared with the treatment effects and with the cohort model results to check that they were sensible.

The model was peer reviewed by an experienced operational researcher from ScHARR, Sheffield University.

41.5 Results

Table 28Table 28: Summary of interventions summarises the interventions evaluated, the resources required (41.2.8) and the effects assumed (41.2.5).

Table 28: Summary of interventions

Intervention	Intervention costs	Treatment effects versus Baseline
RAT in ED	ED consultant time	Short stay admissions averted
		Reduced time in ED (Simul8 model only)
		Reduced deaths in ED (Sensitivity analysis only)
Extended access to therapy in the ED	Time of occupational therapist / physiotherapist / physiotherapy assistant	Short stay admissions averted
Extended consultant hours in AMU	AMU Consultant time	Reduced stay in AMU
		Reduced deaths in AMU
		Reduced referrals to ICU/HDU
Daily consultant review on medical wards	Consultant physician time,	Reduced stay in GMW
	Nurse and junior doctor time at weekend	Reduced deaths in GMW
		Reduced referrals to ICU/HDU
Extended access to therapy on medical wards	Time of occupational therapist / physiotherapist / physiotherapy assistant / nurse	Reduced stay on GMW
		Improved quality of life for 12 months

41.5.1 Cohort model base case

The cost of providing RATing was calculated to be £37 per patient that received the intervention. As the intervention is only considered for 'major' patients, the cost of providing the service for 1000 was only £9435.

RAT was deemed to reduce admissions by 5.5 per 1000 patients that attend the ED. These prevented admissions were assumed to be short stays; therefore, the impact on bed days was calculated to be a reduction of 10.94 bed days. There was assumed no impact on ICU referrals.

As the only impact of the intervention was on admissions, the only cost savings come from reduced bed days, which was calculated to save £3,236 per 1000 ED patients.

The intervention was assumed to have no impact on health outcomes.

Taking all of this into account the net increase in costs to the health service of providing RAT was calculated to be £6,199 per 1000 patients. As there are no impacts on health, RAT was dominated by current practice. A full breakdown of the results can be seen in Table 29:RAT versus baseline (per 1000 ED presentations).

Table 29: RAT versus baseline (per 1000 ED presentations)

	Baseline	Intervention	Increment (intervention minus baseline)
Intervention			
Number receiving intervention	0%	25.83%	25.83%
Intervention cost per patient receiving intervention	£0	£37	£36.52
Intervention cost (£)	£0	£9,435	£9,435.12
Resource impact			
Admissions	273	267	-5.50
Bed days	1734	1723	-10.94
ICU/HDU referrals	6	6	0
Cost impact			
Stay costs (£)	£512,787	£509,550	-£3,236.33
ICU/HDU costs (£)	£0	£0	£0.00
Post-discharge costs (£)	£1,969,841	£1,969,841	£0.00
Health outcomes			
Deaths in hospital	19.4	19.4	0
Deaths in 30 days	40	40	0
Life-years (discounted)	15491	15491	-
Cost effectiveness			
Total costs (£)	£2,482,628	£2,488,826	£6,198.78
Quality-adjusted life-years (discounted)	11621	11621	-
Incremental cost per QALY gained (£)	-	-	Dominated

The cost of extending access to therapy in the ED was calculated to be an additional £2.30 per patient that receives the intervention. This additional cost is due to the intervention now being available in premium hours. As more people receive the intervention, the additional cost of extending service hours was calculated to be £2,951 per 1000 ED attendances.

Extended access to therapy in the ED was deemed to reduce admissions by 3.8 per 1000 patients that attend the ED. These prevented admissions were assumed to be 'short stays'; therefore, the impact on bed days was calculated to be a reduction of 7.5 bed days. There was assumed no impact on ICU referrals.

As the only impact of the intervention was on admissions, the only cost-savings come from reduced bed-days, which were calculated to save £2,222 per 1000 ED patients.

The intervention was assumed to have no impact on health outcomes.

Taking all this into account the net increase in costs from extending therapy hours in the ED was calculated to be £728 per 1000 patients. As there were no impacts on health, the intervention was dominated by current practice. A full breakdown of the results can be seen in Table 30.

Table 30: Extended access to therapy in ED versus baseline (per 1000 ED presentations)

	Baseline	Intervention	Increment (intervention minus baseline)
Intervention			
Number receiving intervention	7.87%	15.67%	7.80%
Intervention cost per patient receiving intervention	£33	£35	£2.30
Intervention cost (£)	£2,611	£5,562	£2,950.91
Resource impact			
Admissions	273	269	-3.78
Bed days	1734	1726	-7.51
ICU/HDU referrals	6	6	0
Cost impact			
Stay costs (£)	£512,787	£510,564	-£2,222.44
ICU/HDU costs (£)	£0	£0	£0.00
Post-discharge costs (£)	£1,969,841	£1,969,841	£0.00
Health outcomes			
Deaths in hospital	19	19	0
Deaths in 30 days	40	40	0
Life-years	15491	15491	0
Cost effectiveness			
Total costs (£)	£2,485,239	£2,485,967	£728.47
Quality-adjusted life-years	11621	11621	-
Incremental cost per QALY gained (£)	-	-	Dominated

The cost of providing extended hours for consultants in the AMU was calculated to be an additional £0.80 per patient that receives the intervention. This additional cost is due to the intervention now being available in premium hours. As more people receive an extra review, the additional cost of extending service hours was calculated to be £12,082 per 1000 AMU attendances.

Extended hours for consultants in the AMU were deemed to reduce length of stay; the impact on bed days was calculated to be a reduction of 9.2 bed days per 1000 AMU attendances. There was also a reduction in ICU referrals by 0.04 per 1,000 patients.

The intervention was also deemed to have a reduction in mortality on AMU wards. For every 1000 AMU patients there would be a reduction in in-hospital mortality by 0.09. This was found to generate an additional 0.24 QALYs.

Taking all of this into account the net increase in costs from extending hours for consultants in the AMU was calculated to be £9,345. The incremental cost effectiveness ratio was found to be £39,223 per QALY. This is above the £20,000 per QALY threshold and therefore it would not be considered cost effective. A full breakdown of the results can be seen in Table 31.

Table 31: Extended hours for consultants in AMU versus baseline (per 1000 AMU patients)

	Baseline	Intervention	Increment (intervention minus baseline)
Intervention			
Proportion arriving in service hours	54.10%	78.03%	23.93%
Intervention cost per patient receiving intervention	£47.87	£48.67	£0.80
Intervention cost (£)	£25,896	£37,979	£12,082.43
Resource impact			
Admissions	1000	1000	0.00
Bed days	6350	6341	-9.21
ICU/HDU referrals	3	3	-0.04
Cost impact			
Stay costs (£)	£1,878,340	£1,875,616	-£2,723.77
ICU/HDU costs (£)	£0	-£187	-£186.95
Post-discharge costs (£)	£1,835,754	£1,835,928	£173.41
Health outcomes			
Deaths in AMU	9	9	-0.09
Deaths in 30 days	90	90	-0.09
Life-years	10448	10448	0.40
Cost effectiveness			
Total costs (£)	£3,739,990	£3,749,335	£9,345.13
Quality-adjusted life-years	7,453	7,453	0.24
Incremental cost per QALY gained (£)	-	-	£39,222.50

The additional cost of extending service hours was calculated to be £88,889 per 1000 GMW attendances.

Daily consultant reviews were deemed to reduce length of stay; the impact on bed days was calculated to be a reduction of 71 bed days per 1000 GMW attendances. There was also a reduction in ICU referrals by 0.6 per 1000 patients.

The intervention was also deemed to have a reduction in mortality on GMW wards. For every 1000 patients there would be a reduction in in-hospital mortality by 0.64. This was found to generate an additional 1.62 QALYs.

Taking all this into account the net increase in costs from providing daily consultant reviews in the GMW was calculated to be £65,766. The incremental cost effectiveness was £40,681 per QALY. This is above the £20,000 per QALY threshold and therefore it would not be considered cost effective. A full breakdown of the results can be seen in Table 32.

Table 32: Daily consultant review on medical ward versus baseline (per 1000 medical ward patients)

	Baseline	Intervention	Increment (intervention minus baseline)
Intervention			
Number receiving intervention	100.00%	100.00%	0%
Intervention cost per patient receiving intervention	£57	£146	£88.89
Intervention cost (£)	£57,366	£146,256	£88,889.90
Resource impact			
Admissions	1000	1000	
Bed days	6350	6279	-70.83
ICU/HDU referrals	9	8	-0.64
Cost impact			
Stay costs (£)	£1,878,340	£1,857,387	-£20,952.61
ICU/HDU costs (£)	£0	-£3,347	-£3,347.45
Post-discharge costs (£)	£1,835,754	£1,836,931	£1,176.61
Health outcomes			
Deaths in GMW	64	63	-0.64
Deaths in 30 days	90	89	-0.64
Life-years	10448	10451	2.68
Cost effectiveness			
Total costs (£)	£3,771,460	£3,837,226	£65,766.44
Quality-adjusted life-years	7,453	7,454	1.62
Incremental cost per QALY gained (£)	-	-	£40,681.17

The cost of extending access to therapy on the wards was calculated to be an additional £39.41 per patient that receives the intervention. The additional cost of extending service hours was calculated to be £26,451 per 1000 GMW attendances.

Extended therapy access was deemed to reduce length of stay; therefore, the impact on bed days was calculated to be a reduction of 393 bed days per 1000 GMW attendances. There was no impact on ICU referrals.

The intervention was also deemed to have a quality of life benefit for some patients. This was an additional 1.82 QALYs per 1000 patients.

Taking all of this into account, the net decrease in costs from extended access to therapy on the wards was calculated to be £86,123 per 1000 patients. As the intervention also increased QALYs, it was dominant and therefore cost effective. A full breakdown of the results can be seen in Table 33.

Table 33: Extended access to therapy on medical wards versus baseline (per 1000 medical ward patients)

	Baseline	Intervention	Increment (intervention minus baseline)
Intervention			
Number receiving intervention	67.12%	67.12%	0%
Intervention cost per patient receiving intervention	£98	£137	£39.41
Intervention cost (£)	£65,794	£92,245	£26,450.74
Resource impact			
Admissions	1000	1000	
Bed days	6350	5957	-393
ICU/HDU referrals	9	9	0
Cost impact			
Stay costs (£)	£1,878,340	£1,762,090	-£116,250.01
ICU/HDU costs (£)	£0	£0	£0.00
Post-discharge costs (£)	£1,835,754	£1,835,754	£0.00
Health outcomes			
Deaths in hospital	64	64	0.00
Deaths in 30 days	90	90	0.00
Life-years	10448	10448	0.00
Cost effectiveness			
Total costs (£)	£3,779,889	£3,690,089	-£89,799.26
Quality-adjusted life-years	7453	7455	1.82
Incremental cost per QALY gained (£)	-	-	Dominant

41.5.2 Cohort model sensitivity analyses

Table 34: Cost effectiveness of interventions versus baseline

Sensitivity analysis	RAT	Extended access to therapy in the ED	Extended hours for consultants in AMU	Daily consultant review on medical wards	Extended access to therapy on medical wards
Base case	Dominated (net cost increase to the health service: £6,199)	Dominated (net cost increase to the health service: £728)	£39,222 per QALY gained	£40,681 per QALY gained	Dominant (net savings to the health service: £89,799)
SA1: Optimistic treatment effects	£87,463 per QALY gained	Dominant (net savings to the health service: £1,513)	£22,098 per QALY gained	£16,875 per QALY gained	Dominant (net savings to the health service: £150,979)
SA2: Conservative treatment effects	Dominated (net cost increase to the health service: £9,435)	Dominated (net cost increase to the health service: £1,839)	Dominated (net cost increase to the health service: £10,671)	Dominated (net cost increase to the health service: £90,024)	Dominant (net savings to the health service: £28,619)
SA3: Long term costs	Dominated (net cost increase to the health service: £6,199)	Dominated (net cost increase to the health service: £728)	£46,245 per QALY gained	£47,703 per QALY gained	Dominant (net savings to the health service: £89,799)
SA4: improve post-AME survival	Dominated (net cost increase to the health service: £6,199)	Dominated (net cost increase to the health service: £728)	£36,726 per QALY gained	£38,090 per QALY gained	Dominant (net savings to the health service: £89,799)
SA5: improve quality of life	Dominated (net cost increase to the health service: £6,199)	Dominated (net cost increase to the health service: £728)	£36,312 per QALY gained	£37,662 per QALY gained	Dominant (net savings to the health service: £89,799)
SA6: improve quality of life and survival	Dominated (net cost increase to the health service: £6,199)	Dominated (net cost increase to the health service: £728)	£33,905 per QALY gained	£35,614 per QALY gained	Dominant (net savings to the health service: £89,799)
SA7: Optimistic intervention costs	Dominated (net cost increase to the health service: £4,979)	Dominated (net cost increase to the health service: £131)	£32,425 per QALY gained	£33,971 per QALY gained	Dominant (net savings to the health service: £93,927)
SA8: conservative intervention costs	Dominated (net cost increase to the health service: £7,517)	Dominated (net cost increase to the health service: £1,403)	£46,571 per QALY gained	£49,040 per QALY gained	Dominant (net savings to the health service: £84,878)

A full breakdown of the results of this sensitivity analyses can be seen in Table 34. Using the optimistic values for treatment effects, the cost-effectiveness results were as follows:

- RAT remained cost in-effective but it was no longer dominated as it provided some health benefit due to a small decrease in ED mortality. The ICER was now £87,463, which far exceeds the £20,000 per QALY threshold.
- Extended access to therapy in the ED was now cost saving and therefore dominant, given that there were no differences in health outcomes. Rather than costing the health service an additional £728 extended access to therapy in the ED now saved the health service £1513 per 1000 patients.
- Extended hours for consultants in AMU was significantly more cost effective with an ICER of £22,098 per QALY however even under the most optimistic scenario this still exceeds the £20,000 per QALY threshold.
- Daily consultant reviews was significantly more cost effective with an ICER of £16,875 per QALY and therefore now below the £20,000 per QALY threshold.
- Extended access to therapy on wards remained cost saving and was now even more so.

Using the most conservative values for treatment effects, meaning that the interventions were providing the least benefit, the cost-effectiveness results remained completely unchanged.

Including long-term health costs to the NHS un-related to the acute medical emergency had no impact on the cost-effectiveness conclusions for any of the interventions.

Improving survival post 30 days and improving quality of life had no impact on the cost-effectiveness results.

41.5.3 Simulation model base case

Work in progress - to be added after consultation

41.5.4 Simulation model sensitivity analyses

Work in progress - to be added after consultation

41.6 Discussion

41.6.1 Summary of results

RAT

The cohort model showed that the reduction in admissions from providing a RAT service would not compensate for the cost of providing the intervention. Given there were no predicted health outcomes from providing this service, it was dominated in the base case. In an optimistic scenario where the benefits of RAT were explored fully, the committee agreed that there might be a very modest reduction in ED mortality. However, even in this scenario, RAT was not cost effective with an ICER of £88k per QALY, which far exceeds the £20,000 per QALY threshold. Overall, the conclusion was that RAT would be a very expensive intervention for the health service to provide and it is unlikely to generate enough benefits to be considered a cost effective intervention.

Extended access to therapy in ED

The cohort model showed that the reduction in admissions from providing extended access to therapy in the ED would not fully compensate the cost of providing the service in the base case. In an ‘optimistic’ sensitivity analysis the additional admissions allowed the intervention to become cost saving although in a ‘conservative’ sensitivity analysis the net cost of providing the intervention became even higher. Overall, it is possible but perhaps unlikely that extended access to therapy in the ED would save the health service money, however it may produce enough benefit to be considered cost effective if it was felt improvements to hospital flow would arise.

Extended hours for consultants in AMU

The cohort model showed that the reduction in length of stay and ICU admissions did not provide enough cost savings to allow the intervention to provide a net saving to the health service. The intervention did provide health benefits in the form of mortality reduction in the AMU, however, these additional health benefits were not deemed cost effective in the base case with an ICER of £39k per QALY. Using optimistic estimates for the treatment effects the ICER decreased to £21k per QALY however, the intervention was dominated when more conservative treatment effects were applied. Although the cohort model found extended consultant hours in the AMU to not be cost effective (ICER: £39k per QALY) the additional health outcomes associated with improvements in hospital flow may provide enough additional benefits to allow the intervention to be cost effective. There is considerable uncertainty surrounding the magnitude of benefit that the intervention would likely provide and therefore a definitive conclusion cannot be reached concerning its cost effectiveness.

Daily consultant review

The cohort model showed that the reduction in length of stay and ICU admissions did not provide enough cost savings to allow the intervention to provide a net saving to the health service. The intervention did provide health benefits in the form of mortality reduction seen in the GMW, however these additional health benefits were not deemed cost effective in the base case with an ICER of £41k per QALY. Using optimistic estimates for the treatment effects, the ICER decreased to £17k per QALY however, the intervention was dominated when conservative treatment effects were applied.

Overall, there is considerable uncertainty concerning the cost effectiveness of daily consultant reviews. Given the substantial cost of providing this intervention there would need to be considerable health benefits and/or cost savings to justify its implementation.

Therapy on medical wards

The cohort model showed that the reduction in length of stay provided enough cost savings to allow the intervention to provide a net saving to the health service of £89k per 1000 patients. The intervention also provided health benefits in the form of quality of life improvements for patients over 65 years of age with a CFS > 3 therefore making the intervention dominant. The treatment remained dominant even when conservative treatment effects were applied. The intervention would have to have significant negative impacts on hospital flow for the cost effectiveness of the intervention to be reversed. Therefore, from the cohort model alone it was considered highly likely that extended therapy access on the wards would be a cost effective and likely cost saving use of resources. Under all tested scenarios extended access to therapy remained cost effective across both models showing that the likelihood of it being a cost effective and most likely a cost saving intervention are very high.

Conclusions for all interventions

Overall RAT was the least likely to be cost effective and extended access to therapy on the wards was the most likely to be cost effective. There was considerable uncertainty concerning the cost effectiveness of all other strategies.

Consideration was given to how these interventions would interact with each other should they hypothetically all be provided at the same time. The 2 interventions in the ED would likely change the case-mix of individuals being admitted to AMU but would be unlikely to have an impact on GMW case mix as avoided admissions would be of low severity. Therefore, the cost effectiveness of interventions on the GMW would likely be independent of the 2 interventions assessed in the ED. The case mix of patients being admitted to the AMU may get worse, with the introduction of the ED interventions but the net impact on the cost effectiveness of extended consultant hours is not obvious. The ability of the consultant to discharge patients early would be reduced but the health outcomes might increase, since the consultant will be able to focus their attention on the more acutely ill patients.

The 2 interventions that would likely have the most impact on each other would be extended access to therapy on wards and daily consultant reviews. However, it is not clear how they would interact. On the one hand, it seems too optimistic to assume that the length of stay reductions from daily consultant review and extended access to therapy to be additive. However, the 2 interventions could be complementary –it is only possible to discharge a patient if they are signed off by both the therapist and the consultant. This should be a consideration when deciding to implement either service.

41.6.2 Generalisability to other settings

These results are unlikely to be easily transferred to health systems outside of the UK for various reasons, including differences in patient pathways, provision of community and social care.

The models made use of patient flow data from a large district general hospital for the model baseline. The hospital was broadly similar to the national average where comparable data was available. However, the case-mix was a little more severe than average and the data was for the period 2010 to 2016 and we know that hospital outcomes have changed over this time in terms of length of stay, numbers of ED presentations and 4 hour target breeches, to name but a few. At the hospital, most medical admissions started in the AMU and most outliers were patients moved from the GMW, rather than patients arriving at the hospital. We believe this is quite common but certainly, there is quite a lot of variation between the pathways of different hospitals across England and the UK. Perhaps the model will be less transferrable to smaller hospitals or larger tertiary hospitals.

In addition, the relative treatment effects assumed in this model might not be transferrable either. In particular, hospitals that are already operating at a high level of effectiveness and efficiency might see a smaller benefit on average.

41.6.3 Limitations and areas for future research

41.6.3.1 Treatment effects

The source of the treatment effects in the model were the expert opinion of the health economics subgroup of the committee. These opinions were informed by the guideline's systematic review but also by the experience of the individuals and extensive discussion.

Although, the effects and their sizes were initially elicited through a formal consensus process, the subgroup did revise the estimates after extensive discussion, making the effect sizes more modest in each case. There was a deliberate attempt to make the analyses conservative by moderating the effect size (for example, RR=0.99), by targeting the effects on specific patient groups (for example, patients age>65 and CFS>2) and specific parts of the pathway (for example, AMU mortality). Conversely, we tried not to under-estimate intervention costs – these were applied to broad groups of patients and staff time were assumed to be incremental (there is an opportunity cost of the staff time required).

It was believed that the starting point of a hospital, could affect not just the baseline risks and case-mix but also the effect sizes themselves. For example, a hospital/ward that is operating effectively and efficiently with highly trained staff and access to critical care outreach might see much less benefit of daily consultant review than a hospital/ward that is less well-resourced or less well organised.

Analyses were conducted with more optimistic and more conservative effect sizes. In the case of extended therapy on medical wards, it remained cost saving but the other interventions were more sensitive to the magnitude of the treatment effects assumed.

The treatment effects incorporated in the model were those that the committee felt able to quantify. It was believed that these interventions could have other consequences that are not quantifiable. For example, the committee felt that, early consultant assessment in the ED is likely to lead to better quality/location of death for some patients, which are not captured in the model. There might also be reduced testing and fewer adverse events that are not captured.

Critical care outreach teams (CCOT) had been prioritised for modelling but the group decided that they could not estimate key consequences. For example, it was felt that one advantage of CCOT is that it relieves ward nurses and doctors of work but without a time and motions study it was unclear by how much. The only information obtained from the systematic review concerned the impact on cardiac arrests and in-hospital mortality. The committee felt that information on mortality could be misleading as in some instances the use of critical care outreach may be to improve the quality of death, an outcome which could not be captured using the QALY metric.

Overall, we have assessed the analyses as being directly applicable but with potentially serious limitations because the reporting of new trials or other evidence in this area could change the conclusions considerably.

41.6.3.2 Case-mix and baseline data

Since we were interested in the outcome of all non-elective medical patients being seen at an acute hospital, we chose to characterise patients by age, NEWS and CFS rather than diagnosis. In order to have data on patient movements and outcomes in relation to these characteristics, we had to do quite detailed analysis of data from a single large DGH. Had time allowed, we would have liked to repeat this analysis on data from at least one other Trust. Even in this case, we did not have CFS data from the same source as the other data and therefore we had to extrapolate using data from a national audit. In addition, we did not have data for patients in ED to the same level of detail as those admitted (for example, NEWS).

The case-mix of patients from the source hospital were similar to the national average but were slightly more severe. However, changing the case-mix of the population is something that could be dealt with by sensitivity analysis in the future.

We did not explicitly accounted for a weekend admission effect in the model but had we done so the effect might have been to increase the QALY gains from extended consultant hours in AMU and daily consultant review, due to increasing the baseline mortality and absolute reduction in mortality.

The short to long-term survival and quality of life of people who have had an acute medical problem or emergency was done using national data and epidemiological studies. However, this was fraught with difficulties because national statistics and epidemiological are usually either focused on specific diseases or else on the whole population so rarely can people having a specifically medical emergency be identified and followed up. For long-term survival, we found ourselves having to apply standardised mortality ratios to English national mortality data. We think that there is important research that could be done in terms of both:

- analysing the survival of AME patients, and
- cross-mapping utility scores with frailty scores.

41.6.3.3 Costs

Since staff rotas are complex and vary between hospitals, we did not attempt to model the staff numbers required but instead estimated contact time per patient and costed that time. This assumes that the time involved with the intervention would otherwise have been spent in a productive way.

With regard to the unit cost of staff time, we have based them on contracts in place at the time of analysis but we note that these will change as the move towards a 7-day NHS proceeds.

The majority of the intervention costs are either consultant time or therapist time. Implementation of these interventions will require such staff to be moved from other activity (such as outpatient work) or it would mean training of more staff. Therefore, there might be implications for Health Education England.

We have costed (occupied) bed days with a daily cost. We have costed medical outlying bed days the same as those on medical wards on the basis that there is an opportunity cost of a bed per se. This might not capture the cost of cancelled surgery neither from an NHS perspective nor from the perspective of Trust reimbursement. We have not attached a cost to an unoccupied bed day – although in the model these are relatively few in number, with GMW in particular operating at a very high occupancy level.

41.6.3.4 Simulation model

A patient-level simulation model allows interactions of complex systems, such as hospital pathways, to be explored in more depth than a cohort model. The simulation model simulates individual patients, their characteristics, outcomes and movements within the pathway. The individual patient outcomes can then be aggregated and averaged for results. Simulation models offer advantages over cohort models when{Karnon, 2014 KARNON2014 /id}:

- There is heterogeneity in the baseline characteristics of the eligible population and particularly where there is a non-linear relationship between characteristics and outcomes (for example, QALYs at the mean age might not equal the mean QALYs).
- Disease progression is a continuous process.
- Event rates vary by time.
- Prior events affect subsequent event rates.
- We want to explore the impact of an intervention in the context of fixed resources and queueing.

The interventions explored by our model specifically deal with timing of actions, such as timing and availability of staff interaction. Using a simulation model allows us to target interventions on specific patients and investigate the direct and indirect effects on the entire hospital pathway. A key characteristic of the simulation model is the dynamic use of resources, in this case hospital beds. The simulation model allows beds to be used throughout the pathway picked up and dropped by patients when needed. Having beds within the simulation model creates a flow to the hospital pathway that can be impacted upon positively or negatively by changes to the model, replicating a working hospital with the same pressures on capacity and solutions to accommodating patients. This adds to the cohort model as it allows saved bed days from interventions to be reallocated to other patients. An important outcome of the model, tied in with beds, is medical outliers. Medical outliers were generated as an outcome of the simulation model, resulting from blockages to hospital flow.

Hospitals are complex and our aim was to start with a simple but realistic model. With more time and more data, this model could be extended in the following ways. These modifications are unlikely to affect substantially our estimates of cost effectiveness but they could make certain parameters like bed occupancy and number of 4 hour breeches more realistic:

- More detailed specification of locations and patients.

  - Currently the model uses large locations to represent multiple wards within the hospital pathway. By not having to allocate patients to sex-specific wards or specialty-specific wards, a higher bed occupancy level is achievable in the model than would be in reality.
  - The model also does not include elective and non-medical patients and therefore does not capture their interactions with the acute medical emergency pathway. Simulating elective and non-medical patients would allow estimation of whole hospital occupancy, costs and consequences resulting from interventions in the medical emergency pathway.
- More refined transitions between locations.
  - The model updates NEWS when patients move to a new location, daily changes in patients' NEWS scores and corresponding risks, such as mortality and ICU admission, could be implemented to capture variation in condition during a ward length of stay. If we were evaluating interventions that are triggered by NEWS then this would allow a precise estimation of the timing of the intervention.
  - Currently, patients move between beds within the model with no time delay. It has been assumed that the delay is built into the sampled length of stay. However, when patients are having length of stay adjusted through decision rules, this allows patients to move between beds immediately. Time to change beds between patients and delays could be implemented within the model when being forced to move beds, such as to an outlier ward, to capture the service delay in moving between beds.
  - As well as delays to movements between beds, timings of transfers may not always be realistic. The model adjusts sampled length of stay for those being discharged to represent realistic discharge times from hospital. However, it does not do this for transfers between wards. This means that the time distribution of patient transfers between wards is not taken into account when sampling length of stay and not be representative of a real hospital. The result of this could mean a greater proportion of patient transfers occur outside of normal working hours in the model.
  - Systematic reviews of the interventions investigated in the simulation model did not find a significant difference in readmissions. Furthermore, baseline readmission rates by age and CFS are not easily available. Readmissions were therefore not included in the simulated hospital pathway, although data from readmitted patients were not excluded from the data analysis. With the right data, this could be easily incorporated.
- More resource constraints
  - Resource constraints are used throughout the model to capture hospital capacity and investigate occupancy. However, not all the preadmission areas of the simulated hospital had constraints. The ambulatory acute medical unit could hold constraints. The ED could also be separated into locations for majors, minors and resuscitation, to add more detail and realistically represent a working ED. An additional step in the preadmission area would be to include ambulance queues prior to entry into the hospital, including costs and consequences to the first point of care in the acute medical emergency pathway.
  - The model uses staff time to generate unit costs for interventions. However, the model does not simulate individual members of staff and does not take into account their interactions with patients and each other. Including staff as a resource constraint would add a greater level of detail to the model and might allow conclusions on staffing levels to be explored but would probably not be generalisable.
- More scenarios
  - The model so far has looked at isolated interventions being implemented in the pathway. Some of the interventions target similar cohorts of patients. There is scope to investigate multiple interventions being implemented alongside each other to understand how they would interact. Many other service interventions could be evaluated as long as the pathway of the patients affected can be quantified.

The data used in the model for patient flow was from a single source, a large district general hospital, and so it was internally consistent. The data was stratified by age and NEWS so that correlation between outcomes and pathways could be reasonably estimated but this might have been achieved with greater precision had patient-level data for the whole pathway been used but this would be more complex and time-consuming to analyse.

Probabilities were used to model transitions and then time until the transition takes place. An alternative method would have been to use daily rates, with these rates changing by day of admission. However, our method ensured that mortality and length of stay were kept independent. This was important to avoid double counting of treatment effects, otherwise an intervention that reduced length of stay would inadvertently reduce mortality, even if this were not the intention of the committee.

We have tried to model the hospital to simulate what would happen at times of full capacity. This involved specifying decision rules about who is made a medical outlier and activating these rules when a hospital location is at full capacity. The main principle followed that patients in the early part of their stay would not be prioritised to be an outlier nor would patients with a high NEWS score or those going to rehab or a care home. However, by sampling length of stay from distributions that do not account for how busy the hospital is, the model will only be partially successful at mimicking practice for a number of reasons:

- It will not account for staff working more quickly when under greater pressure.
- In the case of the ED, admitted patients stay longer in the ED at times of stress, as they wait for a bed but those who are not admitted take the same time as when the hospital is busy.
- The model assumes increased risks for those who are made medical outliers reflected in their mortality, length of stay and referrals to ICU/HDU. However, it conservatively does not estimate the negative impact of over-occupancy on the patients that remain on the medical wards.

The simulation model holds a large amount of variability. Due to time constraints, the number of runs was capped at 1200. This was above the number deemed necessary for the baseline using Simul8s inbuilt calculator. However, incremental results would be more precise with a greater number of runs (see Figure 6).

The simulation model results do not include any probabilistic sensitivity analyses, such as distributions attached to input parameters. However, as the simulation model has conducted a large number of runs with variability, this may not be a major limitation. It is difficult to put a distribution around the relative treatment effects as these were based on expert opinion.

The model controls for case-mix of patients presenting in the simulated hospital. It would be desirable but not feasible to control further such that the same individual patients die in different scenarios of the same run. Controlling case-mix has reduced ‘noise’ in the analysis substantially but still random variations in mortality by case-mix group seem to be drowning out the effect sizes of interest.

41.6.3.5 Interventions not evaluated

Our modelling has focused on interventions that take place in the hospital. This arose because there were a number of interventions where we had evidence of effectiveness from the guideline’s systematic review but no published evidence of cost effectiveness. There was also reason to believe that the cost of these interventions is substantial. For interventions taking place outside of the hospital, on the other hand, either there was already, published evidence of cost effectiveness (for example, hospital at home) or else there was a lack of evidence of effectiveness (for example, GP home visits). For intermediate care, there were 15 published economic evaluations that were supportive including one based on a discrete event simulation. However, we have planned an analysis using the simulation model looking at the effects of reducing delayed transfers of care, to inform research around social care provision.

The model could be developed to evaluate other interventions both inside and outside the hospital.

41.6.4 Comparisons with published studies

41.6.4.1 Intervention evidence reviews

RAT in the ED

One RCT found that RAT had no effect on admissions, albeit with large confidence intervals. The idea of increasing admissions is plausible; however, it is likely that there would be a health benefit associated with the additional admissions. This evidence was assessed as being moderate quality. Observational evidence was of very low quality but suggested a reduction in admissions and ED length of stay. Overall, the reduction in admissions and ED length of stay in the observational evidence is likely to be an overestimate of the benefit that RAT may have on these outcomes and therefore it is unlikely that RAT is cost effective.

Extended hours for consultants in the AMU

Only one cohort study was identified in the systematic review. The study showed significant decreases to length of stay, early discharge and mortality from extended access to a consultant on the AMU. All 3 outcomes were included in the model although the treatment effects used were more conservative. One of the main concerns of the study was the differences in baseline between the data the model was built on and the hospital being assessed in the study. For example, length of stay and mortality in the control arm of the study were 9 days and 10% respectively. In the model, average length of stay is 6.4 days and mortality in the AMU is only 1%, albeit the study looks at mortality across all wards. Given that the evidence was assessed as very low quality, the committee agreed that choosing more conservative treatment effects, in line with the baseline, were more appropriate.

Daily consultant review on medical wards

One randomised trial was identified; however, this was only for consultants on the ICU and it was assessing 24-hour access versus daytime access to a consultant. Three other studies included were observational and only 1 compared daily versus twice-weekly consultant review on the GMW. The only outcomes reported by this study were reductions in mortality and readmissions. No impact was found on readmissions but the study showed a significant reduction in mortality. The treatment effect that influences the reduction in mortality used in the model is more conservative. Again, a reason for this was due to a difference in baseline. In the study, mortality was 14.6% whereas in the model mortality is 6.4% in the GMW. One study analysed the impact of twice daily consultant review versus twice weekly. This study looked at the impact on mortality, readmissions and length of stay. The study found that twice daily review reduced length of stay by around 4 days and reduced mortality by an absolute amount of 0.2%. The mean readmission rate was also slightly lower at 0.5%. An economic study that was identified in the review was also conducted using this data and found that costs were £108 lower in the twice-daily consultant review arm; however, consultant time was not included as an opportunity cost, as it is in the model. Overall, the committee decided to use conservative estimates for mortality and length of stay as well as also explore the additional benefit of reducing ICU admissions, an outcome not reported in the evidence for daily consultant reviews.

Extended access to therapy

Two RCTs were identified: 1 in elderly patients and 1 in stroke patients. For the elderly, the evidence suggested an increase in quality of life assessed as moderate quality. There was also a reduction in mortality at 3 months but this was assessed as very low quality evidence. Both studies reported a length of stay reduction, however in both studies this difference was only interpreted by comparing the medians of both arms. The difference in median length of stay was assessed as 10 days and 1 day for elderly rehabilitation and stroke patients respectively. In the model, extended access to therapy on the ward was assessed by looking at reductions in length of stay and improvements in quality of life. A 1-day reduction in length of stay was chosen as well as a small increase in quality of life. Both estimates were on the conservative side of what was seen from the evidence. Additional assumptions were also put in place such as quality of life only lasting for 1 year. Overall treatment effects were in line with the clinical evidence; however, we were on the more conservative side of what the evidence showed.

An Australian study found providing therapy on a Saturday was cost saving, although this was in a population where medical patients were in the minority{Brusco, 2015 BRUSCO2015 /id}.

No evidence was found on extended therapy access in the ED. Therefore, conservative estimates were chosen. The only outcome of consideration in the model was impact on short stay admissions.

41.6.4.2 Discrete event simulations of acute medical services

We searched for discrete event simulation models that have evaluated acute medical care at the service level (rather than disease-specific models). We found 25 models that evaluated services within a hospital for acutely ill patients{Gunal, 2011 GUNAL2011 /id;Komashie, 2005 KOMASHIE2005 /id;Holm, 2013 HOLM2013 /id;Peck, 2014 PECK2014 /id;Crawford, 2014 CRAWFORD2014 /id;Hoot, 2008 HOOT2008 /id;Monitor, 2015 MONITOR2015 /id;Paul, 2012 PAUL2012 /id;Lim, 2013 LIM2013 /id;Kang, 2014 KANG2014 /id;Lin, 2015 LIN2015 /id;Laker, 2014 LAKER2014 /id;Day, 2013 DAY2013 /id;Pennathur, 2010 PENNATHUR2010 /id;Bair, 2010 BAIR2010 /id;Thorwath, 2009 THORWATH2009 /id;Connelly, 2004 CONNELLY2004 /id;Kilmer, 1997 KILMER1997 /id;Duguay, 2007 DUGUAY2007 /id;Samaha, 2003 SAMAHA2003 /id;Ruohonen, 2006 RUOHONEN2006 /id;Saunders, 1989 SAUNDERS1989 /id;Eatock, 2011 EATOCK2011 /id;Gunal, 2009 GUNAL2009 /id;Bagust, 1999 BAGUST1999 /id}. Of these, 9 modelled flow beyond the ED{Bagust, 1999 BAGUST1999 /id;Eatock, 2011 EATOCK2011 /id;Gunal, 2011 GUNAL2011 /id;Komashie, 2005 KOMASHIE2005 /id;Holm, 2013 HOLM2013 /id;Peck, 2014 PECK2014 /id;Crawford, 2014 CRAWFORD2014 /id;Hoot, 2008 HOOT2008 /id;Monitor, 2015 MONITOR2015 /id}.

Only one study{Monitor, 2015 MONITOR2015 /id} estimated costs and none looked at mortality or other health outcomes. We reported the results of this model in Chapter 12 on the alternatives to hospital. Our model is unique in terms of estimating QALYs, utility or cost effectiveness.

There are more examples that have used discrete event simulation to evaluate service delivery interventions in terms of costs and health outcomes but these have all focused on specific disease populations, such as heart failure{Schroettner, 2013 SCHROETTNER2013 /id} or stroke{National Audit Office, 2010 NATIONALAUDITOFFICE2010 /id}.

Our model is probably unique in modelling age, NEWS and clinical frailty score as primary characteristics of patients.

41.6.5 Conclusions

Of all the interventions the one that is most likely to be cost saving is extending access to therapy on wards. These cost savings are ‘opportunity cost’ savings and would not necessarily be realised by trusts, unless they lead to ward closures, but they might avoid the need to open more wards in the future and could increase Trust income by reducing cancellations of surgical procedures.

It is likely that RAT would not be a cost effective use of NHS resources. It is unlikely that any health benefits would be realised from implementing the intervention and the assumed cost savings are very far away from making the intervention cost saving

The cost effectiveness of extended consultant hours on the AMU, daily consultant reviews on the GMW and extended access to therapy on the ED is highly uncertain. The cost effectiveness changes under a variety of scenarios, all of which are entirely plausible. The baseline of the hospital under consideration would determine the appropriateness of each intervention. Case-mix, hospital size and efficiency are all key factors that would play a part in determining the cost effectiveness of these interventions. A hospital that has few outliers for example would benefit less from the implementation of these interventions.

Although the analysis gives indications as to which interventions have the highest potential to be cost effective, the conclusions for the majority of interventions cannot be taken to be certain. This means the role of local assessment will be crucial when trusts consider the use of these interventions. Local analysis of patient flow and health and social care system (particularly delayed transfers of care) may indicate which interventions will deliver best value. Following the intervention further analysis of effect is then crucial to confirm that value.

Overall, this analysis was assessed as being directly applicable but with potentially serious limitations. There is considerable complexity and uncertainty concerning hospital flows and each hospital is likely to react to different scenarios, for example, when full capacity is reached. This analysis was conducted with the best available data. However, the evidence to inform treatment effects was largely determined by elicited expert opinion.

There is a need for more research to determine the effects of these service delivery interventions in different settings. There are potential benefits to hospital flow from reducing delayed transfers of care that need further investigation. To inform future models, it would be helpful if there were more observational studies in to the survival and utility of patients presenting with acute medical problems.

41.7 References

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Appendix A: Health economic review protocol

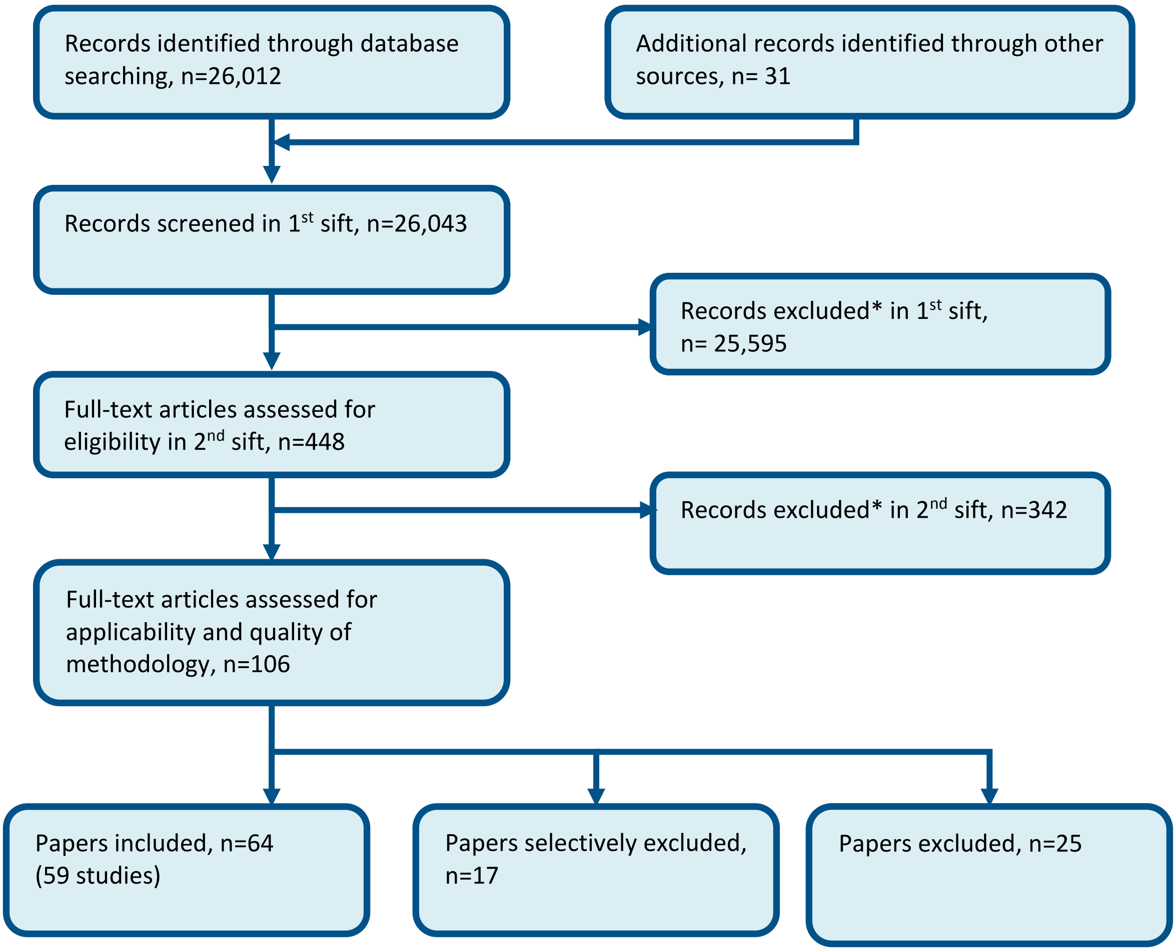
Table 35: Health economic review protocol

Review question	All questions – health economic evidence
Objectives	To identify economic evaluations relevant to any of the review questions.
Search criteria	• Populations, interventions and comparators must be as specified in the individual review protocol above. • Studies must be of a relevant economic study design (cost–utility analysis, cost-effectiveness analysis, cost–benefit analysis, cost–consequences analysis, comparative cost analysis). • Studies must not be a letter, editorial or commentary, or a review of economic evaluations. (Recent reviews will be ordered although not reviewed. The bibliographies will be checked for relevant studies, which will then be ordered.) • Unpublished reports will not be considered unless submitted as part of a call for evidence. • Studies must be in English.
Search strategy	An economic study search will be undertaken which mirrors the clinical study search but with an economic study filter – see Appendix G [in the Full guideline].
Review strategy	Studies not meeting any of the search criteria above will be excluded. Studies published before 2005, abstract-only studies and studies from non-OECD countries or the USA will also be excluded. Each remaining study will be assessed for applicability and methodological limitations using the NICE economic evaluation checklist which can be found in Appendix G of the NICE guidelines manual (2012){National Institute for Health and Clinical Excellence, 2012 NICE2012 /id}. **Inclusion and exclusion criteria** • If a study is rated as both 'Directly applicable' and with 'Minor limitations' then it will be included in the guideline. An economic evidence table will be completed and it will be included in the economic evidence profile. • If a study is rated as either 'Not applicable' or with 'Very serious limitations' then it will usually be excluded from the guideline. If it is excluded then an economic evidence table will not be completed and it will not be included in the economic evidence profile. • If a study is rated as 'Partially applicable', with 'Potentially serious limitations' or both then there is discretion over whether it should be included. **Where there is discretion** The health economist will make a decision based on the relative applicability and quality of the available evidence for that question, in discussion with the committee if required. The ultimate aim is to include studies that are helpful for decision-making in the context of the guideline and the current NHS setting. If several studies are considered of sufficiently high applicability and methodological quality that they could all be included, then the health economist, in discussion with the committee if required, may decide to include only the most applicable studies and to selectively exclude the remaining studies. All studies excluded on the basis of applicability or methodological limitations will be listed with explanation as excluded economic studies in Appendix M [in the Full guideline]. The health economist will be guided by the following hierarchies. *Setting:* • UK NHS (most applicable). • OECD countries with predominantly public health insurance systems (for example, France,

	Germany, Sweden). • OECD countries with predominantly private health insurance systems (for example, Switzerland). • Studies set in non-OECD countries or in the USA will have been excluded before being assessed for applicability and methodological limitations. *Economic study type:* • Cost–utility analysis (most applicable). • Other type of full economic evaluation (cost–benefit analysis, cost-effectiveness analysis, cost–consequences analysis). • Comparative cost analysis. • Non-comparative cost analyses including cost-of-illness studies will have been excluded before being assessed for applicability and methodological limitations. *Year of analysis:* • The more recent the study, the more applicable it will be. • Studies published in 2005 or later but that depend on unit costs and resource data entirely or predominantly from before 1999 will be rated as 'Not applicable'. • Studies published before 2005 will have been excluded before being assessed for applicability and methodological limitations. *Quality and relevance of effectiveness data used in the economic analysis:* • The more closely the effectiveness data used in the economic analysis matches with the outcomes of the studies included in the clinical review the more useful the analysis will be for decision-making in the guideline.

Appendix B: Health economic review flowchart

Figure 7: Flow chart of economic article selection



* Non-relevant population, intervention, comparison, design or setting; non-English language or published before 2005

Table 36: Included and excluded economic studies by guideline chapter

Chapter		Included		Selectively excluded papers	Excluded papers
		Studies	Papers		
	Emergency and acute medical care in the community				
2	Non-emergency phone access	1	1	0	1
3	Paramedic enhanced competencies	1	1	0	1
4	Paramedic remote support	0	0	0	1
5	GP extended hours	1	1	0	0
6	GP led home visits	0	0	0	0
7	GP access to lab tests	3	3	1	0
8	GP access to radiology	0	0	0	0
9	Community nursing	3	3	2	2
10	Community pharmacists	9	11	6	7
11	Social care	0	0	0	0
12	Alternatives to hospital care	13	14	4	2
13	Community rehab	6	7	0	4
14	Palliative care	2	2	0	4
15	Advanced care planning	0	0	0	0
	Emergency and acute medical care in hospital				
16	ED opening hours	0	0	0	0
17	GP-ED	0	0	0	1
18	MIU UCC WiC	1	1	0	0
19	Early versus late consultant review	0	0	0	0
20	Physician extenders	1	1	1	1
21	Standardised criteria for admission	1	1	0	0
22	7 day radiology	0	0	0	0
23	Liaison psychiatry	1	2	0	0
24	AMU admission	0	0	0	0
25	ECAU	1	1	0	0
26	Consultant frequency	1	1	0	0
27	Critical care outreach	1	1	0	0
28	Structured ward rounds	0	0	0	0
29	MDTs	0	0	0	0
30	Pharmacist support	7	7	0	0
31	Enhanced therapy access	0	0	0	0
32	Structured patient handovers	1	1	0	0
33	Integrated patient information systems	0	0	0	0
34	Hospital transfers	0	0	0	0
35	Discharge planning	0	0	0	0
36	Discharge criteria	0	0	0	0
37	Post discharge early follow up clinics	1	1	0	0
	Planning emergency and acute care services				
38	Integrated care models	4	4	3	1
39	Bed capacity	0	0	0	0

Chapter		Included		Selectively excluded papers	Excluded papers
		Studies	Papers		
40	Escalation measures	0	0	0	0
All		**59**	**64**	**17**	**25**

Appendix C: Weekend admissions review

C.1 Review question: Is weekend admission associated with worse outcome than weekday admission in England (after controlling for case-mix)?

For full details see review protocol (C.5).

Table 37: Characteristics of review question

Population	Adults and young people (16 years and over) with a suspected or confirmed AME.
Prognostic variable under consideration	Weekend admission (or weekend attendance at ED). • to include Saturday and Sunday reported together or as separate days.
Confounding factors	Minimum set of confounders that should be adjusted for (will vary per outcome) • Age • Severity of illness – may not be reported
Outcome(s)	• Hospital mortality (CRITICAL) • 30 day mortality (CRITICAL) • Length of stay (IMPORTANT) • Avoidable adverse events (IMPORTANT)
Study design	Prospective or retrospective cohort studies.

C.2 Clinical evidence

Twenty-two studies were included in the review{Aldridge, 2016 ALDRIDGE2016 /id;Anselmi, 2016 ANSELMI2016 /id;Aylin, 2010 AYLIN2010 /id;Bell, 2013 BELL2013 /id;Bray, 2014 BRAY2014 /id;Bray, 2016 BRAY2016 /id;Brims, 2011 BRIMS2011 /id;Campbell, 2014 CAMPBELL2014A /id;Deshmukh, 2016 DESHMUKH2016 /id;Freemantle, 2012 FREEMANTLE2012 /id;Freemantle, 2015 FREEMANTLE2015 /id;Iqbal, 2015 IQBAL2015 /id;Jairath, 2011 JAIRATH2011 /id;Kolic, 2015 KOLIC2015 /id;Meacock, 2016 MEACOCK2016 /id;Mohammed, 2012 MOHAMMED2012B /id;Mohammed, 2016 MOHAMMED2016 /id;Noman, 2012 NOMAN2012 /id;Palmer, 2012 PALMER2012 /id;Rathod, 2013 RATHOD2013A /id;Ruiz, 2015 RUIZ2015 /id;Showkathali, 2013 SHOWKATHALI2013 /id}; these are summarised in Table 46 below. Evidence from these studies is summarised in the clinical evidence summary below (Table 47). See also the study selection flow chart (C.6), forest plots (C.7), study evidence tables (C.8), GRADE tables (C.9) and excluded studies list (C.10).

Table 38: Summary of studies included in the review

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Comments
Aldridge 2016{Aldridge, 2016 ALDRIDGE 2016 /id} Retrospective cohort	All adult (≥16 years) emergency admissions for 141 trusts for financial year 2013-2014 from	Logistic regression	Weekend (Saturday or Sunday by date) Versus Weekday (Wednesday by date)	Trust Sex Age Income deprivation component of the Index of Multiple Deprivation	In-hospital mortality	

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Comments
	hospital episode statistics.			2010 Diagnostic category as represented by the Clinical Classification Software code and a categorised index of comorbidity		
Anselmi 2016{Anselmi, 2016 ANSELMI2016 /id} Retrospective cohort	Patients admitted to hospital following attendance at A&E at 140 non-specialist acute hospitals in England 1 April 2013 to 28 March 2014 from Hospital Episode statistics	Logistic regression	Saturday day (7am-6.59pm) Saturday night (7pm-6.59am) Sunday day (7am-6.59pm) Sunday night (7pm-6.59am) Versus. Wednesday day (7am-6.59pm)	Interaction between gender and age Ethnicity Primary diagnosis Comorbidities (30 binary indicators recorded in the secondary diagnosis fields, measured using Elixhauser conditions) Source of admission Deprivation in area of residence Admitting hospital Month of admission	In-hospital mortality within 30 days of admission	High risk of detection bias – short follow up
Aylin 2010{Aylin, 2010 AYLIN2010 /id} Retrospective cohort	Emergency inpatient admissions extracted from finished consultant episodes of care for inpatients in all acute public hospitals in England from the NHS Wide	Logistic regression	Weekend (admissions starting on a Saturday or Sunday by date) Versus Weekday	Age Sex Deprivation quintile Charlson comorbidity score Case mix (clinical classification system diagnostic groups)	Hospital mortality	

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Comments
	Clearing Service with discharge dates between 1 April 2005 and 31 March 2006 n=4,317,866 Number of events = 215,054					
Bell 2013{Bell, 2013 BELL2013 /id} Retrospective cohort	Adult (≥16 years) acute medical admissions derived from hospital episode statistics for patients admitted to participating hospitals as an acute medical emergency 1 April 2009 to 31 March 2010 n=1.3 million Event rate = 4.3%	Step-wise multivariate regression analysis	Weekend Versus Weekday	Charlson comorbidity index Age Index of multiple deprivation	Hospital mortality	Weekend not defined
Bray 2014{Bray, 2014 BRAY2014 /id} Retrospective cohort	Adults (≥18 years) admitted with stroke from the Stroke Improvement National Audit Programme from 1 June 2011 to 1 December 2012 linked	Cox proportional hazards model	Weekend Versus Weekday	Age Stroke type Pre-stroke independence Hypoxia in the first 24 hours of admission Lowest level of consciousness in the first 24 hours Arm weakness	30 day mortality	Weekend not defined HR for weekend versus weekday with 7 days per week stroke specialist physician rounds

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Comments
	with English national register of deaths n=32,388 Event rate = 11.8%			Leg weakness Hemianopia Dysphasia No. of SU beds Presence of 24/7 on-site thrombolysis service Ratio of HCAs/nurses to beds Presence of 7-day physician ward rounds Management solely in an optimal setting in first 24 hours Antiplatelet therapy if required Brain scan within 24 hours		
Bray 2016{Bray, 2016 BRAY2016 /id} Retrospective cohort	All adults (>16 years) admitted to hospital in England and Wales with acute stroke between April 1, 2013 and March 31, 2014 from the Sentinel Stroke National Audit Programme (SSNAP).	Logistic regression	Weekend (Saturday to Sunday 08:00-19:59 h and Saturday to Sunday 20:00-07:59 h) Versus Weekday (Monday to Friday 08:00-19:59 h and Monday to Friday 20:00-07:59 h)	Age Sex Place of stroke onset (in or out of hospital) Stroke type Vascular comorbidity (atrial fibrillation, heart failure, diabetes, previous stroke or transient ischemic attack, hypertension) Pre-stroke functional level(as measured by the modified Rankin Scale) Time from stroke onset	30-day survival (following admission)	

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Comments
				to admission Stroke severity (National Institutes of Health Stroke Scale score or level of consciousness on admission) Hospital level random intercepts		
Brims 2011{Brims, 2011 BRIMS2011 /id} Retrospective cohort	Acute exacerbations of chronic obstructive pulmonary disease patients admitted to a large secondary care hospital in Portsmouth between January 1997 and December 2004 extracted from hospital databases n=9,915 Number of events = 1,516	Multivariate logistic regression	Weekend (midnight Friday to midnight Sunday) Versus Weekday (all other time)	Age Sex Creatinine PaO2	Hospital mortality (within 7 days)	High risk of detection bias – short follow up
Campbell 2014{Campbell, 2014 CAMPBELL 2014A /id} Retrospective cohort	Stroke admissions to 130 hospitals in England (1 April 2010 - 31 January 2012) from the Stroke Improvement National Audit	Logistic regression	Weekend Versus Weekday Out of hours (weekdays before 08:00 or after 18:00 or at any time on a weekend day or English public	Age Sex Worst level of consciousness in the first 24 hours (surrogate for severity) Stroke type Pre-stroke independence	30 day mortality	

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Comments
	Programme n= 45,726 Number of events = 5,956		holiday) Versus In hours (weekdays 08:00 to 18:00)			
Deshmukh 2016{Deshmukh, 2016 DESHMUKH2016 /id} Retrospective cohort	Patients admitted between January 2009 and December 2011 with acute subarachnoid haemorrhage from 12 hospitals in Northwest England.	Cox proportional hazards	Weekend (16:00 Friday to 16:00 Sunday) Versus Weekday	Age Sex Severity of SAH (baseline World Federation of Neurosurgical Societies grade) Treatment modalities following admission Time from scan to admission and from admission to treatment	In-hospital mortality	
Freemantle 2012{Freemantle, 2012 FREEMANTLE2012 /id} Retrospective cohort	All admissions to National Health Service Hospitals in England April 2009 - March 2010 using inpatient hospital trusts within England. Linked data on mortality from the Office of National Statistics n=14,217,640 Number of events =	Contingency tables for each day, utilising a complementary log-log link function and binomial error	Saturday Sunday Versus Wednesday	Age Sex Ethnicity Source of admission Diagnostic group No. of previous emergency admissions No. of previous complex admissions Charlson comorbidity index Social deprivation Hospital trust Day of the year (seasonality)	Hospital mortality 30 day mortality	Saturday and Sunday analysed separately – both statistics included in weekend versus weekday meta-analysis

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Comments
	187,337 (in-hospital) 284,852 (30 day)					
Freemantle 2015{Freemantle, 2015 FREEMANTLE2015 /id} Retrospective cohort	All admissions to National Health Service Hospitals in England in 2013-2014 n= 14 818 374 Number of events = 280 788	Identical to previous analysis	Saturday Sunday Versus Wednesday	Case mix (clinical classifications software category) Age Time of year Trust Deprivation No. of previous emergency admissions No. of previous complex admissions Admission source Admission urgency Sex Ethnicity Charlson comorbidity index	30 day mortality	Saturday and Sunday analysed separately – both statistics included in weekend versus weekday meta-analysis
Iqbal 2015{Iqbal, 2015 IQBAL2015 /id} Retrospective cohort	Consecutive STEMI patients treated with PPCI between 2005 and 2011 at 8 tertiary centres in London from local British Cardiac Intervention Society databases linked with Office of National Statistics data	Logistic regression and Cox proportional hazards regression models	Out of hours (weekdays 17:00 to 09:00 and any time on a Saturday or Sunday) Versus In hours (09:00 to 17:00 Monday to Friday)	Age Sex Diabetes GP2b-3a inhibitor use Previous MI Renal disease Radial access Cardiogenic shock IABP use Intubation status LMS intervention LAD intervention Multi-vessel intervention Completeness of	30 day mortality Avoidable adverse events (in-hospital bleeding complications)	Procedure time taken as admission time

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Comments
	n=11,466 Number of events = 607			revascularisation		
Jairath 2011{Jairath, 2011 JAIRATH2011 /id} Retrospective cohort	Adults (16 years and over) presenting with acute upper gastrointestinal bleeding from the 2007 UK National audit of AUGIB of all NHS hospitals accepting acute admissions in the UK (majority from England). 1 May - 30 June 2007 n=6,749	Mixed effects logistic regression	Weekend (3 sensitivity analyses performed: 5pm Friday - midnight Sunday, Midnight Friday - 5pm Sunday, 5pm Friday to 5pm Sunday) Versus Weekday	Individual components of the Rockall score (age, presentation with shock, co-morbid illness) Presentation with hematemesis Presentation with melaena Haemoglobin and urea concentration on admission Use of aspirin Use of non-steroidal anti-inflammatory drugs Use of proton pump inhibitors Gender Variceal bleeding Peptic ulcer bleeding Availability of OOH rota enabling 24hr access to endoscopy Admission status (new patient versus inpatient)	Hospital mortality up to 30 days post-index AUGIB Avoidable adverse events (re-bleeding, surgery/radiology, red cell transfusion)	Unclear which weekend definition was used in the analysis High risk of detection bias (for mortality outcome) – short follow up
Kolic 2015{Kolic, 2015 KOLIC2015 /id} Prospectiv	All patients presenting to the acute medical unit at Queen Elizabeth Hospital in London 1	Multivariate logistic regression	Weekend Versus Weekday	Age Severity (NEW score)	Avoidable adverse events (inadequate clinical response to NEW score)	Weekend not defined High risk of detection bias (short follow up)

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Comments
e cohort	October 2013 - 15 October 2013 and 9 December 2013 - 22 December 2013 Exclusion: patients with <12hr inpatient stay n=370 Number of events = 96					and performance bias (unclear whether staff were aware of the study)
Meacock 2016{Meacock, 2016 MEACOCK 2016 /id} Retrospective cohort	Emergency admissions to type 1 units (consultant-led, multispecialty 24-hour services with full resuscitation facilities and designated accommodation for reception of A&E patients) from 140 trusts in England from hospital episode statistics 1 April 2013 to 28 February 2014.	Logistic regression	Weekend (Saturday and Sunday by date) Versus Weekday (Monday to Friday by date)	Age Sex Ethnicity Primary diagnosis (SHMI-grouped Clinical Classifications Software category) Elixhauser (comorbidity) conditions Admission method Admission source Deprivation quintile Month Admitting hospital	30-day mortality (following admission)	Admissions via A&E departments and direct admissions analysed separately
Mohammed 2012{Mohammed, 2012 MOHAM	Emergency admissions April 2008 - March 2009 from all acute	Logistic regression	Weekend (by date) Versus Weekday (by date)	Age category Complex elderly Male Healthcare resource	Hospital mortality	Assumed to be in hospital mortality because the study was on hospital

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Comments
MED2012B /id} Retrospective cohort	hospitals (n=328) in England via Hospital Episode Statistics Exclusion: admissions discharged alive with a zero day length of stay, age <16 years, maternity care, mental health care other than dementia n=3,105,249 Number of events = 206,683			group with comorbidities/complications Interaction: Age and HRG with comorbidities/complications Admission quarter		discharges, no mention of follow up or ONS data
Mohammed 2016{Mohammed, 2016 MOHAMMED2016 /id} Retrospective cohort	All adult (≥16 years) emergency medical and elderly admissions, discharged between 1 January 2014 and 31 December 2014 from 3 general acute hospitals in England.	Linear and logistic regression	Weekend (Saturday and Sunday by date) Versus Weekday (Monday to Friday by date)	Index NEWS Age Sex Calendar month	In-hospital mortality	
Noman 2012{Noman, 2012 NOMAN2012 /id} Retrospective cohort	STEMI patients undergoing PPCI March 2008 - June 2011 at one tertiary cardiac centre in Newcastle from local	Multiple logistic regression	Out of hours (weekdays between 18:00 and 08:00 and any time on a Saturday or Sunday) Versus Routine hours (08:00 to 18:00 Monday to	Age Sex Previous MI Diabetes mellitus Anterior MI site Baseline haemoglobin and creatinine	Hospital mortality	Procedure time taken as admission time

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Comments
	coronary artery disease database (Dentrite) linked with Office of National Statistics data n=2,571 Event rate = 4.5%		Friday)	Admission HR and SBP Cardiogenic shock Onset of symptoms to balloon time Presence of multi-vessel disease Thromolysis in MI flow 3 post-PPCI		
Palmer 2012{Palmer, 2012 PALMER2012 /id} Retrospective cohort	Stroke admissions from Hospital Episode Statistics 1 April 2009 - 31 March 2010 n=93,621 Number of events = 8,772 (7 day hospital mortality)	Logistic regression	Weekend (midnight Friday to Midnight Sunday) Versus Weekday	Age Sex Socioeconomic deprivation quintile No. of previous admissions Comorbidities (Charlson index with weights derived from all admissions in England) Month of discharge Ethnic group Source of admission Stroke type	7-day hospital mortality Avoidable adverse events (aspiration pneumonia) Length of stay (discharge to usual place of residence within 56 days)	High risk of detection bias (for mortality outcome) – short follow up
Rathod 2013{Rathod, 2013 RATHOD2013A /id} Retrospective cohort	Consecutive STEMI patients undergoing PPCI in one tertiary heart attack centre in London January 2004 - July 2012 from clinical database, electronic patient record and	Logistic regression	Out of hours (17:01 to 07:59 Monday to Friday and 17:01 Friday to 07:59 Monday) Versus In hours (08:00 to 17:00 Monday to Friday)	Age Shock eGFR>60 (epidermal growth factor receptor) EF>40 Procedural success Multi-vessel disease	30 day mortality Avoidable adverse events (death, recurrent MI, target vessel revascularisation)	Procedure time taken as admission time

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Comments
	cardiac surgical database linked with Office of National Statistics data n=3347 Number of events = 138					
Ruiz 2015{Ruiz, 2015 RUIZ2015 /id} Retrospective cohort	Emergency admissions from an International dataset from the Global Comparators project consisting of hospital administrative data 2009-2012 (separate English data analysis) Exclusion: day cases, non-acute care, records with missing/invalid entries, short-term emergency admissions not ending in death or transfer within 24 hours and with recorded major procedure n=885,864	Multilevel mixed-effects logistic regression	Saturday Sunday Versus Monday	Age Gender Transfers in from another hospital Year of admission Comorbidity score Diagnosis risk factor Bed numbers Rate of transfers to other hospitals	Hospital 30 day mortality	Saturday and Sunday analysed separately - included in weekend versus weekday meta-analysis High risk of detection bias – short follow up

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Comments
	Number of events = 40,749					
Showkathali 2013{Showkathali, 2013 SHOWKATHALI2013 /id} Retrospective cohort	All patients undergoing PPCI September 2009 - November 2011 at one cardiothoracic centre in Essex from the cardiac service database system n=1471	Binary logistic regression	Out of hours (18:00 to 08:00 weeknights and Saturday 08:00 to Monday 08:00) Versus In hours (08:00 to 18:00 weekdays)	Age >75 years Sex Cardiogenic shock Diabetes Hypertension Previous MI Single vessel PCI Pre-procedure TIMI 0/1 flow Drug eluting stent use Door to balloon time	30 day mortality	Procedure time taken as admission time

Table 39: Clinical evidence summary: Weekend admission

Risk factor and outcome (population)	Number of studies	Pooled effect (95% CI) [if meta-analysed] OR Effect (95% CI) [in single study]	Imprecision	GRADE Quality
Weekend versus weekday admission for predicting hospital mortality (adjusted OR) (emergency admissions)[a]	1	Adjusted OR: 1.10 (1.08 to 1.12)	No serious imprecision	HIGH
Weekend versus weekday admission for predicting hospital mortality (adjusted OR) (emergency inpatient admissions)[a]	1	Adjusted OR: 1.10 (1.08 to 1.12)	No serious imprecision	HIGH
Weekend versus weekday admission for predicting hospital mortality (adjusted OR) (acute medical admissions)[a]	1	Adjusted OR: 1.15 (0.89 to 1.49)	Serious[b]	MODERATE
Weekend versus weekday admission for predicting hospital mortality (adjusted OR) (acute exacerbations of chronic obstructive pulmonary disease admissions)[a]	1	Adjusted OR: 1.75 (0.75 to 4.09)	Serious[b]	LOW
Weekend versus weekday admission for predicting hospital mortality (adjusted HR) (acute subarachnoid haemorrhage admissions)[a]	1	Adjusted HR: 2.10 (1.13 to 3.9)	No serious imprecision	HIGH
Weekend versus weekday admission for predicting hospital mortality (adjusted HR) (all admissions)[a]	1	Adjusted HR: 1.14 (1.12 to 1.15) Range of HR: 1.11-1.16	No serious imprecision	HIGH
Weekend versus weekday admission for predicting hospital mortality (adjusted OR) (acute upper gastrointestinal bleeding admissions)[a]	1	Adjusted OR: 0.93 (0.75 to 1.15)	Serious[b]	VERY LOW
Weekend versus weekday admission for predicting hospital mortality (adjusted OR) (emergency admissions)[a]	1	Adjusted OR: 1.09 (1.05 to 1.13)	No serious imprecision	HIGH

Risk factor and outcome (population)	Number of studies	Pooled effect (95% CI) [if meta-analysed] OR Effect (95% CI) [in single study]	Imprecision	GRADE Quality
Weekend versus weekday admission for predicting hospital mortality (adjusted RR) (emergency medical and elderly admissions)[a]	1	Adjusted RR:0.98 (0.91 to 1.06)	Serious[b]	MODERATE
Weekend versus weekday admission for predicting hospital mortality (adjusted OR) (stroke admissions)[a]	1	Adjusted OR: 1.18 (1.12 to 1.24)	No serious imprecision	MODERATE
Weekend versus weekday admission for predicting hospital mortality (adjusted OR) (emergency admissions)[a]	1	Adjusted OR: 1.08 (1.05 to 1.10) Range of OR: 1.07-1.08	No serious imprecision	MODERATE
Weekend versus weekday admission for predicting hospital mortality (adjusted OR) (emergency admissions)[a]	1	Adjusted OR: 1.02 (1.00 to 1.03) Range of OR: 0.96-1.03	No serious imprecision	MODERATE
Weekend (8am-7.59pm) versus weekday admission for predicting 30 day survival (adjusted OR) (stroke admissions)[a]	1	Adjusted OR 1.03 (0.95 to 1.12)	Serious[b]	MODERATE
Weekend (8pm-7.59am) versus weekday admission for predicting 30 day survival (adjusted OR) (stroke admissions)[a]	1	Adjusted OR 0.89 (0.78 to 1.02)	Serious[b]	MODERATE
Weekend versus weekday admission for predicting 30 day mortality (adjusted OR) (stroke admissions)[a]	1	Adjusted OR: 1.14 (1.06 to 1.23)	No serious imprecision	HIGH
Weekend versus weekday admission for predicting 30 day mortality (adjusted OR) (A&E admissions)[a]	1	Adjusted OR: 1.05 (1.04 to 1.07)	No serious imprecision	HIGH
Weekend versus weekday admission for predicting 30 day mortality (adjusted OR) (direct admissions)[a]	1	Adjusted OR: 1.21 (1.16 to 1.26)	No serious imprecision	HIGH

Risk factor and outcome (population)	Number of studies	Pooled effect (95% CI) [if meta-analysed] OR Effect (95% CI) [in single study]	Imprecision	GRADE Quality
Weekend versus weekday admission for predicting 30 day mortality (adjusted HR) (all admissions)[a]	3	Adjusted HR: 1.13 (1.10 to 1.15) Range of HR: 0.96-1.15	No serious imprecision	MODERATE
Weekend versus weekday admission for predicting avoidable adverse events (re-bleeding) (adjusted OR) (acute upper gastrointestinal bleeding admissions)[a]	1	Adjusted OR: 0.91 (0.74 to 1.12)	Serious[b]	LOW
Weekend versus weekday admission for predicting avoidable adverse events (surgery/radiology) (adjusted OR) (acute upper gastrointestinal bleeding admissions)[a]	1	Adjusted OR: 1.13 (0.81 to 1.58)	Serious[b]	LOW
Weekend versus weekday admission for predicting avoidable adverse events (red cell transfusion) (adjusted OR) (acute upper gastrointestinal bleeding admissions)[a]	1	Adjusted OR: 1.12 (0.94 to 1.33)	Serious[b]	LOW
Weekend versus weekday admission for predicting avoidable adverse events (inadequate clinical response to NEWS) (adjusted OR) (all admissions)[a]	1	Adjusted OR: 4.15 (2.24 to 7.69)	No serious imprecision	MODERATE
Weekend versus weekday admission for predicting avoidable adverse events (aspiration pneumonia) (adjusted OR) (stroke admissions)[a]	1	Adjusted OR: 1.11 (1.04 to 1.18)	No serious imprecision	HIGH
Weekend versus weekday admission for predicting length of stay (discharge to usual place of residence within 56 days) (adjusted OR) (stroke admissions)	1	Adjusted OR: 0.92 (0.88 to 0.96)	No serious imprecision	HIGH

1 *(a) Methods: multivariable analysis, including key covariates used in analysis to assess if weekend admission is an independent risk factor. Key covariates included: age and severity.*
2 *(b) 95% CI around the median crosses null line.*

3 **Table 40: Clinical evidence summary: Out of hours admission**

Risk factor and outcome (population)	Number of studies	Pooled effect (95% CI) [if meta-analysed] OR Effect (95% CI) [in single study]	Imprecision	GRADE Quality
Out of hours versus in hours admission for predicting hospital mortality (adjusted OR) (STEMI admissions)[a]	1	Adjusted OR: 1.33 (0.73 to 2.42)	Serious[b]	LOW
Out of hours versus in hours admission for predicting 30 day mortality (adjusted OR) (stroke admissions)[a]	1	Adjusted OR: 1.07 (1.00 to 1.14)	No serious imprecision	HIGH
Out of hours versus in hours admission for predicting 30 day mortality (adjusted HR) (STEMI admissions)[a]	1	Adjusted HR: 1.03 (0.89 to 1.19)	Serious[b]	LOW
Out of hours versus in hours admission for predicting 30 day mortality (adjusted HR) (STEMI admissions)[a]	1	Adjusted HR: 0.74 (0.42 to 1.30)	Serious[b]	LOW
Out of hours versus in hours admission for predicting 30 day mortality (adjusted HR) (all patients undergoing PPCI)[a]	1	Adjusted HR: 1.10 (0.60 to 2.02)	Serious[b]	LOW
Out of hours versus in hours admission for predicting avoidable adverse events (bleeding complications) (adjusted OR) (STEMI admissions)[a]	1	Adjusted OR: 1.47 (0.97 to 2.23)	Serious[b]	LOW
Out of hours versus in hours admission for predicting avoidable adverse events (major adverse cardiac events) (adjusted HR) (STEMI admissions)[a]	1	Adjusted HR: 0.81 (0.54 to 1.22)	Serious[b]	LOW

(a) Methods: multivariable analysis, including key covariates used in analysis to assess if weekend admission is an independent risk factor. Key covariates included: age and severity.
(b) 95% CI around the median crosses null line.

C.3 Evidence statements

The evidence for weekend versus weekday admission for predicting hospital mortality and avoidable adverse events was inconsistent. Studies examined the effect of weekend admission on varying populations of which some suggested a reduction in mortality with weekend admission, the majority found an increase in mortality.

C.4 Subgroup comments

Question	Comments
Which outcomes are affected by weekend admission?	• Mortality is higher for patients admitted at the weekend. A number of studies have concluded that this is due to reduced staffing and services at the weekend. However, the study that looked at mortality across all ED presentations showed no increase in mortality, suggesting that admissions at the weekend have a more severe case-mix, which has not been completely controlled for in the other studies. • The outcome of avoidable adverse events as defined by inadequate clinical response to national early warning score is the most relevant to clinical workforce.
Which studies best show the effect?	• The following studies produced high and moderate quality evidence and had relatively large sample sizes: Aldridge 2016, Aylin 2010, Bell 2013, Bray 2016, Campbell 2014, Freemantle 2012, Freemantle 2015, Meacock 2016, Mohammed 2012, Mohammed 2016, Palmer 2012 and Ruiz 2015.
Can we say whether or not the effect is preventable or can be reduced by 7 day services?	• Weekend effect shown in specific conditions in which pathways have developed where expertise is available 7 days a week. ○ STEMI – PCI done immediately 7 days a week. ○ Stroke – thrombolysis at hyper acute stroke units available 7 days a week. ○ Upper GI – Endoscopy available within 24 hours. • The effect could have already been partially mitigated in these. Or perhaps these pathways have not been in place long enough to show an effect. • Effect could be due to other parts of the system for example, lack of porters. • Or is it that some of the confounding has not been fully adjusted for? Even though all the studies reported that they had adjusted for age and severity. • Cannot say whether it is preventable or whether it can be reduced until 7 day services are fully evaluated.
Other considerations	• One of the patient members commented on her experience of having problems at the weekend that were preventable. Delays to treatment and incorrect treatments led to her becoming seriously ill. • Guidelines promote good practice but there needs to be staff available to implement guidelines. • Skill mix and experience important factors not just staff numbers at weekends. • Possible lack of seniority or staffing numbers may lead to pathways not being followed. • There are specialist centres in London implementing heart attack and stroke models, but these are less common in other areas of the country.

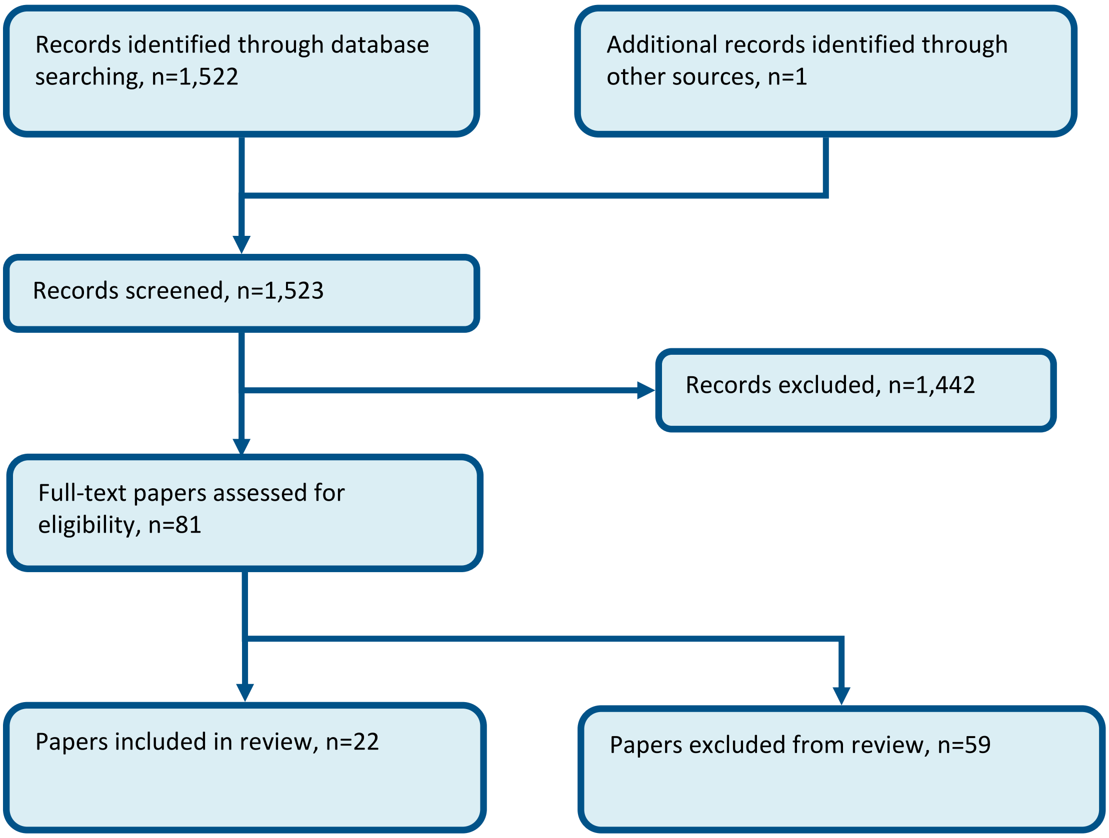
C.5 Review protocol

Table 41: Review protocol: Weekend admission

Component	Description
Review question	Is weekend admission associated with worse outcome than weekday admission in England (after controlling for case-mix)?
Objectives	To determine whether weekend admission is associated with worse outcome than weekday admission in England, after controlling for case-mix
Population	Adults and young people (16 years and over) with a suspected or confirmed AME
Presence or absence of prognostic variable	Weekend admission (or weekend attendance at ED) to include Saturday and Sunday reported together or as separate days
Outcome(s)	• Hospital mortality(CRITICAL) • 30 day Mortality (CRITICAL) • Length of stay • Avoidable adverse events
Study design	Prospective or retrospective cohort studies
Exclusions	Exclude studies from outside of England
How the information will be searched	The databases to be searched are: Medline, Embase, the Cochrane Library Date limits for search: 10 years old (i.e., published after 2005) Language: English only
Key confounders	Minimum set of confounders that should be adjusted for (will vary per outcome) • Age • Severity of illness – may not be reported
The review strategy	Meta-analysis where appropriate will be conducted. Studies in the following subgroup populations will be included: • Frail elderly • Case mix – Cardiovascular /Oncology patients etc. In addition, if studies have pre-specified in their protocols that results for any of these subgroup populations will be analysed separately, then they will be included. The methodological quality of each study will be assessed using the Evibase checklist and GRADE.

C.6 Study selection

Figure 8: Flow chart of clinical study selection for the review of weekend admission



C.7 Forest plots

C.7.1 Weekend versus weekday admission

Figure 9: Weekend versus weekday admission for predicting hospital mortality in acute medical admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Bell 2013	0.1398	0.1308	100.0%	1.15 [0.89, 1.49]
Total (95% CI)			**100.0%**	**1.15 [0.89, 1.49]**
Heterogeneity: Not applicable				
Test for overall effect: Z = 1.07 (P = 0.29)				

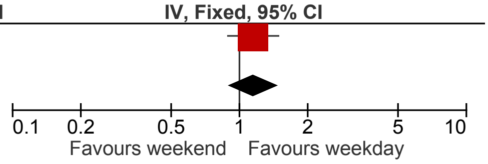


Figure 10: Weekend versus weekday admission for predicting hospital mortality in acute exacerbations of chronic obstructive pulmonary disease admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Brims 2011	0.5596	0.433	100.0%	1.75 [0.75, 4.09]
Total (95% CI)			**100.0%**	**1.75 [0.75, 4.09]**
Heterogeneity: Not applicable				
Test for overall effect: Z = 1.29 (P = 0.20)				

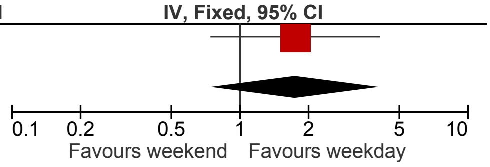


Figure 11: Weekend versus weekday admission for predicting hospital mortality in emergency inpatient admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Aylin 2010	0.0953	0.0094	100.0%	1.10 [1.08, 1.12]
Total (95% CI)			**100.0%**	**1.10 [1.08, 1.12]**
Heterogeneity: Not applicable				
Test for overall effect: Z = 10.14 (P < 0.00001)				

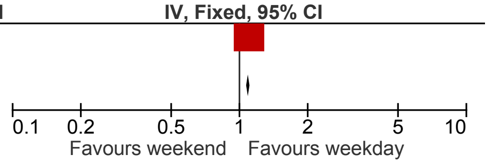


Figure 12: Weekend versus weekday admission for predicting hospital mortality in emergency admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Aldridge 2016	0.0953	0.0094	100.0%	1.10 [1.08, 1.12]
Total (95% CI)			**100.0%**	**1.10 [1.08, 1.12]**
Heterogeneity: Not applicable				
Test for overall effect: Z = 10.14 (P < 0.00001)				

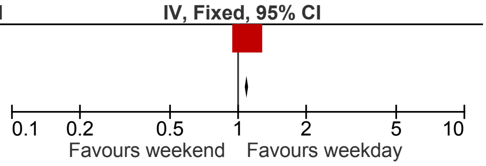


Figure 13: Weekend versus weekday admission for predicting hospital mortality in acute subarachnoid haemorrhage admissions

Study or Subgroup	log[Hazard Ratio]	SE	Weight	Hazard Ratio IV, Fixed, 95% CI
Deshmukh 2016	0.7419	0.3162	100.0%	2.10 [1.13, 3.90]
Total (95% CI)			**100.0%**	**2.10 [1.13, 3.90]**

Heterogeneity: Not applicable
Test for overall effect: Z = 2.35 (P = 0.02)

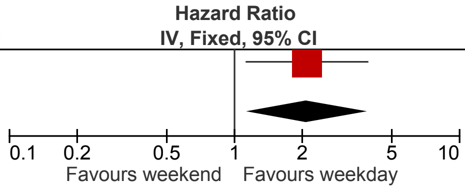


Figure 14: Weekend versus weekday admission for predicting hospital mortality in all admissions

Study or Subgroup	log[Hazard Ratio]	SE	Weight	Hazard Ratio IV, Fixed, 95% CI
Freemantle 2012 (Sat vs. Wed)	0.1044	0.0093	47.8%	1.11 [1.09, 1.13]
Freemantle 2012 (Sun vs. Wed)	0.1484	0.0089	52.2%	1.16 [1.14, 1.18]
Total (95% CI)			**100.0%**	**1.14 [1.12, 1.15]**

Heterogeneity: Chi² = 11.68, df = 1 (P = 0.0006); I² = 91%
Test for overall effect: Z = 19.81 (P < 0.00001)

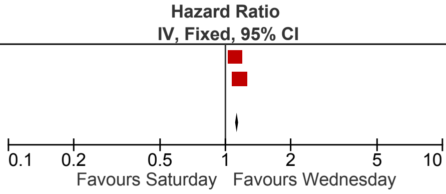


Figure 15: Weekend versus weekday admission for predicting hospital mortality in acute upper gastrointestinal bleeding admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Jairath 2011	-0.0726	0.1098	100.0%	0.93 [0.75, 1.15]
Total (95% CI)			**100.0%**	**0.93 [0.75, 1.15]**

Heterogeneity: Not applicable
Test for overall effect: Z = 0.66 (P = 0.51)

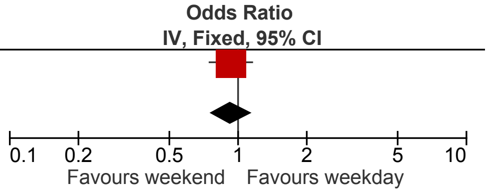


Figure 16: Weekend versus weekday admission for predicting hospital mortality in emergency admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Mohammed 2012B	0.0862	0.0191	100.0%	1.09 [1.05, 1.13]
Total (95% CI)			**100.0%**	**1.09 [1.05, 1.13]**

Heterogeneity: Not applicable
Test for overall effect: Z = 4.51 (P < 0.00001)

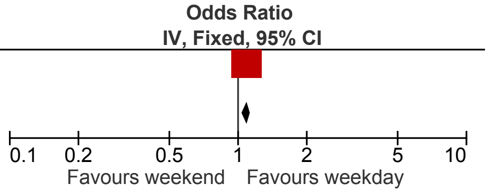


Figure 17: Weekend versus weekday admission for predicting hospital mortality in emergency medical and elderly admissions

Study or Subgroup	log[Risk Ratio]	SE	Weight	Risk Ratio IV, Fixed, 95% CI
Mohammed 2016	-0.0202	0.0378	100.0%	0.98 [0.91, 1.06]
Total (95% CI)			**100.0%**	**0.98 [0.91, 1.06]**

Heterogeneity: Not applicable
Test for overall effect: Z = 0.53 (P = 0.59)

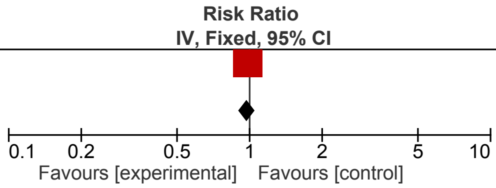


Figure 18: Weekend versus weekday admission for predicting hospital mortality in stroke admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Palmer 2012	0.1655	0.0266	100.0%	1.18 [1.12, 1.24]
Total (95% CI)			**100.0%**	**1.18 [1.12, 1.24]**

Heterogeneity: Not applicable
Test for overall effect: Z = 6.22 (P < 0.00001)

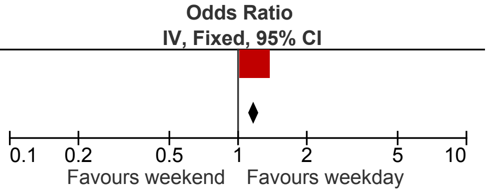


Figure 19: Weekend versus weekday admission for predicting hospital mortality in emergency admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Ruiz 2015 (Sat vs. Mon)	0.0677	0.0194	49.7%	1.07 [1.03, 1.11]
Ruiz 2015 (Sun vs. Mon)	0.077	0.0193	50.3%	1.08 [1.04, 1.12]
Total (95% CI)			**100.0%**	**1.08 [1.05, 1.10]**

Heterogeneity: Chi² = 0.12, df = 1 (P = 0.73); I² = 0%
Test for overall effect: Z = 5.29 (P < 0.00001)

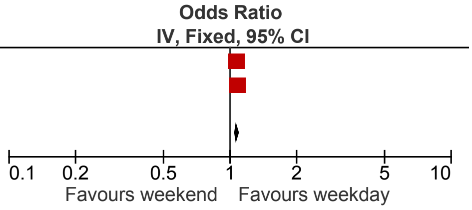


Figure 20: Weekend versus weekday admission for predicting hospital mortality in emergency admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Anselmi 2016 (Fri night vs. Wed day)	-0.0387	0.0189	17.7%	0.96 [0.93, 1.00]
Anselmi 2016 (Sat day vs. Wed day)	0.0305	0.0161	24.3%	1.03 [1.00, 1.06]
Anselmi 2016 (Sat night vs. Wed day)	-0.003	0.0193	16.9%	1.00 [0.96, 1.04]
Anselmi 2016 (Sun day vs. Wed day)	0.0592	0.0161	24.3%	1.06 [1.03, 1.10]
Anselmi 2016 (Sun night vs. Wed day)	0.0188	0.0194	16.8%	1.02 [0.98, 1.06]
Total (95% CI)			**100.0%**	**1.02 [1.00, 1.03]**

Heterogeneity: Chi² = 17.33, df = 4 (P = 0.002); I² = 77%
Test for overall effect: Z = 2.22 (P = 0.03)

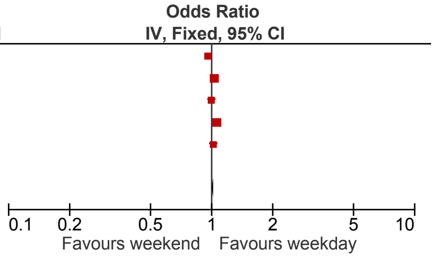


Figure 21: Weekend (8am-7.59pm) versus weekday admission for predicting 30 day survival in stroke admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Bray 2016	0.0296	0.0413	100.0%	1.03 [0.95, 1.12]
Total (95% CI)			**100.0%**	**1.03 [0.95, 1.12]**

Heterogeneity: Not applicable
Test for overall effect: Z = 0.72 (P = 0.47)

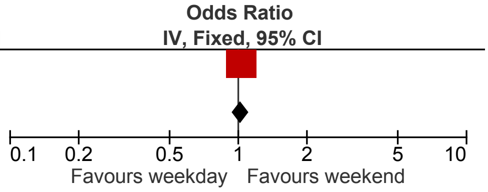


Figure 22: Weekend (8pm-7.59am) versus weekday admission for predicting 30 day survival in stroke admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Bray 2016	-0.1165	0.0673	100.0%	0.89 [0.78, 1.02]
Total (95% CI)			**100.0%**	**0.89 [0.78, 1.02]**

Heterogeneity: Not applicable
Test for overall effect: Z = 1.73 (P = 0.08)

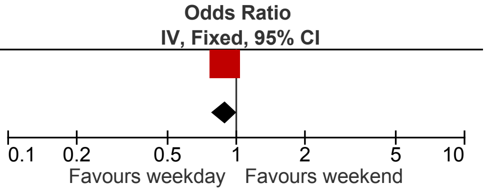


Figure 23: Weekend versus weekday admission for predicting 30 day mortality in stroke admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Campbell 2014	0.131	0.0371	100.0%	1.14 [1.06, 1.23]
Total (95% CI)			**100.0%**	**1.14 [1.06, 1.23]**

Heterogeneity: Not applicable
Test for overall effect: Z = 3.53 (P = 0.0004)

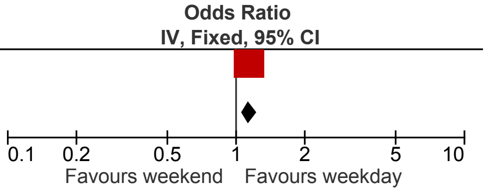


Figure 24: Weekend versus weekday admission for predicting 30 day mortality in emergency admissions through A&E

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Meacock 2016	0.0526	0.0068	100.0%	1.05 [1.04, 1.07]
Total (95% CI)			**100.0%**	**1.05 [1.04, 1.07]**

Heterogeneity: Not applicable
Test for overall effect: Z = 7.74 (P < 0.00001)

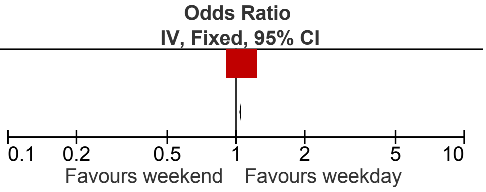


Figure 25: Weekend versus weekday admission for predicting 30 day mortality in direct emergency admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Meacock 2016	0.1923	0.0215	100.0%	1.21 [1.16, 1.26]
Total (95% CI)			**100.0%**	**1.21 [1.16, 1.26]**

Heterogeneity: Not applicable
Test for overall effect: Z = 8.94 (P < 0.00001)

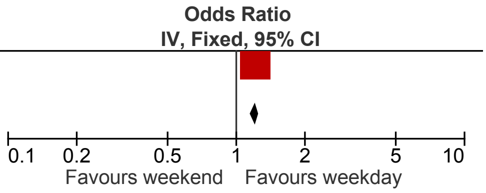


Figure 26: Weekend versus weekday admission for predicting 30 day mortality in all admissions

Study or Subgroup	log[Hazard Ratio]	SE	Weight	Hazard Ratio IV, Random, 95% CI
Bray 2014	-0.0408	0.0621	2.1%	0.96 [0.85, 1.08]
Freemantle 2012 (Sat vs. Wed)	0.1133	0.0092	22.4%	1.12 [1.10, 1.14]
Freemantle 2012 (Sun vs. Wed)	0.131	0.0045	26.7%	1.14 [1.13, 1.15]
Freemantle 2015 (Sat vs. Wed)	0.0953	0.0094	22.2%	1.10 [1.08, 1.12]
Freemantle 2015 (Sun vs. Wed)	0.1398	0.0045	26.7%	1.15 [1.14, 1.16]
Total (95% CI)			**100.0%**	**1.13 [1.10, 1.15]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 29.20$, df = 4 (P < 0.00001); $I^2 = 86\%$
Test for overall effect: Z = 12.46 (P < 0.00001)

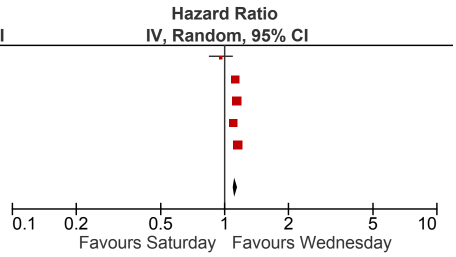


Figure 27: Weekend versus weekday admission for predicting avoidable adverse events (re-bleeding) in acute upper gastrointestinal bleeding admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Jairath 2011	-0.0943	0.1055	100.0%	0.91 [0.74, 1.12]
Total (95% CI)			**100.0%**	**0.91 [0.74, 1.12]**

Heterogeneity: Not applicable
Test for overall effect: Z = 0.89 (P = 0.37)

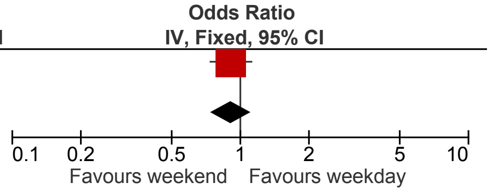


Figure 28: Weekend versus weekday admission for predicting avoidable adverse events (surgery/radiology) in acute upper gastrointestinal bleeding admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Jairath 2011	0.1222	0.1699	100.0%	1.13 [0.81, 1.58]
Total (95% CI)			**100.0%**	**1.13 [0.81, 1.58]**

Heterogeneity: Not applicable
Test for overall effect: Z = 0.72 (P = 0.47)

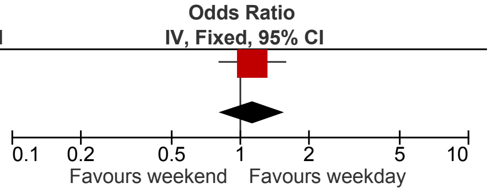


Figure 29: Weekend versus weekday admission for predicting avoidable adverse events (red cell transfusion) in acute upper gastrointestinal bleeding admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Jairath 2011	0.1133	0.0894	100.0%	1.12 [0.94, 1.33]
Total (95% CI)			**100.0%**	**1.12 [0.94, 1.33]**

Heterogeneity: Not applicable
Test for overall effect: Z = 1.27 (P = 0.21)

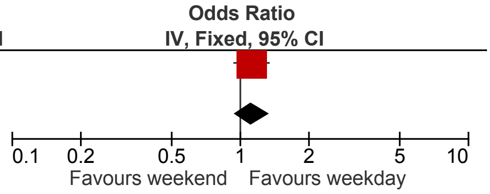


Figure 30: Weekend versus weekday admission for predicting avoidable adverse events (inadequate clinical response to NEWS) in all admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Kolic 2015	1.4231	0.3146	100.0%	4.15 [2.24, 7.69]
Total (95% CI)			**100.0%**	**4.15 [2.24, 7.69]**

Heterogeneity: Not applicable
Test for overall effect: Z = 4.52 (P < 0.00001)

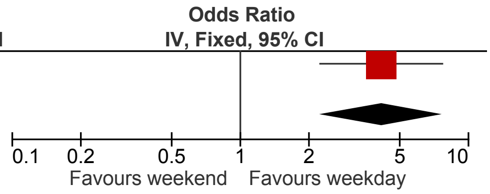


Figure 31: Weekend versus weekday admission for predicting avoidable adverse events (aspiration pneumonia) in stroke admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Palmer 2012	0.1044	0.0332	100.0%	1.11 [1.04, 1.18]
Total (95% CI)			**100.0%**	**1.11 [1.04, 1.18]**

Heterogeneity: Not applicable
Test for overall effect: Z = 3.14 (P = 0.002)

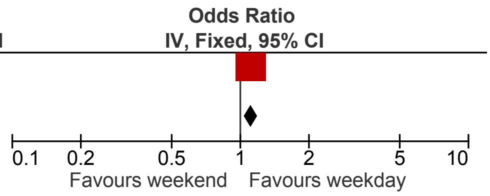
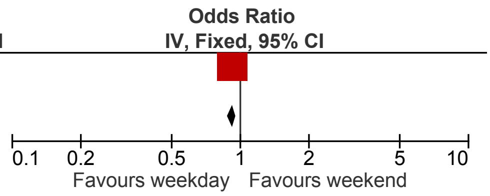


Figure 32: Weekend versus weekday admission for predicting length of stay (discharge to usual place of residence within 56 days) in stroke admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Palmer 2012	-0.0834	0.0227	100.0%	0.92 [0.88, 0.96]
Total (95% CI)			**100.0%**	**0.92 [0.88, 0.96]**

Heterogeneity: Not applicable
Test for overall effect: Z = 3.67 (P = 0.0002)



C.7.2 Out of hours versus in hours admission

Figure 33: Out of hours versus in hours admission for predicting hospital mortality in STEMI admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Noman 2012	0.2852	0.3061	100.0%	1.33 [0.73, 2.42]
Total (95% CI)			**100.0%**	**1.33 [0.73, 2.42]**

Heterogeneity: Not applicable
Test for overall effect: Z = 0.93 (P = 0.35)

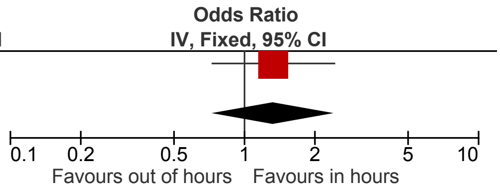


Figure 34: Out of hours versus in hours admission for predicting 30 day mortality in stroke admissions

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Campbell 2014	0.0677	0.0345	100.0%	1.07 [1.00, 1.14]
Total (95% CI)			**100.0%**	**1.07 [1.00, 1.14]**

Heterogeneity: Not applicable
Test for overall effect: Z = 1.96 (P = 0.05)

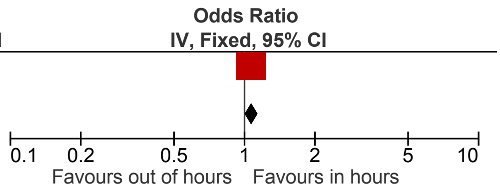


Figure 35: Out of hours versus in hours admission for predicting 30 day mortality in STEMI admissions

Study or Subgroup	log[Hazard Ratio]	SE	Weight	Hazard Ratio IV, Fixed, 95% CI
Iqbal 2015	0.0296	0.0745	100.0%	1.03 [0.89, 1.19]
Total (95% CI)			**100.0%**	**1.03 [0.89, 1.19]**

Heterogeneity: Not applicable
Test for overall effect: Z = 0.40 (P = 0.69)

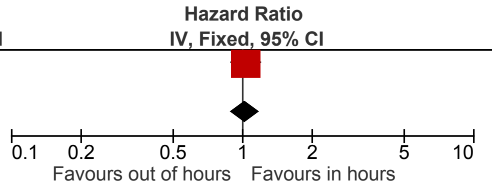


Figure 36: Out of hours versus in hours admission for predicting 30 day mortality in STEMI admissions

Study or Subgroup	log[Hazard Ratio]	SE	Weight	Hazard Ratio IV, Fixed, 95% CI
Rathod 2013	-0.3011	0.289	100.0%	0.74 [0.42, 1.30]
Total (95% CI)			**100.0%**	**0.74 [0.42, 1.30]**

Heterogeneity: Not applicable
Test for overall effect: Z = 1.04 (P = 0.30)

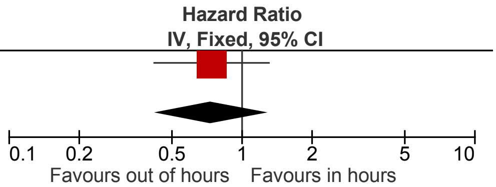


Figure 37: Out of hours versus in hours admission for predicting 30 day mortality in all patients undergoing PPCI

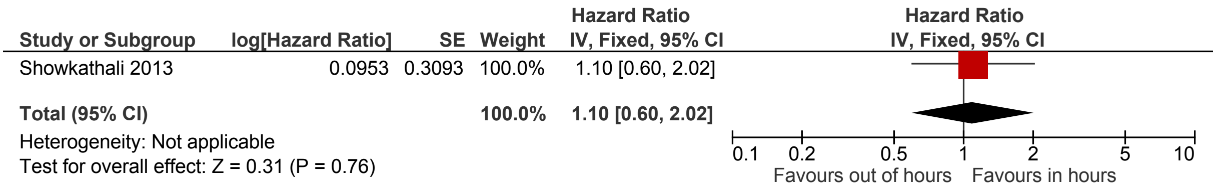


Figure 38: Out of hours versus in hours admission for predicting avoidable adverse events (bleeding complications) in STEMI admissions

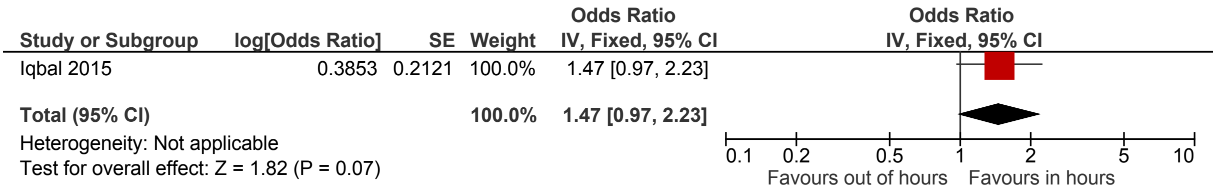
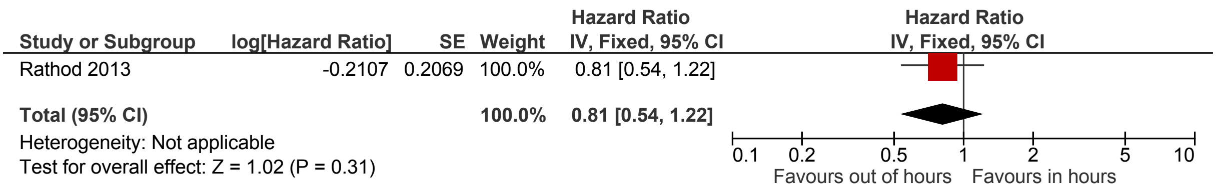


Figure 39: Out of hours versus in hours admission for predicting avoidable adverse events (major adverse cardiac events) in STEMI admissions



C.8 Evidence tables

Reference	Aldridge 2016{Aldridge, 2016 ALDRIDGE2016 /id}
Study type and analysis	Retrospective cohort study. Logistic regression.
Number of participants and characteristics	Total n not reported Weekend admissions n not reported; Weekday admissions n not reported Inclusion criteria: adult emergency hospital admissions for financial year 2013-2014 from the Health and Social Care Information Centre Exclusion criteria: patients younger than 16 years and primary maternity admissions
Prognostic variable	Weekend admission (admissions starting on a Saturday or Sunday by date) versus weekday admission (reference day Wednesday by date)
Confounders	Trust Sex Age Income deprivation component of the Index of Multiple Deprivation 2010 Diagnostic category as represented by the Clinical Classification Software code and a categorised index of comorbidity
Outcomes and effect sizes	Protocol outcome: Hospital mortality OR 1.10 (95% CI 1.08 to 1.12)
Comments	Risk of bias assessments: Low risk of bias

Reference	Anselmi 2016{Anselmi, 2016 ANSELMI2016 /id}
Study type and analysis	Retrospective cohort study. Logistic regression.
Number of participants and characteristics	Total n=3,027,946 Number in each risk factor category not reported Inclusion criteria: emergency admissions via A&E between 1 April 2013 and 28 February 2014 Exclusion criteria: all but first admission in cases of multiple admissions in the last 30 days of life, incomplete information on risk-adjustment variables

Reference	Anselmi 2016{Anselmi, 2016 ANSELMI2016 /id}
Prognostic variable	Weekend admission (7pm Friday night to 6.59am Monday morning) versus weekday admission (reference day Wednesday 7am to 6.59pm)
Confounders	Interaction between gender and age Ethnicity Primary diagnosis Comorbidities (30 binary indicators recorded in the secondary diagnosis fields, measured using Elixhauser conditions) Source of admission Deprivation in area of residence Admitting hospital Month of admission
Outcomes and effect sizes	Protocol outcome: Hospital mortality OR 1.02 (95% CI 1.0 to 1.03)
Comments	Risk of bias assessments: High risk of bias

1

Reference	Aylin 2010{Aylin, 2010 AYLIN2010 /id}
Study type and analysis	Retrospective cohort study. Logistic regression.
Number of participants and characteristics	Total n=4,317,866 Weekend admissions 999,062; Weekday admissions 3,318,804 Inclusion criteria: Emergency inpatient admissions extracted from finished consultant episodes of care for inpatients in all acute public hospitals in England from the NHS Wide Clearing Service with discharge dates between 1 April 2005 and 31 March 2006 Exclusion criteria: Day cases (day surgery) and admissions occurring in non-acute trusts
Prognostic variable	Weekend admission (admissions starting on a Saturday or Sunday by date) versus weekday admission
Confounders	Age Sex Deprivation quintile Charlson comorbidity score Case mix (clinical classification system diagnostic groups)
Outcomes and	Protocol outcome: Hospital mortality

Reference	Aylin 2010{Aylin, 2010 AYLIN2010 /id}
effect sizes	OR 1.10 (95% CI 1.08 to 1.12)
Comments	Risk of bias assessments: Low risk of bias

1

Reference	Bell 2013{Bell, 2013 BELL2013 /id}
Study type and analysis	Retrospective cohort study. Step-wise multivariate regression analysis.
Number of participants and characteristics	Total n=1.3 million Number in each risk factor category not reported Inclusion criteria: Adult (≥16 years) acute medical admissions derived from hospital episode statistics for patients admitted to participating hospitals as an acute medical emergency 1 April 2009 to 31 March 2010 Exclusion criteria: not reported
Prognostic variable	Weekend admission versus weekday admission
Confounders	Charlson comorbidity index Age Index of multiple deprivation
Outcomes and effect sizes	Protocol outcome: Hospital mortality OR 1.15 (95% CI 0.89 to 1.49)
Comments	Risk of bias assessments: Low risk of bias

2

Reference	Bray 2014{Bray, 2014 BRAY2014 /id}
Study type and analysis	Prospective cohort study. Cox proportional hazards model.
Number of participants and characteristics	Total n=32,388 Number in each risk factor category not reported Inclusion criteria: Adults (≥18 years) admitted with stroke from the Stroke Improvement National Audit Programme from 1 June 2011 to 1 December 2012 linked with English national register of deaths Exclusion criteria: Subarachnoid haemorrhage or transient ischaemic attack
Prognostic variable	Weekend admission versus weekday admission

Reference	Bray 2014{Bray, 2014 BRAY2014 /id}
Confounders	Age Stroke type Pre-stroke independence Hypoxia in the first 24 hours of admission Lowest level of consciousness in the first 24 hours Arm weakness Leg weakness Hemianopia Dysphasia No. of SU beds Presence of 24/7 on-site thrombolysis service Ratio of HCAs/nurses to beds Presence of 7-day physician ward rounds Management solely in an optimal setting in first 24 hrs Antiplatelet therapy if required Brain scan within 24 hours
Outcomes and effect sizes	Protocol outcome: 30 day mortality HR 0.96 (95% CI 0.85 to 1.08)
Comments	Risk of bias assessments: Low risk of bias

1

Reference	Bray 2016{Bray, 2016 BRAY2016 /id}
Study type and analysis	Prospective cohort study. Logistic regression.
Number of participants and characteristics	Total n=74,307 Weekend admissions 18,916; Weekday admissions 55,391 Inclusion criteria: adult patients (aged>16 years) admitted with acute stroke in England and Wales between 1 April 2013 and 31 March 2014 from the Sentinel Stroke National Audit Programme (SSNAP) Exclusion criteria: not reported
Prognostic variable	Weekend admission (Saturday to Sunday 08:00-19:59 h and Saturday to Sunday 20:00-07:59 hours) versus Weekday admission (Monday to

Reference	Bray 2016{Bray, 2016 BRAY2016 /id}
	Friday 08:00-19:59 h)
Confounders	Age Sex Place of stroke onset (in or out of hospital) Stroke type Vascular comorbidity (atrial fibrillation, heart failure, diabetes, previous stroke or transient ischemic attack, hypertension) Pre-stroke functional level(as measured by the modified Rankin Scale) Time from stroke onset to admission Stroke severity (National Institutes of Health Stroke Scale score or level of consciousness on admission) Hospital level random intercepts
Outcomes and effect sizes	Protocol outcome: 30 day mortality (30 day survival following admission) OR: 1.03 (95% CI 0.95 to 1.12) (weekend 8am-7.59pm) OR: 0.89 (95% CI 0.78 to 1.02) (weekend 8pm to 7.59am)
Comments	Risk of bias assessments: Low risk of bias

1

Reference	Brims 2011{Brims, 2011 BRIMS2011 /id}
Study type and analysis	Retrospective cohort study. Multivariate logistic regression.
Number of participants and characteristics	Total n=9,915 Weekend admissions 2,071; Weekday admissions 7,844 Inclusion criteria: Acute exacerbations of chronic obstructive pulmonary disease patients admitted to a large secondary care hospital in Portsmouth between January 1997 and December 2004 extracted from hospital databases Exclusion criteria: Admissions occurring within 21 days of a previous admission
Prognostic variable	Weekend admission (midnight Friday to midnight Sunday) versus Weekday admission (all other time)
Confounders	Age Sex Creatinine PaO2

Reference	Brims 2011{Brims, 2011 BRIMS2011 /id}
Outcomes and effect sizes	Protocol outcome: Hospital mortality OR: 1.75 (95% CI 0.75 to 4.09)
Comments	Risk of bias assessments: High risk of bias

Reference	Campbell 2014{Campbell, 2014 CAMPBELL2014A /id}
Study type and analysis	Prospective cohort study. Logistic regression.
Number of participants and characteristics	Total n= 45,726 Out of hours admissions 23,779; In hours admissions 21,947 Inclusion criteria: Stroke admissions to 130 hospitals in England (1 April 2010 - 31 January 2012) from the Stroke Improvement National Audit Programme Exclusion criteria: Subarachnoid haemorrhage
Prognostic variable	Weekend admission versus Weekday admission Out of hours admission (weekdays before 08:00 or after 18:00 or at any time on a weekend day or English public holiday) versus In hours admission (weekdays 08:00 to 18:00)
Confounders	Age Sex Worst level of consciousness in the first 24 hours (surrogate for severity) Stroke type Pre-stroke independence
Outcomes and effect sizes	Protocol outcome: 30 day mortality Weekend admission versus Weekday admission OR: 1.14 (95% CI 1.06 to 1.23) Out of hours admission versus In hours admission OR 1.07 (95% CI 1.00 to 1.14)
Comments	Risk of bias assessments: Low risk of bias

Reference	Deshmukh 2016{Deshmukh, 2016 DESHMUKH2016 /id}
Study type and analysis	Prospective cohort study. Cox proportional hazards model.

Reference	Deshmukh 2016{Deshmukh, 2016 DESHMUKH2016 /id}
Number of participants and characteristics	Total n=385 Weekend admissions 100; Weekday admissions 285 Inclusion criteria: patients admitted between January 2009 and December 2011 with acute subarachnoid haemorrhage from 12 hospitals in Northwest England Exclusion criteria: not reported
Prognostic variable	Weekend admission (16:00 Friday to 16:00 Sunday) versus Weekday admission
Confounders	Age Sex Severity of SAH (baseline World Federation of Neurosurgical Societies grade) Treatment modalities following admission Time from scan to admission and from admission to treatment
Outcomes and effect sizes	Protocol outcome: Hospital mortality HR: 2.10 (95% CI 1.13 to 3.90)
Comments	Risk of bias assessments: Low risk of bias

1

Reference	Freemantle 2012{Freemantle, 2012 FREEMANTLE2012 /id}
Study type and analysis	Retrospective cohort study. Contingency tables for each day, utilising a complementary log-log link function and binomial error.
Number of participants and characteristics	Total n=14,217,640 Number in each risk factor category not reported Inclusion criteria: All admissions to National Health Service Hospitals in England April 2009 - March 2010 using inpatient hospital trusts within England. Linked data on mortality from the Office of National Statistics Exclusion criteria: not reported
Prognostic variable	Saturday admission versus Wednesday admission Sunday admission versus Wednesday admission
Confounders	Age Sex Ethnicity

Reference	Freemantle 2012{Freemantle, 2012 FREEMANTLE2012 /id}
	Source of admission Diagnostic group No. of previous emergency admissions No. of previous complex admissions Charlson comorbidity index Social deprivation Hospital trust Day of the year (seasonality)
Outcomes and effect sizes	Protocol outcome: Hospital mortality Saturday versus Wednesday HR 1.11 (95% CI 1.09 to 1.13) Sunday versus Wednesday HR 1.16 (95% CI 1.14 to 1.18) Protocol outcome: 30 day mortality Saturday versus Wednesday HR 1.12 (95% CI 1.10 to 1.14) Sunday versus Wednesday HR 1.14 (95% CI 1.13 to 1.15)
Comments	Risk of bias assessments: Low risk of bias

1

Reference	Freemantle 2015{Freemantle, 2015 FREEMANTLE2015 /id}
Study type and analysis	Retrospective cohort study. Contingency tables for each day, utilising a complementary log-log link function and binomial error.
Number of participants and characteristics	Total n= 14 818 374 17% admitted on each weekday, 8% on Saturday and 6% on Sunday Inclusion criteria: All admissions to National Health Service Hospitals in England in 2013-2014 Exclusion criteria: At least one case mix item missing
Prognostic variable	Saturday admission versus Wednesday admission Sunday admission versus Wednesday admission
Confounders	Case mix (clinical classifications software category) Age Time of year

Reference	Freemantle 2015{Freemantle, 2015 FREEMANTLE2015 /id}
	Trust Deprivation No. of previous emergency admissions No. of previous complex admissions Admission source Admission urgency Sex Ethnicity Charlson comorbidity index
Outcomes and effect sizes	Protocol outcome: 30 day mortality Saturday versus Wednesday HR 1.10 (95% CI 1.08 to 1.12) Sunday versus Wednesday HR 1.15 (95% CI 1.14 to 1.16)
Comments	Risk of bias assessments: Low risk of bias

1

Reference	Iqbal 2015{Iqbal, 2015 IQBAL2015 /id}
Study type and analysis	Retrospective cohort study. Logistic regression and Cox proportional hazards regression models.
Number of participants and characteristics	Total n=11,466 Out of hours admission 7,496; In hours admission 3,970 Inclusion criteria: Consecutive STEMI patients treated with PPCI between 2005 and 2011 at 8 tertiary centres in London from local British Cardiac Intervention Society databases linked with Office of National Statistics data Exclusion criteria: not reported
Prognostic variable	Out of hours (weekdays 17:00 to 09:00 and any time on a Saturday or Sunday) versus In hours (09:00 to 17:00 Monday to Friday)
Confounders	Age Sex Diabetes GP2b-3a inhibitor use Previous MI Renal disease

Reference	**Iqbal 2015{Iqbal, 2015 IQBAL2015 /id}**
	Radial access Cardiogenic shock IABP use Intubation status LMS intervention LAD intervention Multi-vessel intervention Completeness of revascularisation
Outcomes and effect sizes	Protocol outcome: 30 day mortality HR: 1.03 (95% CI 0.89 to 1.19) Protocol outcome: Avoidable adverse events (in-hospital bleeding complications) OR: 1.47 (95% CI 0.97 to 2.23)
Comments	Risk of bias assessment: Low risk of bias

1

Reference	**Jairath 2011{Jairath, 2011 JAIRATH2011 /id}**
Study type and analysis	Prospective cohort study. Mixed effects logistic regression.
Number of participants and characteristics	Total n=6,749 Weekend admission 1,499; Weekday 5,250 Inclusion criteria: Adults (16 years and over) presenting with acute upper gastrointestinal bleeding from the 2007 UK National audit of AUGIB of all NHS hospitals accepting acute admissions in the UK (majority from England). 1 May - 30 June 2007 Exclusion criteria: not reported
Prognostic variable	Weekend admission versus Weekday admission
Confounders	Individual components of the Rockall score (age, presentation with shock, co-morbid illness) Presentation with hematemesis Presentation with melaena Haemoglobin and urea concentration on admission Use of aspirin Use of non-steroidal anti-inflammatory drugs

Reference	Jairath 2011{Jairath, 2011 JAIRATH2011 /id}
	Use of proton pump inhibitors Gender Variceal bleeding Peptic ulcer bleeding Availability of OOH rota enabling 24hr access to endoscopy Admission status (new patient versus inpatient)
Outcomes and effect sizes	Protocol outcome: Hospital mortality up to 30 days post-index AUGIB OR: 0.93 (95% CI 0.75 to 1.15) Protocol outcome: Avoidable adverse events (re-bleeding) OR: 0.91 (95% CI 0.74 to 1.12) Protocol outcome: Avoidable adverse events (surgery/radiology) OR: 1.13 (95% CI 0.81 to 1.58) Protocol outcome: Avoidable adverse events (red cell transfusion) OR: 1.12 (95% CI 0.94 to 1.33)
Comments	Risk of bias assessment: High risk of bias (for the outcome of hospital mortality); Low risk of bias (for the outcomes of avoidable adverse events) 43% of patients missing at least one baseline variable, but group missing data rates not reported. Multiple imputation used to account for uncertainty caused by missing data

Reference	Kolic 2015{Kolic, 2015 KOLIC2015 /id}
Study type and analysis	Prospective cohort study. Multivariate logistic regression.
Number of participants and characteristics	Total n=370 Weekend admission 75; Weekday admission 295 Inclusion criteria: All patients presenting to the acute medical unit at Queen Elizabeth Hospital in London 1 October 2013 - 15 October 2013 and 9 December 2013 - 22 December 2013 Exclusion criteria: Patients with <12hr inpatient stay
Prognostic variable	Weekend admission versus Weekday admission
Confounders	Age Severity (NEW score)

Reference	Kolic 2015{Kolic, 2015 KOLIC2015 /id}
Outcomes and effect sizes	Protocol outcome: Avoidable adverse events (inadequate clinical response to NEW score) OR: 4.15 (95% CI 2.24 to 7.69)
Comments	Risk of bias assessment: High risk of bias

1

Reference	Meacock 2016{Meacock, 2016 MEACOCK2016 /id}
Study type and analysis	Retrospective cohort study. Logistic regression.
Number of participants and characteristics	Total n=4,656,586 Number in each risk factor category not reported Inclusion criteria: emergency admissions to type 1 units (consultant-led, multispecialty 24-hour services with full resuscitation facilities and designated accommodation for reception of A&E patients) from 140 trusts in England from hospital episode statistics 1 April 2013 to 28 February 2014 Exclusion criteria: single speciality centres, minor injury units and walk-in centres
Prognostic variable	Weekend admission (Saturday and Sunday by date) versus Weekday admission (Monday to Friday by date)
Confounders	Age Sex Ethnicity Primary diagnosis (SHMI-grouped Clinical Classifications Software category) Elixhauser (comorbidity) conditions Admission method Admission source Deprivation quintile Month Admitting hospital
Outcomes and effect sizes	Protocol outcome: 30 day mortality OR: 1.05 (95% CI 1.04 to 1.07) (A&E admissions) OR: 1.21 (95% CI 1.16 to 1.26) (direct admissions)
Comments	Risk of bias assessment: Low risk of bias

1

Reference	Mohammed 2012{Mohammed, 2012 MOHAMMED2012B /id}
Study type and analysis	Retrospective cohort study. Logistic regression.
Number of participants and characteristics	Total n=3,105,249 Weekend admission 735,933; Weekday admission 2,369,316 Inclusion criteria: Emergency admissions April 2008 - March 2009 from all acute hospitals (n=328) in England via Hospital Episode Statistics Exclusion criteria: Admissions discharged alive with a zero day length of stay, age <16 years, maternity care, mental health care other than dementia
Prognostic variable	Weekend admission (by date) versus Weekday admission (by date)
Confounders	Age category Complex elderly Male Healthcare resource group with comorbidities/complications Interaction: Age and HRG with comorbidities/complications Admission quarter
Outcomes and effect sizes	Protocol outcome: Hospital mortality OR: 1.09 (95% CI 1.05 to 1.13)
Comments	Risk of bias assessment: Low risk of bias

2

Reference	Mohammed 2016{Mohammed, 2016 MOHAMMED2016 /id}
Study type and analysis	Retrospective cohort study. Linear and logistic regression.
Number of participants and characteristics	Total n=58,481 Weekend admission 14,198; Weekday admission 44,283 Inclusion criteria: all adult (≥16 years) emergency medical and elderly admissions, discharged between 1 January 2014 and 31 December 2014 from 3 general acute hospitals in England Exclusion criteria: records where NEWS was missing or recorded outside ±24 hours of the admission time
Prognostic variable	Weekend admission (Saturday and Sunday by date) versus Weekday admission (Monday to Friday by date)

Reference	Mohammed 2016{Mohammed, 2016 MOHAMMED2016 /id}
Confounders	Index NEWS Age Sex Calendar month
Outcomes and effect sizes	Protocol outcome: Hospital mortality RR: 0.98 (95% CI 0.91 to 1.06)
Comments	Risk of bias assessment: Low risk of bias

1

Reference	Noman 2012{Noman, 2012 NOMAN2012 /id}
Study type and analysis	Retrospective cohort study. Multiple logistic regression.
Number of participants and characteristics	Total n=2,571 Out of hours 1,535; Routine hours 1,036 Inclusion criteria: STEMI patients undergoing PPCI March 2008 - June 2011 at one tertiary cardiac centre in Newcastle from local coronary artery disease database (Dentrite) linked with Office of National Statistics data Exclusion criteria: not reported
Prognostic variable	Out of hours (weekdays between 18:00 and 08:00 and any time on a Saturday or Sunday) versus Routine hours (08:00 to 18:00 Monday to Friday)
Confounders	Age Sex Previous MI Diabetes mellitus Anterior MI site Baseline haemoglobin and creatinine Admission HR and SBP Cardiogenic shock Onset of symptoms to balloon time Presence of multi-vessel disease Thromolysis in MI flow 3 post-PPCI

Reference	Noman 2012{Noman, 2012 NOMAN2012 /id}
Outcomes and effect sizes	Protocol outcome: Hospital mortality OR: 1.33 (95% CI 0.73 to 2.42)
Comments	Risk of bias assessment: Low risk of bias

1

Reference	Palmer 2012{Palmer, 2012 PALMER2012 /id}
Study type and analysis	Retrospective cohort study. Multiple logistic regression.
Number of participants and characteristics	Total n=93,621 Weekend admission 23,297; Weekday admission 70,324 Inclusion criteria: Stroke admissions from Hospital Episode Statistics 1 April 2009 - 31 March 2010 Exclusion criteria: not reported
Prognostic variable	Weekend (midnight Friday to Midnight Sunday) versus Weekday
Confounders	Age Sex Socioeconomic deprivation quintile No. of previous admissions Comorbidities (Charlson index with weights derived from all admissions in England) Month of discharge Ethnic group Source of admission Stroke type
Outcomes and effect sizes	Protocol outcome: Hospital mortality OR: 1.18 (95% CI 1.12 to 1.24) Protocol outcome: Avoidable adverse events (aspiration pneumonia) OR: 1.11 (95% CI 1.04 to 1.18) Length of stay (discharge to usual place of residence within 56 days) OR 0.92 (95% CI 0.88 to 0.96)
Comments	Risk of bias assessment: High risk of bias (for outcome of mortality); Low risk of bias (for outcomes of avoidable adverse events); Low risk of bias

Reference	Palmer 2012{Palmer, 2012 PALMER2012 /id}
	(for outcome of length of stay)

1

Reference	Rathod 2013{Rathod, 2013 RATHOD2013A /id}
Study type and analysis	Retrospective cohort study. Logistic regression.
Number of participants and characteristics	Total n=3347 Out of hours admissions 2,048; In hours admissions 1,299 Inclusion criteria: Consecutive STEMI patients undergoing PPCI in one tertiary heart attack centre in London January 2004 - July 2012 from clinical database, electronic patient record and cardiac surgical database linked with Office of National Statistics data Exclusion criteria: not reported
Prognostic variable	Out of hours (17:01 to 07:59 Monday to Friday and 17:01 Friday to 07:59 Monday) versus In hours (08:00 to 17:00 Monday to Friday)
Confounders	Age Shock eGFR>60 (epidermal growth factor receptor) EF>40 Procedural success Multi-vessel disease
Outcomes and effect sizes	Protocol outcome: 30 day mortality HR: 0.74 (95% CI 0.42 to 1.30) Protocol outcome: Avoidable adverse events (death, recurrent MI, target vessel revascularisation) HR: 0.81 (95% CI 0.54 to 1.22)
Comments	Risk of bias assessment: Low risk of bias

2

Reference	Ruiz 2015{Ruiz, 2015 RUIZ2015 /id}
Study type and analysis	Retrospective cohort study. Multilevel mixed-effects logistic regression.
Number of participants	Total n=885,864 Number in each risk factor category not reported

Reference	Ruiz 2015{Ruiz, 2015 RUIZ2015 /id}
and characteristics	Inclusion criteria: Emergency admissions from an International dataset from the Global Comparators project consisting of hospital administrative data 2009-2012 (separate English data analysis) Exclusion criteria: day cases, non-acute care, records with missing/invalid entries, short-term emergency admissions not ending in death or transfer within 24 hours and with recorded major procedure
Prognostic variable	Saturday admission versus Monday admission; Sunday admission versus Monday admission
Confounders	Age Gender Transfers in from another hospital Year of admission Comorbidity score Diagnosis risk factor Bed numbers Rate of transfers to other hospitals
Outcomes and effect sizes	Protocol outcome: Hospital mortality Saturday admission versus Monday admission OR 1.07 (95% CI 1.03 to 1.11) Sunday admission versus Monday admission OR 1.08 (95% CI 1.04 to 1.12)
Comments	Risk of bias assessment: High risk of bias

Reference	Showkathali 2013{Showkathali, 2013 SHOWKATHALI2013 /id}
Study type and analysis	Retrospective cohort study. Binary logistic regression.
Number of participants and characteristics	Total n=1471 Out of hours admission: 866; In hours admission 605 Inclusion criteria: All patients undergoing PPCI September 2009 - November 2011 at one cardiothoracic centre in Essex from the cardiac service database system Exclusion criteria: not reported
Prognostic variable	Out of hours admission (18:00 to 08:00 weeknights and Saturday 08:00 to Monday 08:00) versus In hours admission (08:00 to 18:00 weekdays)
Confounders	Age >75 years Sex

Reference	Showkathali 2013{Showkathali, 2013 SHOWKATHALI2013 /id}
	Cardiogenic shock Diabetes Hypertension Previous MI Single vessel PCI Pre-procedure TIMI 0/1 flow Drug eluting stent use Door to balloon time
Outcomes and effect sizes	Protocol outcome: 30 day mortality HR: 1.10 (95% CI 0.60 to 2.02)
Comments	Risk of bias assessment: Low risk of bias

C.9 GRADE tables

Table 42: Clinical evidence profile: Weekend admission

Quality assessment							Effect	Quality
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Pooled effect (95% CI)	
Hospital mortality (assessed with: No. of patients dying in hospital)								
1	observational studies	no serious risk of bias	no serious inconsistency	no serious indirectness	no serious imprecision	none	Adjusted OR 1.10 (1.08 to 1.12)	⊕⊕⊕⊕ HIGH
Hospital mortality (assessed with: No. of patients dying in hospital)								
1	observational studies	no serious risk of bias	no serious inconsistency	no serious indirectness	no serious imprecision	none	Adjusted OR 1.10 (1.08 to 1.12)	⊕⊕⊕⊕ HIGH
Hospital mortality (assessed with: No. of patients dying in hospital)								
1	observational studies	no serious risk of bias	no serious inconsistency	no serious indirectness	serious[1]	none	Adjusted OR 1.15 (0.89 to 1.49)	⊕⊕⊕O MODERATE
Hospital mortality (follow-up 7 days; assessed with: No. of patients dying in hospital)								
1	observational studies	serious[2]	no serious inconsistency	no serious indirectness	serious[1]	none	Adjusted OR 1.75 (0.75 to 4.09)	⊕⊕OO LOW
Hospital mortality (assessed with: No. of patients dying in hospital)								
1	observational studies	no serious risk of bias	no serious inconsistency	no serious indirectness	no serious imprecision	none	Adjusted HR 2.10 (1.13 to 3.9)	⊕⊕⊕⊕ HIGH
Hospital mortality (assessed with: No. of patients dying in hospital)								
2	observational studies	no serious risk of bias	no serious inconsistency	no serious indirectness	no serious imprecision	none	Adjusted HR 1.14 (1.12 to 1.15) Range of HR: 1.11-1.16	⊕⊕⊕⊕ HIGH

Hospital mortality (follow-up 30 days; assessed with: No. of patients dying in hospital)								
1	observational studies	serious[2]	no serious inconsistency	serious[3]	serious[1]	none	Adjusted OR 0.93 (0.75 to 1.15)	⊕OOO VERY LOW
Hospital mortality (assessed with: No. of patients dying in hospital)								
1	observational studies	no serious risk of bias	no serious inconsistency	no serious indirectness	no serious imprecision	none	Adjusted OR 1.09 (1.05 to 1.13)	⊕⊕⊕⊕ HIGH
Hospital mortality (assessed with: No. of patients dying in hospital)								
1	observational studies	no serious risk of bias	no serious inconsistency	no serious indirectness	serious[1]	none	Adjusted RR 0.98 (0.91 to 1.06)	⊕⊕⊕O MODERATE
Hospital mortality (follow-up 7 days; assessed with: No. of patients dying in hospital)								
1	observational studies	serious[2]	no serious inconsistency	no serious indirectness	no serious imprecision	none	Adjusted OR 1.18 (1.12 to 1.24)	⊕⊕⊕O MODERATE
Hospital mortality (follow-up 30 days; assessed with: No. of patients dying in hospital)								
1	observational studies	serious[2]	no serious inconsistency	no serious indirectness	no serious imprecision	none	Adjusted OR 1.08 (1.05 to 1.1) Range of HR: 1.07-1.08	⊕⊕⊕O MODERATE
Hospital mortality (follow-up 30 days; assessed with: No. of patients dying in hospital)								
1	observational studies	serious[2]	no serious inconsistency	no serious indirectness	no serious imprecision	none	Adjusted OR 1.02 (1.00 to 1.03) Range of HR: 0.96-1.03	⊕⊕⊕O MODERATE
30 day survival (follow-up 30 days; assessed with: No. of patients surviving to 30 days post admission) (weekend 8am-7.59pm)								
1	observational studies	no serious risk of bias	no serious inconsistency	no serious indirectness	serious[1]	none	Adjusted OR 1.03 (0.95 to 1.12)	⊕⊕⊕O MODERATE
30 day survival (follow-up 30 days; assessed with: No. of patients surviving to 30 days post admission) (weekend 8pm-7.59am)								
1	observational studies	no serious risk of bias	no serious inconsistency	no serious indirectness	serious[1]	none	Adjusted OR 0.89 (0.78 to 1.02)	⊕⊕⊕O MODERATE

30 day mortality (follow-up 30 days; assessed with: No. of patients dying within 30 days of admission)								
1	observational studies	no serious risk of bias	no serious inconsistency	no serious indirectness	no serious imprecision	none	Adjusted OR 1.14 (1.06 to 1.23)	⊕⊕⊕⊕ HIGH
30 day mortality (follow-up 30 days; assessed with: No. of patients dying within 30 days of admission) (A&E admissions)								
1	observational studies	no serious risk of bias	no serious inconsistency	no serious indirectness	no serious imprecision	none	Adjusted OR 1.05 (1.04 to 1.07)	⊕⊕⊕⊕ HIGH
30 day mortality (follow-up 30 days; assessed with: No. of patients dying within 30 days of admission) (direct admissions)								
1	observational studies	no serious risk of bias	no serious inconsistency	no serious indirectness	no serious imprecision	none	Adjusted OR 1.21 (1.16 to 1.26)	⊕⊕⊕⊕ HIGH
30 day mortality (follow-up 30 days; assessed with: No. of patients dying within 30 days)								
3	observational studies	no serious risk of bias	serious[4]	no serious indirectness	no serious imprecision	none	Adjusted HR 1.13 (1.1 to 1.15) Range of HR: 0.96-1.15	⊕⊕⊕O MODERATE
Avoidable adverse events (assessed with: re-bleeding)								
1	observational studies	no serious risk of bias	no serious inconsistency	serious[3]	serious[1]	none	Adjusted OR 0.91 (0.74 to 1.12)	⊕⊕OO LOW
Avoidable adverse events (assessed with: surgery/radiology)								
1	observational studies	no serious risk of bias	no serious inconsistency	serious[3]	serious[1]	none	Adjusted OR 1.13 (0.81 to 1.58)	⊕⊕OO LOW
Avoidable adverse events (assessed with: red cell transfusion								
1	observational studies	no serious risk of bias	no serious inconsistency	serious[3]	serious[1]	none	Adjusted OR 1.12 (0.94 to 1.33)	⊕⊕OO LOW
Avoidable adverse events (follow-up 24 hours; assessed with: inadequate response to NEWS)								
1	observational studies	serious[2]	no serious inconsistency	no serious indirectness	no serious imprecision	prospective single centre study, unclear whether staff were aware of the study and outcome was appropriate	Adjusted OR 4.15 (2.24 to 7.69)	⊕⊕⊕O MODERATE

						clinical response - potential for performance bias		
Avoidable adverse events (assessed with: aspiration pneumonia)								
1	observational studies	no serious risk of bias	no serious inconsistency	no serious indirectness	no serious imprecision	none	Adjusted OR 1.11 (1.04 to 1.18)	⊕⊕⊕⊕ HIGH
Length of stay (follow-up 56 days; assessed with: discharge to usual place of residence within 56 days)								
1	observational studies	no serious risk of bias	no serious inconsistency	no serious indirectness	no serious imprecision	none	Adjusted OR 0.92 (0.88 to 0.96)	⊕⊕⊕⊕ HIGH

[1] Downgraded by 1 increment if the confidence interval crossed the null line.
[2] Downgraded by 1 increment if the majority of the evidence was at high risk of bias, and downgraded by 2 increments if the majority of the evidence was at very high risk of bias.
[3] Downgraded by 1 increment if the majority of evidence included an indirect population or 2 increments if the majority of the evidence included a very indirect population.
[4] Downgraded by 1 or 2 increments because heterogeneity, I2=50%, p=0.04, unexplained by subgroup analysis.

Table 43: Clinical evidence profile: Out of hours admission

Quality assessment							Effect	Quality
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Pooled effect (95% CI)	
Hospital mortality (assessed with: no. of patients dying in hospital)								
1	observational studies	no serious risk of bias	no serious inconsistency	serious[1]	serious[2]	none	OR 1.33 (0.73 to 2.42)	⊕⊕OO LOW
1	observational studies	no serious risk of bias	no serious inconsistency	no serious indirectness	no serious imprecision	none	OR 1.07 (1.00 to 1.14)	⊕⊕⊕⊕ HIGH
30 day mortality (follow-up 30 days; assessed with: no. of patients dying within 30 days)								
1	observational studies	no serious risk of bias	no serious inconsistency	serious[1]	serious[2]	none	HR 1.03 (0.89 to 1.19)	⊕⊕OO LOW
30 day mortality (follow-up 30 days; assessed with: no. of patients dying within 30 days)								

1	observational studies	no serious risk of bias	no serious inconsistency	serious[1]	serious[2]	none	HR 0.74 (0.42 to 1.3)	⊕⊕OO LOW
30 day mortality (follow-up 30 days; assessed with: no. of patients dying within 30 days)								
1	observational studies	no serious risk of bias	no serious inconsistency	serious[1]	serious[2]	none	HR 1.10 (0.6 to 2.02)	⊕⊕OO LOW
Avoidable adverse events (assessed with: bleeding complications)								
1	observational studies	no serious risk of bias	no serious inconsistency	serious[1]	serious[2]	none	OR 1.47 (0.97 to 2.23)	⊕⊕OO LOW
Avoidable adverse events (follow-up 30 days; assessed with: MACE (death, recurrent MI, target vessel vascularisation))								
1	observational studies	no serious risk of bias	no serious inconsistency	serious[1]	serious[2]	none	HR 0.81 (0.54 to 1.22)	⊕⊕OO LOW

[1] Downgraded by 1 increment if the majority of evidence included an indirect population or 2 increments if the majority of the evidence included a very indirect population.
[2] Downgraded by 1 increment if the confidence interval crossed the null line.

C.10 Excluded studies

Table 44: Studies excluded from the clinical review

Reference	Reason for exclusion
Arabi 2006{Arabi, 2006 ARABI2006 /id}	Outside of England
Barer 2016{Barer, 2016 BARER2016 /id}	No adjustment for age
Barnett 2008{Barnett, 2008 BARNETT2008 /id}	Inappropriate exposure (odds of being discharged alive by day of the week)
Becker 2008{Becker, 2008 BECKER2008 /id}	Report; no outcomes
Beecher 2015{Beecher, 2015 BEECHER2015 /id}	Outside of England
Cavallazzi 2010{Cavallazzi, 2010 CAVALLAZZI2010 /id}	Systematic review (not relevant or unclear PICO)
Clark 2007{Clark, 2007 CLARK2007 /id}	Outside of England
Clark 2012{Clark, 2012 CLARK2012 /id}	Outside of England
Conway 2016{Conway, 2016 CONWAY2016 /id}	Outside England (Ireland)
Conway 2016A{Conway, 2016 CONWAY2016A /id}	Outside England (Ireland)
Cubeddu 2009{Cubeddu, 2009 CUBEDDU2009 /id}	Outside of England
De Cordova 2012{de Cordova, 2012 DECORDOVA2012 /id}	Systematic review (not relevant or unclear PICO)
Degenhardt 2011{Degenhardt, 2011 DEGENHARDT2011 /id}	Report; no outcomes
Geraci 2005{Geraci, 2005 GERACI2005 /id}	Outside of England
Goldacre 2013{Goldacre, 2013 GOLDACRE2013 /id}	No adjustment for severity of illness
Gordon 2005{Gordon, 2005 GORDON2005 /id}	Outside of England
Gralnek 2014{Gralnek, 2014 GRALNEK2014 /id}	Editorial (US study)
Haas 2012{Haas, 2012 HAAS2012 /id}	Outside of England
Hamilton 2010{Hamilton, 2010 HAMILTON2010 /id}	Outside of England; inappropriate study design (nurse survey)
Hoehn 2016{Hoehn, 2017 HOEHN2016 /id}	Outside England (USA)
Hohloch 2014{Hohloch, 2014 HOHLOCH2014 /id}	Outside of England
Horwich 2009{Horwich, 2009	Outside of England

Reference	Reason for exclusion
HORWICH2009 /id}	
Hsu 2015{Hsu, 2015 HSU2015 /id}	Outside of England
Jansen 2013{Jansen, 2013 JANSEN2013 /id}	Outside of England
Jauss 2009{Jauss, 2009 JAU2009 /id}	Outside of England
Jiang 2011{Jiang, 2011 JIANG2011 /id}	Outside of England
Karthikesalingam 2014{Karthikesalingam, 2014 KARTH2014 /id}	Incorrect population (ruptured abdominal aortic aneurysm patients)
Keatinge 2005{Keatinge, 2005 KEATINGE2005 /id}	Study does not adjust for any confounders
Kruth 2008{Kruth, 2008 KRUTH2008 /id}	Outside of England
Lecumberri 2011{Lecumberri, 2011 LECUMBERRI2011 /id}	Outside of England
Leong 2015{Leong, 2015 LEONG2015 /id}	Observational intervention study (before and after 7-day services); no adjustment for key confounders
Lorenzano 2014{Lorenzano, 2014 LORENZANO2014 /id}	Outside of England (multinational analysis)
Magid 2005{Magid, 2005 MAGID2005 /id}	Outside of England
Maggs 2010{Maggs, 2010 MAGGS2010 /id}	No adjustment for severity of illness
McCallum 2016{McCallum, 2016 MCCALLUM2016 /id}	Not review population (emergency surgical patients)
McLean 2016{McLean, 2016 MCLEAN2016 /id}	Not review population (emergency surgical patients)
Meacock 2015{Meacock, 2015 MEACOCK2015 /id}	Inappropriate study design (uses ORs reported by Freemantle to calculate potential QALYs gained with a 7-day service); no relevant outcomes
Mohammed 2016A{Mohammed, 2016 MOHAMMED2016A /id}	Only risk-risk cases included; no adjustment for key confounders
Morton 2015{Morton, 2015 MORTON2015 /id}	No relevant outcomes
Mpotsaris 2015{Mpotsaris, 2015 MPOTSARIS2015 /id}	Outside of England
Murphy 2015{Murphy, 2015 MURPHY2015 /id}	Commentary
Nakajima 2015{Nakajima, 2015 NAKAJIMA2015 /id}	Outside of England
Neuraz 2015{Neuraz, 2015 NEURAZ2015 /id}	Outside of England
Ortolani 2007{Ortolani, 2007 ORTOLANI2007 /id}	Outside of England
Ozdemir 2015{Ozdemir, 2015 OZDEMIR2015 /id}	No protocol outcomes reported (90 day mortality)

Reference	Reason for exclusion
Ozdemir 2016{Ozdemir, 2016 OZDEMIR2016 /id}	Not review population (emergency surgical patients)
Park 2013{Park, 2013 PARK2013 /id}	Outside of England
Patel 2014A{Patel, 2014 PATEL2014A /id}	Observational intervention study (before and after a handover intervention); analysis of weekend in-hospital mortality; no adjustment for key confounders
Peberdy 2008{Peberdy, 2008 PEBERDY2008 /id}	Outside of England
Qureshi 2012{Qureshi, 2012 QURESHI2012 /id}	Outside of England
Raghavan 2014{Raghavan, 2014 RAGHAVAN2014 /id}	Inappropriate study design (before and after; intervention was introduction of seven-day consultant working)
Rudd 2007{Rudd, 2007 RUDD2007 /id}	No relevant outcomes
Sato 2015{Sato, 2015 SATO2015 /id}	Outside of England (multinational analysis)
Shokouhi 2013{Shokouhi, 2013 SHOKOUHI2013 /id}	No comparator (evaluation of a weekend service)
Sorita 2014{Sorita, 2014 SORITA2014 /id}	Systematic review (not relevant or unclear PICO)
Sorita 2014A{Sorita, 2014 SORITA2014A /id}	Outside of England
Southey 2014{Southey, 2014 SOUTHEY2014 /id}	Inappropriate study design (before and after; intervention was nurse weekend cover)
Soyiri 2011{Soyiri, 2011 SOYIRI2011 /id}	Inappropriate comparison (Sunday used as the reference day)
Triggle 2014{Triggle, 2014 TRIGGLE2014 /id}	Article; no outcomes reported

Appendix D: Medical Outliers review

D.1 Review question: What is the impact on clinical outcomes for medical outliers admitted to hospital with an acute medical emergency?

For full details see review protocol (D.5).

Table 45: Characteristics of review question

Population	Adults and young people (16 years and over) with a suspected or confirmed AME.
Prognostic variable under consideration	Outliers/boarded patients Inter-speciality boarding (for example, medical patient in to surgical ward). Sub-speciality boarding (for example, respiratory patient in to cardiology ward).
Confounding factors	• Age • Case-mix • Co-morbidities
Outcome(s)	Patient outcomes: • Mortality (critical) • Length of stay (critical) • Quality of life (critical) • Cancelled surgery (important) • Serious adverse events (for example, medication or prescribing errors, emergency calls) (critical) • Patient and/or carer satisfaction (critical) • A&E 4 hour waiting time (important)
Study design	• Prospective and retrospective cohort studies

D.2 Evidence

Five studies were included in the review{Alameda, 2009 ALAMEDA2009 /id;Perimal-Lewis, 2013 PERIMALLEWIS2013 /id;Santamaria, 2014 SANTAMARIA2014 /id;Serafini, 2015 SERAFINI2015 /id;Stowell, 2013 STOWELL2013 /id}; these are summarised in Table 46 below. Evidence from these studies is summarised in the clinical evidence summary below (Table 47). See also the study selection flow chart (D.6), forest plots (D.7), study evidence tables (D.8), GRADE tables (D.9) and excluded studies list (D.10).

Summary of included studies

Table 46: Summary of studies included in the review

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Limitations
Alameda 2009{Alameda, 2009 ALAMEDA 2009 /id}	n=243 patients with congestive heart failure and cardiac arrhythmia	Multiple regression for length of stay, logistic regression for other	Medical outlier (admitted to a ward different from the internal medicine ward; outliers	Age Sex Diabetes mellitus Hypertension Coronary heart disease	Mortality Length of stay Serious adverse	No adjustment for comorbidity; all patients had complication

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Limitations
Retrospective cohort study	with major complications or comorbidity discharged from the Department of Internal Medicine, 1 hospital, Spain	primary outcomes	transferred to the internal medicine ward were included) Versus. No medical outlier (admitted to the internal medicine ward)	Cerebrovascular disease Chronic obstructive pulmonary disease Cancer Cognitive impairment before admission Serum creatinine Haemoglobin PaO2 Serum albumin at admission Nursing home resident Previous hospital stay within 12 months Weekend/bank holiday admission	events (Intra-hospital morbidity - infection, haemorrhage)	/comorbidity
Perimal-Lewis 2013{Perimal-Lewis, 2013 PERIMALLEWIS2013 /id} Retrospective cohort study	n=19,923 patients admitted and discharged by the general medicine service (university hospital, Australia)	Poisson regression	Outlier (not treated within a 'home ward' for the general medical unit allocated to care for the patient) Versus. Inliers (treated within a 'home ward' for the general medical unit allocated to care for the patient; patients under the care of GM but housed in the intensive care, high dependency or coronary care units were included as	Age Charlson index Gender Length of time spent waiting for a bed in ED	Mortality (hospital mortality) Length of stay (statistic not reported)	No adjustment for case mix

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Limitations
			inliers)			
Santamaria 2014{Santamaria, 2014 SANTAMARIA2014 /id} Prospective cohort study	n=58,158 patients admitted (university tertiary hospital, Australia)	Zero-inflated negative binominal regression	Outlier (any time spent outside the home ward) Versus. Non-outlier (no time spent outside the home ward; time spent in an intensive care or coronary unit was included as non-outlier)	Age Predicted mortality (calculated using diagnostic codes and Charlson Comorbidity index) Interhospital transfer Same-day admission Neurosurgery unit Cardiothoracic surgery unit General surgery unit Nephrology unit General medicine unit	Serious adverse events (emergency calls)	Population indirectness – all patients including surgical
Serafini 2015{Serafini, 2015 SERAFINI2015 /id} Retrospective cohort study	n=3828 patients admitted to internal medicine or geriatrics (one hospital, Italy)	Not reported	Outlier (patients admitted in beds outside of medicine or geriatrics) Versus. Non-outlier (in-ward patients)	Total number of admissions Gender Age Degree of dependence Length of stay Outlying location (medical or surgical) Diagnosis related group at discharge Readmission within 90 days	Mortality (hospital mortality)	No adjustment for comorbidity
Stowell 2013{Stowell, 2013 STOWELL2013 /id} Matched pair cluster study	n=483 patients outlying in one ward but under the responsibility of another ward matched	Student, chi-square, Fisher exact test and Mann and Whitney test	Outlier (patients outlying in one ward but under the responsibility of another ward) Versus. Non-outlying patients	Matched for age, sex and reason for admission	Mortality (90 day) Length of stay (median and range) Serious adverse	No consideration of comorbidity Population indirectness – all patients including surgical

Study	Population	Analysis	Prognostic variable	Confounders	Outcomes	Limitations
	with non-outlying patients consecutively included among all patients hospitalised during the study period				events (transfer to intensive care) ED 4 hour transit time (median and range)	

Table 47: Clinical evidence summary: outliers (adjusted for all key confounders)

Risk factor and outcome (population)	Number of studies	Effect (95% CI)	Imprecision	GRADE Quality
Outlier versus non-outlier for predicting serious adverse events (emergency calls) (all admitted patients)[a]	1	Adjusted RR: 1.53 (1.31 to 1.77)	No serious imprecision	MODERATE

(a) Methods: multivariable analysis, including key covariates used in analysis to assess if outlier status is an independent risk factor. Key covariates included: age, case-mix, co-morbidities.

Table 48: Clinical evidence summary: outliers

Risk factor and outcome (population)	Number of studies	Effect (95% CI)	Imprecision	GRADE Quality
Outlier versus non-outlier for predicting mortality (hospital mortality) (congestive heart failure and cardiac arrhythmia patients)[a]	1	Adjusted RR: 0.80 (0.40 to 1.60)	Serious[b]	LOW
Outlier versus non-outlier for predicting mortality (hospital mortality) (general medical patients)[a]	1	Adjusted RR: 1.41 (1.16 to 1.71)	No serious imprecision	MODERATE
Outlier versus non-outlier for predicting mortality (hospital mortality) (medical and geriatric patients)[a]	1	Adjusted HR: 1.8 (1.28 to 2.53)	No serious imprecision	MODERATE
Outlier versus non-outlier for predicting mortality (90 day mortality) (all admitted patients)[a]	1	RR: 0.75 (0.51 to 1.11)	Serious[b]	VERY LOW
Outlier versus non-outlier for predicting length of stay (days) (congestive heart failure and cardiac arrhythmia patients)[a]	1	Adjusted mean difference: 2.60 (0.60 to 4.60)	No serious imprecision	MODERATE
Outlier versus non-outlier for predicting serious adverse events (infection) (congestive heart failure and cardiac arrhythmia patients)[a]	1	Adjusted RR: 1.50 (0.80 to 2.81)	Serious[b]	LOW
Outlier versus non-outlier for predicting serious adverse events (haemorrhage) (congestive heart failure and cardiac arrhythmia patients)[a]	1	Adjusted RR: 1.20 (0.40 to 3.60)	Serious[b]	LOW
Outlier versus non-outlier for predicting serious adverse events (transfer to ICU) (all admitted patients)[a]	1	RR: 1.05 (0.5 to 2.18)	Serious[b]	VERY LOW

(a) Methods: multivariable analysis, including key covariates used in analysis to assess if outlier status is an independent risk factor. Key covariates included: age, case-mix, co-morbidities.
(b) 95% CI around the median crosses null line.

Narrative findings

Outlier versus non-outlier for predicting length of stay (days) (all admitted patients): median day (IC) outlying 8 (4-15); non-outlying 7 (4-13).

Outlier versus non-outlier for predicting ED length of stay (hours) (all admitted patients): median hour (25%-75%) outlying 9 (6-14); non-outlying 10 (6-16).

D.3 Evidence statements

Clinical

- Five studies comprising 82,635 people evaluated the clinical outcomes of medical outliers in adults and young people admitted to hospital with a suspected or confirmed AME. The evidence suggested that being an outlier increased risk of length of stay and adverse events. The evidence for mortality was inconsistent across 4 studies. Two studies suggesting a benefit from being an outlier in terms of mortality were either in a specific population (congestive heart failure and cardiac arrhythmia patients) which may not be generalisable or graded very low quality. The other 2 studies suggested being an outlier had an increase in mortality. These studies were more generalisable populations and graded moderate quality.

D.4 Subgroup comments

Question	Comments
Which outcomes are affected by weekend admission?	• Mortality. • Severe adverse events (emergency calls to medical team only). • Length of stay.
Which studies best show the effect and could inform the model?	**Mortality** Alameda 2009 is in a very specific population (congestive heart failure and cardiac arrhythmia patients), which may not be generalisable to other patient groups and also is of low quality and should therefore not be used. Evidence from Stowell 2013 is of very low quality. This study compared control cases with outlying patients using a matched pair design based on age, sex and reason for admission. However, it is likely that patients who are less severely ill are admitted to outlying wards and are therefore less likely to die, so the study may have underestimated the effect of outlying status on mortality. Perimal-Lewis 2013 and Serafini 2015 were the best quality studies (moderate) and were in a more generalisable population. The effect sizes seem realistic and had no serious imprecision. These studies should be used to inform the economic model. These studies showed a modest but expected increase in mortality for outliers. This could be an underestimate though due to the nature of the observational studies where the more acutely ill patients are less likely to be outliers. **Severe adverse events** Santamaria 2014 was the only study to adjust for all 3 confounders and was moderate quality and no serious imprecision around the point estimate. Serious adverse events were defined as call outs for the emergency medical team. It is likely that medical emergency teams are variable in staff makeup both nationally and internationally. Therefore the evidence may not be generalisable to the UK. Evidence from Stowell 2013 is of very low quality. This study compared control cases with outlying patients using a matched pair design based on age, sex and reason for admission. However, it is likely that patients who are less severely ill are admitted to outlying wards and are therefore less likely to require transfer to the ICU, so the study (which showed no effect of outlier status) may have underestimated the effect of outlying status on serious adverse events defined as transfer to ICU. Alameda 2009 is in a very specific population (congestive heart failure and cardiac arrhythmia patients), which may not be generalisable to other patient groups and also is of low quality with serious imprecision around the point estimate and should therefore not be used. The subgroup considered that overall, there appears to be an increase in serious adverse event rate in outlying patients. **Length of stay** Alameda 2009 is in a very specific population (congestive heart failure and cardiac arrhythmia patients), which may not be generalisable to other patient groups. However, the study was the only one to report mean differences in length of stay and provided moderate quality evidence. The evidence suggested that outlying patients have a longer length of stay, which the subgroup felt fitted with clinical experience. However, the results of this study may not generalisable to the entire AME population, as these patients may require specialised tests prior to discharge, which are more difficult to arrange from an outlying ward. The subgroup expected an increase in length of stay for outliers as these patients are seen less and it will take longer for them to be discharged, however this increase is

Question	Comments
	difficult to quantify from the evidence.
Other considerations	• The analysis is likely to underestimate the true financial cost of outlying. • Cancelled elective surgeries are likely to occur if a medical patient is outlying on a surgical ward. • There will be additional time constraints on ward rounds for an outlying patient. Staff will need to cover more patients in their ward rounds with outlying patients having a greater effect on this. It is more time consuming to undertake a ward round on a different ward to your own and is not just an additional patients worth of time. • It is likely an outlying patient will be seen at the end of a ward round which may cause problems. The timing of the ward round may not fit in with routine and could occur at detrimental times to efficiency for example, at a nurse handover time slot • Geographical constraints of being on a different ward could mean that discharge time is affected for example, a patient may not be assessed to be ready for discharge until late in the day due to staffing locations which could lead to an extra overnight stay • Boarding patients is seldom a deliberate process. The existence of outliers is an indicator of high occupancy that could lead to detrimental effects on patients and flow due to prioritisation of tasks, especially for outlying patients. • Opportunity cost of emergency medical team – impact on hospital staffing and other patients who need their help. • Outliers may start on the correct ward and then move out to their 'outlying' ward rather than the perceived traditional assumption that outlying is at the start of a patients stay. • At what point in their pathway a patient becomes an outlier may affect their outcomes for example, if they are moved from their 'home' ward to a ward where they are defined as an outlier rather than admission straight to an outlying ward, they may have a lower acuity. • Transferring elderly patients to different wards can cause them to become confused, especially if they experience multiple moves. This can make their condition worse and lead to a longer length of stay, creating a vicious cycle. • The committee agreed that outlying is inevitable in most hospitals and is associated with worse patient outcomes. The cost of preventing outliers would be great, therefore practical steps should be taken to mitigate the risks and ensure that care for outlying patients is not compromised. For example, accepting temporal changes in occupancy parameters and making appropriate allowances. Patients perspective: For patients, being on a ward that doesn't specialise in their condition is associated with feelings of anxiety and fear that they will not receive the best treatment or that they are being forgotten by the appropriate specialists. In some circumstances, patients can feel embarrassed if they have a different condition from other patients on the ward as the other patients may not understand their symptoms. It may also be emotionally insensitive to board certain patients in certain wards. Patients would like there to be recommendations in place to aid outlying patient care.

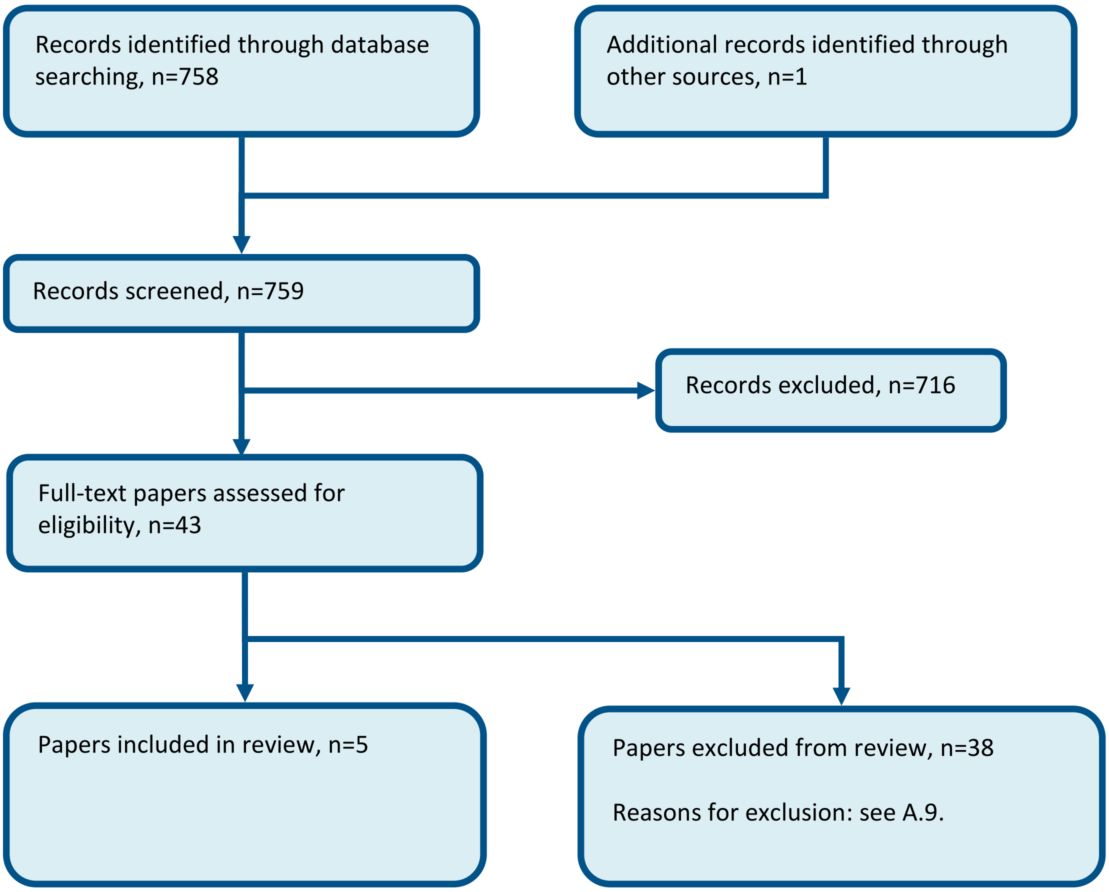
D.5 Review protocol

Table 49: Review protocol: outliers

Component	Description
Review question	What is the impact on clinical outcomes for medical outliers admitted to hospital with an acute medical emergency?
Objectives	To estimate the prognostic value of medical outlier status on clinical outcomes.
Population	Adults and young people (16 years and over) with a suspected or confirmed AME
Presence or absence of prognostic variable	Outliers/boarded patients; Inter-speciality boarding (for example, medical patient in to surgical ward); Sub-speciality boarding (for example, respiratory patient in to cardiology ward). Versus Non-outliers/non-boarded patients: patients treated within their speciality (that is, no boarding present).
Outcome(s)	Patient outcomes: • Mortality (critical) • Length of stay (critical) • Quality of life (critical) • Cancelled surgery (important) • Serious adverse events (e.g. medication or prescribing errors, emergency calls) (critical) • Patient and/or carer satisfaction (critical) • A&E 4 hour waiting time (important)
Study design	Prospective and retrospective cohort studies
Exclusions	Non OECD countries
How the information will be searched	The databases to be searched are: Medline, Embase, the Cochrane Library Language: English Dates: 1990
Key confounders	Minimum set of confounders that should be adjusted for (will vary per outcome) • Age • Case-mix • Co-morbidities
The review strategy	Meta-analysis where appropriate will be conducted. Studies in the following subgroup populations will be included in subgroup analysis: • Frail elderly • Type of boarding – inter-speciality boarding and sub-speciality boarding • UK versus non-UK studies

D.6 Study selection

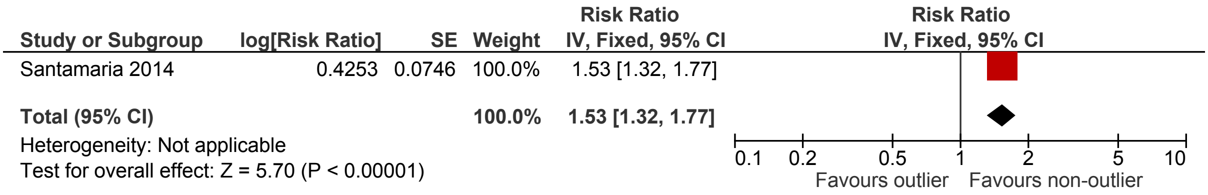
Figure 40: Flow chart of clinical study selection for the review of outliers



D.7 Forest plots

D.7.1 Outlier versus non-outlier (adjusted for all key confounders)

Figure 41: Serious adverse events (emergency calls)



D.7.2 Outlier versus non-outlier

Figure 42: Mortality (hospital mortality)

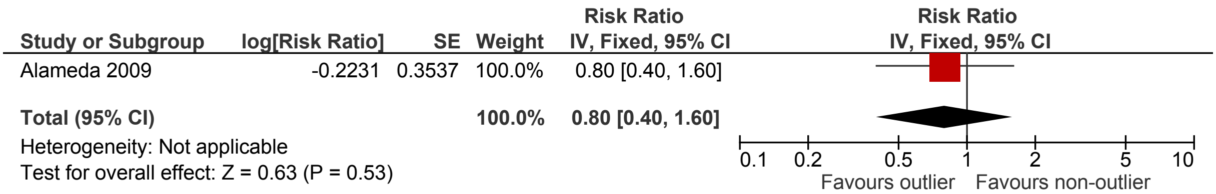


Figure 43: Mortality (hospital mortality)

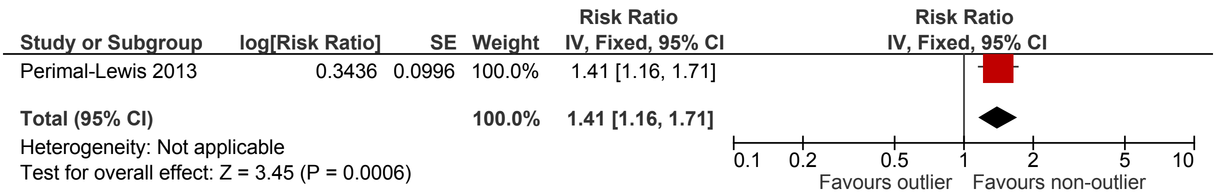


Figure 44: Mortality (hospital mortality)

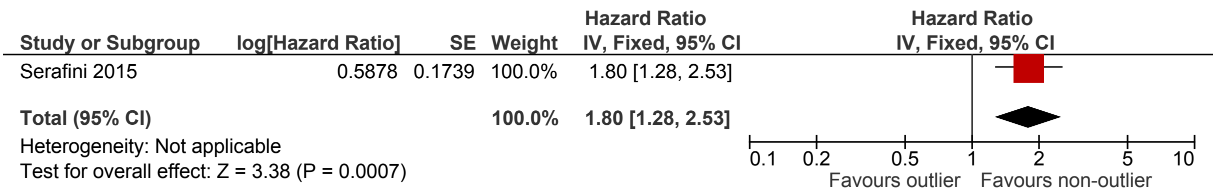


Figure 45: Mortality (90 day)

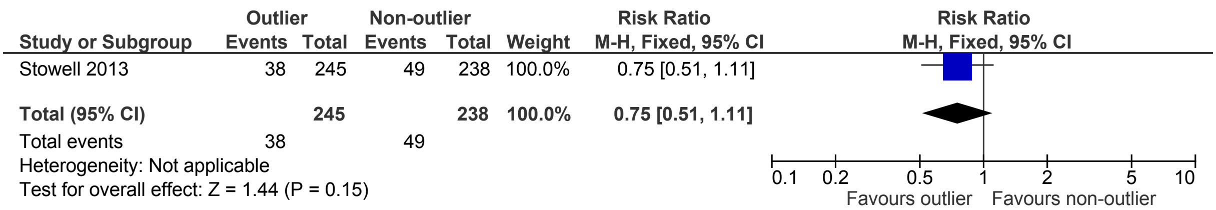


Figure 46: Length of stay

Study or Subgroup	Mean Difference	SE	Weight	Mean Difference IV, Fixed, 95% CI
Alameda 2009	2.6	1.0204	100.0%	2.60 [0.60, 4.60]
Total (95% CI)			**100.0%**	**2.60 [0.60, 4.60]**

Heterogeneity: Not applicable
Test for overall effect: Z = 2.55 (P = 0.01)

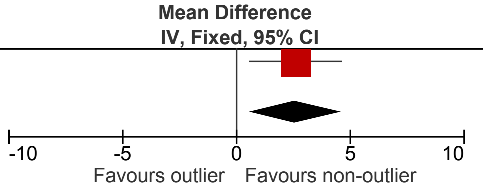


Figure 47: Serious adverse events (infection)

Study or Subgroup	log[Risk Ratio]	SE	Weight	Risk Ratio IV, Fixed, 95% CI
Alameda 2009	0.4055	0.3207	100.0%	1.50 [0.80, 2.81]
Total (95% CI)			**100.0%**	**1.50 [0.80, 2.81]**

Heterogeneity: Not applicable
Test for overall effect: Z = 1.26 (P = 0.21)

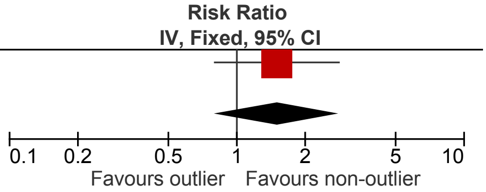


Figure 48: Serious adverse events (haemorrhage)

Study or Subgroup	log[Risk Ratio]	SE	Weight	Risk Ratio IV, Fixed, 95% CI
Alameda 2009	0.1823	0.5605	100.0%	1.20 [0.40, 3.60]
Total (95% CI)			**100.0%**	**1.20 [0.40, 3.60]**

Heterogeneity: Not applicable
Test for overall effect: Z = 0.33 (P = 0.74)

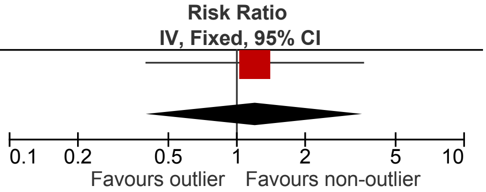
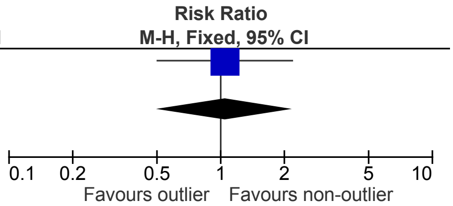


Figure 49: Serious adverse events (transfer to ICU)

	Outlier		Non-outlier			Risk Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Fixed, 95% CI
Stowell 2013	14	245	13	238	100.0%	1.05 [0.50, 2.18]
Total (95% CI)		**245**		**238**	**100.0%**	**1.05 [0.50, 2.18]**
Total events	14		13			

Heterogeneity: Not applicable
Test for overall effect: Z = 0.12 (P = 0.90)



D.8 Evidence tables

Reference	Alameda{Alameda, 2009 ALAMEDA2009 /id}
Study type and analysis	Retrospective cohort study. Multiple regression for length of stay; logistic regression for mortality and serious adverse events.
Number of participants and characteristics	n=243 Outliers n=109 Non outliers n=134 Inclusion criteria: patients discharged from the Department of Internal Medicine with the All Patients Diagnosis-Related Group 544 (congestive heart failure and cardiac arrhythmia with major complications or comorbidity). Exclusion criteria: patients admitted to departments other than Internal Medicine or the Intensive Care Unit. Data from the minimum basic data set, discharge summaries and test records from La Princesa University Hospital, Madrid, Spain, 2006.
Prognostic variable	Medical outlier (admitted to a ward different from the internal medicine ward; outliers transferred to the internal medicine ward were included) Versus. No medical outlier (admitted to the internal medicine ward)
Confounders	Age, sex, diabetes mellitus, hypertension, coronary heart disease, cerebrovascular disease, chronic obstructive pulmonary disease, cancer, cognitive impairment before admission, serum creatinine, haemoglobin, PaO2, serum albumin at admission, nursing home resident, previous hospital stay within 12 months, weekend/bank holiday admission.
Outcomes and effect sizes	Mortality: RR 0.8 (95% CI 0.4 to 1.6) Length of stay: Mean difference 2.6 days higher (95% CI 0.6 to 4.6) Serious adverse events (infection): RR 1.5 (95% CI 0.8 to 2.81) Serious adverse events (haemorrhage): RR 1.2 (95% CI 0.4 to 3.6)
Comments	Risk of bias: High (no adjustment for comorbidity)

Reference	Perimal-Lewis 2013{Perimal-Lewis, 2013 PERIMALLEWIS2013 /id}
Study type and analysis	Retrospective cohort study. Poisson regression.
Number of	n= 19,923

Reference	Perimal-Lewis 2013{Perimal-Lewis, 2013 PERIMALLEWIS2013 /id}
participants and characteristics	Outliers n=2,592 Non outliers n=15, 213 Inclusion criteria: patients admitted and discharged by the general medicine service Exclusion criteria: patients discharged from the ED, patients staying in hospital over 30 days Data extracted from Flinders Medical Centre patient journey database (1 Jan 2003 to 20 September 2009)
Prognostic variable	Outlier (not treated within a 'home ward' for the general medical unit allocated to care for the patient) Versus. Inliers (treated within a 'home ward' for the general medical unit allocated to care for the patient; patients under the care of GM but housed in the intensive care, high dependency or coronary care units were included as inliers)
Confounders	Age, charlson index, gender, length of time spent waiting for a bed in ED
Outcomes and effect sizes	Mortality: RR 1.41 (95% CI 1.16 to 1.71) Length of stay: 0.77 (95% CI 0.74 to 0.80)
Comments	Risk of bias: High (no adjustment for case mix)

1

Reference	Santamaria 2014{Santamaria, 2014 SANTAMARIA2014 /id}
Study type and analysis	Prospective cohort study. Zero-inflated negative binominal regression.
Number of participants and characteristics	n= 58,158 Outliers n= 11,034 Non outliers n= 47,124 Inclusion criteria: all admitted patients Exclusion criteria: patients admitted for outpatient testing, mental health care, rehabilitation or palliative care Consecutive patients admitted to St Vincent's Hospital, Melbourne between 1 July 2009 and 30 November 2011
Prognostic variable	Outlier (any time spent outside the home ward) Versus. Non-outlier (no time spent outside the home ward; time spent in an intensive care or coronary unit was included as non-outlier)
Confounders	Age, predicted mortality (calculated using diagnostic codes and Charlson Comorbidity index), interhospital transfer, same-day admission, neurosurgery unit, cardiothoracic surgery unit, general surgery unit, nephrology unit, general medicine unit

Reference	Santamaria 2014{Santamaria, 2014 SANTAMARIA2014 /id}
Outcomes and effect sizes	Serious adverse events (emergency calls): RR 1.53 (95% CI 1.32 to 1.77)
Comments	Risk of bias: Low. Population indirectness – all patients including surgical

1

Reference	Serafini 2015{Serafini, 2015 SERAFINI2015 /id}
Study type and analysis	Cohort study. Multivariate analysis (method not reported)
Number of participants and characteristics	n=3,828 Outlier n=339 Non-outlier n=3,489 Inclusion criteria: patients admitted to internal medicine or geriatrics Exclusion criteria: not reported Consecutive patients admitted to medicine and geriatrics of a hub hospital in Italy during 2012
Prognostic variable	Outlier (patients admitted in beds outside of medicine or geriatrics) Versus. Non-outlier (in-ward patients)
Confounders	Total number of admissions Gender Age Degree of dependence Length of stay Outlying location (medical or surgical) Diagnosis related group at discharge Readmission within 90 days
Outcomes and effect sizes	Mortality (hospital mortality): HR 1.8 (95% CI 1.28 to 2.53)
Comments	Risk of bias: High (no adjustment for comorbidity)
Study type and	Matched pair cluster study

Reference	Serafini 2015{Serafini, 2015 SERAFINI2015 /id}
analysis	
Number of participants and characteristics	n=483 Outlier n=245 Non-outlier n=238 Inclusion criteria: any patient outlying in one ward but under the responsibility of another ward Exclusion criteria: refusal to take part, persons under judicial protection or guardianship, persons under 18 years, patients hospitalised directly in intensive care units from the ED Patients selected from a period from February to May 2010 (outlying patients). Control group were consecutively included among all patients hospitalised during the study period.
Prognostic variable	Outlier (patients outlying in one ward but under the responsibility of another ward) Versus. Non-outlying patients
Confounders	Matched for age, sex and reason for admission
Outcomes and effect sizes	Mortality (90 day): RR 0.75 (0.51 to 1.11) Serious adverse events (transfer to intensive care): RR 1.05 (0.5 to 2.18)
Comments	Risk of bias: High (no consideration of comorbidity). Population indirectness – all patients including surgical and trauma

D.9 GRADE tables

Table 50: Clinical evidence profile: outliers (adjusted for all key confounders)

Quality assessment							Effect	Quality
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Relative (95% CI)	
Serious adverse events (assessed with: emergency calls)								
1	Cohort study	no serious risk of bias	no serious inconsistency	serious[1]	no serious imprecision	none	RR 1.53 (1.31 to 1.77)	⊕⊕⊕O MODERATE

[1] Downgraded by 1 increment if the majority of the evidence included an indirect population, or downgraded by 2 increments if the majority of the evidence included a very indirect population

Table 51: Clinical evidence profile: outliers

Quality assessment							Effect	Quality
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Relative (95% CI)	
Mortality (assessed with: hospital mortality)								
1	Cohort study	serious[1]	no serious inconsistency	no serious indirectness	serious[2]	none	RR 0.8 (0.4 to 1.6)	⊕⊕OO LOW
Mortality (assessed with: hospital mortality)								
1	Cohort study	serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	none	RR 1.41 (1.16 to 1.71)	⊕⊕⊕O MODERATE
Mortality (assessed with: hospital mortality)								

1	Cohort study	serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	none	HR 1.8 (1.28 to 2.53)	⊕⊕⊕O MODERATE
Mortality (assessed with: 90 day mortality)								
1	Matched pair study	serious[1]	no serious inconsistency	serious[3]	serious[2]	none	RR 0.75 (0.51 to 1.11)	⊕OOO VERY LOW
Length of stay (measured with: length of hospital stay (days); Better indicated by lower values)								
1	Cohort study	serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	none	Mean difference 2.6 higher (0.6 to 4.6 higher)	⊕⊕⊕O MODERATE
Serious adverse events (assessed with: infection)								
1	Cohort study	serious[1]	no serious inconsistency	no serious indirectness	serious[2]	none	RR 1.5 (0.8 to 2.81)	⊕⊕OO LOW
Serious adverse events (assessed with: haemorrhage)								
1	Cohort study	serious[1]	no serious inconsistency	no serious indirectness	serious[2]	none	RR 1.2 (0.4 to 3.6)	⊕⊕OO LOW
Serious adverse events (assessed with: transfer to ICU)								
1	Matched pair study	serious[1]	no serious inconsistency	serious[3]	serious[2]	none	RR 1.05 (0.5 to 2.18)	⊕OOO VERY LOW

[1] Downgraded by 1 increment if the majority of the evidence was at high risk of bias, and downgraded by 2 increments if the majority of the evidence was at very high risk of bias.
[2] Downgraded by 1 increment if the confidence interval crossed the null line.
[3] Downgraded by 1 increment if the majority of the evidence included an indirect population, or downgraded by 2 increments if the majority of the evidence included a very indirect population.

D.10 1 Excluded studies

2 **Table 52: Studies excluded from the clinical review**

Reference	Reason for exclusion
Alakeson 2010{Alakeson, 2010 ALAKESON2010 /id}	Commentary (no outcomes reported)
American College of Emergency Physicians 2005{American College of Emergency Physicians, 2005 AMERICANCOLLEGEOFEMERGENCYPHYSICIANS2005 /id}	Policy statement (no outcomes reported)
Anon 2012A{2012 ANON2012A /id}	Article (no outcomes reported)
Anon 2012B{2012 ANON2012B /id}	Article (no outcomes reported)
Bair 2010{Bair, 2010 BAIR2010 /id}	No relevant outcomes (effects of boarding on ED crowding)
Bakhsh 2014{Bakhsh, 2014 BAKHSH2014 /id}	No comparator
Bazarian 1996{Bazarian, 1996 BAZARIAN1996 /id}	Inappropriate study design (before and after); No multivariate analysis; Inappropriate comparison (all patients before versus after intervention)
Bing-Hua 2014{Bing-Hua, 2014 BINGHUA2014 /id}	Incorrect population (surgical patients)
Blay 2002{Blay, 2002 BLAY2002 /id}	No multivariate analysis
Blom 2015{Blom, 2015 BLOM2015 /id}	Inappropriate exposure (high occupancy); Inappropriate comparison (low occupancy); Inappropriate outcome (admission)
Bornemann-Shepherd 2015{Bornemann-Shepherd, 2015 BORNEMANNSHEPHERD2015 /id}	Inappropriate study design (before and after); No relevant outcomes
Carr 2010{Carr, 2010 CARR2010 /id}	No relevant outcomes (trends in boarding)
Cha 2015{Cha, 2015 CHA2015 /id}	Inappropriate exposure and comparison (delayed admission versus non-delayed admission)
Chalfin 2007{Chalfin, 2007 CHALFIN2007 /id}	Inappropriate exposure and comparison (delayed admission versus non-delayed admission)
Cohen 2009{Cohen, 2009 COHEN2009 /id}	No relevant outcomes (predictors of length of stay after colorectal surgery)
Coil 2016{Coil, 2016 COIL2016 /id}	Inappropriate exposure and comparison (delayed admission versus not delayed)
Creamer 2010{Creamer, 2010 CREAMER2010 /id}	No multivariate analysis; No relevant outcomes
Denno 2014{Denno, 2014 DENNO2014A /id}	Article (no outcomes reported)
Falvo 2007{Falvo, 2007 FALVO2007 /id}	No relevant outcomes (no patient outcomes)

Reference	Reason for exclusion
Hwang 2008{Hwang, 2008 HWANG2008 /id}	Inappropriate exposure (high boarding); Inappropriate comparison (low boarding); Outcomes reported for all patients (boarders and non-boarders together)
Kulstad 2010{Kulstad, 2010 KULSTAD2010 /id}	Inappropriate exposure (ED overcrowding); Outcomes reported for all patients (boarders and non-boarders together)
Liu 2009{Liu, 2009 LIU2009 /id}	No multivariate analysis
Lloyd 2005{Lloyd, 2005 LLOYD2005 /id}	Incorrect population (trauma patients)
Mahmoudian-Dehkordi 2016{Mahmoudian-Dehkordi, 2016 MAHMOUDIANDEHKORDI2016 /id}	Simulation paper comparing different ICU management strategies during times of crisis
Mansbach 2003{Mansbach, 2003 MANSBACH2003 /id}	No relevant outcomes
McKnight 2012{McKnight, 2012 MCKNIGHT2012 /id}	Article (no outcomes reported)
Metcalfe 2016{Metcalfe, 2016 METCALFE2016 /id}	Systematic review – references screened
Mustafa 2016{Mustafa, 2016 MUSTAFA2016 /id}	Effect of ED boarding on delayed discharges (overall); no adjustment for confounders
Nicks 2012{Nicks, 2012 NICKS2012 /id}	Inappropriate exposure (psychiatric patients); Inappropriate comparison (non-psychiatric patients)
Pascual 2014{Pascual, 2014 PASCUAL2014 /id}	Incorrect population (surgical patients)
Perimal-Lewis 2014{Perimal-Lewis, 2014 PERIMALLEWIS2014 /id}	No relevant outcomes (characteristics/predictors of boarders)
Puvaneswaralingam 2016{Puvaneswaralingam, 2016 PUVANESWARALINGAM2016 /id}	Incorrect exposure and comparison (boarded patient outcomes before and after a communication tool intervention)
Ranasinghe 2016{Ranasinghe, 2016 RANASINGHE2016 /id}	Outlying was an outcome rather than an exposure
Schmid-Mazzoccoli 2008{Schmid-Mazzoccoli, 2008 SCHMIDMAZZOCCOLO2008 /id}	No adjustment for key confounders
Simpson 2014{Simpson, 2014 SIMPSON2014 /id}	No relevant outcomes
Sullivan 2015{Sullivan, 2015 SULLIVAN2015 /id}	Inappropriate exposure and comparison (delayed admission versus not delayed); no adjustment for confounders
Warne 2010{Warne, 2010 WARNE2010 /id}	No multivariate analysis
Zhou 2012{Zhou, 2012 ZHOU2012 /id}	No comparator (predictors of poor outcome in boarded patients)

Appendix E: Analysis of activity data from an acute hospital trust

E.1 Introduction

To evaluate the cost effectiveness of various interventions, the guideline technical team developed a simulation model of a district general hospital (DGH). To populate the baseline model bespoke analyses were conducted for a large DGH, Queen Alexandra Hospital, Portsmouth. This appendix describes those analyses.

E.2 Methods

E.2.1 Conceptual model

The health economics subgroup of the committee discussed the requirements of a simulation of a hospital that could evaluate costs, QALYs and explore the variation of performance over time.

Generally, the analyses were designed on the basis that workload and case-mix (age and NEWS) is determined by season and day of the week and hour of the day. Case-mix determines mortality, movements and length of stay.

It was agreed that to achieve this, the following characteristics would be essential.

- Patient characteristics:
  - Age group
    - 16-44, 45-64, 65-75, 75-85, 85+
  - NEWS group
    - 0, 1-4, 5-6, 7+
    - Zero indicates normal healthy life signs. A score of 7+ indicates referral to critical care outreach.
  - Frailty scores would have been desirable but were not recorded.
- Hospital pre-admission locations:
  - Emergency Department (ED)
  - Ambulatory Acute Medical Unit – acute medicine experts provides outpatient care for AME patients during daytime
  - Clinical Decision Unit – short stay wards provided by emergency medicine experts. Although these are technically admissions, we have made a distinction, since they are part of the emergency pathway rather than medical pathway and patients were not recorded on VitalPAC, which computes NEWS.
- Hospital admission locations
  - Acute Medical Unit (AMU) – where undifferentiated AME patients are assessed and managed usually for up to 24 hours
  - General medical wards (GMW) – provide level 1 care to medical patients, includes specialist wards such as gastroenterology, care of the elderly.
  - Intensive care unit / high dependency unit (ICU/HDU) – the intensive medicine department providing level 2 and level 3 care

- Specialist high care units (HCU) – level 2 care in the hyper-acute stroke unit, coronary care unit, respiratory high care unit and renal high care unit.
- Rehab wards – long stay wards
- Medical outliers – AME patients on non-medical (surgery, gynaecology, trauma) wards
- Non-medical pathway – Patients that are admitted under a medical consultant but subsequently take a non-medical pathway

- Discharge locations:
  - Usual residence
  - Care home (new admission) – a source of delayed transfers of care
  - NHS service
  - Other
- Outcomes:
  - Mortality – 30-day mortality data was not available; in-hospital mortality should be treated cautiously. Reduced in-hospital mortality might be due to reduced length of stay and could be offset by more deaths in the community. However, generally, death at home is considered preferable to patients and family members.
  - Length of stay (LOS) – excessive length of stay impedes flow and represents a cost to the NHS
  - ICU/HDU referral – we consider this an indicator of adverse events, other adverse events are captured by mortality and length of stay
  - Medical outlying – an indicator of suboptimal care
  - Queuing in ED – an indicator of the hospital being under stress and sub-optimal care.

E.2.2 Data

Data was extracted from the Queen Alexandra Hospital records and statistics computed by an experienced analyst from Portsmouth Hospitals Trust.

Admissions

For admitted patients data was combined from Patient Admissions System (PAS) and VitalPAC. Data was extracted from 1st May 2010, when VitalPAC was first used routinely to 30th April 2016, the most recently available data at the time of analysis. However, data for the period 8 March 2015 to 20 June 2016 was omitted because the hospital experimented with an integrated ED and AMU, and therefore it was felt that this period would not be comparable. In total there was 5.7 years of data.

Included patients were those aged ≥16 who had a non-elective admission with a medical treatment specialty code.

Each patient's hospital spell was segmented in to the different locations.

Identified medical outliers by comparing ward with consultant

Pre-admission attendances (not specifically medical)

The data was from PAS. To be consistent, the data was extracted for the same period as the admissions data. For these areas, all patients were included, it was not possible to differentiate, those with medical conditions from those with trauma or gynaecological problems. Children were excluded because they have a separate ED and pathway at the hospital.

E.2.3 Analysis

For stays, mean, standard deviation and sample size were computed. For categorical outcomes, sample size and number of events were computed.

E.2.4 Validation

The guideline technical team checked that the numbers added up – for example, that the numbers leaving each destination were the same as the numbers entering.

The committee considered the face validity of the results in terms of their understanding of the pathway in their own hospitals. Generally, the results were considered generalisable. The one exception was the admission source, with Queen Alexandra having proportionately fewer patients coming from GPs and more patients coming from the ED and other NHS referrals than other hospitals.

E.3 Results

E.3.1 Overview

Figure 50 and Figure 51 show the total activity analysed and the mean activity per day, respectively.

Figure 50: Acute medical emergency activity 2010-2016

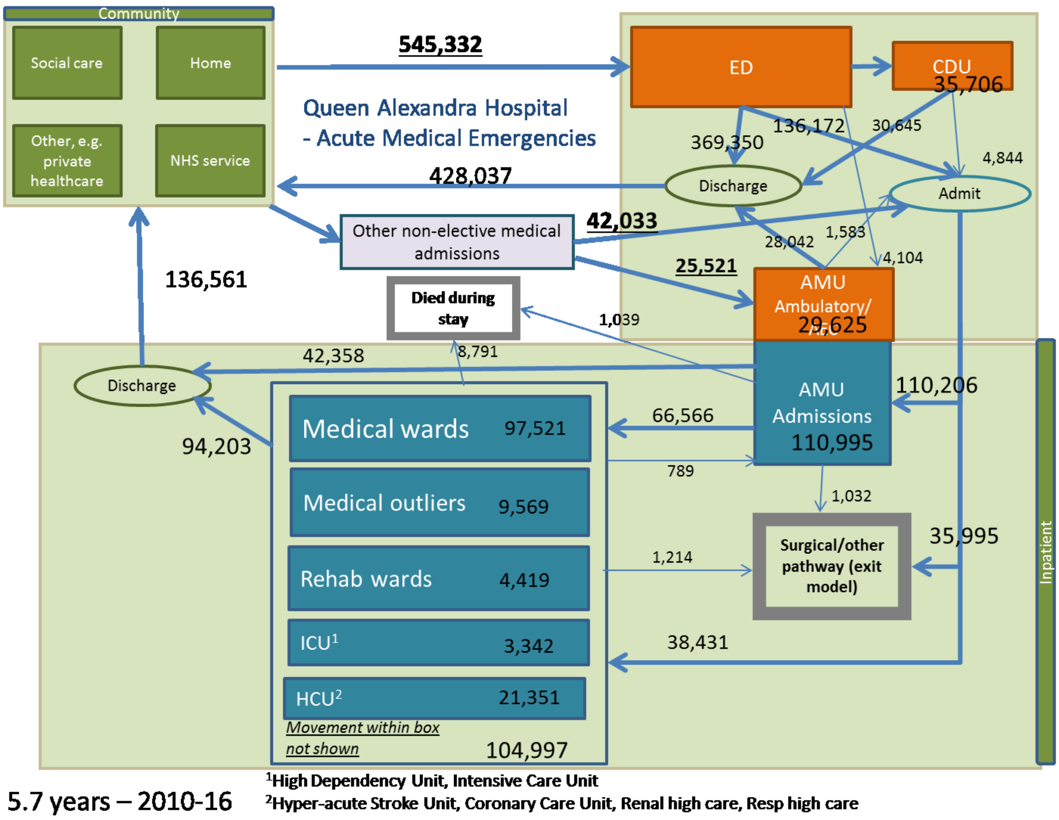
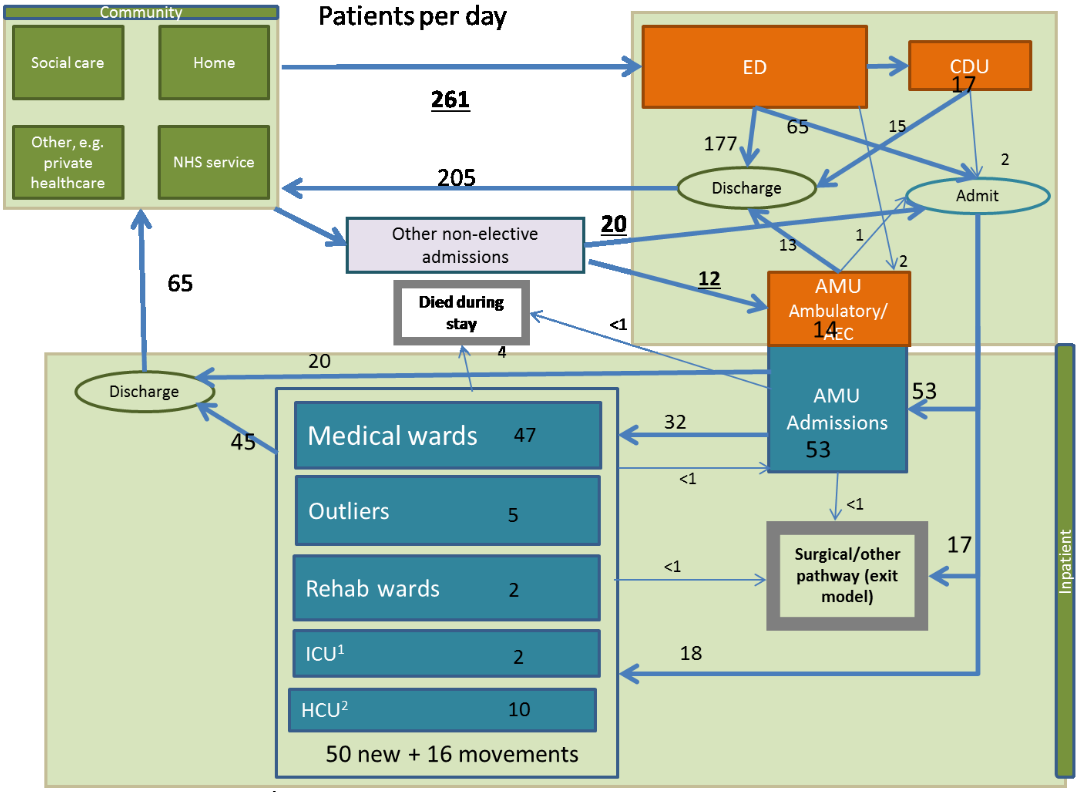


Figure 51: Acute medical emergency activity per day



[1]High Dependency Unit, Intensive Care Unit
[2]Hyper-acute Stroke Unit, Coronary Care Unit, Renal high care, Resp high care

E.3.2 Pre-admission activity

The following statistics were extracted:

- ED attendances
    - o By age group and whether admitted
- ED attendances
    - o By time, quarter, day(Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday), admitted(y/n)
- ED attendances
    - o By time & destination(CDU, Ward, AAMU, discharge)
- ED attendances
    - o by week
- ED LOS mean SD and in 5 min intervals
    - o By destination (CDU, Ward, AAMU, discharge)
- CDU discharges
    - o by destination (Ward, AAMU, discharge)
- CDU LOS – mean, sd & n
    - o By admitted(y/n)
- AAMU attendances
    - o By hour, quarter, admitted(y/n)

The distribution of ED presentations can be seen by day of the week (Table 53) and hour of the day (Figure 52 and Figure 53). Presentations were highest on Sundays and Mondays, as were absolute numbers of admissions. But admission rates were lowest on these days.

Table 53: ED attendances by day of week and whether admitted

Day of week	Not admitted	Admitted	All	Admissions per 1000
Monday	59,469	25,741	85,210	302
Tuesday	52,155	24,017	76,172	315
Wednesday	49,760	23,829	73,589	324
Thursday	49,486	23,785	73,271	325
Friday	48,063	24,053	72,116	334
Saturday	54,805	25,167	79,972	315
Sunday	59,472	25,530	85,002	300
All	373,210	172,122	545,332	316

Figure 52: ED attendances by hour of the day

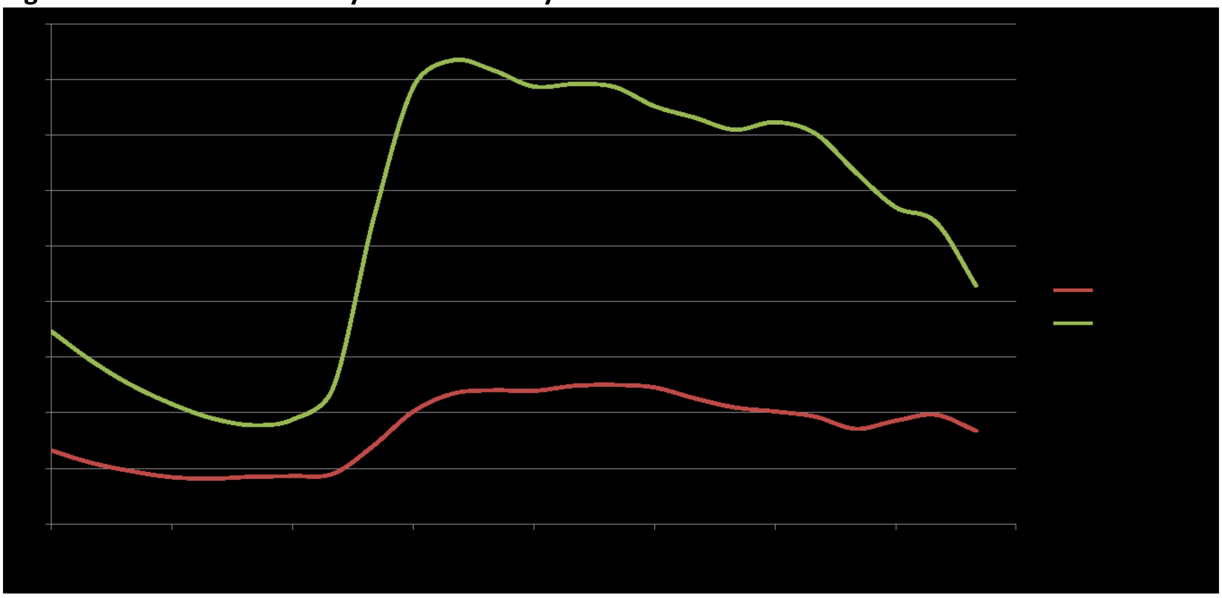
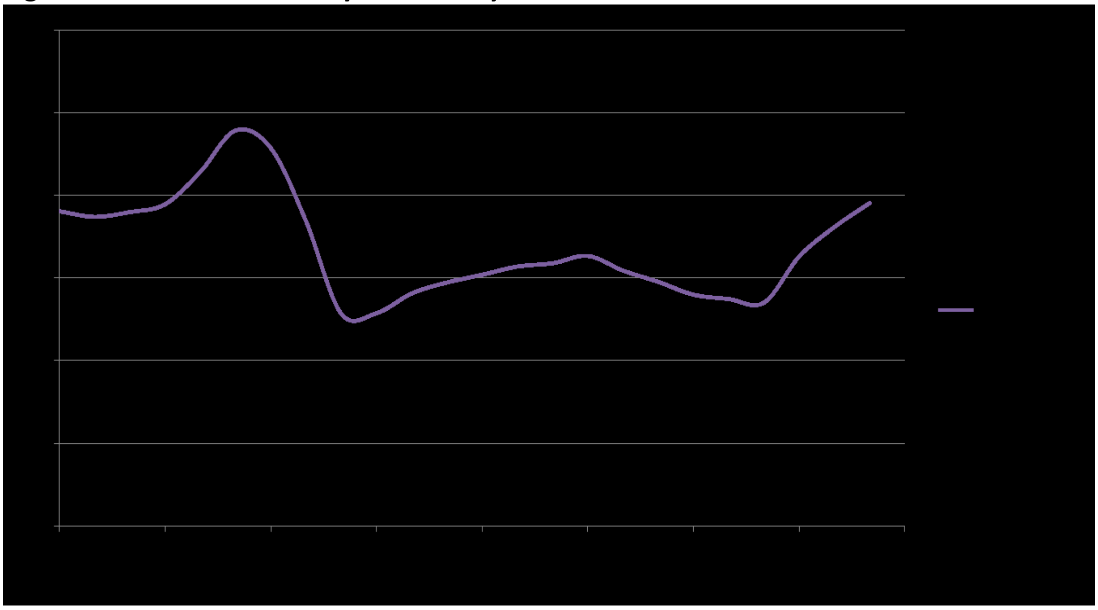


Figure 53: Admission rate by hour of day



People presenting to ED were broken down by age group (Table 54). As expected, admission rates increased considerably with age from 17% in the lowest age group to 68% in the highest.

Table 54: Admissions from ED by age group

Age group	Not admitted	Admitted	All	Admissions per 1000 patients
16-44	208,097	42,733	250,830	170
45-64	91,829	36,969	128,798	287
65-74	32,115	24,922	57,037	437
75-84	26,552	35,859	62,411	575
85+	14,617	31,639	46,256	684
All	373,210	172,122	545,332	316

Patients spent an average 2.6 hours in the ED but this was close to the 4 hour target for those who were subsequently admitted (Table 55).

Table 55: ED length of stay by destination

Destination	Mean LOS (hours)	Attendances
Ambulatory AMU	2.4	4,101
Clinical Decision Unit	3.4	35,680
Discharge	2.1	369,013
Admission	3.8	136,122
All	2.6	544,916

CDU

Mean LOS in CDU was 8.1 hours for patients who were discharged (n=30,645) and 16.1 hours for those who went on to be admitted to another part of the hospital (n=4844).

Ambulatory AMU

Clinic runs 8 am to 8 pm – max=12 hours. For the Ambulatory AMU stay we only have narrative information. Average LOS was around 6 hours:

- Reviews - 30 min to 3 hours
- New patients - 1 to 6 hours, up to 12 hours for multiple investigations, or fluid infusions
- Procedures - 3 to 12 hours.

Attendances at the ambulatory AMU peaked at 9am and then gradually declined over the course of the day (Table 53); 5.3% of these patients were subsequently admitted.

Table 56: Attendances at ambulatory AMU by hour of day and whether admitted

Hour of arrival	Not admitted	Admitted	All
7	1250	35	1285
8	2205	110	2315
9	4168	167	4335
10	4102	205	4307
11	3439	199	3638
12	3692	259	3951
13	2383	132	2515
14	2660	162	2822
15	1938	141	2079
16	1173	74	1247
17	714	68	782
18	304	30	334
19	14	1	15
All	**28042**	**1583**	**29625**

E.3.3 Admission activity

The following statistics were extracted:

- Admissions
  - By method of admission (ED, GP, outpatient, other)
- GMW[a] stays where GMW was the first location
  - Next location, age group, NEWS group at beginning of GMW stay, NEWS at discharge from GMW.
- GMW[a] stays where GMW was not the first location
  - Next location, age group, NEWS group at beginning of GMW stay, NEWS at discharge from GMW.
- Discharges
  - By destination & hour

[a] These analyses were repeated for ICU/HDU and HCU. They were also conducted for medical outliers, rehab wards and the AMU, but for these locations, we did not distinguish between first location and subsequent location because of the smaller numbers.

- Mortality
  - by age group, NEWS group at admission, ITU stay (ICU/HDU, No but HCU, no), Medical outlier (yes at some point, no)
- LOS –mean, sd and n
  - by age group, NEWS group at admission, ITU stay (ICU/HDU, No but HCU, no)
- LOS –mean, sd and n
  - By current location, location, next location age group, news group at admission

Table 57: Admissions by location of admitting ward and NEWS at admission

Location of admitting (first) ward	NEWS score at admission						
	0	1-4	5-6	7+	Not recorded	All	Per 1000
GMW	6,363	12,983	1,393	757	3,334	24,830	167
HCU	4,066	5,336	908	802	139	11,251	76
ICU/HDU	69	298	82	45	1,300	1,794	12
AMU	33,462	59,120	9,953	6,623	1,048	110,206	741
Outlier	190	262	19	11	36	518	3
Rehab	18	16	3		1	38	0
All	44,168	78,015	12,358	8,238	5,858	148,637	1,000
Per 1000	297	525	83	55	39	1,000	

Table 57 shows the admissions by first location and NEWS score at admission. Most patients admitted via the AMU but significant numbers go direct to GMW or HCU wards. 29.7% of patients had a NEWS score of zero (normal) at admission. NEWS was not recorded within the first 24 hours in 3.9% of patients - Table 57. This included ICU/HDU where it is not routinely recorded. However, most of the omissions were on the general medical ward. There are a number of reasons for these omissions including:

- Very short stay might mean it does not get recorded
- Patients admitted overnight might get it recorded on paper only
- Wards being refurbished
- Random selection
- Terminally ill patients – this seems to be borne out in Table 61 by the high mortality for patients who did not have a NEWS score recorded (after excluding patients on the ICU/HDU).

The proportion of patients with a NEWS at admission greater than 4 was more than double in the highest age group that of the lowest age group (Table 58).

Table 58: NEWS distribution at admission by age group

age group	NEWS score at admission					
	0	1-4	5-6	7+	Not recorded	All
16-44	330	543	49	21	58	1,000
45-64	318	513	69	42	57	1,000
65-74	280	517	91	68	44	1,000
75-84	284	522	98	69	27	1,000
85+	280	538	101	70	13	1,000
All	297	525	83	55	39	1,000

Table 59: Mortality by NEWS at admission

NEWS at admission Age 75-84	Admissions	Deaths	Deaths per 1000
0	10,098	320	32
1-4	18,569	1,418	76
5-6	3,475	587	169
7+	2,444	769	315
Not recorded	968	261	270
All	35,554	3,355	94

The following were associated with high mortality:

- Higher NEWS – Table 59
- No NEWS recorded in first 24 hours - Table 59 and Table 61
- An admission to ICU - Table 60
- Older age - Table 58.

Table 60: Mortality by whether there was an intensive therapy stay

HCU or ICU/HDU at any time during admission	Admissions	Deaths	Deaths per 1000
No HCU/ITU stay	126,624	6,938	55
HCU stay (not ICU/HDU)	18,859	2,046	108
ICU/HDU stay	3,154	1,034	328
All	148,637	10,018	67

Table 61: Mortality by age group, NEWS at admission and HCU stay

		No ICU/HDU or HCU stay			HCU stay		
	News at admission	Admissions	Deaths	Probability of death	Admissions	Deaths	Probability of death
16-44	0	6620	5	0.1%	450	0	0.0%
	1-4	10909	32	0.3%	623	7	1.1%
	5-6	904	7	0.8%	114	2	1.8%
	7+	322	12	3.7%	77	4	5.2%
	NR	883	3	0.3%	24	3	12.5%
16-44 Total		19638	59	0.3%	1288	16	1.2%
45-64	0	9700	37	0.4%	1572	5	0.3%
	1-4	15753	313	2.0%	2207	62	2.8%
	5-6	1979	100	5.1%	377	32	8.5%
	7+	1066	137	12.9%	334	59	17.7%
	NR	1469	31	2.1%	85	10	11.8%
45-64 Total		29967	618	2.1%	4575	168	3.7%
65-74	0	6532	87	1.3%	1294	29	2.2%
	1-4	12176	473	3.9%	2137	155	7.3%
	5-6	2085	192	9.2%	412	68	16.5%
	7+	1389	245	17.6%	431	97	22.5%
	NR	892	40	4.5%	58	19	32.8%
65-74 Total		23074	1037	4.5%	4332	368	8.5%
75-84	0	8501	230	2.7%	1545	74	4.8%
	1-4	15956	1055	6.6%	2469	295	11.9%
	5-6	2836	388	13.7%	572	163	28.5%
	7+	1845	541	29.3%	547	210	38.4%
	NR	665	89	13.4%	63	36	57.1%
75-84 Total		29803	2303	7.7%	5196	778	15.0%
85+	0	6781	304	4.5%	958	91	9.5%
	1-4	13137	1275	9.7%	1732	298	17.2%
	5-6	2348	558	23.8%	432	153	35.4%
	7+	1611	664	41.2%	311	149	47.9%
	NR	265	120	45.3%	35	25	71.4%
85+ Total		24142	2921	12.1%	3468	716	20.6%
All		126624	6938	5.5%	18859	2046	10.8%

Table 62 shows the movement of medical patients between different hospital and discharge locations. From the AMU, 55% move to GMW, 36% are discharged to their usual residence and the remaining patients are distributed to the other locations.

Table 62: Next location by current location

Next location	Current location								
	AMU	GMW 1st	GMW subs	Outlier	Rehab	HCU 1st	HCU subs	ICU/HDU 1st	ICU/HDU subs
AMU		1	9	0	20	0	0		1
GMW	552			152	71	298	481	446	419
Outlier	15	22	85		0	34	18	37	54
Rehab	2	6	30	27		100	51	2	1
HCU	28	113	47	13	26			123	174
ICU/HDU	3	12	8	6	0	8	19		
Non-medical	9	5	6	48	15	4	3		30
Usual Res	357	728	623	646	596	445	299	130	22
Care Home	1	7	43	36	118	5	8	2	1
NHS Service	12	32	45	43	71	34	27	35	26
Other discharge	11	34	33	18	56	5	11	11	8
Died	9	41	71	11	27	66	82	213	264
	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000

Table 63: NEWS at end of AMU stay by NEWS at start of AMU stay

NEWS at start of AMU stay	NEWS at end of AMU stay					
	0	1-4	5-6	7+	Not recorded	Total
0	637	355	6	2	0	1000
1-4	250	683	52	14	0	1000
5-6	70	572	268	90	0	1000
7+	29	367	292	311	1	1000
Not recorded	56	60	4	6	874	1000
All	336	548	72	35	9	1000

Table 64 shows how the proportion of patients with a high NEWS score diminishes over the course of the AMU stay.

Table 64: Length of stay by age group

	Admissions	Bed days	Mean LOS (days)
16-44	21,569	66,900	3.1
45-64	35,680	188,755	5.3
65-74	28,116	198,930	7.1
75-84	35,554	336,300	9.5
85+	27,718	326,200	11.8
	148,637	1,117,084	7.5

There was a clear trend towards increased length of stay by age (Table 64), less so by NEWS (Table 65).

Table 65: Length of stay by NEWS at admission (age 75-84)

	Admissions	Bed days	Mean LOS (days)
0	10,098	83,897	8.3
1-4	18,569	183,909	9.9
5-6	3,475	37,752	10.9
7+	2,444	24,729	10.1
Not recorded	968	6,013	6.2
	35,554	336,300	9.5

The hospital location with the longest stay by far, was the rehabilitation wards followed by the GMW (Table 66). Patients stayed 24 hours on average in the AMU. Next location was correlated with the length of stay on the GMW, with those going to a care home having by far the longest stay followed by those going to rehabilitation wards, being transferred to another NHS provider and those who died (Table 67).

Table 66: Length of stay in each location

	Stays	Bed days	Mean LOS
AMU	110,995	114,720	1.0
GMW	97,521	682,525	7.0
Outlier	9,569	48,410	5.1
Rehab	4,419	114,931	26.0
HCU	21,351	101,320	4.7
ICU/HDU	3,342	16,323	4.9
	247,197	1,078,230	4.4

Table 67: Length of stay on general medical ward, by next location

	Stays	Bed days	Mean LOS (days)
AMU	694	173	0.2
Outlier	6,687	47,529	7.1
Rehab	2,300	26,261	11.4
HCU	6,235	14,667	2.4
ICU/HDU	866	3,513	4.1
Non-medical	576	4,530	7.9
Usual Residence	63,332	378,109	6.0
Care Home	3,314	68,362	20.6
NHS Service	4,060	46,191	11.4
Other discharge	3,263	23,504	7.2
Death	6,194	69,685	11.3
	97,521	682,525	7.0

Table 68 shows three quarters of discharges from hospital took place between 9am and 6pm.

Table 68: Discharges by time of day

Hour	Discharges	
0-3	1,939	1%
3-6	1,504	1%
6-9	2,537	2%
9-12	22,480	15%
12-15	38,611	26%
15-18	49,722	33%
18-21	25,715	17%
21-24	6,129	4%
	148,637	

E.3.4 Medical Outliers

The probability of being an outlier was lower at lower NEWS scores (Table 69) but higher at higher ages (Table 68), presumably, because younger patients tend to be discharged more quickly.

Mortality was low during the outlying part of the hospital stay (Table 62) and was substantially lower in patients that experienced an outlying stay compared to those that did not after accounting controlling for age and NEWS at admission to hospital (Table 69). We offer two explanations:

- Patients are being appropriately selected to be outliers on the basis that they are lower risk
- At Portsmouth, patients become outliers only after spending a number of days on other wards. Hence, they have to survive the highest risk part of the admission in order to become an outlier.

We did not set out to measure the impact of being an outlier on mortality. To do so would require analysing mortality by day of admission, as well as fully controlling for confounders.

Table 69: Mortality by age and whether patient has been a medical outlier for any part of their stay

	Patients		Deaths in hospital		
Age	No outlier stay	Outlier stay	No outlier stay	Outlier stay	Risk ratio (outlier versus no)
16-44	20,811	758	1%	0%	0.4
45-64	34,146	1,534	3%	1%	0.4
65-74	26,535	1,581	6%	3%	0.6
75-84	32,890	2,664	10%	4%	0.4
85+	25,058	2,660	14%	5%	0.4
All	139,440	9,197	7%	4%	0.5

Table 70: Mortality by age group, NEWS at admission and whether patient has been a medical outlier for any part of their stay

		Patients		Deaths in hospital		
Age	**NEWS at admission**	**No outlier stay**	**Outlier stay**	**No outlier stay**	**Outlier stay**	**Risk ratio (outlier versus no)**
16-44	0	6876	233	0%	0%	5.9
	1-4	11244	464	0%	0%	0.0
	5-6	1031	29	1%	3%	3.2
	7+	435	12	5%	0%	0.0
	NA	1225	20	4%	0%	0.0
		20811	**758**	**1%**	**0%**	**0.4**
	0	10954	388	1%	1%	0.9
	1-4	17419	890	3%	1%	0.6
	5-6	2329	145	7%	3%	0.4
	7+	1436	74	16%	1%	0.1
	NA	2008	37	10%	5%	0.5
		34146	**1534**	**3%**	**1%**	**0.4**
65-74	0	7465	405	2%	2%	1.3
	1-4	13649	878	5%	3%	0.6
	5-6	2397	166	12%	5%	0.5
	7+	1796	109	21%	6%	0.3
	NA	1228	23	15%	22%	1.4
		26535	**1581**	**6%**	**3%**	**0.6**
75-84	0	9435	663	3%	2%	0.7
	1-4	17091	1478	8%	5%	0.6
	5-6	3180	295	18%	4%	0.2
	7+	2241	203	34%	7%	0.2
	NA	943	25	27%	12%	0.4
		32890	**2664**	**10%**	**4%**	**0.4**
85+	0	7022	727	5%	3%	0.6
	1-4	13431	1471	11%	4%	0.4
	5-6	2493	293	28%	10%	0.4
	7+	1775	157	45%	8%	0.2

		Patients		Deaths in hospital		
Age	NEWS at admission	No outlier stay	Outlier stay	No outlier stay	Outlier stay	Risk ratio (outlier versus no)
	NA	337	12	50%	42%	0.8
		25058	**2660**	**14%**	**5%**	**0.4**
All		**139440**	**9197**	**7%**	**4%**	**0.5**

E.4 Comparisons with national data sources

The age distribution, length of stay and mortality were broadly similar to medical patients nationally – Table 71. NEWS distribution by age was also broadly similar but there were fewer patients with the lowest NEWS score at Portsmouth 31% versus 35% in SAMBA 2013 - Table 72. Table 73 shows that the distribution of admission sources is quite different to the national pattern. Overall, it would seem that the case-mix for Portsmouth admissions is somewhat worse than average, as indicated by:

- A lower proportion having NEWS=0,
- A lower proportion age<65,
- Longer length of stay,
- Higher mortality.

Table 71: Comparison with national data sources

	Portsmouth	England (HES)	England (HES)	England (SAMBA){Subbe, 2015 SUBBE2015 /id}	England (HES-ONS) – see 41.2.6.2
Years	2010-2016	2010-2015	2014-2015	2013	2013-14
n	148,637	13,999,919	2,958,602	2,990	3,576,663
Mean length of stay (days)	7.5	6.5	6.4		6.4
Probability of death in hospital	6.7%	6.0%	5.8%		
Age profile					
18-44	14.5%*		16.3%	18.7%*	18.6%
45-64	24.0%		23.2%	23.8%	25.3%
65-74	18.9%		18.0%	17.7%	17.7%
75-84	23.9%		23.5%	22.7%	21.8%
85+	18.6%		18.9%	17.1%	16.6%

**Ages 16-44*

Table 72: NEWS distribution by age group, compared with SAMBA 2013

SAMBA 2013(SAMBA){Subbe, 2015 SUBBE2015 /id}	0	1-4	5-6	7+	All
16-44	41%	51%	5%	3%	100%
45-64	39%	49%	8%	4%	100%
65-74	35%	49%	7%	9%	100%
75-84	28%	55%	8%	9%	100%
85+	31%	53%	10%	6%	100%
All	35%	52%	7%	6%	100%
Portsmouth 2010-16	**0**	**1-4**	**5-6**	**7+**	**All**
16-44	35%	58%	5%	2%	100%
45-64	34%	55%	7%	4%	100%
65-74	29%	55%	9%	7%	100%
75-84	30%	54%	10%	6%	100%
85+	29%	56%	10%	6%	100%
All	31%	55%	8%	5%	100%

Table 73: Admission method, compared with SAMBA 2015

	SAMBA 2015		Portsmouth 2010-2016	
Referral source	**AMU all ages**		**Medical admissions age>16**	
Emergency Department	1,835	59%	105,021	71%
GP	1,065	34%	19,270	13%
Other*	210	7%	24,346	16%
All	3,110	100%	148,637	100%

** Renal and Oncology patients seem to account for about 60% of the 'Other' patients. Renal and Oncology are regional centres taking patients out of catchment area.*

Appendix F: Treatment effect calculations

In the MS Excel model treatment effects are being applied to a whole cohort whereas in the Simul8 model the treatment effect is more targeted. In some cases, additional calculations needed to be made to enable the treatment effect elicited from the committee subgroup to be applied correctly in the model. These are explained in more detail below.

Length of stay reductions were estimated as absolute average stays reductions (for example, 1 day less). This was applied as a relative reduction in stay to all relevant patients, since some patients might have less than a full day's stay even before the treatment effect has been applied – hence the effects in Table 6 are expressed as relative risks. For example, 0.84 represents a 16% reduction in length of stay.

F.1 RAT in the ED

F.1.1 [A] – Mortality within ED

Mortality within ED is mostly prevalent in resuscitation patients who do not normally come through RAT. The RAT intervention affects majors patients only and therefore there was unlikely to be a substantial mortality effect. However, a small decrease in mortality of 1 in 100 (RR=0.99) has been included for the optimistic treatment effect analysis. This treatment effect is applied to ED mortality only. The probability of dying in the ED was found to be 0.1%. Therefore, applying the treatment effect of 0.99 reduces this probability to 0.099%. With this treatment effect applied, for every 100,000 patients that go through the ED you would expect to prevent 1 death.

Applying this treatment effect in the MS Excel model

In the MS Excel model this treatment effect was incorporated into the 30 day mortality rate. Using the values calculated above it was estimated that there would be 0.01 fewer deaths per 1000 ED patients. After 30 days for every 1000 patients that entered the ED there are, on average, 39.92 deaths. Therefore, this value would decrease to 39.91 when the deaths averted from the intervention are incorporated. The treatment effect applied to the 30 day mortality rate is therefore (39.91/39.92) = 0.9997.

F.1.2 [B] – Admissions

A midpoint of 1 in 20 patients avoiding admission was agreed (RR=0.95). It was agreed that the range around the effect size should include the possibility of increasing admissions. The admissions avoided would be those where patients are admitted to AMU and subsequently discharged with a short length of stay.

Applying this treatment effect in the MS Excel model

As this effect only applies to those who receive the intervention, additional adjustments needed to be made when applying it to a cohort of patients, some of whom will not receive the intervention. The probability of receiving the intervention, based on the inclusion criteria for the intervention, was found to be 27.1% (Table 23). For every 1000 ED attendances, 271 would receive the intervention. All of these patients would be 'majors' and the admission rate for majors was found to be 42.6% (41.2.4.2), therefore, of the 271 patients we would expect 116 admissions. This is where the treatment effect is now applied. Avoiding 1 in 20 admissions would reduce this number to 110 admissions. For every 1000 ED attendances, we would currently expect 289 admissions (41.2.4.2). With the intervention in place, we would expect 283 admissions, the equivalent of a 0.979 risk ratio being applied to the admission rate for the whole cohort. The model assumes these avoided admissions are in short stay patients only.

Applying this treatment effect in the Simul8 model

F.1.3 The model does not identify whether a simulated patient has been through majors or not. Therefore, the treatment effect elicited is transformed for use within the simulation model. Using the Portsmouth data analysis, 85.4% of ED attendances are during RATing hours with 30.1% of those being admitted. This equates to 257 admissions during RATing hours for every 1000 ED attendances. We estimated that 39.1% of ED admissions are majors (41.2.4.2). This makes 1 in 20 major admissions avoided equivalent to 1 in 51 admissions avoided. Applying this to the 257 admissions during RATing hours leads to 5 admissions avoided per 1000 ED attendances. All of the admissions avoided should be patients who received the intervention, majors patients who would be avoiding a short stay. The simulation model is able to identify the exact type of patient that would be able to avoid admission and apply the treatment effect to only those patients. Therefore, the treatment effect needs to be modified. 74.1% (190) of the 257 admissions during RATing hours are admitted to the AMU. 38.2% (73) of those are discharged from the AMU after a short stay. Avoiding 5 of the 73 admissions to match the 1 in 20 majors admissions avoided elicited as the treatment effect equates to a risk ratio of 0.93 applied to simulated patients that arrived during RATing hours and subsequently admitted to the AMU for a short stay.[C] – ED length of stay

The presence of RATing would reduce the time to decision of admission or discharge. However, it was discussed that admitted patients might not see their overall length of stay change dependent on bed availability. This should be captured in the capacity of the model. 26.0% of patients in ED receive RAT, which was majors equating to 30.5% of ED patients - 41.2.4.2 multiplied by 85.4% arriving in service hours from the Portsmouth data). These patients would see an average decrease in time to decision of around 15 minutes (20-10 minute range). For our average length of stay of 157 minutes (41.2.4.3), this equates to treatment effect of 0.904 with an upper and lower range of 0.873- 0.936. As the main benefit of this treatment effect is to improve hospital flow it was omitted from the MS Excel model as the impact of hospital flow is not captured.

F.2 Extended hours for consultants in AMU

F.2.1 [D] – Within AMU mortality

There would only be a small number of preventable deaths, as a large number of patients are on an end of life pathway. It was proposed that 1 in 100 (RR=0.99) reduction in mortality would be realistic. The effect is applied to all AMU patients. This treatment effect is applied to AMU mortality only. The probability of dying in the AMU was found to be 0.94% in the Portsmouth hospital data analysis. Therefore applying the risk ratio of 0.99 reduces this probability to 0.93%. With this treatment effect applied, for every 10,000 patients that go through the AMU you would expect to prevent one death.

Applying this treatment effect in the MS Excel model

In the MS Excel model this treatment effect was incorporated into the 30 day mortality rate. Using the values calculated above it was estimated that there would be 0.1 fewer deaths per 1,000 AMU patients. After 30 days for every 1,000 patients that entered the AMU there are, on average, 89.97 deaths (See 41.2.6 and Table 32: Daily consultant review on medical ward versus baseline (per 1000 medical ward patients)). Therefore, this value would decrease to 89.87 when the deaths averted from the intervention are incorporated. The treatment effect applied to the 30 day mortality rate is therefore (89.87/89.97) = 0.99896.

F.2.2 [E] – Adverse events (admissions to ICU/HDU directly from AMU)

The treatment effect was only applied to those that enter the AMU during extended hours 6pm - 10pm weekday, 8am – 10pm weekend). It was agreed that for these patients, of those that would have been referred to ICU/HDU, 1 in 20 would be avoided.

Applying this treatment effect in the MS Excel model

As this treatment effect only applies to those who arrive in extended hours, additional adjustments needed to be made when applying it to a cohort of patients, some of whom will not arrive in extended hours. The probability of arriving in extended hours was found to be 23.9% (Table 22). For every 100,000 AMU admissions, 23,900 would arrive in extended hours. The probability of being admitted to the ICU/HDU was found to be 0.3% from the Portsmouth data analysis; therefore, of the 23,900 patients we would expect 72 admissions to ICU/HDU from AMU. Avoiding 1 in 15 ICU/HDU admissions would reduce this number by 5 admissions. For every 100,000 AMU attendances, we would currently expect 300 ICU/HDU admissions. With the intervention in place, we would expect 295 ICU admissions, the equivalent of a 0.98 risk ratio being applied to the ICU/HDU admission rate for the whole cohort.

Applying this treatment effect in the Simul8 model

This treatment effect is applied only to those that arrive during extended hours. It was agreed that 1 in 20 would avoid ICU/HDU admission under the intervention. This is implemented in the model by applying a 5% (0.95 risk ratio) reduction in the probability of ICU admission from the AMU for patients arriving during extended hours.

F.2.3 [F] – Length of stay in AMU (earlier discharge)

It was decided to break this down into 2 parts:

1. Some patients who arrive during extended hours can be discharged a day earlier as a consequence of being seen earlier:

- 1 in 15 of all such patients could avoid an overnight stay (1 in 30 in the conservative analysis and 1 in 10 in the optimistic analysis)
- Those that benefit are under age 65 and are being discharged the next day to usual residence.

2. Some patients who can be discharged hours earlier due to earlier testing/cancelled unnecessary tests:

- Patients who are admitted to AMU during extended hours are under age 65 and are being discharged the next day to usual residence will have reduced length of stay if they are not discharged a day earlier, as above.
- One hour reduction (0.5 in the conservative analysis and 2 in the optimistic analysis).

Applying this treatment effect in the MS Excel model

As this treatment effect only applies to those who arrive in extended hours, additional adjustments needed to be made when applying it to a cohort of patients, most of whom will not arrive in extended hours. The probability of arriving in extended hours was found to be 23.9%. For every 1000 AMU attendances, 239 would arrive in extended hours. 1 in 15 of these patients would be discharged a day earlier meaning for every 1000 AMU attendances 16 patients would now be discharged a day earlier. The committee decided that all these patients would be <65 and expected to be discharged the next day. The proportion of AMU attendances that fit the criteria was found to be 19.0% in the Portsmouth data. Therefore, of the 239 who arrive in extended hours, 45.5 would be under 65 and planned to be discharged the next day. The committee agreed that for those who met the criteria but who were not discharged a day earlier, length of stay would be reduced by 1 hour on average, due to earlier testing and cancelling of unnecessary tests. Of the 45.5, if 16 were discharged earlier, as calculated above, then 29.5 would therefore have their length of stay reduced by 1 hour.

Applying this treatment effect in the Simul8 model

The length of stay treatment effects are only applied to those that arrive during the extended hours who are under 65 and being discharged to usual residence the next day in a 2 stage approach.

1) It was noted above that the intervention would avoid an overnight admission in 1 in 15 patients arriving in extended hours, equivalent to 310 per year (=4,654/15) from the Portsmouth data analysis. Of the 4,654, 884 patients fulfil the criteria of being under 65 years of age and being discharged home from AMU. Therefore, 35.1% of these patients would avoid overnight admission (310/884). These patients were computed a discharge time between arrival and midnight using a uniform distribution.
2) In the data analysis, the average AMU length of stay for this cohort was 28 hours. Those who arrived in extended hours, were aged under 65 and being discharged home and did not avoid an overnight admission would have a 1-hour reduction in length of stay. The weight applied for these patients was 0.964=1-1/28.

F.3 Daily consultant review on medical wards

All these treatment effects apply to everyone who receives the intervention, therefore no adjustments need to be made to the MS Excel cohort model:

F.3.1 [G] – Mortality within GMW

It was felt that daily consultant reviews would prevent only a small number of deaths on the GMW. It was proposed that 1 in 100 (0.99) reduction in mortality would be realistic. The effect was applied to all GMW patients. This treatment effect is applied to GMW mortality only. The probability of dying in the GMW was found to be 6.35% in the Portsmouth data analysis (41.2.4.4). Therefore applying the treatment effect of 0.99 reduces this probability to 6.29%. With this treatment effect applied, for every 10,000 patients that go through the AMU you would expect to prevent 6 deaths.

Applying this treatment effect in the MS Excel model

In the MS Excel model this treatment effect was incorporated into the 30 day mortality rate. Using the values calculated above it was estimated that there would be 0.63 fewer deaths per 1,000 GMW patients. After 30 days for every 1000 patients that entered the GMW there are, on average, 89.97 deaths (See 41.2.6 and Table 32: Daily consultant review on medical ward versus baseline (per 1000 medical ward patients)). Therefore, this value would decrease to 89.33 when the deaths averted from the intervention are incorporated. The treatment effect applied to the 30 day mortality rate is therefore (89.33/89.97) = 0.993.

F.3.2 [H] – Adverse events (admission to ICU/HDU directly from GMW)

The consensus was that 1 in 14 referrals to ICU/HDU would be avoided (1 in 7 in the optimistic treatment effects sensitivity analysis; 0 in the conservative treatment effects analysis).

F.3.3 [I] – Length of stay on GMW

It was agreed that there would be a 1-day reduction in length of stay for 1 in 10 patients (24 * 0.1 = 2.4 hours) in the base case and 1 in 5 patients for the optimistic treatment effects sensitivity analysis. There would be a partial effect in the control arm where consultant review takes place 2 days a week, therefore the net effect was (2.4 * (5/7)) = 1.7 hours.

Applying this treatment effect in the MS Excel model

The average reduction of 1.7 hours length of stay for all GMW patients being discharged equates to a weight of 0.989 (=1-1.7/[6.4x24]) assuming an average length of hospital stay of 6.4 days (HES 2014-15 – 41.2.4.4).

Applying this treatment effect in the Simul8 model

The average reduction of 1.7 hours length of stay for all GMW patients being discharged equates to a weight of 0.990 (=1-1.7/[7.0x24])assuming an average length of GMW stay of 7.0 days (Portsmouth hospital data analysis).

F.4 Extended access to therapy in the ED

F.4.1 [J] – Admissions

The committee expected 1-2 admissions to be avoided per day for a hospital with 250 ED presentations per day. This is the equivalent of preventing 4-8 admissions per 1000 ED attendances. In the base case, it was assumed that 4 admissions would be averted (8 in the optimistic treatment effects analysis and 2 in the conservative analysis).

The patients benefiting would be those with a CFS 3-6, NEWS 0-1, and who would have had a short length of stay.

Applying this treatment effect in the MS Excel model

For every 1000 ED attendances, it was calculated that there would be, on average, 289 ED admissions (41.2.4.2). By preventing 4 admissions per 1000 this number would reduce to 285 admissions per 1000 ED attendances. This equates to a treatment effect of 0.986 being applied to the admission rate for the whole cohort of patients going through the ED. It was assumed these avoided admissions would be in short stay patients only.

Applying this treatment effect in the Simul8 model

Applying the SAMBA CFS distributions to the Portsmouth admission data gave 3,819 patients per year of CFS 3-6 who had a short length of stay (10.5 per day). Avoiding 1 admission per day is equivalent to a risk ratio of 0.904 (1-1/10.5) applied only to the targeted cohort.

F.5 Extended access to therapy on medical wards

F.5.1 [K] –Length of stay

It was agreed that patients on the GMW with CFS ≥3, age over 65 and being discharged would see a stay reduction of 1 day on average (0.5 to 1.5 days in sensitivity analyses).

Applying this treatment effect in the MS Excel model

For every 1000 GMW attendances, it was estimated that there would be, on average, 393 who had a CFS over 3 and were over 65 years of age (using SAMBA 2013 data). A 1 day reduction in length of stay would bring the average length of stay down from 6.4 (41.2.4.4) to 5.4 in these patients only (5.4/6.4=0.84). The average length of stay for the whole GMW cohort, including those who do not receive the intervention, decreases to 6.0. This equates to a weight of 0.94 being applied to the length of stay for the entire GMW cohort.

Applying this treatment effect in the Simul8 model

The effect was applied specifically to the cohort of patients in GMW with CFS ≥3, age over 65 and being discharged. The 1-day length of stay reduction was applied as a relative weight of 1-1/7.0=0.857, where 7.0 was the average length of stay for patients on GMW in the Portsmouth hospital data.

F.5.2 [L] – Quality of life

It was agreed that there would be an increase of 1% in quality of life for patients on the GMW with CFS ≥3, age over 65 and being discharged to their usual place of residence from the GMW that would last for 1 year.

Applying this treatment effect in the MS Excel model

Using Samba 2013, it was calculated that 63% of those over 65 years of age would have a CFS > 3. These would be the patients that would receive a 1% improvement in quality of life for 1 year. If 63% received a 1% improvement in quality of life and 37% received no increase in quality of life then this works out as a [(63% x 1%) + (37% x 0%) = 0.63%] improvement in quality of life for all patients aged 65 years of age.

Appendix G: Simulation model labels, workstations and procedures

Table 74: Model labels (that is, patient-level variables)

Label name	Type	Function	Workstations where label is used	Procedures where label is used
lbl_30mort	Binary	Indicator of if simulated patient died between discharge and 30 days post admission.	-	Proc_End, Proc_LongTerm
lbl_AdmAvoid	Binary	Indicates if patient avoided admission (where we are applying a treatment effect in the model)	AMU	Proc_BedDrop
lbl_AdmDay	Categorical	Day of the week that the patient was admitted.(Monday=1)	Route, AMU	Proc_End
lbl_admit	Binary	Whether or not to admit patient.	AMUamb, pt info	Proc_PreAdmRoute, Proc_LOS, Proc_LongTerm
lbl_AdmNEWS	Categorical	NEWS score on admission. (1=0, 2=1-4, 3=5-6, 4=7+, 5=unknown)	Route, AMU	Proc_End
lbl_AdmPatNum	Categorical	Unique patient number for admitted patients.	AMUamb, AMU	Proc_PreAdmRoute, Proc_DecisionRules, Proc_End
lbl_AdmQuart	Categorical	Quarter of the year that the patient is admitted. (Jan-Mar=1)	Route	Proc_End
lbl_Age	Continuous	Exact age at presentation (16-100).	pt info	Proc_End, Proc_LongTerm
lbl_AgeCat	Categorical	Age category. (1=16-44, 2=45-64, 3=65-74, 4=75-84, 5=85+)	pt info, AMU, GMW, Route, Death	Proc_PreAdmRoute, Proc_route, Proc_LOS, Proc_Discharge, Proc_End, Proc_LongTerm

Label name	Type	Function	Workstations where label is used	Procedures where label is used
lbl_ArrivalTime	Continuous	Arrival time into simulation. (exact minute of the year entered simulation)	pt_info set wait, AMU	Proc_PreAdmRoute, Proc_BedDrop, Proc_End
lbl_arrival mode	Categorical	Mode of arrival (1=ED, 2=direct, 3=ambulatory AMU).	pt info, Route, Outlier	Proc_End
lbl_BedHeld	Categorical	Resource (bed) simulated patient currently holding (e.g. 1=AMU).	Death	Proc_BedPickUp Proc_BedDrop
lbl_BedLOS	Continuous	Length of stay in current resource (bed).		Proc_BedDrop
lbl_CFS	Categorical	Patient clinical frailty scale score.	pt info, ED, GMW, Route, Death	Proc_BedDrop, Proc_LOS, Proc_Discharge, Proc_End, Proc_LongTerm
lbl_changebed	Binary	Indicating if patient queuing for rehab should change to GMW bed	Change Bed	Proc_DecisionRules
lbl_Cost	Continuous	Simulated patient running total cost.	ED, CDU, AMUamb, AMU, GMW, Death	Proc_BedDrop, Proc_End, Proc_LongTerm
lbl_CostAMUamb	Continuous	Cost of having ambulatory AMU stay	AMUamb	Proc_End
lbl_CostAMUround	Continuous	Costs associated with AMU consultant ward round (extended hours)	AMU	Proc_End
lbl_CostAMUstay	Continuous	Cost of stay on AMU	-	Proc_BedDrop, Proc_End
lbl_CostCDU	Continuous	Cost of having CDU stay	CDU	Proc_End
lbl_CostEDatt	Continuous	Costs of attending ED	ED	Proc_End
lbl_CostGMWround	Continuous	Cost of GMW consultant ward round (additional days)	-	Proc_BedDrop,

Label name	Type	Function	Workstations where label is used	Procedures where label is used
				Proc_End
lbl_CostGMWstay	Continuous	Cost of stay on GMW	-	Proc_BedDrop, Proc_End
lbl_CostHCUstay	Continuous	Cost of stay on HCU	-	Proc_BedDrop, Proc_End
lbl_CostICUstay	Continuous	Cost of stay on ICU	-	Proc_BedDrop, Proc_End
lbl_CostOUTstay	Continuous	Cost of stay as a medical outlier	-	Proc_BedDrop, Proc_End
lbl_CostPTOTEDRef	Continuous	Costs of having therapy intervention in ED	ED	Proc_End
lbl_CostPTOTWard	Continuous	Cost of having therapy intervention on medical wards	-	Proc_BedDrop, Proc_End
lbl_CostRAT	Continuous	Costs of RAT in ED	ED	Proc_End
lbl_CostREHstay	Continuous	Cost of stay on Rehabilitation wards	-	Proc_BedDrop, Proc_End
lbl_CostsHosp	Continuous	Simulated patient running total hospital cost.	Death	Proc_End, Proc_LongTerm
lbl_currentoutlier	Binary	Indicating if patient has been a medical outlier.	Route	Proc_LOS, Proc_End
lbl_Dcost	Continuous	Simulated patient running total discounted cost.	-	Proc_End, Proc_LongTerm
lbl_direct	Binary	Indicating patient was a direct admission.	pt info, ED, CDU, Route	Proc_PreAdmRoute, Proc_route, Proc_NEWS
lbl_DQALYS	Continuous	Simulated patient running total discounted quality adjusted life years.	-	Proc_End, Proc_LongTerm

Label name	Type	Function	Workstations where label is used	Procedures where label is used
lbl_EDpat	Binary	Indicating if patient entered model from ED.	ED, AMUamb	-
lbl_EDRoute	Categorical	Route patient takes from ED. (1=CDU, 2=Admitted wards, 3=Ambulatory AMU, 4=Discharge)	-	Proc_PreAdmRoute, Proc_LOS
lbl_expirytime	Continuous	Time patient can wait for their next location until decision rules triggered.	All queues(a), pt info, AMU	Proc_LOS
lbl_LOS	Continuous	Length of stay in current location.	All location workstations(b)	Proc_LOS, Proc_DischargeProfile, Proc_DecisionRules
lbl_meanLOS	Continuous	Mean length of stay for current location to create distribution to sample length of stay.	-	Proc_LOS(c)
lbl_NEWs	Categorical	Current NEWS. (1=0, 2=1-4, 3=5-6, 4=7+, 5=unknown)	pt info, Route, Death	Proc_PreAdmRoute, Proc_NEWS, Proc_LOS, Proc_route, Proc_DecisionRules, Proc_Discharge, Proc_End, Proc_LongTerm
lbl_NEWsAVPU	Categorical	NEWS minus AVPU at admission for use in calculating CFS (1=0, 2=1-4, 3=5-6, 4=7+, 5=unknown)	pt info	-
lbl_outlierdata	Binary	Indicator if simulated patient sampled to become a medical outlier.	pt info, Route	-
lbl_PatNum	Categorical	Unique patient number for all attendances.	pt info	Proc_BedDrop, Proc_End
lbl_PreviousDestination	Categorical	Indicating patient previous location in the model.	CDU, AMUamb,	Proc_PreAdmRoute, Proc_route,

Label name	Type	Function	Workstations where label is used	Procedures where label is used
			AMU, GMW, Change Bed, Death	Proc_DecisionRules, Proc_Discharge, Proc_End, Proc_LongTerm
lbl_priority	Continuous	Rank priority of patients in same queue by certain variable (e.g. patients queuing into AMU have following priority based on their current location: 1=CDU, 2=ED, 3=Ambulatory AMU)	-	-
lbl_QALYS	Continuous	Simulated patient running total quality adjusted life years.	-	Proc_End, Proc_LongTerm
lbl_QOLTE	Binary	Indicating if patient should have a quality of life treatment effect applied.	GMW	Proc_LongTerm
lbl_ResultsPat	Binary	Indicates if patient came in during results collection period (rather than the burn-in or cool-off periods).	pt info, Route, Discharge locations(d)	Proc_BedDrop
lbl_route	Categorical	Next location in patient pathway	CDU, AMUamb, AMU, GMW	Proc_PreAdmRoute, Proc_NEWS, Proc_LOS, Proc_route, Proc_DecisionRules, Proc_DischargeProfile, Proc_BedDrop, Proc_End
lbl_RouteAdjust	Binary	Indicating if patient should have route adjusted based on a treatment effect (removing, for example, an ICU stay from their pathway).	AMU, GMW	Proc_route
lbl_sdLOS	Continuous	Standard deviation length of stay for current location to create distribution to sample length of stay.	-	Proc_LOS(c)
lbl_StayCost	Continuous	Total cost of bed days (all locations)	ED,	Proc_BedDrop,

Label name	Type	Function	Workstations where label is used	Procedures where label is used
			CDU, AMUamb, AMU, Death	Proc_LongTerm
lbl_SurgicalAdm	Binary	Indicating if simulated patient was a surgical admission.	Non-medical	Proc_PreAdmRoute, Proc_End
lbl_TimeBedEntered	Continuous	Exact minute of the year patient picked up current resource (entered current bed).	-	Proc_DecisionRules, Proc_BedPickUp, Proc_BedDrop,
lbl_TimeRemaining	Continuous	Time remaining in sampled length of stay for current location.	-	Proc_DecisionRules
lbl_TotalLOS	Continuous	Total hospital length of stay	Discharge locations(d)	Proc_BedDrop
lbl_wait	Continuous	Exact minute of the week patient enters model from weekly distribution.	Set wait	

(a) Used in queues to all workstations
(b) Used in all workstations that represent an area of the simulated hospital, indicates how long simulated patient should spend in that workstation
(c) Also used within the distribution distLOS to sample for lbl_LOS
(d) All locations where simulated patient exits model: Usual res, Care home, NHS service, Other discharge, Non-medical, Death

1 **Table 75: Model workstations**

Object	Description	Procedures called	Resources	Enter from	Exit to
Start points					
Walk_amb	Arrival mode. One batch of patients enter per week. Arrival mode captured by label.	None	None	n/a	set wait
Referrals	Arrival mode. One batch of patients enter per week. Arrival mode captured by label.	None	None	n/a	set wait
Direct admissions	Arrival mode. One batch of patients enter per week. Arrival mode captured by label.	None	None	n/a	set wait
Pre-admission - general					
set wait	Sets wait time until arrival into hospital sampled from arrival hour distribution dependent on ED or ambulatory arrival.	None	None	Start points	pt info
pt info	Calculate if patient will be admitted (admit includes movement to CDU, discharge includes movement to ambulatory AMU), patient age and patient NEWS. Route out on arrival mode label.	None	None	set wait	Pre-admission locations
Pre-admission locations*					
ED	Preadmission route (preadmission, admitted wards, discharge locations). ED length of stay. Counts if patient breaches 4 hour target. Labels patient as direct admission.	Proc_PreAdmRoute Proc_LOS	ED Bed. Assigned in workstation. Wait in queue if not available.	pt info	Route

Object	Description	Procedures called	Resources	Enter from	Exit to
AMUamb	Decides whether admitted or discharged (0.84 calculated from data, meaning 84% discharged). Sets discharge area based on ED discharge locations. Those that are admitted go to AMU. Counts number of admissions and gives patient an admitted patient number. Labels patient as direct admission.	None	AMUamb Bed. Assigned in bed workstation. Wait in queue if not available.	pt info	Route
CDU	Preadmission route (preadmission, admitted wards, discharge locations). CDU length of stay. Labels patient as direct admission.	Proc_PreAdmRoute Proc_LOS	CDU Bed. Assigned in bed workstation. Wait in queue if not available.	pt info	Route
Admissions - general					
Route	Moves patient to next location. Routes out using lbl_route, which was assigned at previous destination. Re-categorises those in data who were medical outliers as GMW.	None	None	Preadmission locations Admission locations	Preadmission locations Admission locations Discharge locations Death
Admission locations*					
AMU	Calculate next destination, LOS, changing NEWS. Counts number of AMU patients and AMU overall LOS.	Proc_route Proc_LOS Proc_NEWS	AMU Bed. Assigned in bed workstation. Wait in queue if not available.	Route	Route

Object	Description	Procedures called	Resources	Enter from	Exit to
GMW	Calculate next destination, LOS, changing NEWS.	Proc_route Proc_LOS Proc_NEWS	GMW Bed. Assigned in bed workstation. Wait in queue if not available.	Route	Route
Outlier	Calculate next destination, LOS, changing NEWS. Counts number of outliers created in the simulation.	Proc_route Proc_LOS Proc_NEWS	Outlier Bed. Assigned in bed workstation. Wait in queue if not available.	Route	Route
Rehab	Calculate next destination, LOS, changing NEWS.	Proc_route Proc_LOS Proc_NEWS	Rehab Bed. Assigned in bed workstation. Wait in queue if not available.	Route	Route
ICU	Calculate next destination, LOS, changing NEWS.	Proc_route Proc_LOS Proc_NEWS	ICU Bed. Assigned in bed workstation. Wait in queue if not available.	Route	Route
HCU	Calculate next destination, LOS, changing NEWS.	Proc_route Proc_LOS Proc_NEWS	HCU Bed. Assigned in bed workstation. Wait in queue if not available.	Route	Route
Change bed	Changes resource used for patients waiting for a rehab ward bed when determined by decision rule.	None	Change from current bed to GMW bed	Queue to rehab	Queue to rehab
Discharge locations					

Object	Description	Procedures called	Resources	Enter from	Exit to
Non-medical	Discharge location. Records discharge location and runs end procedures.	Proc_Longterm Proc_End	None	Route	end
Care home	Discharge location. Records discharge location and runs end procedures.	Proc_Longterm Proc_End	None	Route	end
Usual res	Discharge location. Records discharge location and runs end procedures.	Proc_Longterm Proc_End	None	Route	end
NHS service	Discharge location. Records discharge location and runs end procedures.	Proc_Longterm Proc_End	None	Route	end
Other discharge	Discharge location. Records discharge location and runs end procedures.	Proc_Longterm Proc_End	None	Route	end
Death	End location. Records end location and runs end procedures.	None	None	Route	end

** Each pre-admission and admission location has two workstations (e.g. AMU and AMU bed); one to pick up the bed and a second that performs the other calculations.*

Table 76: Procedures

Procedure	Details
Proc_LOS	Set length of stay for patient for current area. If ED, based on next destination. If CDU, based on admitted or discharged. If wards, based on age, NEWs and next destination. Set LOS as mean LOS if there is no SD. If there is SD, sample from distribution.
Proc_NEWS	Change NEWS score based on current location and next destination. Updates lbl_NEWS and lbl_casemix.
Proc_PreAdmRoute	Decide if admitted patients go to CDU or ward and if discharged go to ambulatory AMU or discharge locations. Decides what ward or discharge location as necessary. Counts number of admissions and gives patient an admitted patient number.
Proc_quarter of year	Sets quarter of the year based on day of year in simulation. Changes number of arrival per week distribution based on quarter of year, which is in turn sampled from to generate the number of attendances at the start of each week.
Proc_route	Sets next destination based on case mix, current location and direct/subsequent admission sets lbl_direct to show next wards are subsequent stays. Used by inpatient wards.
Proc_set_index	Sets index number of work stations and queues from ssActivityInformation (spreadsheet of each workstation and queue within the model and the desired index number to make them identifiable in code).
Proc_BedDrop	Called when exiting bed. Calculates length of stay and applies cost for bed used.
Proc_BedPickUp	Called when entering bed. Records type of bed (e.g. AMU) and attaches to lbl_BedHeld
Proc_DecisionRules	Called when wait time expires in queue/decision rule needs to be implemented. Carries out decision rules (outlined elsewhere)
Proc_Discharge	Called when patient being discharged. Records results relating to discharge: discharge location, ward discharged from, discharge case mix.
Proc_DischargeProfile	Called when patient being discharged. Recalculates what time the patient should be discharged to fit with the discharge distribution from data.
Proc_End	Called as patient leaves model. Records all key variables into results spread sheet.
Proc_Longterm	Called as patient leaves model. Calculates post hospital mortality, QALYs and cost.

Appendix H: Additional simulation model results

Work in progress - to be added after consultation

Appendix I: Unit costs

This appendix contains unit costs presented to the committee to aid their consideration of cost effectiveness. These unit costs were not necessarily used in the models.

Table 77: Unit costs of staff time

Health care professional	Costs per hour	Notes
Medical Consultant	£140	
Surgical Consultant	£142	
Associate Specialist	£124	
Registrar	£61	Weighted average unit cost across 3 categories of working hours (40-hour week, 48-hour week and 56-hour week).
Foundation House Officer 2	£41	
Foundation House Officer 1	£39	
Nurse (24-hour ward)	£44	Includes staff nurse, registered nurse and registered practitioner.
Nurse team leader	£49	Includes deputy ward/unit manager, ward team leader and senior staff nurse.
Paramedic (qualified)	£33	
Community based GP	£195	Patient contact, includes direct care staff cost. Does not include travel.
Hospital pharmacist	£48	
Hospital physiotherapist	£38	
Hospital occupational therapist	£36	
Social worker	£57	

Source: Unit costs of health and social care 2014{Curtis, 2014 CURTIS2014 /id} including salary, salary-on-costs, overheads, qualifications and training (for non-consultant staff).

Table 78: Unit costs of emergency department attendances

	Mean unit cost	Notes
ED admitted	£138	Weighted average for type 01 (Emergency departments), Type 02(consultant-led monospeciality A&E departments) and Type 03(Other types of A&E or minor injury [include minor injury units and urgent care centres]). Patients who are admitted for further investigation and treatment rather than discharged from A&E.
ED non-admitted	£114	Weighted average for type 01 (Emergency departments), Type 02(consultant-led monospeciality A&E departments) and Type 03(Other types of A&E or minor injury [include minor injury units and urgent care centres]). Patients who are not admitted but are discharged or die whilst in A&E.
Minor injury units/urgent care centre visit	£67	Weighted average for Type 03 (other types of A&E or minor injury [include minor injury units and urgent care centres]). Either stand-alone or co-located but reported separately from the ED activity.
Walk-in centre visit	£46	Weighted average for Type 04 (walk-in centres). Walk-in centres are defined as predominantly nurse-led primary care facilities dealing with illnesses and injuries - including infections and rashes, fractures and lacerations, emergency contraception and advice, stomach upsets, cuts and bruises, or minor burns and strains - without the need to register or make an appointment. They are not designed for treating long-term conditions or immediately life-threatening problems.

Source: National Schedule for Reference Costs 2013-2014{Department of Health, 2014 NHSREFCOSTS2014 /id}.

Table 79: Unit costs of relevant hospital admissions

	Mean cost per finished consultant episode (FCE)	Notes
Non Elective Inpatients - Short Stay	£588	Length of stay is equal to 1 day. {Department of Health, 2014 DH2014 /id}
Non Elective Inpatients - Long Stay	£2,806	Length of stay equal to 2 or more days{Department of Health, 2014 DH2014 /id}.
Non Elective Inpatients - Excess Bed Day	£296	Costs not including high cost drugs, critical care, rehabilitation or specialist palliative care{Department of Health, 2014 DH2014 /id}.
Hyper acute stroke unit	£583	Per diem cost, National Audit Office 2010{National Audit Office, 2010 NATIONALAUDITOFFICE2010 /id}.
Acute stroke unit	£231	Per diem cost, including only the costs associated with the ward cost pool group and any other relevant costs such as blood tests, drugs, dressings or therapies{Department of Health, 2014 DH2014 /id}.
Critical care	£1,262	Per diem, weighted average cost. HRG codes for adult critical care patients (codes CC01 to CC91).

Source: National Schedule for Reference Costs 2013-2014{Department of Health, 2014 NHSREFCOSTS2014 /id}except where stated.

Table 80: Unit costs of condition specific hospital admissions

	Non-Elective Inpatients-short stay	Non-Elective Inpatients- long stay	Notes
Pneumonia	£484	£2,587	HRG codes: DZ11D to DZ11J (Lobar, Atypical or Viral Pneumonia, with CC Score0 to 15+).
GI bleeding	£461	£1,824	HRG codes: FZ38G to FZ38P (Gastrointestinal Bleed without Interventions, with CC Score 0 to 9+ and Gastrointestinal Bleed with Interventions, with CC Score 0 to 9+).
Syncope	£422	£1,524	HRG codes: EB08A to EB08E (Syncope or collapse with CC score 0-3 to 13+).
MI	£561	£2,244	HRG codes: EB10A to EB10E (Actual or suspected MI with CC score 0-3 to 13+).
Unspecified chest pain	£404	£1,146	HRG codes: EB12A to EB12C (unspecified chest pain with CC score 0-4 to 11+).
Angina	£442	£1,433	HRG codes EB13A to EB13D (Angina with CC score 0-3 to 12+).

Source: National Schedule for Reference Costs 2013-2014 {Department of Health, 2014 NHSREFCOSTS2014 /id}

Table 81: UK costs of diagnostic tests and referrals

Staff type	Unit cost
X-ray	£30
Biochemistry	£1
Haematology	£3
Microbiology	£7
Electrocardiography	£52

Source: NHS National Schedule of Reference Costs{Department of Health, 2014 NHSREFCOSTS2014 /id}

Table 82: Unit costs for ambulance service

Currency Description	Activity	National Average Unit Cost	Lower Quartile Unit Cost	Upper Quartile Unit Cost	No. Data Submissions
Calls	8,926,215	£7	£6	£8	11
Hear and treat or refer	400,005	£44	£37	£44	11
See and treat or refer	2,113,757	£180	£155	£188	11
See and treat and convey	5,069,806	£231	£206	£254	11

Source: NHS National Schedule of Reference Costs{Department of Health, 2014 NHSREFCOSTS2014 /id}