Reviewing Equitable Access to healthCare outcomes out of Hours and at the weekend (REACH) Project

A review of health outcomes for patients admitted out of hours and at the weekend: is there an effect and what are the characteristics and contributing factors?

Queensland Government

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Forward

Does a patient admitted out of hours and at the weekend receive the same level of care as someone admitted during the week?

It's a question healthcare providers have long asked, but there has been no definitive answer. The *Reviewing Equitable Access to healthCare outcomes out of Hours and at the weekends* (REACH) Project aims to address the challenge of seven-day healthcare delivery from a Queensland perspective through analysis of existing research, safety and quality data, and anecdotal evidence from clinicians.

This systematic review of literature provides a strong foundation for a Queensland wide data-linkage project that further examines the issue with the CSIRO. By understanding the variation in healthcare outcomes, we can examine strategic opportunities to provide the very best care available at any time.

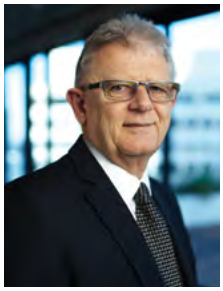
The REACH Project has been an important collaboration between Metro North Hospital and Health Service, Queensland Clinical Senate and Clinical Excellence Division, Queensland Health. It furthers our understanding of the nature of healthcare outcomes for patients admitted to public hospitals out of hours and at weekends.

Through this study, we have found that a number of factors – protective care mechanisms, staffing profiles and system efficiencies – may be key to understanding why one patient has better outcomes than another regardless of their admission day.

I commend the Queensland Clinical Senate and Metro North Hospital and Health Service for undertaking this important piece of work to ensure equitable healthcare access for all Queenslanders.

Ken Whelan

Metro North HHS
Executive Officer



Dr John Wakefield PSM

Deputy Director,
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Executive Summary

This review was commissioned by the Queensland Clinical Senate in 2015, in partnership with the Clinical Excellence Division, Queensland Health and Metro North Hospital and Health Service, to inform research into health outcomes for patients admitted to Queensland hospitals out of hours and to influence the future development and implementation of best practice models of care. The objectives which guided the review were:

- To identify and analyse the factors that influence inequality of health outcomes to patients admitted/presenting to hospital out of hours and at the weekend.
- To identify the range and scope of services or other interventions specifically targeting inequality of health outcomes of patients admitted/presenting to hospital out of hours and at the weekend.
- To identify care processes that have demonstrably reduced the inequality of health outcomes for patients admitted/presenting to hospital out of hours and at the weekend.
- To identify the potential application of the review findings in the Queensland setting and areas requiring further research.

Overall, there is mixed evidence of inequitable outcomes for patients admitted out of hours, based predominantly on retrospective analysis of large administrative data sets. Clinical dataset analyses, which were often adjusted for severity of illness, are less supportive that differential outcomes exist. Where evidence does exist, it is limited to a small mortality differences, is condition specific so not generalisable across conditions and fails to address other morbidity or patient reported qualitative outcomes. Since a landmark study in 2001,[4] over 100 papers have explored the difference in outcome across a range of patient populations and health systems.

Published literature in the area identifies a range of human resource, system and process considerations that may improve outcomes for patients admitted at these times. Many contributing factors are identified as being associated with or mitigating against differential mortality for patients admitted out of hours. These were generally hypothesised through the expert analysis by researchers when discussing their findings, rather than definitively tested to determine causality or multifactorial causal linkages. No published pre-and-post intervention studies could be identified, by this review, which specifically examined the impact on mortality that a given intervention, for example timeliness to investigation, treatment, models of care or staffing, may have had if a differential outcome had previously been identified.

There are a number of limitations of the largely descriptive and retrospective studies included in this review making definitive recommendations from the literature difficult to make. In part, the questions that guided the review remain unanswered highlighting a number of gaps in our current knowledge. No studies identified any mechanisms that specifically targeted addressing unequal outcomes as a result of out of hours admission. Any methodological limitations, and the opportunity to explore patient outcomes beyond mortality differences, were noted as part of the review and have provided guidance to the development of a Queensland based data linkage outcome study which is under way. Whilst mortality remains an important quantitative patient outcome differential, any demonstrable differences will be broadened and viewed in the context of patient experience, staffing profiles and non-mortality patient outcome measures.

The authors of this report have been wholly responsible for all data collection, analysis, interpretation and manuscript preparation in consultation with the REACH Project Steering Committee and Research Advisory Group. The findings of the review highlight the gaps in the literature regarding where improvement efforts should be targeted to reduce outcome variation, to then stimulate health services research into the impact of newly implemented interventions that will ultimately better inform strategic planning around the delivery of out of hours care.

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Abbreviations

AAA	Abdominal Aortic Aneurysm
ACS	Acute Coronary Syndrome
AE	Acute Epiglottis
AF	Atrial Fibrillation
AKI	Acute Kidney Injury
AMI	Acute Myocardial Infarction
ATC	Acute Traumatic Coagulopathy
AusHSI	Australian Centre for Health Services Innovation
AVH	Acute Variceal Haemorrhage
BP	Blood Pressure
CABG	Coronary Artery Bypass Graft
CAP	Community Acquired Pneumonia
CCU	Critical Care Unit
CHF	Congestive Heart Failure
CI	Confidence Interval
CMR	Crude Morbidity Rate
COPD	Chronic Obstructive Pulmonary Disease
CSC	Comprehensive Stroke Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DNT	Door to Needle Time
DRG	Diagnosis Related group
ECG	Electrocardiogram
ED	Emergency Department
EGD	Esophagogastroduodenoscopy (upper GI endoscopy)
EVH	oEsophageal Variceal Haemorrhage
GI	Gastrointestinal
GWTG	Get With The Guidelines (stroke program)
HDU	High Dependency Unit
HF	Heart Failure
Hip #	Hip Fracture
H&M	Haematemesis and Malaena

HR	Hazard Ratio
ICH	Intra Cerebral Haemorrhage
ICU	Intensive Care Unit
IWH	In Working Hours
HDU	High Dependency Unit
LoS	Length of Stay
MACE	Major Adverse Cardiac Events
MELD	Model End Stage Liver Disease
MI	Myocardial infarction
MNHHS	Metro North Hospital and Health Services
NHS	National Health System
NIHSS	National Institutes of Health Stroke Scale
NSTEMI	Non-ST Segment Elevation Myocardial Infarction
OR	Odds Ratio
OWH	Out of Working Hours
PCI	Percutaneous Coronary Intervention
PE	Pulmonary Embolism
PICU	Paediatric Intensive Care Unit
PR	Pulse Rate
QCS	Queensland Clinical Senate
REACH	Reviewing Equitable Access to healthCare out of Hours and at the weekend
RR	Risk Ratio
SAH	SubArachnoid Haemorrhage
SDH	Subdural Haematoma
SMR	Standardised Mortality Ratio
STEMI	ST-Elevation Myocardial Infarction
TIA	Transient Ischemic Attack
T-PA	Tissue Plasminogen Activator
UGIB	Upper Gastrointestinal Bleeding
UGIH	Upper Gastrointestinal Haemorrhage

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Chapter 1: Background

Differences in out of hours admissions compared to working hours

The challenge of delivering care to achieve equitable outcomes whether patients are admitted during the week, at night or at the weekend has been the focus of a growing body of research. Although higher mortality has been reported for babies born at the weekend than for those born during the week in the USA[1], the UK[2] and Australia[3] since the 1970s, the first investigation of the differential outcomes for patients admitted out of hours in other areas was not reported until 2001.[4]

Since then, international research has investigated the possible dangers of out of hours admissions. In more recent times, the issue has become politicised in some jurisdictions and policy makers, health system managers and clinicians have been increasingly interested in the potential risks involved for patients admitted out of hours. The growing body of evidence suggesting outcome differences for patients admitted out of hours remains largely observational, and more recently has matured to include improved risk adjustment methodology, and consideration of patient acuity measures so as to better understand the often contradictory findings.

The aim of the review is to identify whether in fact there is a unequal outcomes for patients admitted out of hours and examines the potential underlying causes of differential health outcomes for patients admitted out of hours. Stemming from this are a range of human resource, system and process considerations that may improve outcomes for patients admitted at these times. More specifically, the reviewers sought to identify any published interventions to address a difference in outcome, had it been present, to obtain a thorough understanding of our current knowledge, practice and experience for health outcomes of patients admitted out of hours.

This synthesis of the literature was commissioned by MNHHS on behalf of the QCS to examine evidence around the risks involved in being admitted to hospital out of hours.

The review is a precursor to, and informs commissioned health outcomes research being undertaken by the CSIRO examining linked hospital data from April 2013 to December 2015 including, workforce, patient experience and death registry data from Queensland. AusHSI has also been engaged to undertake health economic analysis of areas showing differential outcomes to assist in policy formulation for the modification of out of hours health provision across Queensland.

The objectives which guided the review are:

- To identify and analyse the factors that influence inequality of health outcomes to patients admitted/presenting to hospital out of hours and at the weekend.
- To identify the range and scope of services specifically targeting reducing the mortality of patients admitted /presenting to hospital out of hours and at the weekend.
- To identify care processes that have been demonstrated to reduce the inequality of health outcomes for patients admitted/ presenting to hospital out of hours and at the weekend and evaluate their effectiveness.
- To identify the potential application of the review findings in the Queensland setting and areas requiring further research.

Chapter 2: Criteria for considering studies for this review

Types of studies

Research studies and systematic reviews conducted from 1995 through to 2015 were considered.

Our aim was to provide a broad overview of the existing evidence base in the context that intervention studies, that reduced the inequality of health outcomes for patients admitted out of hours were the initial focus of our search criteria. The criteria that were applied to structure the review process are discussed below.

We have concentrated on identifying and synthesising the key evidence using a focused, policy relevant framework to keep the tasks relevant and manageable. Framework-based synthesis has been identified as an efficient method for synthesising evidence to inform policy within relatively tight time constraints.[5] Due to the lack of intervention studies, per se, any administrative and clinical research for out of hours admissions were then included.

A systemised approach was used to ensure the efficient identification and synthesis of the most relevant evidence. The multiple dimensions covered by the review questions posed a challenge to the process. This challenge was further complicated by the fact that out of hours admission research encompassed a spectrum from population-based literature (for a heterogeneous mix of clinical conditions) to clinically based literature (for specific or mixed patient populations).

As a consequence, there was a huge pool of related literature. The review did not attempt to identify all such related evidence; instead we have used a structured search approach to identify the key evidence. The data extraction and quality assessment, of selected papers, have focused on the most critical information for evidence synthesis rather than aiming to exhaustively extract and critique all the available information in individual papers. We have not appraised the evidence in terms of how future services should be provided nor make recommendations about service configurations. A copy of the project plan that provides detailed description of the review methods is provided in *Appendix 1*.

Search strategies

Because of the broad and diverse nature of the review topic, a search strategy was developed and was cycled through a number of iterations in order to maximise comprehensiveness and precision. A variety of search methods were undertaken in order to identify relevant evidence for the review question in a timely fashion. This search aimed to find studies that evaluate the mechanisms that address inequality of healthcare delivery and outcomes out of hours. Key issues for consideration were access to services, appropriate management of patients, service delivery, and models of delivery and clinically appropriate treatment of patients. Limits were applied for time periods specified. Additional search terms were identified from papers discussed with practitioners and the project Research Advisory group. Searches were conducted in two stages with a general search on PUBMED run for each area prior to combining with the below detailed strategies as follows:

Stage 1: general search on PUBMED.

Stage 2: targeted database searches around concepts were:

The **condition / domain search strategy** of the core areas of out of hours; hospital; study design and outcomes. The general structure of combining following relevant terms was used:

Population: Users of the range of healthcare services presenting or admitted to acute care facilities outside of hours.

Exposure: Delivery of acute care services that addresses the inequality of healthcare outcomes for patients admitted out of hours.

Comparator(s) (control): Users of the range of healthcare services presenting or admitted to acute care facilities within regular working hours.

Outcomes: *Processes* – appropriateness of level of care, adverse events;
Patient outcomes – patient experience and satisfaction, decision making, cost consequences and cost-effectiveness.

The **concepts** and possible synonyms **(search terms)** considered were:

Concept: Out of hours and at the weekend. 24/7 model; 7-day care; 7-day health; 7-day services; after hours; day of week; late in week; night care; night time; night time; off-hours; off shift; out of hours; round the clock; utilisation; weekend; weekend service.

Concept: Hospital & Departments. acute; allied health; care; chemotherapy; elective; emergency department; endoscopy; health care; hospital; intensive care; intracranial haemorrhage; medical; microbiology; myocardial infarction; nursing; operating theatre; pathology; PCI; radiology; rehabilitation; service/s; STI; stroke; surgery/surgical; trauma; unit; unscheduled; unscheduled; ward.

Concept: Study design. cohort study/studies; longitudinal study/studies; follow up studies; prospective study/studies; retrospective study/studies; prevalence study/studies; incidence study/studies; transversal.

Concept: Outcomes. assessment; clinical governance; co morbidity; criteria led discharge; discharge; equity; governance; intervention; medical error; models of care; morbidity; mortality; patient harm; patient safety.

Inclusion and exclusion criteria

We have included both quantitative and qualitative empirical evidence in the review where relevant. Both Australian and international evidence has been included to ensure that alternative models of out of hours healthcare delivery designed to address the same objectives set out in the QCS Review are considered. We have only included published peer reviewed evidence in order to ensure that we have synthesised evidence that has already undergone methodological and expert scrutiny. Evidence was limited to include the years from 1995 to 2015 to ensure the evidence assessed has context and relevance to current policy and practice, as it was assumed clinical systems and service delivery has substantially changed over time.

We have used a core set of inclusion and exclusion criteria:

Inclusion criteria: empirical data (all study designs); independent variable of interest was out of hours acute health care; report relevant outcomes; written in English and published between 1995 and 2015.

Exclusion criteria: descriptive studies with no assessment of an outcome; opinion pieces and editorials; non-English language papers; conference abstracts.

Studies identified through these searches that were clearly not relevant to the issues under the review were eliminated. Two reviewers independently assessed citations for eligibility. Those thought to fulfil the selection criteria were re-tried in full. Where a judgement could not be made based on the citation, or when consensus could not be reached regarding eligibility the full article was obtained to enable a more comprehensive assessment.

A detailed description of the search strategy is provided in *Appendix 2*. The search retrieved a large number of results and refinements were made to the search to reduce this number.

Retrieved records were imported into EndNote (Thomson and Reuters).

Data extraction

A standard data extraction was developed. Data extraction from the papers selected for two reviewers performed the review independently without blinding to authorship or journal publication and results confirmed. If differences were identified they were resolved by discussion.

The approached utilised involved 3 stages:

1. **Title (eye-balling):** Screened titles for relevance (including check for duplicates) to the aims of the study.

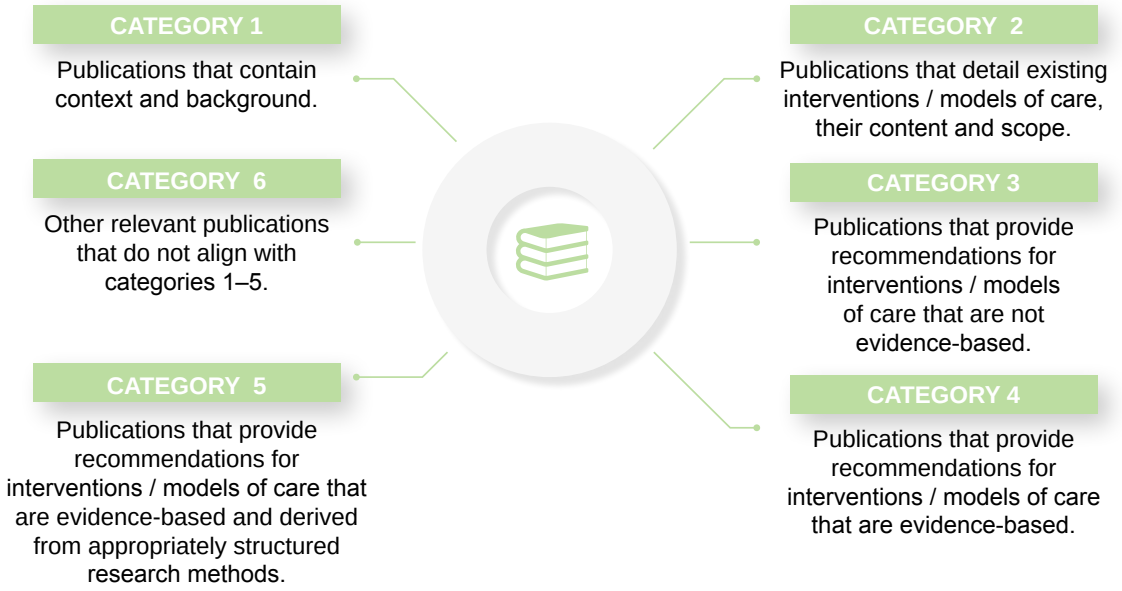
   Reference titles were scanned to identify contributions to the definition, criteria, components and conceptual framework of models of care targeting the identified causes of inequitable outcomes for patients admitted out of hours. All searchers were run in PUBMED (incl. MEDLINE); EMBASE and Scopus (via Ovid); Emerald Insight, Cumulative Index to Nursing and Allied Health Literature (CINAHL (incl. PsycInfo); via EBSCOhost) and The Cochrane Library (via Wiley Online Library). Focussed review on the contents of national and international medicine, quality safety, health and economic journals and theses were undertaken with the assistance of ‘advanced’ Google search, Proquest Dissertations and Theses Global. Additional references were identified though examination of references manually from the most recent publications from specific journals and through scrutiny of contents pages of highly relevant journals for the last three years including: British Medical Journal (BMJ); Journal of America Medical Association (JAMA); New England Journal of Medicine, BMJ Quality & Safety; Critical Care Medical Journal; Emergency Medical Journal, Medical Journal of Australia, The Lancet and Canadian Medical Association Journal.

Abstract Review: Included abstracts were then screened for significance (& utility) (impact) to the aims of the study.

Articles included were those that appeared to make a significant contribution to the literature around the health outcomes of those admitted out of hours. That is, for an article to be included it had to provide evidence to either support the background (content and scope), or the factors contributing to inequality of health for people admitted out of hours. It was also included if it provided an analysis of the strategies/ interventions or models of care shown to effect the inequality of health for patients admitted/presenting to the hospital out of hours. Studies that were excluded at this stage were recorded with a short explanation for the exclusion.

Reviewers assessed the abstracts based on the following:

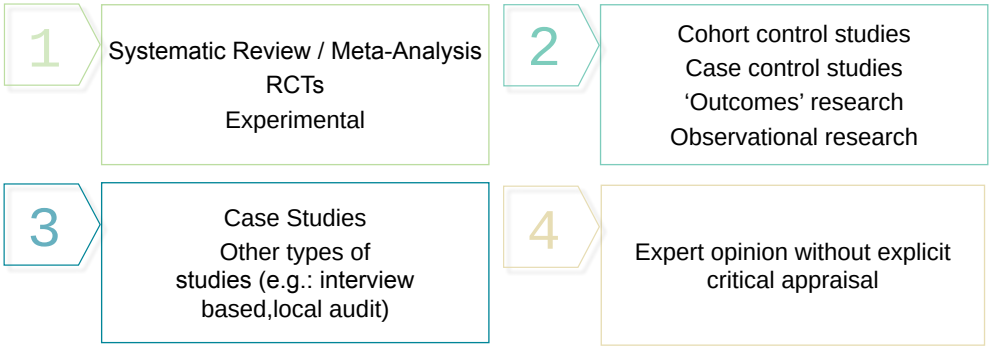
Figure 1: Quality assessment criteria for assessment of abstracts



2. **Full Text Review:** We analysed the full text of publications for their contribution (significance) and included those that met the objectives of the study.

   Articles included were those that appeared to have a robust underlying logic from which the investigators were confident that conclusions may be drawn. The assessment of the evidence was performed by two reviewers independently. In case of disagreement consensus was sought via discussion, and in case of further disagreement a third party was consulted. Reviewers assessed the full text format for their contribution towards objectives of the project. Reviewers assessed the full text based on the following:

Figure 2: Evidence hierarchy for assessment of the full text articles



This framework has provided a clear structure with which to guide the review while retaining the flexibility that has allowed the development of defining the scope of the search strategies, defining inclusion and exclusion criteria to specify what types of studies will be included.

All data extraction was carried out directly into summary tables rather than detailed data extraction forms, which would subsequently require summarising. The research was highly heterogeneous therefore a simple, yet inclusive template to summarise the key characteristics and findings from each individual paper was used. The table summarised the study design used, population and setting, main purpose and objectives including outcomes measures and key findings and conclusions (including limitation and implications).

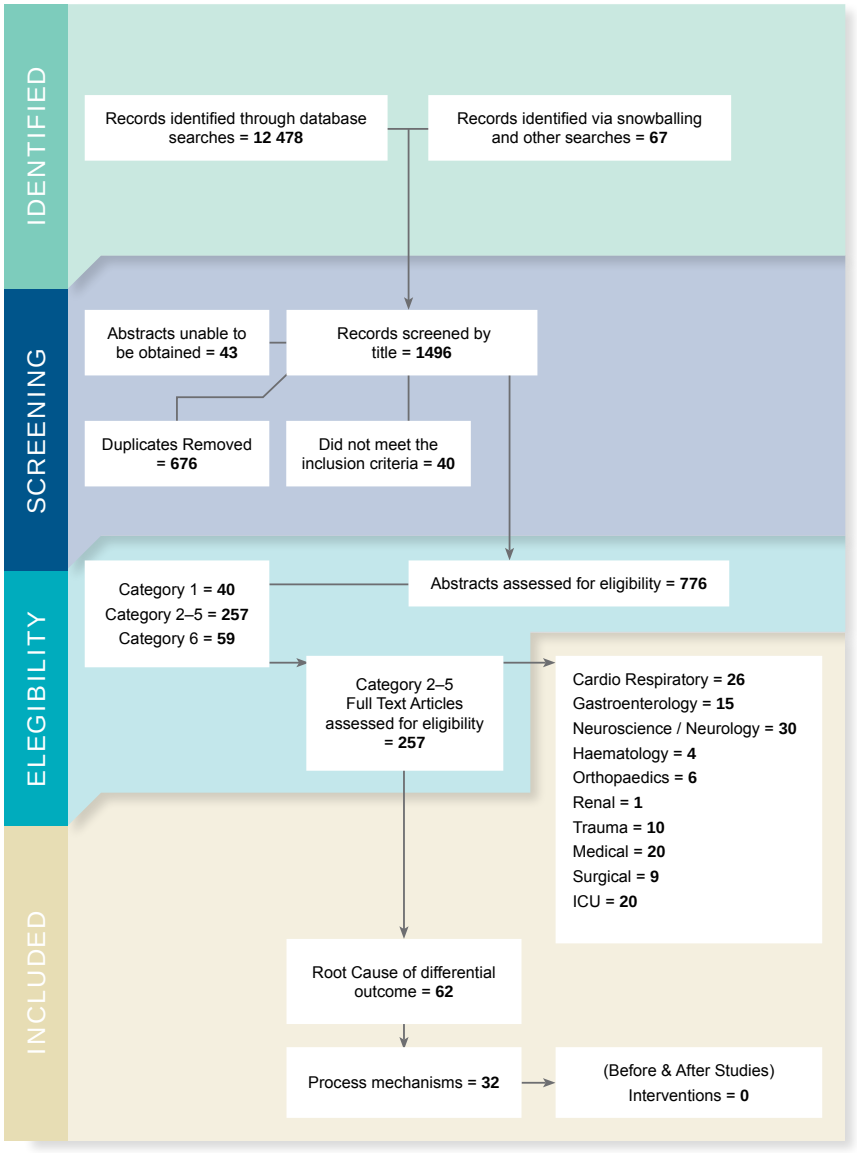
Quality review

The reviewers were also careful to ensure important contextual information was understood. For example, data definitions, outcome measures, quality of analysis and reporting, the country and health system in which the research was conducted, and whether the research was single-site, multi-site or population based. Existing systematic reviews were also contributory. Literature was then grouped according to themes, both by condition type and for likely factors that may influence out of hours outcomes. A brief narrative commentary was then provided, to complement tabulated summaries, for each grouping, to allow readers the opportunity to explore specific evidence as required.

We have presented the review describing methods, an appraisal and summary of the existing evidence and any evidence gaps identified which are likely to be critical to further development of broader out of hours healthcare delivery strategies. This includes where additional, more detailed, topic specific reviews could be of value or where more primary research is needed, for example on a larger scale to provide definitive evidence on effectiveness.

The results of the review sifting process are given in *Figure 3.*

Figure 3: A Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow diagram for out of hours



Chapter 3: The size and consequence of differential outcomes for patients admitted to hospitals out of hours and at the weekend

The main focus of this review is assessment of the evidence relevant to the QCS Review to identify the underlying causes of differential health outcomes of patients admitted out of hours. However, to provide context we have presented a short overview of the current state of knowledge of the characteristics and drivers that underpin any potential inequality of healthcare outcomes and out of hours.

Mortality rates

Mortality, which was variably defined (in terms of days post admission) between papers, is the most often reported metric against which a difference is assessed. There is conflicting evidence from the literature examined as to whether mortality is in excess out of hours. There are two principal schools of thought as to whether this reflects lower quality care or other differences in patient acuity and or severity. Care quality is a complex endpoint of human resource, system and process differences that exist Monday to Friday (during the day) to other times. The idea has been supported in the literature by large scale trials, which examine administrative data suggesting that case mix-adjusted mortality rates are higher for patients admitted to hospital out of hours (with most focussing on weekends). [6–18] Other studies seem to debunk the idea identifying mixed or no adverse effects from out of hours admission. [4 19-37] A breakdown of these variables are summarised in *Appendix 3*.

Treatment delay

It may be assumed that treatment delays would be associated with adverse outcomes in patients admitted out of hours. Whilst some studies do show an inequitable outcome (morbidity and mortality) [38-54] for treatment delays characterised by delay in admission, delayed evaluation in the emergency department, delays in initial evaluation to patients experiencing longer times to consultation and arrival during shift changes others did not discover the impact as a result of admission timing. [19 20 55-66] A breakdown of these variables are summarised in *Appendix 4*.

Morbidity rates

From the limited information available, for patient morbidity, the results are again mixed. A number of studies indicate a discrepancy in patient care, especially for those requiring time-sensitive management, [22 33 59 67-72] care was compromised out of hours to the extent that patients became unnecessarily vulnerable out of hours. Other studies, however, have shown different outcomes depending on the condition for which the patient was being admitted. These discrepancies emphasise the importance in considering the impact of factors such as staffing, [68 73-74] overall hospital activity, [26 48 70 75-79] seniority and experience of staff, [16 21 52 80] access to services [81-84] in addition to patient comorbidities.

Length of Stay

Length of stay (LoS) is often an indicator for poorer outcomes and increased mortality. Again, the results are mixed with some researchers finding a difference in LoS for patients admitted either out of hours. [10 40 47 50 54 73 85-88] In particular, Freemantle (2012) [10] investigated 30-day mortality and LoS for patients admitted Monday-Friday was 1 day, but for Saturday-Sunday it was 3 days. However, a number of papers [19-21 27 33 35 37 38 56 78 89-94] have not found any differences with the researchers concluding that patients were generally sicker and faced an increased likelihood of stay in-hospital, as well as death, even when severity of illness was taken into account. A breakdown of these variables is summarised in *Appendix 5*.

Readmission rates

It is not disputed that the timing of when services are delivered to patients' care can affect outcomes. Some studies have analysed the consequences of discharges out of hours compared to those during the day, [84 95] however no studies were found as part of the review that investigated the magnitude of readmission rates for patients initially admitted out of hours. It is generally recognised that fewer discharges are made out of hours, perhaps because of decreased staffing or the cross coverage of patients during these times.

Politics

The recent politicisation and system wide policy changes, in some jurisdictions, in response to earlier research that identified a difference in mortality out of hours has further clouded the issue. In particular, public policy attempting to provide a more consistent 7-day health service relied on research finding higher rates of in-hospital death following admission at the weekend compared to Wednesday admissions (1.10 and 1.15 for Saturday and Sunday respectively). [11] The UK government, for example, sought to implement major changes to the industrial framework for clinical staff working in the NHS. Complicating matters further are the questions surrounding what causes differential outcomes, if it does exist; due to the emergence of recent evidence and expert opinion after the policy changes were already put in place.

Costs

Attempts to quantify the costs and benefits of introducing 7-day services in response to the purported higher death rates for out of hours admissions is beginning to be undertaken in the literature [96] with conclusions that as yet there is little evidence that the planned costs of implementing 7-day services, more broadly, will be cost effective. As such it is likely that further literature will emerge to examine this issue that will ideally guide a more targeted risk based approach to prevent an opportunity cost to other publically funded services.

Chapter 4: Trends and characteristics of outside of hours admissions

The aim of this section is to provide an overview of the current literature around whether patients admitted to hospital out of hours experience differential outcomes compared to similar patients admitted during weekdays.

We identified 146 papers that were included in the review, with the main characteristics summarised in *Table 1*. The studies fall into two broad groups: those concerned with outcome from out of hours admission for patients admitted with a well-defined diagnostic condition (96) and more general (47) studies. Add to this two relevant systematic reviews; [23 25] and one meta-analysis.[45] As such, 117 papers were identified from the primary search and an additional 32 papers met the inclusion criteria secondarily. Formal data extraction was undertaken for all papers meeting the inclusion criteria and included in systematic reviews *Table 2* lists these 32 papers and the systematic reviews in which they were included. We have summarised the characteristics of the three systematic reviews *Tables 5, 11* and *15* respectively.

Definitional variation

It is important to note that there is no general consensus as to what actually may be meant by out of hours. Of the papers reviewed, 64 studies [4 7 10-13 15-20 22 23 26 32 37 43 44 46 47 49 50 53 55 58 60 62 64 66 68 71 74-77 81 83 86 90 92 93 107 109-127] compared nights and weekends together; 40 studies [21 28 29 31 33 34 36 42 48 51 52 56 57 59 63 65 67 69 78 82 84 94 98 100 101 103 105 108 128-139] compared nights and weekends separately; and 20 [6 9 14 24 27 35 39 40 54 73 80 88 89 91 93 140-144] comparing 'weekends' with all other days/times. Five studies [79 99 145-147] compared each day of the week and one study [87] compared 'day time' to 'night time'. The remainder (16 studies), [8 25 38 41 45 72 85 148-156] did not clearly identify an out of hours definition.

These differences in definition of day and time of admission may also partly explain the differences between studies. We have summarised the various timeframe definitions of the 146 studies analysed as part of the review in *Appendix 6*.

Regional (health-system) variation

A breakdown of the 146 studies reviewed identified that most prevalent studies were from the USA (62) [9 13 15 16 19 20 22 25-28 31 34 38-40 43 47 50 56 59 60 64 71-73 75 76 78 80 82 83 85-87 90 92-94 99 107 116 121 124 125 127 130 132-134 139 140 142 145 146 148-151 155] followed by the UK (25), [6 7 10-12 14 17 18 35 37 49 53 55 61 63 65 66 68 74 89 115 117 131 147 154] other Europe (21)[33 42 51 52 57 67 69 77 79 81 84 98 103 105 110 112 119 122 135 137 141 152] and then Asia (15), [33 41 48 58 62 108 109 113 114 123 143 144 152 156] Canada (12), [4 44 46 54 70 91 100 101 126 129 138 153] and Australia (6), [8 24 36 111 118 120] have also published research of mortality of patient admitted out of hours. This is counter to the perception that the published UK experience is of higher prevalence, given the policy debate and decisions that have been adopted there. A breakdown of these variables is summarised in *Appendix 7*.

Data considerations

Of the studies selected from the database searches, the majority were retrospective, observational studies. The review identified that studies finding higher mortality rates for patients admitted to hospital out of hours rely on routine administrative data to adjust for risk of death, but these data may not adequately capture severity of illness. Whilst studies based on routine administrative data use sophisticated methods to account for case mix difference between admissions in traditional working hours compared to those out of working hours, administrative data is heterogeneous and lacks information on patient acuity and complexity of patients on admission. Furthermore, those studies using aggregated data make interpretation for specific disease categories or conditions, as well as geographical variations harder to interpret. Studies using specialist clinical dataset samples where disease or department specific studies collected better patient level data the demonstration of an effect for a mortality difference was either mixed or not apparent. A breakdown of these variables is summarised in *Appendix 8*. An alternative interpretation for the identification of a differential outcome in administrative studies over clinical studies is the requirement for large sample sizes required to substantiate small outcome differences, which are most often the case when present.

TABLE 1: Summary of main characteristics of included studies

Characteristics	Number of included studies n = (%)
Country	
Australia	**6= (4.1%)**
Asia	15= (10.3%)
Canada	12= (8.3%)
Global	3= (2%)
Middle-East	2= (1.3%)
Other Europe	21= (14.3%)
USA	62= (42.5%)
UK	25= (17.2%)
Study design	
Retrospective Cohort	130= (89%)
Prospective Cohort	12= (8%)
Meta Analysis/ Systematic Review	3= (2%)
Case Series	1= (0.7%)
Setting	
Cardio Respiratory	26= (17.9%)
Gastroenterology	15= (10.3%)
Haematology-Oncology and other medical specialties	4= (2.7%)
Intensive Care	20= (14.5%)
Medical	20= (14.5%)
Neuroscience & Neurology	30= (20.7%)
Orthopaedics	6= (4.1%)
Paediatrics and Obstetrics	5= (3.4%)
Nephrology and Renal	1= (0.6%)
Surgical	9= (6.2%)
Trauma	10= (6.8%)
Variables Tested	
Timeframe *(see Appendix 6 for breakdown which analysed time frame admitted)*	
Analysed nights and weekends separately	40= (27.3%)
Analysed nights and weekends together	64= (44%)
Saturday and Sunday studied	20= (13.7%)
Other	22= (15%)
Mortality *(see Appendix 3 for breakdown of studies which analysed mortality)*	
'In-hospital' (no. of days not otherwise specified)	96= (66%)
2-days	6= (4.1%)
3-days	2= (1.3%)
5-days	1= (0.6%)
7-days	9= (6.2%)
14-days	3= (2%)
15-days	1= (0.6%)
28-days	1= (0.6%)
30-days	24= (16.5%)
60-days	1= (0.6%)
90-days	1= (0.6%)
365 Days	1= (0.6%)
Re-admission	2= (1.3%)
Treatment Delay *(see Appendix 4 for breakdown of studies which also analysed timeframes to treatment)*	32= (22%)
Length of Stay *(see Appendix 5 for breakdown of studies which also analysed patients' LoS)*	25= (17.2%)

TABLE 2: Summary primary papers reviewed and also included within a systematic review paper

Primary Study	De Cordova, 2012, USA. [25]	Cavallazzi, 2010, Global. [23]	Hinds, 2014, Global. [97]
Ananthakrishnan, 2009, USA. [39]			✓
Arabi, 2006, Saudi Arabia. [21]	✓		
Barba, 2006, Spain. [98]	✓		
Barnett, 2002, USA. [85]	✓	✓	
Bell, 2001, Canada. [4]	✓		✓
Button, 2011, UK. [74]			✓
Byun, 2012, South Korea. [41]			✓
Carr, 2015, USA. [56]	✓		
Cram, 2004, USA. [9]	✓		
De Groot, 2012, Netherlands. [42]			✓
Dorn, 2010, USA. [43]			✓
Ensminger, 2004, USA. [26]	✓	✓	
Gould, 2003, USA. [99]	✓		
Haas, 2010, USA. [27]			✓
Hixson, 2005, USA. [28]	✓		
Jairath, 2010, UK. [49]			✓
James, 2010, USA. [13]	✓		
Kostis, 2007, USA. [50]	✓		
Laupland, 2008, Canada. [100]	✓	✓	
Laupland, 2011, Canada. [101]	✓		
Lee, 2012, Singapore. [102]		✓	
Luyt, 2007, France. [103]	✓	✓	
Myers, 2006, Canada. [104]			✓
Meynaar, 2009, Netherlands. [105]		✓	
Morales, 2003, USA. [78]		✓	
Saposnik, 2008, USA. [106]	✓		
Schilling, 2010, USA. [107]	✓		
Shaheen, 2009, Canada. [54]			✓
Sheu, 2007, Taiwan. [33]	✓	✓	
Uusaro, 2003, Finland. [84]	✓	✓	
Wunsch, 2004, UK. [108]	✓	✓	
Youn, 2012, South Korea. [109]			✓

Chapter 5: What is the size and consequence of unequal outcomes for patients admitted to hospitals out of hours and at the weekend?

In as much as this review has been conducted to provide a sound basis of understanding mortality variation for admitted patients, it is formative in the sense that it will inform subsequent research using linked Queensland public hospital datasets. In identifying the gaps in existing literature and being mindful of the multifactorial nature of the problem MNHHS has engaged the CSIRO to further explore the issue in this context. The types of papers and high level observations supporting or not supporting an effect are outlined below.

Retrospective v. prospective: Of the 146 studies, we have examined in more detail 130 were retrospective, observational studies. [4 6-18 20 22 24 26-29 31-41 43 44 46 47 50-54 56-67 69-76 78-94 98 101 103 105 107 108 110-118 120-126 129-156] Twelve were prospective observational studies. [19 21 42 48 49 55 68 77 84 100 119 128] The remaining four studies being two systematic reviews, [23 25] 1 meta-analysis [45] and 1 case series. [99]

Specific v. non-specific disease types: Ninety-seven papers [19 20 38-43 46 55-57 68 73-76 80 81 89 110 128 129 131-134 148-152 13 18 27 34-36 44 45 47-54 58-66 69-72 77 82 83 86 88 90-94 99 109 112-116 118 119 121-123 125 126 135 136 138 140 142-146 153 154 156] analysed specific patient cohorts (cardio respiratory, gastroenterology, haematology, nephrology, neurology/neuroscience, paediatrics and obstetrics, orthopaedics and trauma). The remaining 49 papers [4 6-12 21-26 67 85 98 111 130 14-17 28 29 31-33 37 78 79 84 87 93 100 101 103 105 107 108 117 120 124 127 137 139 141 147 155] analysed non-disease specific aggregated data.

Multi-site v. Single-site: One hundred and five (studies were multi-site studies [4 6-20 22 24 31 32 35 36 38 39 43 44 46-51 53-60 62 64 66 68-76 79-82 84-86 88-94 99-101 103 105 107-111 115-117 119 121 122 124-126 128 130 131 135-140 142-146 151-153 155 157] with 70 of these analysing administrative datasets. [4 6-20 22 24 32 38 39 43 44 46 49-51 53 54 57 58 60 64 66 69 71 73-76 80 81 85 86 89 90 92 93 107 111 113 116 117 122 124-127 135 138-144 146 147 149-153 155]

Relationship between a 'positive' study and administrative nature: We identified that of 60 studies [6-18 42-46 48 50 52-54 68 69 72-74 76 77 79 80 82 85 86 88 93 98 107 111 116 118 119 122 125 134 137 139-141 143 146 149 151 152 154 155] reporting higher mortality outcome, 45 [6-18 43 44 46 50 53 54 69 73 74 76 80 85 86 88 93 107 111 116 122 125 126 139-141 143 146 149 151-153 155] of these studies analysed an administrative data set.

Relationship between a 'positive' study and clinical nature: We identified of the 66 clinical studies [21 26-29 31 33-37 40-42 47 48 52 55 56 59 61-63 65 67 68 70 72 77-79 82-84 87 91 94 98 100 101 103 105 108-110 112 114 115 119-121 123 128-134 136 137 145 148 154 156] reviewed, 40 papers [21 27-29 31 35-37 40-41 47 56 59 61-63 65 67 70 78 83 87 91 94 101 103 105 108-110 114 120 128-129 132-133 136 145 148 156] found little or no significant difference in mortality outcome by day of admission. A breakdown of the non-disease specific and specific specialised cohort patient group studies is discussed in more detail below.

These studies have shown that an effect does not apply to all diagnoses. Mortality associated with out of hours has been reported by a number of authors across a spectrum of diseases, being most evident when diseases are studied within a system at the same time. However, for every paper supporting the presence of increased mortality rates with out of hours admission, another paper can be found that disputes this finding. This is most evident in the research surrounding stroke and AMI where there are a number of papers supporting and refuting the presence of an effect for patients admitted out of hours. Further work is needed to clarify the cause of these outcomes and in particular to distinguish the patient and pre-hospital factors from the in-hospital factors.

Non-disease specific (unselected) patients

We identified 49 relevant studies [4 6-12 14-17 21-26 28 29 31-33 37 67 78 84-85 87 93 98 100 101 103 105 107 108 111 117 120 124 127 130 137 139 141 147 155] from the database searches that have been categorised as analysing the outcomes for non-specific patient cohorts. Of these 49 non-disease specific (unselected) patient group studies, 20 papers [4 6 8-12 16 22 24-25 37 98 107 117 124 127 139 141 147] addressed medical patient cohorts; nine papers [7 14-15 17 31 32 87 93 155] analysed surgical patient cohorts and 20 papers [21 23 26 28 29 33 67 78 84 85 100 101 103 105 108 111 120 130 137] analysed intensive care patient cohorts.

Seventeen papers [4 9 21 26 28-29 33 78 84 85 98 100 101 103 105 107 108] of which were included in two systematic reviews. [23 25] These systematic reviews are not included in the summary tables.

The papers examined have variable results. Thirty-three of these studies [6-12 14-16 22 24 31 32 79 84 85 100 101 103 105 108 111 117 124 127 130 137 141 147] included multiple sites with 23 [6-12 14-16 22 24 32 85 93 111 117 124 127 139 141 147 155] of these using administrative datasets in their analyses. Of the 21 studies examining clinical datasets, [21 26 28 29 31 33 37 67 78 79 84 87 98 100 101 103 105 108 120 130 137] 13 papers [21 28-29 31 37 67 78 87 101 103 105 108 120] found no difference in outcome based on time of admission, with five [26 33 84 100 130] concluding mixed outcomes.

Mortality rates and other outcome differences for patients admitted out of hours compared to in hours are for non-disease specific (unselected) hospital admissions are summarised in *Tables 3–8.*

Medical

Of the 20 papers analysing non-specific medical patient cohorts, 11 papers reported a positive impact; three found no difference in outcome of patients admitted out of hours compared with admissions on other times of the week. The remaining six reported mixed outcomes. Seventeen papers analysed administrative datasets, two undertook clinical dataset analysis and one paper a systematic review. The characteristics and findings of the included reviews and primary studies are summarised in *Tables 3–5.*

Fourteen papers [4 6 8-12 16 22 24 107 117 124 139] reviewed were multi-site studies, all analysing administrative data sets. Of these multi-site papers, nine [6 8 10-12 16 107 139] found differences in outcomes, two [117 124] found no difference and three [4 22 24] confirmed mixed outcomes for patients admitted out of hours compared to those who are not.

The majority (9) [4 10-12 16 22 107 117 124] of the papers analysed nights and weekends together with seven [10-12 16 37 107 127] of these papers finding a difference in outcome, three [117 124 37] finding no difference and three [4 22 127] finding mixed outcomes. Four [6 9 24 141] papers defined out of hours as the weekend (Saturday & Sunday) and compared this with all other times. Three [6 9 141] of these papers confirmed a difference in outcome for patients admitted out of hours and one [24] finding a mixed result. Two [98 139] papers compared weekends and nights separately finding a difference in outcome . One paper [147] compared each day to the next finding mixed outcomes. The remaining two papers did not clearly define the timeframe variable.

Of the papers assessing in-hospital mortality, five [6 12 16 98 107] found a difference in outcome; two [37 124] finding no difference and three studies [4 22 147] finding mixed outcomes. All of these studies analysed administrative data sets with only two [37 98] papers examining clinical data. Thirty-day mortality was examined in six papers with three finding a difference, three mixed and one concluding no difference in outcome. Only one paper [37] evaluated LoS, finding no difference. A breakdown of these variables is summarised in *Appendix 5*.

Surgical

Of the nine papers analysing non-specific surgical patient cohorts, six papers reported a positive impact; two found no difference in outcome of patients admitted out of hours compared with admissions on other times of the week and one reported mixed outcomes. Seven studies analysed administrative datasets and with the remaining four analysed clinical data. The characteristics and findings of the included reviews and primary studies are summarised in *Tables 6–8.*

Thirty-day mortality was analysed on four [7 17 31-32] of the nine papers. Five [14 32 87 93 155] included a review of in-hospital mortality. Only two papers evaluated differences in LoS [87 93]. A breakdown of these characteristics is summarised in *Appendix 5.*

Four of the papers [7 14 17 87] reviewed identified analysis of elective surgical patients. Three papers [7 14 17] analysed administrative data sets and all finding a positive impact on out of hours admission compared with admission at other times. The remaining paper [87] analysed a single-site and after adjustment found that patients undergoing non-emergency surgery procedures out of hours did not seem to have an increased risk for mortality or morbidity. They concluded that performing elective procedures at night may be a safe solution for daytime overcrowding of operating rooms.

Intensive Care

Twenty papers analysed patients admitted to the ICU. Four papers reported a positive impact; ten found no difference in outcome of patients admitted out of hours compared with admissions on other times of the week and six reported mixed outcomes. Seventeen papers analysed clinical data. One paper was a systematic review which included eight of the primary studies named below and marked with a '*****'. The remaining two studies analysed an administrative dataset. The characteristics and findings of the included reviews are summarised in *Tables 9–11.*

The majority (11) [79 84-85 100-101 103 108 111 130 137] of papers consisted of multi-site studies of which nine [79 100-101 103 108 111 130 137] analysed clinical datasets. Four of the papers reviewed LoS with three [21 33 78] finding no differential outcome. All of the papers were retrospective observational studies except for three [21 84 100] that were prospective examinations of a clinical dataset and analysed weekends and nights separately compared to weekday office hours.

TABLE 3: Data extraction of studies reporting an impact from admission out of hours with higher mortality or other adverse outcomes – Medical patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Aylin, 2010, UK.[6]	Retrospective analysis of **administrative** data: 2005–2006.	4,317,866 inpatient admissions via ED (5% 215,054 deaths). All acute hospitals in England.	Difference in mortality, for 23 (adjusted) for the top 100 highest mortality conditions. Of a total of 4,317,866 emergency admissions, found 215,054 in-hospital deaths with an overall CMR of 5.0% (5.2% for all weekend admissions & 4.9% for all weekday admissions). The overall adjusted odds of death for all emergency admissions was 10% higher (OR: 1.10; 95% CI: 1.08-1.11) in those patients admitted at the weekend compared with patients admitted during a weekday (p<0.001).
Barba, 2006, Spain.[98]	Retrospective analysis of **clinical** data: 1999–2003.	35,993 ED admissions to hospital. (single-site).	The study suggests a higher risk of death for patients. (OR: 1.40 in-hospital mortality) Risk of death within the first 48 hours is higher for patients admitted on weekends than for patients admitted on a weekday.
Concha, 2013, Australia.[8]	Retrospective analysis of **administrative** data: 2000–2007.	3,381,962 (917,257 weekend) inpatient admission via ED. Multi-centre (501 public & private hospitals) (18,282 weekend deaths).	Patterns consistent with both patient & care factors (early risk pattern-majority of excess deaths occurred in first 24h & 48h of admission) but not consistent across DRGs. Risk of death out of hours (OR: 2.12 (adjusted)) in 16 of 430 diagnostic groups.
Cram, 2004, USA.[9]	Retrospective analysis of **administrative** data: 1998 Hospital survey.	641,860 inpatients admitted via ED for 50 diagnoses (41,702 deaths). Most Acute US hospitals.	Being admitted to hospital on a weekend was associated with slightly higher mortality risk than being admitted to hospital on a weekday. In-hospital mortality (OR: 1.03) for 3 of 50 diagnoses. Risk of death out of hours was greater in major teaching hospitals than minor or no teaching hospitals.
Freemantle, 2012, UK.[10]	Retrospective analysis of **administrative** data: 2009–2010.	14,217,640 ED admissions &/or already an inpatient on weekend days (187,337 in-hospital deaths). NHS hospitals England.	Admission on weekend was associated with increase in rise of subsequent death. Risk of death out of hours (HR: 1.16 in-hospital mortality for Sunday v. Wednesday HR: 1.11 in-hospital mortality for Saturday v. Wednesday). But being in-hospital at the weekend was associated with reduced death.
Freemantle, 2015, UK.[11]	Retrospective analysis of **administrative** data: 2013–2014.	14,818,374 ED admissions &/or already an inpatient of weekend days (280,788 deaths). NHS hospitals in England.	Patients admitted at the weekend are more like to be in the highest category of risk of death & face increased likelihood of death even when severity of illness is accounted for. Risk of death out of hours (HR: 1.1 on Saturdays & 1.15 on Sundays: p= 0.001) for death within 30 of admission compared to Wednesdays.
Handel, 2012, UK.[12]	Retrospective analysis of **administrative** data: 1999–2009.	5,271,327 ED admissions to hospital. NHS hospitals in Scotland.	There was a significantly increased probability of death associated with a weekend emergency admission compared with admission on a weekday (OR: 1.27; 95% CI: 1.26–1.28, p<0.0001). Despite a general reduction in mortality over the last 11 years, there was still a significant excess mortality associated with weekend emergency admissions.
Marco, 2010, Spain.[141]	Retrospective analysis of **clinical** data: 2005.	429,880 admissions from the ED (single-site) to the hospital.	Higher mortality associated with out of hours admission than admission during the week. Risk of death out of (RR:1.15 in-hospital mortality). Differences in mortality persisted after adjustment for age, sex, & coexisting disorders (OR: 1.071; 95% CI: 1.046–1.097). Analysis of deaths within 2 days after admission showed larger relative differences in mortality between weekend & weekday admissions.
Ricciardi, 2014, USA.[16]	Retrospective analysis of **administrative** data: 2003–2008.	48,253,968 patient discharges (26,038,921 non-elective inpatient admissions. (multi-centre).	Risk of death out of hours (RR: 1.15 in-hospital mortality).
Schilling, 2010, USA.[107]	Retrospective cohort study of **administrative** data: 2003–2006.	166,920 admissions to EDs (39 sites) for diagnosis of AMI, heart failure, stroke, pneumonia, hip fracture GI Bleeding).	Difference in mortality (OR: 0.32: CI: 0.11–0.54) associated with out of hours admission than admission during the week.
Vest-Hansen, 2015, Netherlands.[139]	Retrospective cohort study of **administrative** data: 2010.	174,192 acute medical admissions to hospitals.	Whilst admission rates decreased from office hours to weekend hours there was an observed increase in mortality 30-day mortality was 5.1% (95% CI: 5.0–5.3) after admission during weekday office hours, 5.7% (95% CI: 5.5–6) after admission during weekday (out of hours), 6.4% (95% CI: 6.1–6.7) after admission during weekend night time hours. Researchers concluded differences in severity of illness as the proportion admitted to hospital.

TABLE 4: Data extraction of studies reporting no impact from admission out of hours on outcomes – Medical patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Mikulich, 2010,UK.117	Retrospective cohort analysis of **administrative** data: 2002-2009.	49,337 medical admissions single-site, Dublin, Ireland hospitals.	Patients admitted at the weekend had an approximate 11% increased 30-day in-hospital mortality, compared with a weekday admission; although this was not statistically significant either before or after risk adjustment (30-day in-hospital mortality 9.9% v. 9.0% unadjusted OR: 1.05; 95% CI: 0.88=1.24). The authors pointed out that "admission at the weekend was not independently predictive in a risk model that included illness severity (age & biochemical markers) & co-morbidity".
Powell, 2013, USA.124	Retrospective cohort study of **administrative** data: 2008.	114,611 ED admissions from 576 hospitals.	ED admissions with a principal diagnosis consistent with sepsis, & found that the difference for overall inpatient mortality (in terms of the weekend) was not significant (17.9% v. 17.5%, p= 0.08).
Schmulewitz, 2005, UK.37	Retrospective cohort study of **clinical** data: 2001.	3,244 admissions (938 weekend admissions) for 6 predetermined diagnoses (COPD, CVA, PE, CAP, GI Bleed & 'collapse') (single-site).	No significant risk of death out of hours for any of the selected conditions (OR: 0.5 to 1.65 across diagnostic groups) compared to traditional working hours.

TABLE 5: Data extraction of studies reporting mixed outcomes for patients admitted out of hours' – Medical patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Becker, 2008, USA.[22]	Retrospective analysis of **administrative** data: 1989–1998.	922,074 elderly Medicare claim admissions with AMI.	Positive correlation between weekend hospitalisation & mortality. Weekend patients experience a 0.38 percentage point (p= 0.001) increase in 1-year mortality. Patients admitted on weekend significantly less likely to receive primary intensive treatment associated with AMI within the first days of admission. Weekend admission with AMI leads to lower subsequent expenditure but higher 1-year mortality & higher rate of one major cardiac complication, readmission with CHF. Out of hours admissions lead to inappropriate reduction in intensive medical care. The effects on weekend admission do vary with patient health status: while weekend admission leads to delay in invasive treatments for all patients, sicker patients (defined by inpatient admission the previous year) are less likely to experience delays.
Bell, 2001, Canada.[4]	Retrospective analysis of **administrative** data: 1988–1997.	3,789,917 ED patients (all (190 Ontario hospitals). Selected DG hypothesized to be susceptible (AAA, AE, PE) or non-susceptible (AMI, ICH, Hip #) to differences in outcome	Greater severity of illness among patients admitted to acute care hospitals out of hours would still raise questions about the adequacy of medical care & staffing patterns. Significant effect in 23 (adjusted) for the top 100 highest mortality conditions (OR: AAA 1.28; AE 5.28; PE 1.25; AMI 1.02; ICH 1.01; Hip #. 0.95). ** Index cases: ruptured abdominal aortic aneurysm, acute epiglottis, & pulmonary embolism.* ** Controls: Myocardial Infarction, intra cerebral haemorrhage, Hip Fracture*
Clarke, 2010, Australia.[24]	Retrospective analysis of **administrative** data: 2003–2007.	30,522 COPD, 17,910 AMI, 4,183 acute hip fracture and 1,781 intra-cerebral haemorrhage admissions. Queensland hospitals.	Study found a significant effect for acute myocardial infarction (adjusted RR: 1.15; 95% CI: 1.03–1.26: p= 0.007). Two-day in-hospital mortality showed similar results. There was no significant effect on adjusted 30-day in-hospital mortality for COPD (RR: 0.92; 95% CI: 0.81–1.04: p= 0.222), intra cerebral haemorrhage (RR:1.01; 95% CI: 0.86–1.16: p= 0.935) or acute hip fracture (RR: 0.78; 95% CI: 0.54–1.03, p= 0.13).
De Cordova, 2012, USA.[25]	**Systematic Review.**	66 Studies.	Focus on weekends. Most studies (9 of 12) did not find an important association between patients admitted at night & mortality.
Maggs, 2010, UK.[147]	Retrospective cohort analysis of **administrative** data: 2007–2008.	15,594 adults admitted under care of physician (single-site).	After adjusting for age & sex, we did not detect a significantly increased overall mortality in patients admitted at the weekend compared with those admitted on weekdays. However, total mortality was increased in patients admitted on Mondays & at night compared with those admitted in the daytime, & in all out of hours periods taken together compared with normal working hours.
Smith, 2013, USA.[127]	Retrospective cohort study of **administrative** data: 2008–2010.	20,072 admissions to single-site hospital.	Mortality of patients admitted out of hours not significantly higher at 7-days (OR: 1.10; 95% CI: 0.92–1.31; p= 0.312) or at 30-days (OR 1.07; 95% CI: 0.94–1.21; p= 0.322). By contrast, they found adjusted public holiday mortality in the all public holidays was 48% higher at 7-days (OR: 1.48; 95% CI: 1.12–1.95; p= 0.006) & 27% higher at 30-days (OR: 1.27; 95% CI: 1.02–1.57; p= 0.031).

TABLE 6: Data extraction of studies reporting an impact from admission out of hours with higher mortality or other adverse outcomes – Surgical patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Aylin, 2013, UK. [7]	Retrospective analysis of **administrative** data: 2008–2010.	4,133,346 **elective** surgical patients. NHS hospitals England.	The study suggests a higher risk of death for patients who have elective surgical procedures carried out later in the working week & at the weekend. There were 27,582 deaths within 30-days after 4,133,346 inpatient admissions for elective operating room procedures (overall CMR 6.7 per 1000). The number of weekday & weekend procedures decreased over the three years (by 4.5% & 26.8%, respectively). The adjusted odds of death were 44% & 82% higher, respectively, if the procedures were carried out on Friday (OR: 1.44; 95% CI: 1.39–1.50) or a weekend (OR: 1.82; 95% CI: 1.71–1.94) compared with Monday.
Mohammed, 2012, UK. [14]	Retrospective cohort analysis of **administrative** data: 2008.	1,535.267 **elective surgical** patients (0.54% deaths) 3,105,249 **emergency surgical** patients (6.67% deaths) (328 acute hospitals from 221 NHS Trusts) 3,105,249 emergency patients (6.67% deaths) (328 acute hospitals from 221 NHS Trusts).	Difference (OR: 1.32 for elective patients in-hospital mortality; OR 1.09 for emergency patients in-hospital mortality).
Ricciardi, 2011, USA. [15]	Retrospective analysis of **administrative** data: 2003–2007.	29,991,621 (6,842,030 weekend admissions) patients with a **non-elective** admission of 20 US community hospitals.	Difference OR: 1.10 (in-hospital mortality); 10.5% higher at weekends 15 out of 26 major diagnostic categories. Higher co-morbidity scores for weekend admissions.
Ruiz, 2016, UK. [17]	Retrospective observational study using **administrative** data: 2009–2011. **examination of same dataset of Aylin* 2013. [7]	3,922,091 (26,409 deaths) **elective** procedures in 163 NHS hospitals.	The adjusted odds of death remained higher for Friday (OR: 1.48; 95% CI: 1.42 to 1.54), Saturday (OR: 1.97, 95% CI: 1.83–2.12) & Sunday (OR: 1.67; 95% CI: 1.50–1.85) after adjusting for consultant seniority & patient characteristics. Interestingly, in the **Australian** hospitals, data indicated that there was no significant daily change in the elevated risk of death within 30-days for emergency admissions over weekends. These hospitals actually accounted for largest number of emergency admissions overall.
Tadisina,2015, USA.[93]	A serial cross sectional study of **administrative** data: 2000–2010.	50,346 **plastic surgery** patients. US hospitals.	For patients who had body contouring procedures their mortality rates to be higher on weekend admission (3.7%) v. weekdays (0.5%).
Zapf, 2015, USA.[155]	Retrospective cohort study of **administrative** data: 2007–2010.	80,861 same **day surgeries** (19,078 occurred during the weekend).	Differential outcomes for paediatric surgery; increased mortality for children undergoing urgent surgery during the weekend rates of wound complications (OR: 1.29: 95% CI: 1.05–1.58; P<0.05), & urinary tract infection (OR: 1.39; 95% CI: 1.05–1.85; p<.05). Patients undergoing appendectomy had greater rates of transfusion (OR: 1.43; 95% CI: 1.09–1.87; p= 0.01), wound complications (OR: 1.32; 95% CI: 1.04–1.68; p<0.05), UTI (OR: 1.76; 95% CI: 1.17–2.67; p< 0 .01), & pneumonia (OR: 1.41; 95% CI: 1.05–1.88; p<0.05). Patients undergoing cholecystectomy had a greater duration of stay (p= 0.001) & greater charges (p= 0.003).

TABLE 7: Data extraction of studies reporting no impact from admission out of hours on outcomes – Surgical patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Orman, 2012, USA. [31]	Retrospective cohort analysis of **clinical** data: 1987–2010.	94,768 (4% death) liver transplant operations (multi-site).	No impact of weekend admission on outcome (RR: 0.99 at 30-days).
Turrentine, 2010, USA. [87]	Retrospective cohort analysis of **clinical** data: 5 years.	10,426 operative procedures performed.	Patients undergoing procedures at night had a greater prevalence of serious preoperative comorbid conditions. Procedure complexity as measured by relative value unit did not differ between groups, but LoS was longer after night procedures (7.8 days v. 4.3 days, p<0.0001). Patients undergoing non-emergent general & vascular surgery procedures at night in an academic medical centre do not seem to be at increased risk for postoperative morbidity or mortality. Performing non-emergent procedures at night seems to be a safe solution for daytime overcrowding of operating rooms.

TABLE 8: Data extraction of studies reporting mixed outcomes for patients admitted out of hours – Surgical patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Ruiz, 2015, Global (UK, USA, Netherland, Australia). [32]	Retrospective cohort analysis of **administrative** data: 2009–2011. **Examination of same data set of Aylin (2013)* [7]	2,982,570 admissions hospital records from 28 metropolitan teaching hospitals in UK, USA, Netherlands & Australia.	Difference in mortality rates for patients admitted out of hours for emergency admissions to 11 UK hospitals (OR: 1.08; 95% CI: 1.04–1.13 on Sunday) 5 US hospitals (OR: 1.13; 95% CI: 1.04–1.24 on Sunday) & 6 Netherlands hospitals (OR: 1.13: 95% CI: 1.09–1.33 on Saturday). No effect to **Australian** hospitals. Effect for all elective patients showed higher adjusted odds of 30-day postoperative death with Friday effect for 6 Netherlands hospitals).

TABLE 9: Data extraction of studies reporting an impact from admission out of hours with higher mortality or other adverse outcomes – Intensive Care Unit patients.

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Barnett*, 2002, USA. [85]	Retrospective cohort analysis of **administrative** data: 1991–1997.	156,136 admissions from 38 ICUs on 28 Ohio hospitals.	None of the diagnoses had lower mortality for out of hours admission compared to the rest of the week. In-hospital death were 9% higher (OR: 1.09; 1.04–1.15; p= 0.001) for weekend admissions (Sat–Sun) than in patients admitted mid-week (Tues–Thurs). However adjusted odds of death were also higher for patients admitted on Monday (OR: 1.09) or Friday (OR: 1.08). Findings were generally similar in analysis by admission type (medical v. surgical), hospital teaching status, & illness severity.
Bhonagiri, 2011, Australia.[111]	Retrospective cohort analysis of **administrative** data: 2000–2008.	245,057 admissions to 41 **Australian** ICUs (48% after-hours admissions & 20% weekend admissions).	Difference in mortality rates. Patients admitted after hours had a 17% hospital mortality rate compared with 14% of patients admitted in hours. Weekend admissions had a 20% hospital mortality rate compared with 14% on weekdays. (p<0.001), with SMRs of 0.95 (95% CI: 0.94–0.97) & 0.92 (95% CI: 0.92–0.93.)
Kuijsten, 2015, Netherlands. [137]	Retrospective cohort analysis **clinical** data: 2002–2008.	149,894 patients admitted to the ICU (multi-site).	Study showed an increase in the risk of hospital mortality for patients admitted during off-hours compared with patients admitted during office hours (RR: 1.059), & an increase of hospital mortality risk for patients admitted during the weekend compared with patients admitted during the week (RR: 1.103).
Neuraz, 2015, France. [79]	Retrospective observational cohort **clinical** data: 2013.	5,718 ICU inpatient stays (8 ICUs).	The risk of death increased with an (OR: 3.5; 95% CI: 1.3–9.1) when the patient-to-nurse ratio was greater than 2.5, & by (OR: 2.0; 95% CI: 1.3–3.2) when the patient-to-physician ratio exceeded 14. The highest ratios occurred more frequently during the weekend for nursing staff & during the night for physicians (OR: 3.08; 95% CI: 1.34–7.09) with a greater risk of CPR in off-hours & holiday times than day shifts.

TABLE 10: Data extraction of studies reporting no impact from admission out of hours on outcomes – Intensive Care patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Arabi, 2006, Saudi Arabia. [21]	Prospective cohort tudy ICU **clinical** data: 1999–2003.	2,093 ICU patients (single-site) 31% admitted weekdays; 35% weeknights; 34% weekends.	There was no significant difference in-hospital mortality rates among the 3 time periods (36%, 36%, & 37%, respectively, p= 0.90).
Arslankoylu, 2008, Turkey. [67]	Retrospective cohort study of **clinical** data: 2005–2006 (6 months).	210 admissions to PICU the (single-site) for patients aged 1mth–18 years.	No significant difference for overall mortality rates between weekend & weekday admissions (12.2% v. 17.4%, p= 0.245), & daytime & evening admissions (11.3% v. 15.4%: p= 0.254). There was also no significant difference between different admission times for within 24 hours, 48 hours & 72 hours mortality rates.
Hixson, 2005, USA. [28]	Retrospective cohort study PICU **clinical** 1996–2003.	5,968 PICU patients aged 0 days–21yrs. (single-site).	No significant difference in mortality (p= 0.146), weekend discharge/death (p= 0.348), nor evening PICU admission (p= 0.711) showed a significant relationship with mortality controlling for other significant factors. Limiting the scope to the emergency admissions subset, neither weekend admission (p= 0.135), weekend discharge/death (p= 0.278), nor evening PICU admission (p= 0.867) were significant predictors of mortality.
Laupland, 2011, Canada.[101]	Retrospective cohort study of **clinical** dataset: 2006–2010.	7,380 patients (multi-site).	No difference in mortality between admissions in working hours v. out of working hours once adjusted for case mix.
Lee*, 2008, Singapore. [29]	Retrospective cohort study of **clinical** severe head injury database: 1999–2006.	848 (327 night; 248 weekend) admissions to specialised neuroscience ICU.	No significant difference in ICU & hospital mortality for day & time of ICU admission.
Luyt*, 2007, France. [103]	Retrospective cohort analysis of prospectively collected **clinical** data 2000–2003.	51,643 ICU patients (33 857 admitted off-hours) from 23 sites.	No significant difference in mortality. After adjustment, in-hospital mortality was not higher for off-hours admissions than weekdays day admissions & even remained slightly lower (adjusted OR: 0.93; 95% CI: 0.87–0.98).
Meynaar*, 2009, Netherlands. [105]	Retrospective cohort study with prospectively collected **clinical** ICU database: 2004–2007.	6,725 ICU (2,712 (32.3%) weekend) admissions across 3 hospitals.	No effect. Mortality ratios were similar for patients admitted during off-hours & patients admitted during daytime unadjusted (OR: 1.36; CI: 1.20–1.55).
Morales*, 2003, USA. [78]	Retrospective cohort study of **clinical** ICU database: 1995–2000.	6,034 ICU admissions (single-site).	No increase in mortality for night admissions: patients admitted at nights had lover morality rate (13.9 v. 17.2; p <0.001).
Numa, 2006, Australia.[120]	Retrospective cohort analysis of prospectively collected **clinical** PICU database: 1997–2006.	6,980 PICU admissions (4,456 non-elective) to 12 bed PICU Sydney, Australia.	Patients admitted after hours had a lower risk adjusted mortality than those admitted during normal working hours, with death (OR: 0.712; 95% CI: 0.518–0.980: p= 0.037).
Wunsch*, 2004 UK.[108]	Retrospective cohort study **clinical** ICU database: 1995–2000.	56,250 ICU patients (102 sites).	Higher crude mortality for weekend & night admissions. (Fri OR: 1.19 1.11-1.27; Sat OR: 1.41 1.32–1.52 or Sun OR: 1.56, 1.45–1.68). No differential outcome after appropriate adjustment for case mix day of the week & time of day of ICU admission were not associated with significant differences in-hospital mortality (Sat OR: 1.03 0.9–1.12; Sun OR: 1.09 1.00–1.19).

TABLE 11: Data extraction of studies reporting mixed outcomes for patients admitted out of hours – Intensive Care patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Arias,2004, USA. [130]	Retrospective cohort study of **clinical** ICU database: 1995–2001.	20,547 admissions to 15 PICU's.	There was no association between mortality rates & the day of admission (weekend admissions v. weekday admissions). Paediatric patients admitted to the PICU during evening hours had higher odds of death (OR: 1.28; 95% CI: 1.00–1.62) than did those admitted during daytime hours. Subgroup analyses revealed higher odds of death among patients admitted with shock (OR: 4.09; 95% CI: 1.65–10.1), with congenital cardiovascular disease (OR: 3.90; 95% CI: 1.37–11.1), or after cardiac arrest (OR: 1.80; 95% CI: 1.04–3.13).
Cavallazzi, 2010, Global. [23]	**Systematic Review** *(studies included marked *)*	10 cohort studies (8 included night-time admission, 6 evaluated weekend admissions).	Mixed results. Night-time admissions was not associated with an increased mortality (OR: 1; 95% CI: 0.87–1.17; p= 0.956); however, patients admitted over the weekend had a significant increase in the adjusted risk of death (OR: 1.08; CI: 95% 1.04–1.13 p<0.001).
Ensminger*, 2004, USA. [26]	Retrospective cohort study of **clinical** ICU database: 1994–2002.	29,084 ICU patients (single-site).	Higher crude mortality for out of hours admissions. The increased mortality persisted after risk adjustment for surgical patients but not medical patients (OR: 1.23 in-hospital mortality). No significant effect for medical or multispecialty patients with weekend ICU admission not found to be independently associated with increased hospital mortality (OR: 1.057; 95% CI: 0.952–1.74).
Laupland*, 2008, Canada. [100]	Prospective cohort study of **clinical** ICU database: 2002–2006.	20,466 patients (24 204 ICU admissions (9,987 weekend admissions) (multi-centre).	Mixed results. No effect after controlling for confounding variables weekend admission. Weekend admission was not associated with death. (OR: 1.05; CI: 95% 0.95–1.17; p = 0.328). However, night admission was independently associated with mortality (OR: 1.37; CI: 95% 1.24–1.50; p<0.001). clinical data included & used to adjust for severity of illness – no difference was found after this adjustment.
Sheu*, 2007, Taiwan. [33]	Retrospective cohort study of **clinical** ICU database: 2006.	611 ICU patients (single-site) 372 patients admitted off-hours.	The differences were not significant, the adjusted odds of hospital death were higher for patients admitted to the ICU at night, compared to those admitted during the days (OR: 1.46; 95% CI: 0.99–2.14; p = 0.056). On the other hand, the adjusted odds of hospital death were not higher for patients admitted to ICU on weekends, compared with those admitted to ICU on weekdays (OR: 0.79; 95% CI: 0.5–1.25; P= 0.31).
Uusaro*, 2003, Finland. [84]	Prospective cohort study Multiple centre ICU **clinical** database.	23,134 emergency admissions (4,677 [20.2% weekend admissions] across 18 ICUs); 126,754 acute care admissions from 190 emergency departments.	Risk of dying in the ICU was higher during 'out of office hours' as compared with 'office hours'. Weekend ICU admissions are associated with increased ICU mortality (by 20%) in critically ill patients. (OR: 1.20; 95% CI: 1.01–1.43). However, admissions in the evening & during the night-time were not associated with increased risk of death.

Disease specific (selected) patients

Cardio Respiratory

We identified 26 relevant studies from database searches and snowballing articles. Ten studies confirmed an increased risk of mortality for patients admitted out of hours compared to traditional working hours. Eleven found no difference in outcome with five concluding mixed outcomes. Fifteen studies analysed clinical datasets with 11 analysing administrative datasets. Only one study was a prospective cohort investigation. The characteristics and findings of the included reviews and primary studies are summarised in *Tables 12–14.*

An additional 11 studies [4 6 9 10 12 22 24 37 107 139 141] are not included in the below summary table, as they were examined in *Tables 3–5.* Only one [37] of these studies analysed clinical data, finding no difference in outcome. The remaining studies analysed administrative data finding a difference in outcome for patients admitted out of hours apart from three papers [4 22 24] which concluded mixed outcomes.

In large administrative datasets AMI, AF, PE, PCI and pneumonia were associated with poorer outcomes for patients that are admitted to hospital out of hours. The majority of studies (15) investigated AMI (incl. NSTEMI, STEMI). [34 44 50 59 62 65-66 69 83 110 112 113 115-116 128] Ten of the studies analysed clinical data sets, with seven [59 62 65 83 110 136 158] finding no differences in outcome while the remaining three [34 112 115] found the outcomes to be mixed. Four papers investigated the outcomes for patients undergoing PCI [52 63 65 82] by analysing clinical data sets with two finding [63 65] no difference.

Two studies investigated patients admitted with COPD [131 153] with the administrative dataset concluding unequal outcomes for patients admitted out of hours and mixed results for studies analysing clinical datasets.

Nineteen studies analysed multi-centre, with nine [73 44 50 69 80 82 116 152 153] concluding an increased risk of mortality. Eight [44 50 69 73 80 116 152 153] of these analysed administrative datasets. Eight multi-site studies found no difference in outcome, with six [59 62 110 128 136 145] analysing clinical datasets. The remaining two [115 131] papers interrogating clinical data found the outcomes mixed. Seventeen [34 44 52 59 63 65 66 69 80 82 83 92 110 115 116 131 153] of these multisite studies investigated in-hospital mortality and seven [50 62 65 66 73 113 128 136 152] investigated mortality at 30-days. Two [73 92] papers investigated whether LoS was increased for out of hours admission with one [73] paper finding an increased LoS. Eight papers investigated treatment delay with the majority (5) [59 62 63 65 66] finding no difference in delay in treatment for patients admitted out of hours.

TABLE 12: Data extraction of studies reporting an impact from admission out of hours with higher mortality or other adverse outcomes – Cardio Respiratory patients

Author, Year, Country	Study design	Patient Number and Type	Main Findings
Aujesky, 2009, USA. [73]	Retrospective cohort analysis of **administrative** data: 2000–2002.	15,531 acute PE discharges (3,286 weekend admissions) from 186 hospitals.	Differential outcome. Patients with PE who are admitted on weekends have a significantly higher short-term mortality than patients admitted on weekdays. (unadjusted) OR: 1.17; 95% CI: 1.03–1.34).
Chang, 2012. Taiwan. [152]	Retrospective cohort analysis of **administrative** National Health Insurance claims: 1997–2008.	788,011 pneumonia admissions.	Patients admitted on weekends had 3% higher odds of 30-day death compared with those admitted on weekdays (OR: 1.03; 95% CI: 1.01–1.05).
Deshmukh, 2012, USA. [80]	Retrospective cohort analysis of **administrative** data: 2008.	86,497 AF hospitalisations (16,949 weekends) with AF.	Patients admitted on weekends experienced greater proportions of in-hospital mortality than those admitted on weekdays (1.1% v. .9%; p= 0.01). The use of a cardio-vascular procedure for AF on weekends was lower than that on a weekday (7.9% v. 16.2%: p<0.0001; OR: 0.5; 95% CI: 0.45–0.55; p<0.0001). After adjusting for patient & hospital characteristics & disease severity, the adjusted in-hospital mortality odds were greater for weekend admissions (OR: 1.23; 95% CI: 1.03–1.51; p<0.0001).
Glasser, 2008, USA. [82]	Retrospective cohort study of **clinical**: 1997–2006.	Of 10,948, 685 patients underwent PCI (228 procedures during off-hours).	Patients presenting in off-hours were more likely to present with greater severity of illness.Patients undergoing PCI on weekends had better outcomes during daytime than night time.
Gyenes, 2013, Canada. [44]	Retrospective cohort analysis of **administrative** data: 1999–2003.	6,711 NSTEMI patients (19,56 admitted at the weekend). Canadian hospitals.	Patients admitted on weekends had higher adjusted mortality & cardiovascular event rates. Higher risk patients were less likely to undergo angiography & waited longer, with higher observed in-hospital event rates. Weekend admission was independently associated with higher mortality (OR: 1.52; 95% CI: 1.15–2.01; p= 0.004).
Khera, 2013, USA. [116]	Retrospective cohort analysis of **administrative** data: 2001–2010.	1,434,579 patients with a STEMI. US hospitals.	Out of hours admission & multi-vessel PCI were independent predictors of in-hospital mortality among patients who underwent PCI for STEMI.
Kostis, 2007, USA. [50]	Retrospective cohort analysis of **administrative** data: 1987–2002.	231,164 heart attack patients from all New Jersey hospitals.	Significant difference of mortality (HR: 1.048). 30-day mortality after adjustment for patient & disease characteristics. Less frequent use of invasive cardiac procedures - not significant (HR: 1.023) after further adjustments for cardiac procedures.
Kruth, 2008, Germany. [69]	Cohort study of **administrative** data: 1994–2002.	45 508 consecutive AMI patients from 385 German hospitals with & without onsite cardiac catheterization facilities.	The study found a significant higher in-hospital mortality (11.1 v. 9.4%: p= 0.01) & at night there was a trend to higher in-hospital mortality when compared with regular working hours (10.6 v. 9.4%, p= 0.07).
Lairez, 2009, France. [52]	Retrospective cohort analysis of prospectively collected **clinical** data: 2005–2008.	2,266 consecutive emergency PCIs (870 during off-hours).	Mortality higher for night-time & weekend group. This was sustained after adjusting for risk factors.
Suissa, 2014, Canada. [153]	Cohort study of **administrative** data: 1990–2007.	323,895 patients with COPD & pneumonia.	Found mortality was higher for weekend (OR: 1.06; 95% CI: 1.03–1.09) but not Friday admissions (OR: 95%; CI: 0.65–0.99).

TABLE 13: Data extraction of studies reporting no impact from admission out of hours on outcomes – Cardio Respiratory patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Al-lawati, 2012, UAE. [128]	Prospective cohort analysis of **clinical** data: 2008–2009.	4,616 AMI patients with ACS (76% on weekdays).	No significant effect in mortality in 1-month (OR: 0.88; 95% CI: 0.68–1.14) & 1-year mortality (OR: 0.88; 95% CI: 0.70–1.10) between weekday & weekend admissions. Similarly, there were no significant differences in 1-month (OR: 0.92; 95% CI: 0.73–1.15) & 1-year mortality (OR: 0.98; 95% CI: 0.80–1.20), between nights & day admissions.
Berger, 2008, Switzerland. [110]	Retrospective cohort analysis of **clinical** data: 1997–2006.	12,480 AMI patients (48% admitted out of hours) 106 hospitals, Switzerland.	No differences in terms of in-hospital survival rates between the 2 groups (91.5% v. 91.2%; p= 0.633) or MACE-free survival rates (both 88.5%; p= 1.000) were noted. In conclusion, the outcome of patients with AMI admitted out of hours was the same compared with those with a weekday admission. Of predictors for in-hospital outcome, timing of admission had no significant influence on mortality &/or MACE incidence.
Fonarow, 2008, USA. [145]	Retrospective cohort analysis of **clinical** data: 2003–2004.	48,612 patient data from 259 US hospitals with heart failure.	When analysed by admission of weekend v. weekday the in-hospital death rate did not significantly differ. Weekend admission was not associated with increase for in-hospital rate compared with weekday admission (OR: 0.99; 95% CI: 0.84–1.17). Differences in out of hours admission was not associated with a significant increase in post discharge death, death/ rehospitalisation, or rehospitalisation rates on multivariable analysis (HR: 1.16, 95% CI: 0.87–1.55; OR: 1.03; 95% CI: 0.91–1.18; & OR: 1.07; 95% CI: 0.91–1.26, respectively).
Jneid,2008, USA. [59]	Retrospective cohort analysis of the GWGCAD **clinical** database: 2000–2005.	62,814 (982 out of hours admissions).	No measurable differences, however, were found in in-hospital mortality between regular hours & off-hours in the overall AMI, ST-elevated MI, & non-ST-elevated MI cohorts (adjusted OR: 0.99; 95% CI: 0.93–1.06; adjusted OR: 1.05; 95% CI: 0.94–1.18; & adjusted OR: 0.97; 95% CI: 0.90–1.04, respectively).
Koike, 2011, Japan. [136]	Retrospective cohort analysis of **clinical** data: 2005–2008.	173,137 cases of out-of-hospital cardiac arrest Japanese hospitals.	No significant differences were found between weekday & weekend/holiday cases, with ORs of 1.00 (95% CI: 0.96–1.04; p= 0.96) for 1-month survival & 0.99 (95% CI: 0.94–1.04; p= 0.78) for neurologically favourable 1-month survival. Even after adjusting for confounding factors, admission day (weekday v. weekend/holiday) had no effect on 1-month survival or neurologically favourable 1-month survival. In contrast, daytime admission was associated with significantly better outcomes than night time admissions.
Matsui, 2007, Japan. [62]	Retrospective cohort analysis of **clinical** data: 2000–2003.	4,805 consecutive patients with admitted within 48hours of onset AMI (1,276 weekend onset).	There were no obvious differences in outcome for Japanese AMI patients in the weekday or weekend onset group, suggesting the quality of the Japanese healthcare system is similar for the entire week.
Norman, 2012, UK. [63]	Retrospectively analysis of prospectively collected **clinical** data: 2008–2011.	2,571 PCI treated STEMI patients (single-site).	There was no difference in mortality between weekday & weekend groups (OR: 1.09; 95% CI: 0.82–1.46; p= 0.57). Similarly, no increase in mortality was seen in patients who underwent PCI at night (22:00–06:00 hours).
Orandi, 2014, USA. [92]	Retrospectively analysis of **administrative** data: 2005–2010.	63,768 patients with an ischaemic lower limb. US hospitals.	No statistically significant association between weekend admission & in-hospital mortality (OR: 1.15; 95% CI: 1.06–1.25; p= 0.10).
Rahthod, 2013, UK. [66]	Retrospective analysis of **administrative**: 2004–2012.	3,347 STEMI patients UK Hospitals.	In-hospital mortality rates were comparable between the weekday & weekend groups (3.6% v. 3.2%) with day of presentation not predictive of outcome (OR: 1.25; 95% CI: 0.74–2.11).
Showkathali, 2013, UK. [65]	Retrospective analysis of **clinical** data: 2009–2011.	1,471 STEMI patients (single-site). Large cardiothoracic centre in the UK with 24.7 primary PCI service.	Found a similar result. In-hospital mortality, 30-day mortality, & 1-year mortality was not different between weekday & weekend groups.
Sorita,2014 USA. [83]	Retrospective analysis of **clinical** data: 1998–2010.	3,422 AMI patients admitted off-hours (2,664 admitted in hours) at a single medical centre.	Patients who were admitted during off-hours did not have higher mortality or readmission rates as compared with one admitted during regular hours.

TABLE 14: Data extraction of studies reporting mixed outcomes for patients admitted out of hours – Cardio Respiratory patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Brims, 2011, UK.[131]	Retrospective analysis of **clinical** data: 1997–2004.	9,915 acute admissions with exacerbation of COPD.	The adjusted OR for death on day 1 after winter weekend admission was 2.89 (95% CI: 1.04–8.08). But after opening a MAU, death day 1 after weekend admission fell from OR: 3.63; 95% CI: 1.15–11.5 to 1.65; 95% CI: 0.14–19.01.
Hong, 2010, South Korea.[113]	Retrospective analysis of Korea National Health Insurance Claims (**administrative**) data: 2003–2007.	97,466 heart attack patients.	Differences in the case fatality rate of AMI patients admitted on weekdays & on weekends in Korea are caused by differences in the rate of performance of medical or invasive procedures. 30-day fatality rate was insignificantly different after adjustment for medical or invasive management (OR: 1.05; 95% CI: 0.99–1.11).
Hansen, 2013 Netherlands.[112]	Retrospective analysis of **clinical** data: 1997–2009.	92,164 AMI patients admitted to a Danish hospital.	Mortality rates were higher on weekends within seven days of admission in 1997–99 (absolute difference ranging from 0.8–1.1%), with weekend–weekday HR: 1.13 (95% CI: 1.03–1.23) at day HR: 2 & 1.10 (95% CI: 1.01–1.18) at day 7. But there were no significant differences in 2000–09 & suggesting an attenuation of the initial 'weekend-effect', perhaps relating to more equitable care.
Keatinge, 2005, UK.[115]	Retrospective analysis of **clinical** data: 1989–2001.	NHS hospitals south east England.	No adverse effect on mortality was apparent within 2-days from reduction in medical services at weekends. However, respiratory deaths accelerated sharply after reduction in elective & emergency admissions at Christmas, when rates of infection & mortality from respiratory disease were high.
Magid, 2008, USA.[34]	Retrospective analysis of **clinical** data: 1999–2002.	68,439 patients with ST segment elevation myocardial infarction treatment with fibrinolytic therapy & 33,647 treated with percutaneous coronary intervention.	Differences in mortality for STEMI (OR: 1.07). Increased LoS associated with PCI but not fibrinolytic therapy. No difference in mortality out of hours were identified when they looked at two separate groups.

Gastroenterology

We identified15 studies from the database searches investigating outcomes of patients admitted to hospital with gastroenterological conditions out of hours. six papers reported differences in outcome for patients admitted out of hours compared to those who were not, eight found no difference and the remaining one paper reported a mixed outcome. Eight of the papers analysed administrative datasets, eight clinical datasets and one paper a meta-analysis.[45] Ten of the studies reviewed are also included in the meta-analysis and are marked in the tables below with an '*'. The characteristics and findings of the included reviews and primary studies are summarised in *Tables 15–17.*

An additional ten[4 6 9-12 14 37 127 139] studies are not included in the below summary as they are examined in detail above within *Tables 3–5.* Only one paper[37] analysed clinical data and the only paper concluding no difference in outcome. The remaining studies all analysed administrative data finding six[9-12 14 139] papers concluding difference in outcome for patients admitted out of hours and three[4 6 127] papers found the outcomes mixed

The majority of studies (8) related to UGIB,[27 38 42 43 49 54 74 89] with others specifically analysing UGIB from peptic ulcer,[54 109] diverticulitis,[88] cirrhosis,[41] appendicitis[35] and oesophageal variceal haemorrhage.[91]

Eight papers[27 35 38 41 49 89 91 109] found that patients admitted to hospital out of hours had similar adjusted in-hospital rates. All of these papers analysed clinical data with one[49] utilised both clinical and administrative data in a prospective cohort study.

Twelve studies analysed data from multiple sites.[35 38 39 42 43 49 54 74 88 89 91 109] Of these, the papers finding no difference in outcome, three[38 89 49] interrogated administrative data with the remaining three[35 91 109] using clinical data. Of the five multi-site studies finding a difference in outcome four[43 54 74 88] analysed administrative data with one paper[42] investigating a clinical dataset.

All seven[35 38–39 41 45 49 54] papers investigating a risk of delay in treatment for patients admitted out of hours found one. However only one paper reported this risk impacting on patients' LoS.[54] A breakdown of these variables are summarised in *Appendix 4 & 5.*

TABLE 15: Data extraction of studies reporting an impact from admission out of hours with higher mortality or other adverse outcomes – Gastroenterology patients

Author, Year, Country	Study Design	Patient Number and Type	Main Findings
Button*, 2011, UK. [74]	Retrospective cohort **administrative** study: 1999–2007.	24,421 admissions for UGIB among 22,299 from hospital inpatient & mortality data.	Differential outcome. Adjusted cast fatality for NVUGIB was higher for weekend (OR: 1.13; CI: 1.02–1.25) & public holiday (OR: 1.48; CI: 1.10–1.98) admissions. UGIB case fatality was 13% higher for we admissions & 41% higher for admissions on public holidays. Not explained by case mix.
DeGroot*, 2012, Netherlands. [42]	Prospective cohort **clinical** study: 2009–2011.	571 patients presenting with UGIB to emergency from 8 hospitals.	Patients admitted during the weekend had higher mortality rate than patients admitted during the week (9% v. 3%; adjusted OR: 2.68; 95% CI: 1.07–6.72). Weekend admissions were not associated with other adverse outcomes. Patients admitted during the evening had a significantly longer time to endoscopy (15, 22 &16 hours for day, evening & night admissions respectively, p<0.01). This may be due to the fact that these patients have more severe outcomes.
Dorn*,2010, USA. [43]	Retrospective analysis **administrative** data: 1998–2003.	Multi-site study of 98,975 patients admitted to hospitals (23,339 on weekend) across 31 states with UGIB. US hospitals.	Out of hours admission for UGIB is associated with an increased risk of death (HR: 1.09; CI: 1.00–1.18), slightly longer LoS, & marginally higher inpatient charges. Discrepancies in the use & timing of endoscopy do not account for differences.
Hinds,2014, Global. [45]	**Meta-Analysis**. *(studies included marked *)*	11 studies (10 examined mortality); 6 examined need for surgery; 6 examined time to endoscopy; 4 evaluated endoscopy of admission day & 4 evaluated hospital LoS).	Patients admitted with UGIB on weekend exhibited a statistically significant increase in mortality (OR: 1.13; 95% CI: 1.06–1.20; p<0.01), need for surgery (OR: 2.46; 95% CI: 1.51–3.99; p<0.01), & time to endoscopy (MD 2.68; 95% CI: 0.017–5.20; p= 0.04) as compared to patient with UGIB on a weekday. Patients with UGIB admitted on weekend experienced statistically significant less endoscopy on day of admission (OR: 0.72; 95% CI: 0.62–0.85). No difference was noted between the two for LoS.
Shaheen*, 2009, Canada. [54]	Retrospective cohort study of **administrative** data: 1993–2005.	237,412 admissions to 3,166 hospitals for peptic ulcer related UGIB.	Higher mortality overall (13% relative increase in risk) was noted in patients admitted to urban teaching hospitals (OR: 1.16; 95% CI: 1.06–1.26). Patients admitted to hospital at the weekend for peptic ulcer-related haemorrhage have higher mortality & more frequently undergo surgery.
Worni, 2012, USA. [88]	Retrospective cohort study of **administrative** data: 2002–2008.	31,832 admissions for acute diverticulitis.	Significant differential outcome for postoperative complications (OR: 1.1) & non-routine hospital discharge OR: 1.33) compared with weekday admission.

TABLE 16: Data extraction of studies reporting no impact from admission out of hours on outcomes – Gastroenterology patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Abougergi, 2014, USA. [38]	Retrospective cohort analysis of **administrative** data: 2009.	202,340 NVUGIB. US hospitals.	Found that patients with NVUGIB admitted on weekends had similar adjusted in-hospital mortality rates (OR: 1.11; 95% CI: 0.93–1.30).
Ahmed, 2015, UK. [89]	Retrospective cohort analysis of **administrative** data: 2000–2010.	60,643 patients with UGIB. NHS Scotland.	There was a significant reduction in 30-day case fatality from 10.3%–8.8% (p<0.001) over 10 years. Patients admitted with UGIB at weekends had a higher 30-day case fatality compared with those admitted on weekdays (p<0.001) after adjusting for comorbidities.
Byun*, 2012, South Korea. [41]	Retrospective cohort analysis of **clinical** data: 2005–2009.	294 patients with cirrhosis admitted for the management of UGIB.	No differential outcome was identified. 23% of 74 patients with a weekend admission & 21% of 220 within a weekday admission died during hospitalisation (p= 0.872).
Haas*, 2010, USA. [27]	Retrospective analysis of **clinical** data: 2008.	174 UGIB admissions patients (50 weekend) (single-site).	No differential outcome. Adverse outcomes were not associated with weekend admission (weekend: 36 of 50 [72%]; weekday: 84 of 124 [68%] p= 0.583).
Jairaith*, 2011, UK. [49]	Large prospective cohort study **clinical** & **administrative** data: 2007. (*Adjusted for clinical severity)*	6,749 UGIB patients admitted to 212 hospitals.	No differential outcome was found in UGIB. After adjustment for confounders there were no evidence of a difference between weekend & weekday mortality (OR: 0.93; 95% CI: 0.75–1.16).
Myers*, 2009, Canada. [91]	Retrospective analysis of volunteer **clinical** stroke database: 1998–2005.	36,734 admissions (EVH) (2,207 hospitals).	After adjusting for confounding factors, including time of endoscopy. No impact of weekend admission or outcome (OR: 1.05; 95% CI: 0.97–1.14).

TABLE 16: Data extraction of studies reporting no impact from admission out of hours on outcomes – Gastroenterology patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Worni, 2012(b), USA. [35]	Retrospective cohort study of **clinical** data: 1999–2008.	151,774 laparoscopic appendectomy for acute appendicitis admissions.	No impact of weekend admission on outcome (OR: 1.37).
Youn*, 2012, South Korea. [109]	Retrospective cohort study of **clinical** data: 2007–2009.	388 UGIB patients (due to peptic ulcer) from 4 referral centres.	Most patients (97%) had undergone early endoscopy but the mortality rate was not different between the two groups (1.8% overall v. 1.6% on weekend).

TABLE 17: Data extraction of studies reporting mixed outcomes for patients admitted out of hours – Gastroenterology patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Ananthakrishnan*, 2009, USA. [39]	Retrospective cohort (cross sectional) analysis of **administrative** data 2004.	28,820 discharges with AVH & 391,119 discharges with acute (NVUGIB).	Out of hours admission was not predictive of in-hospital mortality in patients with AVH (OR: 0.94; 95% CI: 0.75–1.18), but was associated with lower likelihood of early endoscopy in nonteaching hospitals (OR: 0.65; 95%; CI: 0.51–0.82). Higher mortality among NVUGIB patients admitted on weekends (OR: 1.21; 95% CI: 1.09–1.35).

Haematology-oncology and other medical specialities

From the database searches, four studies investigated the outcome for patients admitted to hospital with haematology-oncology and other medical specialities. All papers reported no difference in outcome for patients admitted out of hours compared with admissions on other times of the week. Two of the papers analysed clinical data set with the other two investigating an administrative dataset. The characteristics and findings of the included reviews and primary studies are summarised below in *Table 18.*

A further 12 [4 6 9-12 16 107 124 127 139 141] investigated a number of cancer conditions which out of hours admission was associated with a statistical significant risk of mortality for patients admitted out of hours. The characteristics and findings of these papers are summarised in *Tables 3–5*.

TABLE 18: Data extraction of studies reporting no impact from admission out of hours on outcomes – Haematology-oncology and other medical specialities

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Bejanyan, 2010, USA. [40]	Retrospective follow up cohort study of **clinical** data: 1994–2008.	422 acute myeloid leukaemia (103 weekends) admissions.	Weekend admissions had lower early mortality (p= 0.04) & 30-day mortality (p= 0.02). In multivariate analysis, only time to TLC remained significantly longer for weekend admissions (p<0.001).
Goodman, 2014, USA. [47]	Retrospective cohort study of **clinical** data: 1999–2011.	12,073 patients with acute leukaemia (2009 patients admitted at the weekend).	Found that those admitted on a weekend did not have an increased mortality (OR: 1.0; 95% CI: 0.8–1.6). While paediatric patients with newly diagnosed leukaemia admitted on weekends do not have higher mortality rates, they have a prolonged LoS, increased time to chemotherapy, & higher risk for respiratory failure. Patients who are severely ill at presentation represent a higher proportion of weekend index admissions.
Laupland, 2010, Canada. [138]	Retrospective cohort analysis of **administrative** data: 2000–2008.	7,722 patients presenting with community onset bloodstream infections (4 sites Calgary).	No impact of weekend admission or outcome (OR: 0.99: 95% CI: 0.83–1.16).
Schimd,2014, USA. [142]	Retrospective cohort study of **administrative** data: 1998–2009.	534,011 patients with metastatic carcinoma of the prostate.	No difference in mortality was found. In multivariate analysis, out of hours admission was associated with an increased likelihood of complications (OR: 1.15; 95% CI: 1.11–1.19) & mortality (OR: 1.20; 95% CI:1.14–1.27).

Nephrology and Renal disease

One study was identified from the database searches which observed a higher risk of death among patients with AKI admitted at the weekend. The characteristics and findings of the included review of this study is summarised in *Table 19.* A further ten [6 8 9 10 11 12 141 16 107 139] papers investigated a the outcomes of patients admitted with various renal conditions for patients admitted out of hours. The characteristics and findings of these papers are summarised in the non-disease specific (unselected) medical patients section.

TABLE 19: Data extraction of studies reporting an impact from admission out of hours with higher mortality or other adverse outcomes – Nephrology and renal transplant patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
James, 2010, USA. [13]	Retrospective cohort study of **administrative** (NIS database): 2003–2006.	963,730 with diagnosis of AKI, US hospitals. 214,962 admissions (22%) designated AKI as the primary reason for admission (45,203 on a weekend & 169,759 on a weekday).	Compared with admission on a weekday, patients admitted with a primary diagnosis of AKI on a weekend had higher odds of death [adjusted OR: 1.07; 95% CI: 1.02–1.12]. The risk for death with admission on a weekend for AKI was more pronounced in smaller hospitals (adjusted OR: 1.17; 95% CI: 1.03–1.33) compared with larger hospitals (adjusted OR: 1.07; 95% CI: 1.01–1.13). Increased mortality was also associated with weekend admission among patients with AKI as a secondary diagnosis across a spectrum of co-existing medical diagnoses. In conclusion, among patients hospitalised with AKI, weekend admission is associated with a higher risk for death compared with admission on a weekday.

Neuroscience

Along with cardio respiratory and gastroenterology patients, the most well studied disease is stroke patients, with varying results regarding the outcome of patients admitted out of hours.

Thirty relevant papers were identified investigating risk of mortality for patients admitted out of hours with neurological (including neurosurgical) conditions. Fourteen papers reported a greater risk of mortality for patients admitted out of hours compared with admissions at other times, seven papers found no difference in risk with nine reporting mixed outcomes. Nineteen papers interrogated administrative datasets with the remaining 11 investigating clinical datasets. The characteristics and findings of the included reviews and primary studies are summarised in *Tables 20–22.*

Another 13 papers [4 6 9-12 16 22 93 107 124 127 139] are not included in the below summary table, as they were examined in *Tables 3–5.*

Two studies [134 151] were identified as neurosurgical, of which both found an increased risk of death (30-days) for out of hours admission.

We identified five papers which were prospective cohort analysis studies. Three [48 68 119] studies found an increased risk of mortality for patients admitted out of hours all of which analysed clinical data; one [19] paper concluded no risk in mortality from analysis of administrative data set; the one [55] paper that found mixed outcomes interrogated clinical data. One paper [36] conducted a post hoc analysis of an international multi-centre RCT finding no difference in outcome form patients.

Three [46 48 53] of eight [19 20 46 48 53 55 58 60] papers investigating treatment delay found increased delay for patient admitted out of hours. Of the studies (3) [19 20 90] comparing LoS all three did not find a difference in LoS for patients admitted out of hours compare to those admitted during traditional working hours. A breakdown of these variables are summarised in *Appendix 5.*

The majority (20) of papers investigated nights and weekends together with 15 investigating administrative datasets and 5 clinical datasets. Of the papers interrogating administrative datasets, seven [46 53 76 122 125 126 159] concluded an increased risk in mortality for patients admitted out of hours. Five [58 60 71 81 90] found mixed outcomes and three [19 20 75] papers found no difference. Of the clinical data set studies, two [68 119] found and difference in outcomes, two [55 121] found mixed and one [114] found no difference in risk in mortality. Of the papers (4) comparing the outcomes for patients admitted day time, night time and weekends separately, two [48 134] found an increased risk for patients admitted at nights and or weekends and two [36 129] did not find any difference in outcomes for patients admitted nights and or weekends compared to day-time hours. Only two papers investigated weekends compared to all other times in the week with one [144] finding a mixed outcome and the other [143] concluding an increased risk of mortality for patients admitted during these times. A breakdown of these variables is summarised in *Appendix 6.*

Of the papers which demonstrated excess mortality associated with out of hours admission for acute stroke, the effect size has generally been modest and not all studies have demonstrated such an effect, particularly after adjustment for clinical case mix and admission delay.

TABLE 20: Data extraction of studies reporting an impact from admission out of hours with higher mortality or other adverse outcomes – Neuro Surgery patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Busl , 2013, USA [151]	Retrospective cohort study of **administrative** data: 1995–2001.	14,093 patients with acute non-traumatic SDH. US hospitals.	One in 9 patients with non-traumatic SDH dies during hospitalisation. Among the several predictors of in-hospital mortality, the differential outcome & treatment with surgical evacuation are potentially modifiable factors. Further investigation may lead to improvements in management & outcomes. Multivariate analysis, weekend admission (OR: 1.19; 95% CI: 1.02–1.38) was an independent predictor of in-hospital mortality.
Desai, 2015, USA[134]	Retrospective analysis of **clinical** data: 2011–2014.	580 children undergoing neurosurgical procedures.	After multivariate analysis, children undergoing procedures during a weekday after hours or weekends were more likely to experience complications (p= 0.0227); & had an increased mortality.

TABLE 21: Data extraction of studies reporting an impact from admission out of hours with higher mortality or other adverse outcomes – Neurology patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Campbell, 2014, UK [68]	Prospective observational study of a large **clinical** dataset of acute stroke admissions: 2010–2012.	45,726 stroke patients admitted (23,779 admitted out of hours) to 130 hospitals in England.	There was a stronger association with weekend admission & mortality which was associated with a 14% higher odds for 30-day mortality.
Crowley, 2009a, USA. [76]	Retrospective cohort study of **administrative** data: 2004.	13,821 patients with diagnosis of ICH (26.8% weekend admissions).	Increased risk of death (30-days) for weekend admissions in patients with ICH (OR: 1.15; 95% CI: 1.05–1.25).
Fang, 2010, Canada. [46]	Retrospective cohort study of **administrative** data: 2003–2008.	Consecutive patients with acute stroke or TIA (20,657 patients).	Stroke fatality is higher with weekend compared to weekday admission, even after adjustment for case mix. The all cause 7-day fatality rate was higher in patients seen on weekends compared to weekdays (8.1% v. 7.0%) even after adjustment for age, sex, stroke severity, & comorbid conditions (OR: 1.12; 95% CI: 1.00–1.25).
Hasegawa, 2005, Japan. [48]	Prospective observational study of **clinical** data: 2000–2001.	1,134 consecutively admitting patients (multicentre – 10 centres).	Weekday admission was significantly associated (HR: 1.385 [1.087–1.764]) & case fatality (HR: 0.477 [0.285–0.798]).
Niewada, Poland. [119]	Prospective observational study of **clinical** data: 2004–2005.	19,667 ischemic stroke (5,924 (30.1%) weekend admissions) from (73 centres).	Significant differential outcome (OR: 1.13). More patients admitted on weekends died during hospitalisation or had poor outcome at discharge than weekday patients (15.9% & 59.8 v. 14.1% & 55.3%) respectively. When corrected for clinical severity & effect persisted.
Ogbu. 2011, Netherlands. [122]	Retrospective cohort study of **administrative** data: 2000–2004.	82,219 ischemic stroke admissions to 115 hospitals.	Weekends represent a period of increased death risk for ischaemic stroke patients in the Netherlands. A higher 7-day death risk for weekend admission, when compared to weekday admission was seen (OR: 1.27; 95% CI: 1.20–1.34). However, this increased risk appears to represent an exacerbation of an underlying night-time risk present during the weekdays.
Palmer, 2012, UK. [53]	Retrospective cohort study of **administrative** data: 2009–2010.	93,621 (23,297 (24% weekend) stroke admissions.	Significant differential outcome (OR: 1.26) performance poorer at weekend on 5 of 6 metrics. The rate of 7-day in-hospital mortality for Sunday admissions was 11% (adjusted OR: 1.26; 95% CI: 1.16–1.37 with Monday as a reference) compared with a mean of 8.9% weekday admissions.
Reeves, 2009, USA. [72]	Retrospective analysis of volunteer **clinical** stroke database: 2003–2007.	187,669 acute ischemic stroke (94 000 out of hours) & 34,845 acute haemorrhagic stroke (27,710 out of hours) admissions who presented to emergency departments form 857 hospitals that participated in a stroke program.	Off-hour presentation was associated with increased risk of dying in-hospital, although the absolute effect was small for ischemic stroke (adjusted OR: 1.09; 95% CI: 1.03–1.14) & moderate for haemorrhagic stroke admissions (adjusted OR: 1.19; 95% CI: 1.12–1.27).

TABLE 21: Data extraction of studies reporting an impact from admission out of hours with higher mortality or other adverse outcomes – Neurology patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Saposnik, 2007, USA. [125]	Retrospective data of prospectively collected **administrative** registry data: 2003–2004.	26,676 ischemic stroke patients (606 sites). Weekend admissions 6,629 (24.8% of all admissions).	Stroke patients admitted on weekends had a higher risk adjusted mortality than did patients admitted on weekdays. (OR: 1.14; 7-day mortality).
Sharp, 2013, USA. [159]	Retrospective analysis of **administrative** data: 2008.	4,225,973-in-patient admission via ED. US hospitals.	Patients more likely to die when admitted through the ED at the weekend with 28 (adjusted) for 50 clinical groups. Individual characteristics used for analysis did not explain the reasons for difference (DRG, patient insurance/ income status & or medical care or staffing patterns). Differential outcome across top 10 diagnosis (unadjusted OR: 1.073; 95% CI: 1.06–1.08; adjusted OR: 1.026; 95% CI: 1.005–1.048).
Smith, 2010, Canada. [126]	Retrospective cohort study of **administrative** data: 2001–2007.	274,988 ischaemic stroke patients from 1,036 hospitals.	Characteristics associated with in-hospital mortality were age, arrival mode, history of atrial fibrillation, previous stroke, previous myocardial infarction, carotid stenosis, diabetes mellitus, peripheral vascular disease, hypertension, history of dyslipidaemia, current smoking, & weekend or night admission.
Tung,2009, Taiwan. [143]	Retrospective cohort **administrative** data: 2005.	34,347 ischemic stroke patients (8,055 weekend admissions) from 245 hospitals.	Weekend admissions were associated with increased 30-day mortality. Stroke patients admitted on weekends had a higher 30-day risk adjusted mortality than those admitted on weekdays.

TABLE 22: Data extraction of studies reporting no impact from admission out of hours on outcomes – Neurology patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Albright, 2009, USA. [19]	Prospective collection - retrospective analysis of **administrative** data: 2004–2006.	2,211 stroke patients admitted to 2 centres (800 weekend admissions).	There was no significant difference found for in-hospital mortality in any stroke category when comparing weekend to weekday admissions (OR: 1.01; 95% CI: 0.74–1.39; p= 0.936). Patients admitted on weekends did not have a higher rate of in-hospital mortality or 90-day mortality when compared to weekday admissions. Patients admitted on weekends also did not have worse functional outcome at discharge or at 90-days.
Albright, 2012, USA. [20]	Retrospective analysis of **administrative** data: 2002–2009.	2,090 (720 weekend admission within 6 hours of stroke onset to CSC (8 sites).	Weekend admission was not a significant independent predictor of in-hospital mortality (8.4 v. 9.9% p= 0.056), or 90-day mortality (18.2 v. 19.8%; p= 0.680). No significant difference in treatment rates between weekday & weekend groups.
Almekhlafi, 2014, Canada. [129]	Retrospective cohort study of **clinical** data: 2011–2012.	110 patients (56 out of hours) (single-site).	No significant difference in-hospital mortality (2% for those treated on weekends & evenings v. 5.6% for those treated during working hours (p= 0.3). Independent functional recover at 90-days was noted in 64.3% of those treated on evenings or weekends & 52.1% of those treated during working hours (p= 0.2).
Crowley, 2009, USA. [75]	Retrospective cohort study of **administrative** data: 2004.	5,667 patients admitted with SAH on weekends. US hospitals.	Unlike the groups other study, weekend admission was not a statistically significant independent predictor of death in the study population at 7-days (OR: 1.07; 95% CI: 0.91–1.25), 14 days (OR: 1.01; 95% CI: 0.87–1.17), or 30-days (OR: 1.03; 95% CI: 0.89–1.19). Weekend admission is not associated with significantly increased short term mortality risk (30-days) among patients admitted with subarachnoid haemorrhage (OR: 1.03; 95% CI: 0.89–1.19).
Jiang, 2011, China. [114]	Retrospective cohort analysis of **clinical** data: 2007–2009.	313 patients with ICH (single-site).	Found that weekend admission was not a statistically significant predictive factor of in-hospital mortality (p= 3.15) or functional outcome (p= 0.128).
Sato, 2015, Australia. [36]	Post-hoc analysis of an international multicentre open, blinded endpoint **RCT**: 2008–2012.	2,794 (1,770 (63%) off-hours) ICH admissions to stroke centre.	Off-hour admission was not associated with risk of poor outcome at 90-days (53% off-hour v. 55% on-hour p= 0.49). There were no significant associations after adjustment for various baseline risk factors & clinical features (OR 0.92; CI: 0.76–1.12) for off-hour admission compared to the on-hour admission patients. Similar no clear associations were observed for death (OR 1.29; CI: 0.94–1.77) or disability (OR 0.86; CI: 0.72–1.03).
Zhang, 2011, China. [156]	Retrospective study of **clinical** data: 2006–2009.	183 SAH. (single-cite).	Logistic regression model, weekend admission was not an independent predictor of higher in-hospital mortality (OR: 177; 95% CI: 0.83–3.77) after SAH.

TABLE 23: Data extraction of studies reporting mixed outcomes for patients admitted out of hours – Neurology patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Bejot, 2013, France. [81]	Retrospective cohort study **administrative** data: 1985–2010.	5,864 (1,465 out of hours) cases of TIA. Dijon, France hospitals.	30-day mortality was greater for patients with stroke of TIA onset during weekends/ holidays than for those with events occurring during weekdays (15.2% v. 12.1%). Excess mortality in patients with stroke of TIA onset during weekends/ holidays was observed for the period 1985–2003 (1,821 v. 14%) but was no longer found for the period 2004–2001 (8.4% v. 8.3%).
Bray, 2014, UK. [55]	Prospective cohort study of **clinical** data: 2011–2012.	56,666 patients in 103 stroke units, NHS England hospitals.	In multivariable analysis, patients admitted on a weekend to stroke unit with 1.5 nurses / 10 beds had an estimated adjusted 30-day mortality risk of 15.2% (OR: 1.18; 95% CI: 0.77–0.93).
Hoh. 2010, USA. [90]	Retrospective cohort study - **administrative** data: 2002-2007.	599,087 emergency admissions for ischemic stroke - 159,906 weekend admissions & 439,181 weekday admissions. US hospitals.	Patients admitted out of hours compared with regular hours were more like to receive thrombolytic (OR: 1.114) & have slightly longer LoS (OR: 1.021). No difference for in-hospital mortality or discharge disposition.
Inoue, 2015, Japan. [58]	Retrospective cohort study of **administrative** data: 2010–2011.	47,885 stroke patients.	There was no difference in mortality between week day & weekend for patients that were admitted to the SICU on a weekend (10% v. 9.9%). The in-hospital mortality was significantly higher among patients admitted on a weekend to the GMW (7.9 % v. 7%).
Karlinski, 2013, Poland. [135]	Retrospective cohort study – **administrative** (stroke registry) data: 2003–2006.	1,330 intravenous thrombolysis patients (448 weekends; 868 out of office hours & 105 night admissions) 27 Polish stroke centres.	Significant differential outcome (OR: 1.07). Increases in mortality associated with out of office hours admissions for stroke were most pronounced in smaller hospitals.
Kazley, 2010, USA. [60]	Retrospective cohort study **administrative** data: 1998–2006.	78,657 acute ischemic stroke & 20,101 haemorrhagic stroke admissions from all hospitals in Virginia.	No impact of weekend admission on outcome (OR: 1.024 case mix adjusted mortality).
McKinney, 2011, USA. [71]	Retrospective analysis study of **administrative** data: 1996–2007.	134,441 patients admitted with primary diagnoses of cerebral infarction (27.8% (37,321) admitted on weekends) New Jersey hospitals.	In-hospital & 30-day mortality rates were also increased for patients admitted on weekends Mortality 90-days after admission was significantly higher for patient admitted on weekends than on weekdays (17.2% v. 16.5%; p= 0.001).
O'Brien, 2011, USA. [121]	Observational study of **clinical** data: 2004.	929 stroke patients in 4 US communities.	Overall risk of 28-day mortality was 9.6 % for weekday strokes & 10.1% for weekend strokes. However, in a model controlling for patient demographics, risk factors & event year, weekend arrival was not associated with 28-day mortality (OR: 0.87; 95% CI: 0.51–1.50).
Turin, 2008, Japan. [144]	Retrospective cohort analysis study of **administrative** data: 1998–2003.	1,578 registered first ever cerebral infarction & cerebral haemorrhage stroke cases. Hospitals in central Japan.	For all strokes, the 7-day case fatality rate based on the hospital admission day was 9.5% (95% CI: 6.8-13.1) for weekend admissions & 7.3% (95% CI: 6.0-8.9) for weekday admissions. However, case fatality rates based on the onset day were 7.2% (95% CI: 5.1-10.0) for weekend onset & 8.0% (95% CI: 6.6-9.8) for weekday onset. The 28-day case fatality rate for the weekend admission group was 14.7% (95% CI: 11.3-18.8) and for the weekday admission group it was 10.1% (95% CI: 8.5-11.9). In contrast, the 28-day case fatality rate for the weekend onset group was 11.3% (95% CI: 8.6-14.7) & for the weekday onset group it was 11.0% (95% CI: 9.3-13.0). This phenomenon was observed mainly for cerebral infarction & to some extent for cerebral haemorrhage.

Paediatrics and Obstetrics

We identified five obstetric and paediatric studies from the database searches and snowballing. All of these studies were analysis of administrative datasets except for one case series analysis. Each of the studies investigating administrative datasets found a statistically significantly greater risk of mortality for patients admitted out of hours. The case series study concluded no impact of out of hours admissions on outcome. The characteristics and findings of the included reviews and primary studies are summarised in *Tables 23–24*.

All five papers reviewed in-hospital mortality only. No papers reviewed LoS or compared delay in treatment to patients admitted within traditional working hours. One [149] study was a single-site study with the remaining four [18 99 140 146] analyses from mult-site centres.

TABLE 24: Data extraction of studies reporting an impact from admission out of hours with higher mortality or other adverse outcomes – Paediatrics and Obstetrics patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Auger, 2015, USA. [149]	Retrospective analysis of **administrative** data: 2006–2012.	55,383 hospitalisation at a tertiary care children's hospital.	Children admitted at the weekend had significantly higher odds of unplanned readmission compared to children admitted on weekdays (adjusted OR: 1.09; 95% CI: 1.004–1.18). In contrast, being discharged at the weekend was not associated with readmission. In conclusion, children admitted at the weekend have higher rates of 30-day unplanned readmission than children admitted during the week, suggesting care differences at the weekend related to initial clinical management rather than discharge planning.
Goldstein, 2014 USA. [140]	Retrospective cohort analysis of **administrative** data: 1988–2010.	439,457 paediatric patients who underwent a range of surgical procedures.	After multivariate adjustment & regression, patients undergoing a weekend procedure were more likely to die (OR: 1.63; 95% CI: 1.21–2.20).
Hamilton, 2003, USA. [146]	Retrospective descriptive design study of **administrative** data: 1999–2000.	111,749 Births to Teenage mothers (397 neonatal deaths).	Significant weekend mortality confined to African Americans & Hispanics (not Caucasians) (OR: 1.42).
Pasupathy, 2010, Scotland. [18]	Retrospective descriptive design study of **administrative** data: 1985–2004.	Live born term singletons with cephalic presentation. Perinatal deaths from congenital anomalies excluded. Final sample comprised 1,039,560 live births.	Delivering an infant outside of the normal working week was associated with an increased risk of neonatal death at term ascribed to intra-partum anoxia. Risk of neonatal death was 4.2 per 10,000 during the normal working week & 5.6/10,000 at all other times (out of hours) (unadjusted OR: 1.3; 95% CI: 1.1–1.6).

TABLE 25: Data extraction of studies reporting no impact from admission out of hours on outcomes – Paediatrics and Obstetrics patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Gould,2003, USA. [99]	**Case Series** of live births (weigh >500g) 1995–1997.	16,150,41 live births. Hospitals, California, US.	Observed neonatal mortality increased was 2.80/1000 for weekday births & 3.12/1000 for weekend births (OR: 1.12; 95% CI: 1.05-1.19; p= 0.001). But after adjusting for birth weight, the increased odds of death for infants born at the weekends were no longer significant.

Orthopaedics

We identified six papers that were included in the review. Two papers each reported a difference in mortality for patients admitted out of hours, no difference in outcome or mixed outcomes. Three papers interrogated administrative datasets with the remaining three analysing clinical datasets. One study was a prospective population cohort study. The characteristics and findings of the included reviews and primary studies are summarised in *Tables 25–27.*

An additional eight papers [4 6 7 9-11 24 107 123] are not included in the below summary table, as they examined in detail above within the above in *Tables 3–5.*

Four studies [57 61 150 154] investigated in-hospital mortality. Patient outcomes at 30-days were also investigated in four studies. [51 61 77 154] The variable, delay in treatment was tested in one study,[61] finding no difference in treatment delay for patients admitted outside of hours compared to other times. Both of these studies were an interrogation of clinical data. No studies investigated the difference in LoS. A breakdown of these variables are summarised in *Appendix 5.*

Hip fractures related to fragility account for a significant and clinical and economic burden on our health system, especially in an aging population. The studies reviewed indicated that patients admitted with hip fracture often have multiple co-morbidities and can present with concomitant medical pathologies such as ischaemic heart disease, electrolyte imbalances, renal impairment and sepsis. The studies highlight that the effective management of these, medical optimisation and access to timely surgery are key factors in the effective treatment of hip fractures and prevention of further complications.

TABLE 26: Data extraction of studies reporting an impact from admission out of hours with higher mortality or other adverse outcomes – Orthopaedics patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Foss, 2006, Netherlands. [77]	Prospective cohort study of **clinical** data: 2002–2004.	600 (118 weekend & 150 holiday periods) consecutive patients with patients presenting with acute hip fracture.	Found significantly higher rate of mortality for those admitted over holiday periods. Both 5-day & 30-day postoperative mortality were significantly higher in patients admitted during holiday periods than during weekends & weekdays, 8.0% v. 2.5% & 1.8%, respectively (p= 0.01) & 19.3% v. 12.7% & 11.1%, respectively (p= 0.05). In a multivariate analysis, admission during holiday periods was still a significant independent risk factor for both 5-day (4.34; 95% CI: 1.74–10.8) & 30-day mortality (OR: 1.84; 95% CI: 1.08–3.12).
Thomas, 2014, UK. [154]	Retrospective cohort study of **clinical** data: 2009–2013.	2,989 fractured neck of femur (single-site).	Researchers found that (whether managed surgically or conservatively), patients were more likely to die as an inpatient when admitted at the weekend (OR: 1.4; 95% CI: 1.02–1.80; p= 0.032).

TABLE 27: Data extraction of studies reporting no impact from admission out of hours on outcomes – Orthopaedics patients

Author, year, country	Study design	Patient Number and Type	Main Findings
Daugaard, 2012, Netherlands. [57]	Retrospective cohort analysis of **administrative** data: 2003–2010.	38,020 fractured neck of femur. Entire Danish population.	The mortality rate for patients admitted during weekends or public holidays or at night was similar to those four those admitted during working days.
Mathews, 2016, UK. [61]	Retrospective cohort analysis of prospectively collected **clinical** data: 2009–2011.	796 patients admitted to single-site hospital (235 weekend admissions) with hip fracture (edge of femoral head & 5cm below the lesser trochanter).	Weekend admission was not associated with increased time-to-surgery or mortality in hip fracture patients. Demographic factors affect mortality. Weekend admission was not associated with an increased time-to-surgery (p= 0.975), 30-day mortality (p= 0.842) or 120-day mortality (p= 0.425).

TABLE 28: Data extraction of studies reporting mixed outcomes for patients admitted out of hours – Orthopaedics patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Boylan, 2015, USA. [150]	Retrospective analysis of **administrative** data: 1998–2010.	344,989 fractured neck of femur.	Compared with patients admitted on weekdays. Patients admitted on weekends had lower mortality (OR: 0.94; 95% CI: 0.89–0.99) & shorter mean hospital stay (estimate 3.74%; 95% CI: 3.4–4.08); but did not differ in risk of perioperative complications (OR: 1.00; 95% CI: 0.98–1.02). The study data did not support a differential outcome among hip fracture admissions in the US.
Kristiansen, 2016, Netherlands. [51]	Cohort study, **administrative** data: 2010–2013.	25,305 Danish patients undergoing hip fracture surgery, aged >65 years.	When comparing admission on weekdays (evenings & nights v. days), off-hours admission was associated with a lower risk of surgical delay (adjusted OR: 0.75; (95% CI: 0.66–0.85) while no differences in 30-day mortality was found (adjusted OR: 0.91; 95% CI: 0.80–1.04). When comparing admission during weekends with admission during weekdays, off-hours admission was associated with a higher risk of surgical delay (adjusted OR: 1.19; 95% CI: 1.05–1.37) & a higher 30-day mortality risk (adjusted OR: 1.13; 95% CI: 1.04–1.23). The risk of surgical delay appeared not to explain the excess 30-day mortality.

Trauma

We identified ten papers investigating the difference in outcomes for patients admitted out of hours compared to other times admitted with a trauma. Two papers concluding an increased risk of mortality, seven found no difference and one concluded mixed outcomes. Eight studies analysed clinical data with two interrogated administrative data. The characteristics and findings of the included reviews and primary studies are summarised in *Tables 28–30.*

All ten studies were retrospective cohort studies all investigating in-hospital mortality. Three [56 70 94] were multi-centre studies all interrogating clinical data. Five [64 70 86 118 123] of the papers analysed the out of hours time frame as nights and weekends together with four [56 94 132 133] analysing the outcomes of patients admitted at nights and weekends separately. Only two papers [70 133] reviewed patient severity of illness, neither finding how unwell the patient was on presentation impacted on the risk of mortality. Three studies [56 86 94] investigated whether LoS was greater for patients admitted out of hours, two [56 94] finding no difference. A breakdown of these variables are summarised in *Appendix 5.*

TABLE 29: Data extraction of studies reporting an impact from admission out of hours with higher mortality or other adverse outcomes – Trauma patients

Author, year, country	Study design	Patient Number and Type	Main Findings
Mitra, 2014, Australia. [118]	Retrospective analysis of **clinical** data; 2006–2011.	398 patients with ATC (197 (49.5%) presented after hours).	The out of hours model of care was associated with worse outcomes among some of the most critically ill trauma patients. Mortality among patients presenting after hours was 43.1%, significantly higher than among those presenting in hours (33.1%; p= 0.04). Following adjustment, after-hours presentation was significantly associated with higher mortality at hospital discharge (adjusted OR: 1.77; 95% CI: 1.1–2.87).
Schneider, 2012, USA. [86]	Retrospective cohort analysis of (NIS database) **administrative** data: 2006–2008.	38,675 individuals aged 65–89 years with head trauma.	Weekend patients demonstrated 14% increased risk of mortality (OR: 1.14; 95% CI: 1.05–1.23). Older adults with substantial head trauma admitted on weekends are less severely injured, carry less comorbidity, & generate similar total charges compared with those admitted on weekdays. However, after accounting for known risk confounders, weekend patients demonstrated 14% greater odds of mortality. Mechanisms behind this disparity must be determined & eliminated.

TABLE 30: Data extraction of studies reporting no impact from admission out of hours' on outcomes – Trauma patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Arbari, 2005, USA. [148]	Retrospective cohort study of **clinical** data: 1994–2002.	30,686 admissions to a Level 1 Trauma Centre.	After controlling for confounding variables, no difference in mortality or LoS was observed in association with weekend or night admission.
Buse, 2004, USA. [132]	Retrospective cohort study of **clinical** data 1995–2001.	1,044 trauma patients admitted to single-site trauma centre.	Time of presentation (night time v. day time weekend v. weekday, month of year, & year) was not associated with in-hospital mortality after adjustment of illness & other confounding variables.
Carmody, 2002, USA. [133]	Retrospective cohort study of **clinical** data: 1994–1996.	8,015 trauma admissions to a large teaching centre LA, California.	Subset analysis were performed for time of admission, day or admission & mechanism of injury: morning v. night admission; weekday v. weekend; least busy-day (Tuesday) v. busiest day (Sunday); week-night v. weekend night admission. Penetrating trauma: morning v. night; blunt trauma: morning v. night. None of the 6 comparisons showed a significant difference in mortality.
Carr, 2011,USA. [56]	Retrospective cohort analysis of **clinical** data: 2004–2008.	90,461 trauma patients 32 trauma centres, Pennsylvania, US.	No difference. Patients presenting on weekends were less likely to die presenting on weekdays (OR: 0.89; 95% CI: 0.81–0.97).
Laupland, 2009, Canada. [70]	Retrospective cohort study of **clinical** data: 2002–2006.	4,000 major trauma patients Calgary.	Neither admission of weekends nor on evenings or nights increased the risk for in-hospital mortality. The time of admission during the day or day of the week does not influence the risk for adverse outcome & may reflect highly developed multi hospital acute care & trauma system.
Taira, 2009, USA. [94]	Retrospective cohort study – (secondary analysis) of **clinical** data: 2002–2006.	25,572 patients (17,625 arriving off-hours) 700 trauma facilities included with injury mechanism of burn.	No difference in ICU LoS, hospital LoS, or mortality (p= 0.546) for those admitted during off-hours compared with weekday admits. After adjustment hospital type, off-hours admission was not predictive of mortality (OR: 1.06; 95% CI: 0.91–1.23).
Nandyala, 2012, USA. [64]	Retrospective cohort study of **administrative** data: 2002–2011.	34,122 patients who undergone cervical fusion for cervical spine trauma. US hospitals.	Found the mortality rate was not significantly different among the weekend patients. There were no significant differences in mortality based on the admission day for any surgical approach.

TABLE 31: Data extraction of studies reporting mixed outcomes for patients admitted out of hours – Trauma patients

Author, Year, Country	Study Design	Patient number and Type	Main Findings
Ono, 2015, Japan. [123]	Retrospective cohort study of **clinical** data: 2002–2013.	805 patients (426 presentations out of hours).	Off-hours presentation was associated with longer ER stays for patients with systolic blood pressure <90mmHg on admission (p= 0.021), ISS >15 (p= 0.047), & pelvic fracture requiring trans arterial embolization (p<0.001). Off-hours presentation was also associated with increased risk of adverse events in the ED (OR: 1.7; 95% CI: 1.1 -2.7; p= 0.020). After adjustment for confounders, an increased risk of adverse events (OR: 1.6; 95% CI: 1.1–2.7; p= 0.049) persisted, but no differences were detected in mortality (p= 0.80) & unexpected death (p= 0.44) between off-hours & business hours.

Chapter 6: What influences the inequitable outcome for patients admitted out of hours and at the weekend (when there is one) is undecided

A number of potential causes of a differential outcome for patients admitted out of hours are proposed by the authors of papers examining this issue These suggestions are made broadly speaking, based on the expert opinion in one of two scenarios:

1. That the presence of certain human resource, system or process factors mitigated against there being a difference in outcome; or

2. That the absence of those features is postulated to be associated with differential outcomes out of hours.

From review of the literature, when an effect was present, causation was postulated but not proven. Furthermore, no studies were found that specifically evaluated an intervention to modify or reduce a differential outcome should one have been previously identified. As such any hypothesised factors, that may explain differences in outcome, have not as yet been formally evaluated.

Patient differences, out of hours access to diagnostic investigations and treatments, and staffing profiles have all been implicated in either the association with or mitigation of a differential outcome. The largely retrospective nature of all studies, clinical and administrative, suggests to the reviewers that these are hypothesis generating for factors that may impact upon outcomes out of hours rather than being definitive in and of themselves.

This review has identified that the majority of studies that corrected for severity based on clinical data did not identify an association between out of hours admission as opposed to those studies that only corrected for comorbidities.

It is impossible to make any conclusion regarding the role that delay to treatment and investigations plays in increasing mortality of those admitted out of hours due to the paucity of research in this area.

Finally, staffing appears to be an important factor in contributing to the differential outcome. However, determining exactly which part of staffing (medical, nursing, allied health) remains elusive with most of the studies based on specific models of care (see below) making it difficult to determine which components contribute to the effect more than others.

Patient acuity and/or severity of illness

An increased patient acuity and/or severity of illness has been proposed as an influence in the inequitable outcome for patients admitted out of hours.

To determine the impact of illness acuity and/or severity (if any), studies have been separated into those that used adjusted clinical data and those that used administrative data are presented. The adjustments included physiological variables and other severity scores such as APACHE, stroke severity, and trauma severity scores. Studies using administrative data do not have the same access to these admission variables and use comorbidities or socioeconomic measures to adjust for severity.

The majority of studies using clinical data to adjust for illness severity did not identify an association between out of hours admission and mortality. The studies that did identify an association were mostly based on administrative data and corrected only for comorbidities.

Of the 146 studies, we have examined in more detail 20 administrative dataset studies and 36 clinical dataset studies proposed that patient acuity and/ or severity of illness may have been an influence on the outcomes. The characteristics and findings of the included reviews and primary studies are summarised in *Tables 31* and *32*.

Five papers from the 11 administrative dataset studies investigating the outcomes for admitted cardio respiratory patients indicated that diagnosis and severity of diseases and conditions may be a contributor of differences of admission, LoS and mortality. Of the 15 clinical dataset papers concerning cardio respiratory patients, seven considered severity of illness. One study [83] found higher complication rates admitted off-hours. Other studies of AMI did not demonstrate higher complication rates measured by major adverse cardiovascular events (re-infarction stroke repeat target vessel revascularisation of severe bleeding). [22 69]

Of the 30 papers investigating outcomes of patients acutely admitted for neurosurgery, stroke and other neurological diagnoses four administrative data set studies and seven clinical dataset studies indicate severity of illness as a possible factor.

From a total of 15 studies of gastroenterology patients, four [43 49 74 49] of eight administrative dataset studies and four [27 35 42 91] of six clinical data set studies determined patient acuity and or severity as a factor. Of the four clinical dataset studies, three [27 35 91] found no difference in outcome for patients once adjusted for these factors. For example, one [91] comparing admissions of patients on weekends compared to other days of the week had higher prevalence of coagulopathy and were likely to be admitted emergently.

Fourteen studies of patients admitted to the ICU from the 20 papers reviewed from the database search indicated severity of illness and/or patient acuity to be a factor contributing to the outcome. One study [103] found that patients admitted during off-hours were less sick. This contrasts with three [26 78 108] papers reviewed finding that patients admitted out of hours were not the same as those admitted during regular 'day' shifts, finding that patients admitted out of hours were older, more critically ill and frequently required supportive procedures.

One study [132] indicated that emergency surgery, with possibly more dangerous outcomes could more commonly be carried out on a weekend than a weekday.

Any effect might partly be explained by the average admitted patient being sicker at the weekend with patients admitted out of hours had predominantly more complex disorders and as such had higher associated mortality. [4 46 91 125]

Staffing number and seniority

It is reasonable to hypothesise that differences in outcomes for patients admitted out of hours may be due to a lower quality of clinical services at these times.

There is variable evidence that working patterns are a factor in the differences in outcome for patients admitted out of hours. Very few papers were identified to compare different physician staffing patterns or test whether one staffing model was superior to another in terms of the effect of admission or time of day on patient outcomes. Further, from the papers reviewed there was not enough information about the severity of a patient diagnosis and the time staff resources were needed in the care of that patient. The studies referred to acuity and quality of care as the workload and burden of care needed for severity of illness. In theory, quality of care with regard to the acuity of severity of illness with each patient diagnosis would produce a different workload burden for staff. As such more work is needed on acuity processes and patient outcomes in order to determine how patient diagnosis affects the workload of staff.

Of the 146 studies, we have examined in more detail 33 papers that identified that staffing may be a contributory factor, however, very few papers investigated these components individually even though they are frequently mentioned as possible influences. The majority of studies investigating staffing and seniority factors looked more at whole teams or units providing a specific model of care for a particular condition. Consequently, specific models of care are reviewed in more detail in a separate section. The characteristics and findings of the included reviews and primary studies are summarised in *Tables 33 (a–f)* and *34 (a–e)*.

A number of papers identified that staffing may be a contributory factor to differences in outcome for patients admitted out of hours. Many postulate that the differences in care may be associated with nursing ratios and senior consultant direct patient care.

One [81] paper identified mixed outcomes and one paper [79] purporting that nurse to patient ratios may be a factor however no difference in outcomes for admitted patients was found. One study [68] investigated inadequate staffing numbers or seniority. The research broke down stroke care into a number of bundles of which nursing ratios and senior consultant presence was analysed. Interestingly, they reported that 24/7 consultant ward rounds had no effect on stroke mortality with out of hours admission but the nursing ratio did. They identified that a lower ratio of nurses to patients had a higher mortality. Another study [106] reported that competing tasks and the less experience of the treating physicians in the rural setting, who may be general practitioners as opposed to stroke specialist, may be the cause of increased mortality of afterhours admissions.

Treatment delay

It is plausible to think that delay in appropriate diagnosis and management in several medical conditions may ultimately affect the potential success of any intervention or specified medical treatment.

There is a paucity of studies directly investigating this component. Of the 146 studies, we have examined 22 papers in more detail indicating that treatment delay was or was not a factor to impact on the outcomes of patients admitted out of hours. The characteristics and findings of the included reviews and primary studies are summarised in *Tables 35 (a–g) and 36 (a–d).*

The majority of these papers analysed clinical datasets. Of these studies, five [42 68 82 119] determined a delay in treatment for patients admitted out of hours and concluded that this delay in treatment impacted on the outcome. six [27 36 61 91 128 129] determined treatment delay for patients admitted out of hours, yet however this did not appear to impact on outcome.

TABLE 32 (a–e): Data extraction of administrative studies identifying patient acuity as a contributory factor of predicting unequal health outcomes for patients admitted out of hours

a. Cardio Respiratory patients

Difference in outcome	Author, Year Country	Comment
Yes	Aujesky, 2009, USA. [73]	Several explanations are possible for the association between weekend admission & increased 30-day mortality, particularly among the most severely ill patients. The higher mortality for patients hospitalised on weekends was driven by the increased mortality rate among patients within the highest severity of illness risk class at presentation.
Mixed	Becker, 2008, USA. [22]	The study found that patients are no more likely to have been hospitalised in the year prior, or Charlson Indices that are statistically indistinguishable from those of weekday patients. Researchers also found a slight spike in the number of AMI patients admitted on Mondays, the absence of a weekends effect suggests that this is unlikely to be the result of less severely ill patients experiencing weekend symptom onset deferring admission until Monday.
Yes	Deshmukh, 2012, USA. [80]	Patients with 3 or more co-morbidities had the greatest association with in-hospital mortality compared to all other parameter.
Yes	Kostis, 2007, USA. [50]	In the investigation of 4 cohorts with over 230,000 patients during 1987–2002, for possible differences in outcome for patients admitted out of hours . They reported 4.8% higher mortality rates at 1-month in patients admitted on weekends v. week-days, which persisted even after adjustment of demographic variables. The magnitude of this increase in mortality how-ever, was reduced to 2.3% and became non-significant (p= 0.09) once analysis accounted for invasive cardiac procedure.
Yes	Kruth, 2008, Germany. [69]	The study found that in a multivariate analysis after adjusting for age, gender, previous MI, diabetes, hypertension, pre-hospital delay and tachycardia, we identified a significant increase of in-hospital mortality on weekends. Also, there was a non-significant increase of in-hospital mortality at nights as compared with "on"-hours.

b. Gastroenterology patients

Difference in outcome	Author, Year Country	Comment
No	Jairaith*, 2011, UK. [49]	The study found that patients presenting at weekends were more likely to present with shock and hematemesis and to receive blood transfusion compared with weekday presentations; and that there was no difference in the risk adjusted mortality of patients presenting with UGIB at weekends compared with weekday.
Yes	Button*, 2011, UK. [74]	The study found that people admitted on weekends and public holidays were slightly but significantly younger (63.4 v. 64.4 years; p= 0.020), were discharged slightly sooner (overall median LoS = 4 days for both; but p= 0.022) and had similar levels of co-morbidities recorded compared with patients who were admitted during the week.
Yes	Dorn,* 2010, USA. [43]	The study found that patients admitted with UGIB over the weekend are likely sicker. Based on a Bonferroni correction for multiple testing (a=0.05/29), those admitted over the weekend were significantly more likely to have baseline coagulopathy, fluid and electrolyte disorders, and a history of alcohol abuse, and less likely to have chronic blood loss anaemia. However, despite statistical significance on these effects of out of hours admission was stronger (HR: 1.17: 95% CI: 1.03–1.32).

c. Haematology-Oncology and other medical specialities patients

Difference in outcome	Author, Year Country	Comment
No	Laupland, 2010, Canada. [138]	While we did not adjust for severity of disease in our study, our observation that neither crude nor adjusted risk was increased argues against a significant after hours effect. The present study was not powered to exclude very small but potentially statistically significant differences in risk. However, given that no excess risk was observed in this study that included all first admissions with community onset bloodstream infection in a population of more than a million people over a 9-year period, argues against a clinically significant effect.

d. Medical patients

Difference in outcome	Author, year country	Comment
Yes	Aylin, 2010, UK. [6]	The study concluded that there could have been differences in case mix between patients admitted during the week and weekends, but acknowledge that all confounding factors were accounted for.

d. Medical patients		
Difference in outcome	**Author, year country**	**Comment**
Yes	Aylin, 2013, UK. [7]	The study investigated 'risk of procedure', but as this was not based on clinical severity, it might not have captured the complete risk profile of patients. The researchers purport however that given that our analysis suggests that patients operated on at the weekend were likely to undergo lower risk procedures, however, again this seems unlikely to account for the findings.
Mixed	Clarke, 2010, Australia. [24]	Researchers purported that it can also be speculated that we found a significant differential outcome on myocardial infarction compared with COPD because myocardial infarction has a relatively higher baseline mortality and thus severity. However, the researchers also acknowledge that they cannot exclude the possibility that patients admitted on weekends were sicker than those admitted on weekdays. The only potential markers of disease severity available in state wide database were ventilation received (relevant for COPD and intracerebral haemorrhage) and presence of acute respiratory failure (relevant for COPD). These did not vary much across weekend v. weekday admissions and were adjusted for in the logistic regression. Therefore, we believe there was little, if any, confounding. Also, morbidities we were unable to distinguish between pre-existing conditions and complications because this information was not available on the entire data set.
Mixed	Maggs, 2010, UK. [147]	The study found that patients admitted at the weekend who survived the first seven days do not have a higher subsequent mortality rate, but those admitted on Monday take days, at night or out of hours do appear to have a worse outcome even if they survive the first seven days. We postulate that these differences in late mortality are more likely to be explained by variation in initial illness severity, since any in-hospital factors around the time of admission would be expected to have less impact after seven days.
Yes	Freemantle, 2012, UK. [10]	The study found that the cohort of patients admitted on weekend were patients who would otherwise had they been less ill, have had their admission postponed until a weekday.
Yes	Freemantle, 2015, UK. [11]	Although fewer hospital admissions occur at the weekend, patients admitted on Saturday and Sunday are sicker and face an increased likelihood of death within 30-days even when severity of illness is taken into account.

e. Neuroscience patients		
Difference in outcome	**Author, Year Country**	**Comment**
No	Crowley, 2009, USA. [75]	The study did not have any reason to believe that the severity of patients presenting with SAH is different on weekends as opposed to weekday.
No	Bejot, 2013, France. [81]	The study found no differences between the two groups for either distribution of cerebrovascular event subtype or stroke severity (measured either by the means of clinical proxies of using the NIHSS score) which is known to be the strongest predictor of a poor outcome in stroke patients.
Yes	Crowley, 2009, USA. [76]	This study was unable to measure and adjust for potentially important confounders such as differences in cause of death, admission grade and stroke severity, level of consciousness, imaging findings, size of haemorrhage, the need for cerebrospinal fluid diversion, whether the ICH was evacuated, and graded outcome scale.
Yes	Palmer, 2012, UK. [53]	The researchers we cannot evaluate how much, if any, of the differential outcome can be attributed to differences in stroke severity.

TABLE 33 (a–f): Data extraction of clinical studies identifying patient acuity as a contributory factor of predicting unequal health outcomes for patients admitted out of hours

a. Cardio Respiratory patients		
Difference in outcome	**Author, Year Country**	**Comment**
No	Al-lawati, 2012, UAE. [128]	Similar number of patients with diagnosis of ST-elevation (39 v. 41%; p= 0.14) and non-ST elevation (32 v. 33%; p= 0.57) MI were admitted on weekdays and weekends, respectively. There were slightly more admissions with unstable angina on weekdays than weekends (29 v. 26%; p= 0.02). There were no significant differences between patients admitted on weekdays and those admitted on weekends in terms of age, gender preponderance (72% men), smoking, co-existing morbidities, prior history, anatomical site of MI, medication administered in the first 24 hours, rate of in-hospital complications and LoS in-hospital.

a. Cardio Respiratory patients		
Difference in outcome	**Author, Year Country**	**Comment**
No	Fonarow, 2008, USA. [145]	Patient characteristics were also similar when patients admitted on weekdays were compared with those admitted on weekdays. Patients admitted on weekends for HF did not appear to be sicker than those admitted on weekdays, as judged by the severity of symptoms and multiple prognostic variables.
No	Jneid,2008, USA. [59]	Patients arriving during off-hours were younger, were more likely to belong to minority groups, and had slightly higher body mass index. They also were less likely to have a history of atrial fibrillation but more likely to have diabetes mellitus, heart failure, previous MI, and adult history of smoking and to present with STEMI.
Yes	Lairez, 2009, France. [52]	The study found no significant differences in the occurrence of recurrent MI, CABG, new PCI, stroke, or renal and vascular events between patients treated with emergency PCI at night and during the day (2.2% v. 2.0%; p= 0.73) or between patients treated during off-hours and regular hours (2.2% v. 1.9%; p= 0.68 respectively).
No	Sorita,2014 USA. [83]	This study found that patients with AMI admitted during off-hours were more likely to have STEMI, present with cardiogenic shock, and develop shock after presentation compared with those admitted during regular hours.
No	Magid, 2008, USA. [34]	However, patients in the fibrinolytic and PCI cohorts who came to the hospital during off-hours were younger, more likely to be smokers, and less likely to have had a pre-hospital ECG than patients who came to the hospital during regular hours. Compared with patients who presented during regular hours, patients in the fibrinolytic cohort who presented during off-hours were more likely to be admitted to hospitals with cardiac surgery capability but less likely to be admitted to hospitals that used fibrinolysis for more than 90% of reperfusion cases. Finally, patients in the PCI cohort presenting during off-hours were more likely to be admitted to high-volume PCI centres and hospitals that used PCI for more than 90% of reperfusion cases than patients presenting during regular hours.
No	Sato, 2015, Australia. [36]	Patients with off-hour admissions were less likely to have had prior antihypertensive, antithrombotic and lip lowering treatment and also had lower GCS scores. Researchers purported that this may be partly due to the difficulty in obtaining an accurate history off-hour, especially in patients with lower consciousness levels. Even though there could have been external factors causing these differences in baseline characteristics, it seems to suggest that patients who were critically ill were more likely to be admitted to stroke centres during off-hours. The researchers also found it intriguing that off-hour admissions were related to greater risk of death at 90-days in patients receiving surgical intervention within 7-days. Though off-hour admission might affect decision making over the indication of surgery and / or postoperative care, the strength of evidence is limited by the small number of clinical events.

b. Gastroenterology patients		
Difference in outcome	**Author, Year Country**	**Comment**
Yes	De Groot, 2012, Netherlands. [42]	Patients admitted during the weekend more often presented with haematemesis and collapse and more often had a lower systolic and diastolic blood pressure and tachycardia at presentation. Rates for re-bleeding and need for angiographic and surgical interventions were also higher in patients admit-ted during the weekend.
No	Haas*, 2010, USA. [27]	The study found that no mortality difference and no difference between groups – severity or presenting symptoms.
No	Myers*, 2009, Canada. [91]	The only clinically significant difference was a higher frequency of emergent admissions for patients hospitalised at the weekend v. patients hospitalised on a weekday (68.2% v. 64.2%, respectively; p<0.0001).
No	Worni, 2012, USA. [35]	No significant difference was detected in severity of appendicitis between weekday and weekend admission.

c. Intensive Care patients		
Difference in outcome	**Author, Year Country**	**Comment**
No	Arabi, 2006, Saudi Arabia. [21]	Elective admissions were excluded because they occurred mainly during weekdays and are typically of lower severity of illness. Admissions to the intermediate care unit, coronary care unit, and cardiac surgical ICU were also not included in the study. The study also shows that two-thirds of emergency admissions are actually admitted during the after-hours with no measurable differences in severity of illness among the three time periods.

c. Intensive Care patients		
Difference in outcome	**Author, Year Country**	**Comment**
No	Ensminger*, 2004, USA. [26]	Patients admitted to ICU at the weekend were sicker, as measured by the APACHE III score and predicted mortality rate. Patients admitted to the ICU at the weekend were less likely to be admitted from recovery rooms or operating rooms or to have a postoperative diagnosis. They were also more likely to require high risk monitoring or active treatment. The 3 most common ICU admission diagnosis groups for both on & off-hours admissions were cardiovascular, respiratory, and GI. The current study showed that the intensity of treatment and the ICU admission source, as well as the APACHE III predicted mortality rate, were independently associated with increased hospital mortality. *(Subgroup analysis demonstrated increased severity on weekends but no effect on mortality after adjustment for severity)*
Yes	Glasser, 2008, USA. [82]	The study found sicker patients may present during off-hours because of inability to wait for routine hours. The researchers postulated that off-hour patients are sicker because MI onset while sleeping may lead to longer ischemic times upon arrival. The study found higher rates of cardiogenic shock and higher rates of multi-vessel coronary artery disease in those patients presenting during off-hours. However, after accounting for these factors, off-hour presentation remained associated with poorer outcomes.
No	Kuijsten, 2015, Netherlands. [137]	Researchers disclosed that although APACHE II was used to correct for illness severity patients were matched based upon propensity score, this did not fully exclude the influence of case mix differences. The study found that surgical patients admitted in the middle of the night are different from patients admitted during office hours. The study found that there as an increase in the difference between observed and predicted mortality from 4pm onwards.
No	Laupland, 2011, Canada. [101]	Patients admitted during weekdays were different based on a number of characteristics from those admitted during nights and/ or weekends. This study identified that while most admissions to ICU occur in the afterhours and that the weekends admissions were associated with higher crude case fatality, the day of the week or night time admissions were not associated with mortality once adjustment for confounding variables were performed.
No	Meynaar*, 2009, Netherland. [105]	This study found no difference in case mix adjusted hospital mortality between ICU patients admitted during daytime as compared with those admitted during office hours. This study found no mortality difference in urgent surgery and in medical patients between patients admitted during daytime and patients admitted off-hours. Standardised mortality ratios are no different for patients admitted during daytime as compared to those admitted during off-hours. Logistic regression analysis confirmed that age APACHE II and expected mortality and admission type were related to outcome but off-hour admission was not. Results were similar with SAPS II expected mortality instead of APACHE II expected mortality. The researchers conclude that the differences in mortality could all be explained by differences in disease severity.
No	Morales*, 2003, USA. [78]	When researchers implemented the logistic regression analysis model with hospital mortality rate as the dependent variable and admission source, admission diagnosis category, APACHE III predicted hospital mortality rate, and group of night time admission as independent variables, we did not find significant difference in mortality rates between the early and late night time admissions (p= 0.6191; OR: 1.063; 95% CI: 0.835–1.354).
No	Numa, 2006, Australia. [120]	After multivariate analysis, 3 of 9 diagnostic subgroups analysed (congenital heart disease, cardiac arrest, and shock) demonstrated a significantly higher risk of death for evening but not weekend admissions.
Mixed	Uusaro*, 2003, Finland. [84]	The study findings were not explained by disease severity, intensity of care given to patients in ICU or by decisions to restrict patient's care.
No	Wunsch*, 2004, UK. [108]	The researchers conclude that the finding that admission to an ICU at night and at the weekend is not associated with significantly higher case mix adjusted hospital mortality is reassuring. The association for night was still significant after adjustment for case mix using the UK APACHE II model (OR (night): 1.16; 95% CI: 1.10–1.23) but was non-significant when adjusted using the component model (APACHE II components OR (night): 1.02, 95% CI: 0.96–1.09).
No	Hixson, 2005, USA. [28]	The study found that out of hours admissions were more likely to be emergency, non-operative patients; differ in the distribution of patients by primary diagnosis and have lower PRISM III score but have a higher overall PRISM III predicted mortality risk. The researchers purported that the reason for this has to do with the differences in the number of emergency, non-operative patients, cardiovascular surgery patients, and the frequency of cardiopulmonary resuscitation for patients admitted at the weekend and their effects on the PRISM III risk of mortality model.
No	Arias, 2004, USA.[130]	Paediatric patients admitted during out of hours had a higher odd of death than did patients admitted during the daytime hours, after adjustment for the severity of illness and other covariates diagnosis specific analyses (except for shock or congenital cardiovascular disease) did not demonstrate different mortality rates when out of hours admissions were compared with daytime admissions.
No	Arslankoylu, 2008, Turkey. [67]	The study found the velocity of admissions to the PICU was higher in daytime and weekdays than evenings and weekends. That may be due to the delay at the admission of the patients to the PICU, because parents may prefer daytime or weekdays to admit their children to the hospitals or may be less vigilant to the symptoms of the critically ill children in the evening time. Truly the higher PIM2 scores and longer LoS of the daytime admissions support that thought.

c. Intensive Care patients		
Difference in outcome	**Author, Year Country**	**Comment**
No	Schmulewitz, 2005, UK. [37]	The study did not adjust data for severity of illness on admission although the research did subsequently look for information on those admissions that had passed through HDU and ICU settings.

d. Neuroscience patients		
Difference in outcome	**Author, Year Country**	**Comment**
Yes	Niewada, 2012, Poland. [119]	The study found patients were older, more likely to have AF or coronary heart disease, were more disabled prior to stroke and suffered more severe stroke, which corresponds to more urgent medical seeking and shorter mean time from onset admission.
No	Albright, 2009, USA. [19]	Study found no significant differences in NIHSS scores, age, race or admission glucose levels when comparing the weekend and weekday groups. In addition, the study did not find a significant difference in IV T-PA treatment rates. While the study did not find the rate of weekend admissions for AIS- T-PA to be significantly different between the 2 sites (37%, 35%), it did find the weened stroke rate to be greater than the expected 28.6% 24/7. This increased incidence of stroke on weekends is consistent with previous reports of an increased incidence of stroke on holidays and weekends.
No	Almekhlafi, 2014, Canada. [129]	The study found baseline differences between the two groups – with atrial fibrillation and smoking being more prevalent in the cohort treated during evenings and weekends. It was also expected that the two groups have other unknown clinical and pathophysiological differences.
Yes	Campbell, 2014,UK. [68]	Patients admitted out of hours are more likely to present with haemorrhagic stroke, have reduced consciousness and have pre-morbid dependency; those patients with ischaemic stroke are more likely to present with more severe stroke subtypes. These data suggest that the observed excess mortality associated with out of hours admission reported in previous studies can largely be explained by un-measured differences in severity and prognosis. However, despite presenting with a greater illness severity, patients admitted out of hours are also less likely to receive timely access to key investigations and interventions, such as brain scanning and stroke unit admission.
No	Karlinski, 2013, Poland. [135]	The study found, patients admitted at out-of-office hours and on non-working days appear to be very similar to patients admitted during regular working hours, both in terms of baseline characteristic and outcome. The tendency for a lower proportion of mild strokes may correspond with the higher proportion of the hyper dense artery sign, but it does not seem to modify the effect of thrombolysis.
Yes	Reeves, 2009, USA. [72]	This study found clinically important differences in the study for ischemic and haemorrhagic stroke was non-existent for patients presenting off or on-hours.
Mixed	Sheu*, 2007, Taiwan. [33]	This study found that patients with AMI admitted during off-hours were more likely to have a STEMI, present with cardiogenic shock and develop shock after presentation compared with those admitted during regular hours. After adjustment for the difference in risk, off-hours admission was not significantly associated with higher complication rates, especially ventricular arrhythmias and gastrointestinal bleeding. There was no difference in outcomes between STEMI and NSTEMI. The researchers found higher complication rates for patients admitted during off-hours.

e. Surgical (Emergency) patients		
Difference in outcome	**Author, Year Country**	**Comment**
No	Buse, 2004, USA. [132]	The study found that older age and higher severity of injury were predictive of increased major complications and mortality following trauma care. The study identified that for patients requiring emergency trauma surgery, major complications and mortality were not associated with whether a patient presented during the night or day, on a weekend v. weekday, month or presentation or year of presentation.
No	Orman, 2012, USA. [31]	A fully adjusted model was created that controlled for age, race, sex, diabetes, BMI, vasopressor support, dialysis, previous upper abdominal surgery, portal vein thrombosis, re- transplantation, donor location, pre-MELD era v. MELD era, diagnosis, donor age, cold and warm ischemia times, night-time organ procurement, donor cause of death, and daytime operations v. night-time operations. The results for each of these models were unchanged from the results for the unadjusted model.

f. Trauma patients		
Difference in outcome	**Author, Year Country**	**Comment**
No	Carmody, 2002, USA. [133]	The study found more patients were admitted on weekends and at night-time and they had higher injury severity and a higher percentage of penetrating trauma. When patients were matched for injury severity the researchers found no evidence of increased mortality related to fixed trauma team staffing.
No	Laupland, 2009, Canada. [70]	The study identified that the case-mix of patients was an important determinant of outcome and variation during times of the day and days of the week and likely explains much of the afterhours increased mortality effect seen. However, after controlling for diagnosis and severity of disease and case mix reduced (eliminated) unequal outcomes of patients. There researchers surmised that adjustment for case mix is clearly an important consideration to define consistency in processes of care afterhours.

TABLE 34 (a–e): Data extraction of administrative studies identifying staffing as a contributory factor of predicting unequal health outcomes for patients admitted out of hours

a. Cardio Respiratory patients		
Difference in outcome	**Author, Year Country**	**Comment**
Yes	Aujesky, 2009, USA. [73]	It is purported that the possible association between weekend admission and increased 30-day mortality (particularly among the most severely ill patients) is that fewer medical providers and professional staff tend to work in-hospitals on weekends than on weekdays and those who do work on weekends may have less clinical experience. Also, fewer supervisors are present on weekends and they are often responsible for supervising the work of staff members they do not know as well.
Yes	Deshmukh, 2012, USA. [80]	Authors purport that one possible reason for the difference in outcome could be differences in staffing. During weekends, hospital staffing is reduced in overall quantity and in the number of qualified to perform certain procedures. It may be surmised that subtle early signs of acute problems go unnoticed until later. In many hospital settings, a physician not entirely familiar with the patients' problem is likely to provide coverage on weekends; hence, the patient might not have access to a physician familiar with all the medical issues.

b. Gastroenterology patients		
Difference in outcome	**Author, Year Country**	**Comment**
Yes	Button*, 2011, UK. [74]	Researchers purport that possible explanation for the increased mortality at weekends and on public holidays include reduced staffing levels that may lead to less thorough assessment, lack of specialist or senior consultant cover, less application of multidisciplinary team care, poor communication at handover and possible delay to investigation such as endoscopy in some hospitals without out of hours services.
Yes	Dorn,* 2010, USA. [43]	The study portends a worse outcome suggests that changes in the delivery of care (i.e., processes) have the potential to improve out-comes. Considering that those seeking care at the weekend are likely sicker, one possible strategy is to increase hospital staffing levels.

c. Intensive Care patients		
Difference in outcome	**Author, Year Country**	**Comment**
Yes	Bhonagiri, 2011, Australia. [111]	The study identified that the unequal outcomes for patients admitted to out of hours may equally be related to patient selection for elective surgery, patient workup for elective surgery, surgical team skill mix or hospital resources. Finally, a lack of early assessment and formation of a management plan by intensivists may be the reason for this difference.

d. Medical patients

Difference in outcome	Author, Year Country	Comment
Yes	Ricciardi, 2014, USA. [16]	Mortality following a weekend admission for patients admitted to hospital with resident trainees was significantly higher than hospitals with no resident trainees. The authors suggest that it may be a problem with supervision of trainees.

e. Neuroscience patients

Difference in outcome	Author, Year Country	Comment
Mixed	Bejot, 2013, France. [81]	The onset during weekends/ public holidays was associated with higher risk of 30-day mortality during 1985–2003 but not during 2004–2010; before and after the introduction of a dedicated stroke care network.
No	Crowley, 2009, USA. [75]	The researchers purported that there are fewer physicians and nurses in-house on weekends, with a concomitant increase in individual workload on those health care providers. Additionally, the physicians who are working on weekends are often less experienced than those available on weekdays, and they will often cover patients with whom they are less familiar. It might seem intuitive that this difference in experience would be more pronounced in academic facilities, where resident coverage is the norm.
Yes	Saposnik, 2007, Canada. [106]	Researchers proposed increased mortality with stroke admissions on weekends in rural settings compared to urban settings that competing tasks and the less experience of the treating physicians in the rural setting, who may be general practitioners as opposed to stroke specialist, may be the cause of increased mortality of afterhours admissions.

TABLE 35 (a–g): Data extraction of clinical studies identifying staffing as a contributory factor of predicting unequal outcomes for patients admitted out of hours

a. Cardio Respiratory patients

Difference in outcome	Author, Year Country	Comment
Yes	Glasser, 2008, USA. [82]	Higher angioplasty failure rates occur at night, although there has not been sufficient angiographic or procedural information to understand potential causes. In this respect, those complications that may be related to operator performance, such as vessel dissection, were more frequent at night, whereas complications potentially related to lesion characteristics, such as distal embolisation, were not. The use of time-consuming devices was also less frequent at night than during daytime hours, despite similar lesion characteristics.
No	Jneid, 2008, USA. [59]	The study found that STEMI patients arriving during off-hours were more likely to receive fibrinolytic therapy and slightly less likely to undergo primary PCI. Whilst this did not result in any net differences in overall reperfusion rates, however may reflect an appropriate clinical decision on the part of off-hour physicians to select fibrinolytic therapy when prompt PCI is not feasible. The researchers purport that regardless of the soundness of these triage decisions, the timeliness of primary PCI, when selected, was suboptimal, pointing out the ongoing system challenges in achieving rapid system activation and staff mobilisation during off-hours.
Yes	Lairez, 2009, France. [52]	The researchers purported that the results evolve from less efficient patient management during night-time hours. This study reflects actual clinical practice and demonstrates the existence of greater mortality risk for emergency PCI performed at night than for daytime emergency PCI, independent of indication and previous treatment. The researchers conclude that better management of ACS is needed and, perhaps, that greater use of adjunctive medications should be considered when PCI is performed at night.
No	Sorita, 2014 USA. [83]	The researchers purported that the mortality increase during off-hours may be alleviated with institutional systems improvement.

b. Gastroenterology patients

Difference in outcome	Author, Year Country	Comment
Yes	DeGroot*, 2012, Netherlands. [42]	Found proposed that physician related factors may be a factor but was unlikely because they did not identify an increased mortality at other times when physician numbers were low (night and evening).

b. Gastroenterology patients

Difference in outcome	Author, Year Country	Comment
No	Haas*, 2010, USA. [27]	The study found that there was no difference in outcome for admissions out of hours. The researchers surmised that the reason for this was that a competent support staff is available at all times as well as the ability of the emergency room physician, internist and gastroenterologist to appropriately risk strategy patients early in their course, validating the consensus recommendations for managing patients presenting with GI bleed .

c. Intensive Care patients

Difference in outcome	Author, Year Country	Comment
No	Arabi, 2006, Saudi Arabia. [21]	The study demonstrates that a majority of patients are in fact admitted during the after-hours, a period in which they are in most need of a qualified intensivist.
Mixed	Arias, 2004, USA. [130]	ICU specific information regarding differences in staff and physician coverage was not present in the database and might independently influence mortality rates.
No	Arslankoylu, 2008, Turkey. [67]	The study found that in day time admissions, mechanical ventilation initiation ratio was higher than the evening admissions. The study purports that the difference might be due to the presence of a paediatric intensivist in the PICU during daytime.
Mixed	Ensminger*, 2004, USA. [26]	The study purported that the structure of their critical care practice compared to structure of ICUs investigated in other studies may be responsible for the absence of overall increase in the mortality of patients admitted to the ICU on weekends in the study.
No	Meynaar*, 2009, Netherlands. [105]	For the purposes of this study the definition of off-hour was based on the presence or absence of the intensivist in the ICU.
No	Morales*, 2003, USA. [78]	Results suggest that night-time admission to an intensive is unit need not be associated with poor out-come as long as adequate staffing and services are maintained. Provided that there are enough nurses, respiratory therapists, physicians, and other medical personnel as well as laboratory, radiology, and other services needed to provide optimal patient care, the timing of ICU admission is unlikely to be associated with mortality rate.
Yes	Neuraz, 2015, France. [79]	The risk of death increased when the patient-to-nurse ratio was greater than 2.5 and when the patient to physician ratio exceeded 14. The highest ratios occurred more frequently during the weekend for nurse staffing and during the night for physicians.
Mixed	Sheu*, 2007, Taiwan. [33]	The study found that results were somewhat compatible with the staffing pattern in the ICU where resident physicians and critical care nurses staffed in the ICU in hours at constant levels all the time, while dedicated intensivists led the morning rounds on all days of the week but did not stay in house overnight. The study found that there were fewer ICU admissions and non-conferences on weekends. Researchers purported that with the same staffing levels the lighter workload might result in better patient care and therefore, lower hospital mortality for patients admitted on weekends. Researchers observed that the adjusted OR of hospital mortality were higher for morning admissions than for afternoon admissions, and were higher for midnight admissions than for evening admissions implied that there might be 'morning-effects' or 'sleep deprivation effects' beyond the effect of staffing levels. The study found that routing morning service, teaching rounds, case conferences and journal clubs were all held in the morning.
Mixed	Uusaro*, 2003, Finland. [84]	Most of the ICUs in this study lacked dedicated full time intensivist coverage for the whole-time period from Friday afternoon till Monday morning. Researchers found that mortality was not increased for patients who were admitted to ICU from 1600 hours to 0800 hours. The researchers speculate that of the ICUs included in the study the physician on-call in-hospital for critically ill patients most often does not work on a daily basis in the ICU during normal working hours. Therefore, the physician on-call does not necessarily have in-depth knowledge of the patients who already are in the ICU at the start of her/his shift (1600 hours). New admissions by this physician occur from 1600 hours to 0800 hours and therefore she or he has to know new patients in detail to make plans for examinations and therapeutic interventions. It may be that during the evenings and night time the physician is more informed of and involved with newly admitted patients and thus more dedicated to their care. This could translate into equal mortality for "out-of-office" hour and "office hour" admissions.
No	Wunsch*, 2004 UK. [108]	Researchers found that patient care on admission to ICU does not appear to be affected by lower levels of either onsite staffing in the ICU, or of support services locating elsewhere in the hospital during certain days and times.

d. Neuroscience patients

Difference in outcome	Author, Year Country	Comment
Mixed	Bray, 2014, UK. [55]	Researchers purported that the highest risk of death observed was in stroke services with the lowest nurse / bed ratios.

Yes	Campbell, 2014, UK. [68]	Researchers broke down stroke care into a number of bundles of which nursing ratios and senior consultant presence was analysed. Interestingly, they reported that 24/7 consultant ward rounds had no effect on stroke mortality with weekend admission but the nursing ratio did. They identified that a lower ratio of nurses to patients had a higher mortality.
Yes	Hasegawa, 2005, Japan. [48]	The study purport that the staffing level on admission is also likely to be an important element of stroke unit care and researchers conclude that health policy makers should be concerned about the staffing level on admission and the ratio during the early stages of stroke.

e. Orthpaedics patients

Difference in outcome	Author, Year Country	Comment
Yes	Foss, 2006, Netherlands. [77]	Staff reduction during holiday periods in units that care for acute surgical patients may adversely influence postoperative outcome. This may have important consequences both for outcome analysis of interventions and the planning of resource management in surgical units.

f. Trauma patients

Difference in outcome	Author, Year Country	Comment
No	Carmody, 2002, USA. [133]	The study found that no clinical significant diurnal-weekend or volume related variation in quality of care. Consistency of outcomes implies consistency in quality of care. The researchers concluded that if a centre is staffed appropriately an injured patient should have the same risk of mortality regardless of time or day of admission.
No	Laupland, 2009, Canada. [70]	Trauma staffing is lower in the afterhours as compared to weekday time hours with fewer resident physicians, nursing staff and allied health professionals such as pharmacists, physiotherapists and respiratory therapists. The study purported that trauma surgeons are not mandated to remain in hours but frequently do during busy trauma seasons.

g. Surgical patients

Difference in outcome	Author, Year Country	Comment
No	Orman, 2012, USA. [31]	At centers where the primary surgical team is on call for a week at a time or for the whole weekend, there may be a resultant decrease in graft survival later in the weekend preceding days. Another explanation for a decline in graft survival at 1-year could involve the support staff for surgical services. During the weekend, these individuals may form a cross-disciplinary team involved in a heterogeneous set of operative cases, including trauma, orthopaedics, and surgical emergencies. During weekdays, the surgical team is likely to be composed of dedicated transplant personnel. Procurement may be left to local surgical teams at non-liver transplant centers more often on weekends, whereas transplant teams may travel to the donors on weekdays and weeknights. Perioperative support, including the physical presence of multiple medical experts (e.g., dedicated transplant pharmacists), may be less available on weekends. Therefore, there are plausible reasons for weekend transplants to have worse graft survival.

TABLE 36 (a–d): Data extraction of administrative studies identifying treatment delay as a contributory factor of predicting unequal health outcomes for patients admitted out of hours

a. Cardio Respiratory patients

Difference in outcome	Author, Year Country	Comment
Yes	Aujesky, 2009, USA. [73]	Authors purport that understaffing in the emergency and radiology departments, numerically and in terms of expertise could potentially result in delayed diagnosis and treatment of PE, with an unfavourable impact on patient prognosis. Provision of care by covering physicians and / or more junior physicians may lead to the underuse of recommended processes of care for PE and that are associated with improved patient outcomes. Inadequate professional staffing and medical coverage during the weekend may also delay the detection of potentially fatal early complications.
Yes	Deshmukh, 2012, USA. [80]	Patients admitted on weekends were less likely to undergo cardio version than those admitted on weekdays (7.9% v. 16.2%; p= 0.0001). Also, the interval between admission and performance of procedures was longer for patients admitted on weekends. When cardio version was added to the regression model, the difference in weekend and weekday mortality was not significant.

a. Cardio Respiratory patients		
Difference in outcome	**Author, Year Country**	**Comment**
Yes	Kostis, 2007, USA. [50]	The time between admission and performance of procedures was longer for patients admitted on weekends. The percentage of patients who underwent a procedure on the day of admission (possibly reflecting primary PCI) was also lower on weekends.
Yes	Kruth, 2008, Germany. [69]	Data show a markedly longer in-hospital delay for primary angioplasty during the weekends as compared to traditional working hours. However, within the observed in-hospital delays door to angiography time did not influence in-hospital mortality.

b. Gastroenterology patients		
Difference in outcome	**Author, Year Country**	**Comment**
Yes	Button*, 2011, UK. [74]	Recorded endoscopy was significantly lower (p<0.001) for admissions on Fridays (37.1%) and Saturdays (38.8%) than on other days (which varied between 44.3% for Sundays and 47.8% for Tuesdays). Rates of endoscopy on the day of admission were lower (p<0.001) for admissions on Saturdays (8.5%) and Sundays (7.4%) than on weekdays (17.5% to 20.9%). The median time to endoscopy was higher (p<0.001) for admissions on Fridays and Saturdays (both 3 days) and on Sundays (2 days) than for other days of the week.
Yes	Dorn*, 2010, USA. [43]	The study found that patients admitted over the weekend were less likely to undergo endoscopy, when we controlled for EGD in our analysis the weekend mortality effect did not change.
No	Jairaith*, 2011, UK. [49]	Here were significant delays to endoscopy in those patients who presented on weekends with only 38% receiving endoscopy within 24 hours of presentation.

c. Intensive Care patients		
Difference in outcome	**Author, Year Country**	**Comment**
Yes	Bhonagiri, 2011, Australia. [111]	After-hours return to the ICU following elective surgery may imply prolonged surgery started in hours, where intraoperative complications have delayed ICU admission, but the resulting physiological derangement is not reflected in the APACHE III- risk of death. Alternatively, these admissions may be of patients whose elective surgical procedures were started at times when a lack of normal facilities, resources and staff have put the patients at increased risk of death.

d. Neuroscience patients		
Difference in outcome	**Author, Year Country**	**Comment**
No	Albright, 2009, USA. [19]	The study was unable to find a significant difference in IV t-PA treatment rates in patients presenting on a weekend and those presenting on a weekday (60.4 v. 58.5%: p= 0.397).
Mixed	Karlinski, 2013, Poland. [135]	In comparison to patients admitted during regular hours, the proportions of those treated within 90 min from the stroke onset were lower in all evaluated groups. Considering the similar rate of DNT 60 min, it may be assumed that increased delays were most likely due to prolonged pre-hospital phase.
Yes	Palmer, 2012, UK. [53]	The researchers found that some of the measures that reveal a significant disparity, particularly same-day brain scan rates, are less likely to be affected by variations in stroke severity (unadjusted OR: 0.83 [95% CI: 0.81-0.86]) and thrombolysis (unadjusted OR: 0.82; 95% CI: 0.73–0.92)

TABLE 37 (a–e): Data extraction of clinical studies identifying treatment delay as a contributory factor of predicting unequal health outcomes for patients admitted out of hours

a. Cardio Respiratory patients		
Difference in outcome	**Author, Year Country**	**Comment**
No	Al-lawati, 2012, UAE. [128]	The study found similar proportion of patients in the weekdays group and weekend group received thrombolytic therapy within the recommended time period (≤ 30 min) (32 v.27%; p= 0.25). Furthermore, recommended door-to-needle time (≤ 90 min) was not significantly different be-tween the 2 groups (51% in weekdays and 53% in weekends; p= 0.87). However, PCI (31 v. 26%; p= 0.006) and CABG (3.2 v. 1.7%; p= 0.01) were significantly higher in admission on weekdays compared with weekends.

b. Gastroenterology patients

Difference in outcome	Author, Year Country	Comment
Yes	DeGroot*, 2012, Netherlands. [42]	The study found that patients admitted during the evening had a significantly longer time to endoscopy compared with patients admitted during daytime and night and 16 h respectively for day, evening and night, p<0.01). However, time between admission and endoscopy was not significantly different during the weekend than during the week (15.9 h v. 17.6 h). The need for endoscopic intervention was not different between the two groups.
No	Haas*, 2010, USA. [27]	The study found that patients presenting with hematemesis received upper endoscopy earlier than patients presenting with melena. There was no statistically significant difference in the rate of surgical interventions was noted for weekend v. weekday admission (4% v. 1.61% p= 0.325). Researchers also purported the reason for no difference in outcome for patients admitted out of hours is that endoscopy for this site is available 24 hours a day, 7-days a week and that the standard of practice employed by the gastroenterology department is the same regardless of the day of the week.
No	Myers*, 2009, Canada. [91]	The mean (± SE) time to endoscopy was similar between groups (weekend 1.14 ± 0.03 days v. weekday 1.12 0.03 days; p= 0.60); however, patients admitted at the weekend were less likely to undergo endoscopy on the day of admission (43% v. 45%; p= 0.01). This difference was most pronounced by the second day, at which time 81% of patients admitted on a week day had undergone endoscopy v. 75% of those admitted at the weekend (adjusted OR: 0.68; 95% CI: 0.63 to 0.73; p<0.0001). After the second day, there were several small but statistically significant differences in the timing of endoscopy between patients admitted at the weekend v. those admitted on a weekday.

c. Intensive Care patients

Difference in outcome	Author, Year Country	Comment
Yes	Glasser, 2008, USA. [82]	The study found off-hour angioplasty was not associated with significant delay when using symptom onset to PCI time. Further researchers found that incidence of adverse events was only slightly higher on weekends, a time when delays would be expected to be greater than weekdays with the majority of difference consistently occurring between night time v. daytime PCI regardless of weekday or weekend.

d. Neuroscience patients

Difference in outcome	Author, Year Country	Comment
Yes	Niewada, 2012 Poland. [119]	The study found that although weekend patients were more likely to arrive within the first 3 or 6 hours after stroke onset, it did not result in more re-PA treatment procedures.
No	Almekhlafi, 2014, Canada. [129]	Significant delays in imaging to reperfusion times were encountered during evenings and weekends compared with working hours. Despite this, the study reported imaging to reperfusion times remain relatively short compared with the existing literature.
Yes	Campbell, 2014, UK. [68]	The study found significant differences in the quality of care received by patients admitted out of hours. Patients admitted out of hours waited longer to receive a brain scan or be admitted to a stroke unit and were less likely to be admitted to a stroke unit directly or to receive thrombolysis, multidisciplinary stroke specific care and therapy early after admission.
Yes	Reeves, 2009, USA. [72]	Clinically important differences in the quality of care provided to patients who presented during off- or on-hours were small to non-existent. The proportion of patients who arrived within 2 hours who were treated with intravenous tissue plasminogen activator was slightly lower during off-hours (56.4% v. 58.8%), but deep vein thrombosis prophylaxis rates were slightly higher in the off-hour group (67.4% v. 65.6%).
No	Sato, 2015, Australia. [36]	The study found no evidence in heterogeneity in the effects according to the time of day for the initiation of treatment. The researchers found that intensive BP lowering is likely to be a generalisable treatment strategy irrespective of admission hours among patients with acute ICH under assuring background stroke care.

e. Orthopaedics patients

Difference in outcome	Author, Year Country	Comment
No	Mathews, 2016, UK. [61]	Time to surgery There was statistically no difference in the odds of time-to-surgery being less than 36 h between weekend and weekday patients (p= 0.975). As ASA increases by one unit, the expected odds of having a time-to-surgery of less than 36 hours are reduced by 32% (p= 0.001; 95% CI: 0.54–0.85) The season also has a significant effect on undergoing surgery within 36 hours (p= 0.014). Patients who were admitted in spring, summer or autumn all have greater odds of having a time to surgery of less than 36 hours compared to the patients admitted in winter.

Chapter 7: Which care processes have been effective in reducing unequal health outcomes for patients admitted out of hours and at the weekend?

It has been suggested that patients presenting out of hours are subject to inferior care. Of the 146 studies, we have examined in more detail an attempt has been made to investigate the correlation between care received by patients admitted out of hours.

A specific model of care was defined as one in which a patient with a particular medical condition is assessed, treated, and cared for by a team of health professionals experienced in treating that condition. This team is responsible for the patient's care on admission to hospital and throughout their hospital stay ensuring a continuous level of care is provided. The team includes a senior medical specialist, appropriate and consistent nursing ratios, experienced allied health members and access to investigations and treatments in a timely fashion.

For example, a patient who presents with a stroke is assessed, treated and cared for in a stroke unit. This stroke unit includes stroke specialists, nurses and allied health professionals that are experienced in treating stroke patients, and has access to the investigations and treatments that are required for patients presenting with a stroke.

Other units displaying specific models of care identified in the review include: the trauma unit that manages patients presenting following trauma; the cardiology unit that is responsible for performing percutaneous coronary interventions in patients presenting with acute myocardial infarct; and the intensive care unit that manages the most critically unwell patients, H&M unit that accepted direct admissions for H&M.

Thirty-two studies analysed a specific model of care. Fourteen studies analysed ICUs, eight comprehensive stroke centres, four percutaneous coronary intervention clinics, four trauma care centres, one transplant team and one H&M unit. The characteristics and findings of the included studies are summarised in *Tables 36–42.*

Studies whose methodologies were not restricted to specific models of care were not included. Studies excluded were investigations of patients admitted to hospital under units with inconsistent staffing or with varying levels of experience with stroke. For example, the methodology used by Saposnik (2007) [125] was one that included patients suffering from a stroke who presented to acute care facility across Canada. These facilities varied between rural, urban and tertiary level hospitals, and as such the patients were cared for in units that may not have been a dedicated stroke unit, instead been staffed by medical and nursing teams with less experience with stroke care.

Four [19 21 84 100] papers were prospective observational studies with only two studies [71 81] performed a pre and post investigation of the model of care or used a control group involved.

The majority of studies (18) [19-21 27-29 31 36 67 70 78 83 103 105 108 129 132–133] did not identify an association between out of hours admission and mortality. This was consistent across all different units providing a specific model of care. This is most evident in the studies on ICU, stroke and trauma admissions. Interestingly the studies in cardiology looking at PCI at first appear to be mixed. However, further analysis reveals that the studies reporting increase in mortality for patients admitted out of hours are older and may not reflect current 24/7 usage of PCI. With regards to GI bleeding the one [27] study identified that where patients were admitted and treated by a specific unit that deals with GI bleeding found no difference in outcome.

It cannot be inferred from these studies that specific models of care ameliorate the unequal outcomes for patients admitted out of hours. From the information reviewed there is no way to determine if there was a problem with out of hours admission prior to the introduction of the models of care or if there has been any improvement in mortality after the introduction of the model of care.

Even if such a connection could be made, the units providing the specific models of care are made up of a number of components and further investigation is required to identify which of components of the team improve outcome. While we have found no evidence base on how to best organise and operate a hospital out of hours to ensure there is no effect on mortality, what we have found is that patients admitted to and treated by a specific health care team did not have an increased mortality if they were admitted out of hours.

Comprehensive Stroke Centres

TABLE 38: Data extraction of studies analysing specific model – Comprehensive Stroke Centre/s

Author	Comment
Albright, 2009, USA. [19]	Stroke Centre may ameliorate differential outcomes in stroke patients. These results may be due to the 24/7 availability of stroke specialists, advanced neuroimaging or ongoing training & surveillance of specialised nursing care. Results require confirmation in prospective studies.
Albright, 2012, USA. [20]	No evidence of differences in outcome. Ischemic stroke patients admitted on weekends did not display significant difference in LoS, inhospitable mortality, favourable hospital discharge or functional outcome at discharge or an inferior 90-day functional outcome or higher 90-day mortality.
Almekhlafi, 2014, Canada. [129]	Some delays were uncounted during evenings and weekend hours. Despite that, it was feasible to achieve relative short image to treatment during these hours in comparison to existing literature (no analysis of mortality just time to intervention after hours compared to in hours in dedicated stroke centre).
Bejot, 2013, France. [81]	The deleterious effect of weekends and holidays on 30-day mortality disappeared after the organisation of a dedicated stroke care network in the community.
Hasegawa, 2005, Japan.[48]	Although specific elements of structures and processes for the effects of stroke unit care have not yet been identified, several possible factors have been emphasised, i.e. a multidisciplinary team approach, well-trained nursing team, early mobilisation, early hydration, early prescription of aspirin for ischemic stroke and protocol adherence. The staffing level on admission is also likely to be an important element of stroke unit care.
Karlinski, 2013, Poland. [135]	There is no bad time for thrombolysis. Stroke centres should feel confident about treatment out of regular working hours, irrespective of equipment and staff availability. However, it may be reasonable to pay attention during night-time.
McKinney, 2011, USA. [71]	More appropriate hospital staffing and organisation of stroke care such as that provided by CSC may negate differences in outcome and save lives.
Sato, 2015, Australia. [36]	Off-hour admission was not associated with poor outcome in patients with acute ICH who participated in the trial. Disadvantage of off-hour admissions may be avoidable when stroke care is standardised and based in 24-hour monitored facilities.

Intensive Care Units

TABLE 39: Data extraction of studies analysing specific model – Intensive Care Unit/s

Author	Comment
Arabi, 2006,Saudi Arabia. [21]	The outcomes are similar for patients admitted during weekdays, weeknights and weekends to and ICU covered on site by qualified intensivist 24 hours a day 7-days a week.
Arslankoylu, 2008, Turkey. [67]	Although there may be some differences according to the time of admission to the PICU with respect of the overall mortality rates, the researchers conclude that closed PICU management under the control of a paediatric intensivist carries gratifying results in terms of continuousness and constancy of the PICU care.
Bhonagiri, 2011, Australia. [111]	Patients admitted to the ICU after hours have increase mortality and SMR. The increased mortality with after hours and weekend admission to the ICU is predominantly accounted for by patients with planned admissions following elective surgery.
Ensminger* 2004, USA. [26]	No significant differential outcome for medical or multispecialty patients.
Hixson, 2005, USA. [28]	Found no difference in mortality associated with weekend v. weekday admission in paediatric ICUs or the paediatric emergency department.
Kuijsten, 2015, Netherlands. [137]	ICU performance is influenced by an intricate interplay of various factors. The ICU organisation during off-hours there is intensive interaction with other medical disciplines, and changes in their quality of care during off-hours might influence ICU outcome as well, which is not reflected by illness severity at admission. The performance of health care workers (physicians and nurses) varies during the day. Although speculative, the detrimental effect of the circadian biorhythm on human performance during the night shift and especially at the end of the night shift is a known factor.

Author	Comment
Laupland, 2011, Canada. [101]	No association was found between timing of admission to ICU and subsequent outcome after controlling for a number of variables. Further investigation is needed to examine whether minimisation of after hour discharges and / or augmentation of ward care post ICU discharge may improve the ultimate outcome of critical illness.
Lee*, 2008, Singapore [102]	In a specialised ICU with adequate staffing and necessary diagnostic and therapeutic modalities, timing of severe head injury ICU admission is unlikely to be associated with mortality rate.
Luyt*, 2007, France. [103]	ICU off-hour admission is not associated with a poorer outcome than day shift admission consistent with a constant level of care, regardless of the time and day.
Meynaar*, 2009, Netherlands. [105]	We speculate that if intensivists are continuously present in the ICU during daytime and present when necessary during off-hours this is sufficient to avoid a quality gap during off-hours.
Morales*, 2003, USA. [78]	Night time admissions to ICU was not associated with a higher mortality rate or a longer hospital or intensive care unit stay compared with day time admission.
Sheu*, 2007, Taiwan. [33]	Non-office hours v. office hours admissions were not associated with poorer ICU, hospital or ventilator outcomes in a medical ICU equipped with patient management guidelines and staffed by intensives on call for 24 hours, who led the morning rounds on all days of the week but did not stay in hours over night. Moreover, time of day and day of week admissions to ICU were not associated with significant differences in-hospital mortality.
Uusaro 2003, Finland. [84]	In the ICU, the risk of dying is higher in evenings and during night-time as compared with daytime. When patients are discharged from the ICU, their risk of hospital death is not associated with the timing of discharge. If our findings can be confirmed elsewhere, they may have important implications for organisation of ICU services.
Wunsch*, 2004 UK. [108]	Admission to an ICU at night and at the weekend is not associated with significantly higher case mix adjusted hospital mortality.

Percutaneous Coronary Intervention and/or Critical Care Units

TABLE 40: Data extraction of studies analysing specific model – Percutaneous Coronary Intervention &/or Critical Care Unit/s

Author	Comment
Glasser, 2008, USA. [82]	Finding appear related to both diurnal differences in presentation and lesion characteristics as well as differences in procedural complication and success rates that extend beyond differences in symptom to balloon time.
Kruth, 2008, Germany. [69]	Patients with STEMI admitted to hospitals with catheterisation facilities, admission during the off-hours is associated with higher in-hospital mortality. This may be due to lower rates of revascularisation therapy and longer pre-hospital and in-hospital delays compared to off-hours.
Lairez, 2009, France. [52]	The study reflects actual clinical practice and demonstrates the existence of greater mortality risk for emergency PCI performed at night than for daytime emergency PCI, independent of indication and previous treatment. The study shows that better management of ACS is needed and, perhaps, that greater use of adjunctive medications should be considered when PCI is performed at night.
Sorita, 2014 USA. [83]	Level I and Level II trauma centres were associated with smaller mortality increase during out of hours. The researchers purport that it is possible to achieve comparable outcomes during off-hours and not by simply adding more hospital staff to work during off-hours.

Trauma Clinics

TABLE 41: Data extraction of studies analysing specific model – Trauma Clinic/s

Author	Comment
Busi ,2004, USA. [132]	Study suggested that for patients requiring emergency surgery, major complication and mortality are not associated with whether patients presented during out of hours or not and that trauma units have long been aware of these issues, and may have made conscious efforts to maintain consistent standards of care at all times.
Carmody, 2002, USA. [133]	Researchers purport that it is essential for services providing continuous lifesaving care - notably trauma emergency medicine and critical care - to show that they have no clinically significant diurnal weekend or volume related variation in quality of care.
Laupland, 2009,Canada. [70]	No influence of the outcome of major trauma patients admitted to our large regional acute care hospitals. While inconsistencies in care in the afterhours may affect outcome of other patient populations, this does not appear to be the case for victims of major trauma, and may reflect the advance organisation of trauma care.
Mitra, 2014, Australia. [118]	In major trauma centres, equipment and tangible resource availability remains the same regardless of time of day. However, staffing levels vary, and there has been substantial debate about the importance of fully staffed trauma centres at all hours - including emergency physicians, trauma surgeons, anaesthetists, intensive care physicians, radiologists and broader support staff.

Transplant Teams

TABLE 42: Data extraction of studies analysing specific model – Transplant Team/s

Author	Comment
Orman, 2012, USA. [31]	The outcome of this study provides reassurance about outcomes to the transplant community and patients awaiting transplantation. It highlights patient safety mechanisms, that is the availability of the appropriate number of surgeons and ancillary staff outside of hours.

Haematemesis and Melaena Units

TABLE 43: Data extraction of studies analysing specific model – Haematemesis & Melaena Units

Author	Comment
Haas*, 2010, USA. [27]	The differences in outcome may be only a small part of the equation leading to adverse outcomes in patients presenting with UGIB but it remains a modifiable risk factors. The practice of this institution proves differences in outcome can be avoided in patients presenting with UGIB. Efficient and safe care should be implemented regardless of the day of admission.

Chapter 8: Reflections, Implications and Conclusions

Reflections on the literature

There are a number of limitations of the largely descriptive and retrospective studies included in this review making definitive recommendations from the literature difficult to make. The review identified that out of hours hospital admissions literature is bountiful and associations have been documented from an array of medical conditions, however it is unclear whether these associations are causal for a lower quality of care or are truly attributable to unobservable differences between patients. The papers that have been included have provided guidance and information to inform the next steps. In part, the questions that guided the review remain unanswered highlighting a number of gaps in our current knowledge. No studies were identified that specifically targeted the mechanisms to address unequal outcomes as a result of out of hours admission. However, a wider range of care processes were hypothesised and potentially contribute to our understanding of variation in the quality of care across the week. Future resourcing decisions to address unequal outcomes, from out of hours admission, requires further investigation of causation for the factors or combinations of factors that may contribute to adverse outcomes.

Key findings

There were essentially no papers found as a result of this rapid review that specifically examined the impact that interventions may have had if a differential outcome had previously been identified, for example in the areas of timeliness of senior decision making, timeliness to investigations, treatment time, models of care or staffing profiles.

In general terms, the weight of evidence that a differential outcome may exist is based largely on retrospective analysis of large administrative data sets, including those studying emergency department admissions out of hours.

Differential outcomes out of hours in clinical data sets, which were risk adjusted for severity of illness, were harder to demonstrate out of hours. However, it is important to note that illness acuity and severity is often reported as being higher out of hours in many of the reviewed articles, to account for higher unadjusted mortality, which is an important consideration in itself.

The vast majority of literature investigating outcome differences for patients admitted out of hours report against mortality (which is variably defined in terms of days after admission) and fails to consider other relevant outcomes. Examples include LoS, patient experience, readmission rates and other measures of patient morbidity such as healthcare associated adverse events.

Human resource, system or process factors that may be associated with or mitigate against a differential outcome has been identified in the review, but in general were hypothesised through expert analysis when the authors discussed their findings, rather than formally testing them to demonstrate causal linkage.

Unit based care delivery for specific cohorts of patients (e.g. ICUs PCIs and/or CCUs, Trauma Clinics, H & M and/or Transplant Teams) was associated with similar outcomes, irrespective of when patients were admitted, because resources were similarly allocated across all time periods.

Next steps

In the Queensland context, data linkage provides the opportunity to investigate if differences in outcomes exist locally, it's magnitude, and if present whether this is a system wide phenomena, or demonstrates regional or diagnostic category variation. Any limitations of existing administrative studies were identified by the reviewers and will be incorporated into the analysis by CSIRO, where possible.

Specifically, system wide staffing data, cost data, patient experience surveys, and the death registry data will be linked to patient episode data to determine what individual factors or combination of factors could explain any discoverable differences in outcome.

As such, whilst mortality remains an important quantitative patient outcome differential, any demonstrable differential outcome will be analysed in the context of patient experience, staffing profiles and other patient outcome measures that extend beyond mortality.

It is unrealistic to expect that out of hours and weekends can replicate weekdays in all facets of care and as such any improvement efforts, for identified outcome variation, are best targeted to regional or diagnostic variation. Given the contribution to overall health budgets comprised by clinical staffing, and its logical connection to care delivery out of hours, this is will be a particular area of focus for the research team.

Cost effectiveness analyses can then be undertaken to assist policy makers and health services executives to target areas of identified need where a differential outcome exists. Following on, high quality health services research is then required to demonstrate the impact of any intervention, so implemented, to ensure that clinical outcomes did in fact improve and that allocation of new or redistributed resources had been effective. The rollout of integrated electronic medical records confers the very real possibility that objective clinical and physiological admission data will enable future prospective research in this area.

Over time, such an approach will inform future planning, and provide the ability to develop services on the weekend and out of hours that are reflective of demonstrated areas of need. Strategic planning of hospital services can successfully overcome the variations in care that have been noted in acute admissions for some conditions.

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Contribution of authors

Ms Michele Romeo, Principal Project Officer, Metro North Hospital and Health Services
(Co-ordinating Investigator) undertook the proposal writing, designed and ran the literature searches, undertook reference sifting and evidence synthesis for the review, data extraction into summary tables; contribution to the writing of the report, including the discussion and conclusions; and managed the project.

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undertook evidence synthesis of the review, contribution of the writing of the report, including the discussion and conclusions.

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Data sharing statement

No new data have been created.

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Appendices

Appendix 1: Project Plan

Reviewing Equitable Access to healthCare outcomes out of Hours and at the weekend (REACH) Project

Project Title

A review of health outcomes for patients admitted after hours and at the weekend: Is there an effect and what are the characteristics and contributing factors?

Reviewers

Associate Professor Anthony Bell: SOM UQ & Medical Director, Department of Emergency Medicine, Royal Brisbane and Women's Hospital.

Dr Roger O'Gorman: Medical Officer, Department of Emergency Medicine, Royal Brisbane and Women's Hospital. Ms Michele Romeo: Principal Project Officer, Office of Chief Executive Metro North Hospital and Health Services.

Beginning and Ending Dates

10 December 2015–30 June 2016.

Definition

***Out of hours*:** out of regular working hours (off-hours), during weekends, during holiday periods, on public holidays and on evening and night-time shifts on weekdays.

Introduction

Over the last decade, an increasing number of research studies have examined the association between weekend hospital admissions and poorer patient outcomes including higher rates of mortality. There is significant evidence demonstrating inequality in health outcomes for patients admitted out of hours.

A range of potential causal links for inequitable outcomes for patients admitted out of hours have been identified, one of these is the availability of staff and services at weekend. It remains unclear how many deaths are avoidable. While further evidence on the causal relationships would be of value, we do not think that this can be a justification for taking no action where there are good clinical reasons for doing so.

Background information

Historically, many healthcare facilities provide all services Monday to Friday, with these reducing skeleton staff out of hours and on the weekend. Whilst the nature of human illness is not determined by time of day or day of week, Queensland Public Health Services currently structure health service delivery in this way around a five day delivery model. It has been documented for in the literature that admission to hospital out of hours and on the weekend is associated with poor patient outcomes. Potentially, this presents inconsistency between demand (patients requiring healthcare seven days a week) and supply (healthcare facilities delivery a full complement of health services five days a week). Internationally a number of countries are now endeavouring to develop a systems based approach to planning a transition from five to seven day health care delivery models and some services independent instituting program reorganisation to achieve these ends as research (and expert opinion) highlights increase mortality and morbidity for weekend and after hours admission to hospitals.

There is a growing body of evidence that morbidity and mortality rates increase for patients admitted to hospital on the out of hours. While researchers continue to argue about cost effective ways of improving health outcomes on the weekend, moves are being made globally and locally to provide consistent access to comprehensive healthcare across the seven day week. Key research papers and reviews in this area to date are:

Freemantle et al. (2015). Increased mortality associated with weekend hospital admission: case for expanded 7-day services. *BMJ*. (http://www.bmj.com/content/351/bmj.h4596)

From analyses 2013-14 Hospital Episode Statistics data it was found that:

- *Although there are fewer hospital admissions at weekends, patients who are admitted on Saturday and Sunday are sicker and face an increased likelihood of death within 30-days, even when severity of illness is taken into account.*
- *Patients admitted on a Saturday or Sunday have a 15% and 10% respectively greater risk of mortality compared to those admitted on Wednesday.*
- *There are approximately 11,000 excess deaths in-hospitals every year among patients admitted on a Friday, Saturday, Sunday or Monday compared with other days of the week. The authors included the effect of Fridays and Monday as "appropriate support services in-hospitals are usually reduced from later Friday through the weekend, leading to disruption on Monday morning."*
- *Oncology patients admitted on a Sunday have a 29% increased risk of death compared to those admitted on a Wednesday.*
- *Patients with cardiovascular disease admitted on a Sunday have a 20% increased risk of death compared to those admitted on a Wednesday.*
- *The research concluded that it is not possible to determine how many of the excess deaths were avoidable, but that the statistic is 'not otherwise ignorable' and 'raises challenging questions about reduced service provision at weekends.'*

Ruiz et al. (2015). The Global Comparators Project: International comparison of 30-day in-hospital mortality by day of the week. *BMJ Quality and Safety.* (http://qualitysafety.bmj.com/content/24/8/492)

- *The Global Comparators dataset collected records of inpatients from 50 hospitals across 10 countries (incl: subset of 28 hospitals across England, Australia, USA and Netherlands) presenting to an emergency department showed:*
- *There is an overall 30-day crude mortality rate of 3.9%; the English hospitals had the highest crude morality rate (4.6%). Crude mortality rates for the English, Dutch and USA hospitals were higher at weekends compared with weekdays.*
- *Emergency patients in the English, USA and Dutch hospitals showed a significantly higher adjusted risk of death within 30-days following admission on a Saturday or Sunday compared with admission on a Monday.*
- *This study did not indicate a difference in mortality within 30-days for patients admitted at weekends in Australian hospitals. However analysis of mortality within 7-days, the Australian hospitals showed 12% higher risk of death when admitted on a Saturday compared to a Monday, and 11% higher risk of death following a Sunday admission.*

East Midlands Clinical Senate (2014), 7-day Services Project: Acute Collaborative Report.
(http://www.hsj.co.uk/Journals/2015/05/05/c/k/v/East-Midlands-Clinical-Senate-report.pdf)

A review of the current provision against the 10 clinical standards for urgent and emergency care that underpin consistently high quality care 7-days a week by ten East Midlands acute trusts found that:

- *There is more to do for all trusts to meet the 10 clinical standards, or all of the 4 priority standards, with current performance rated as amber overall.*
- *There is a potential need for network arrangements between trusts to ensure 7-day access to quality care, such as by developing a larger pool of clinicians in specific specialities or services.*
- *While services will need to be redesigned to ensure the availability of workforce, a more fundamental culture shift is also needed to embrace the necessity to provide necessary services across 7-days.*

NHS services. (2013). 7-days a week forum.
(http://www.england.nhs.uk/wp-content/uploads/2013/12 /evidence-base.pdf)

NHS England's NHS Services, Seven Days a Week Forum was a clinically-led process which included an extensive review of the published literature alongside analysis of HES data to explore patient outcomes at weekends compared to during the week.

The review found that:

- *There is significant variation in patient outcomes for those admitted as an emergency. This variation is seen in patient experience, mortality rates, length of hospital stay and re-admission rates.*
- *There is a large body of evidence associating timely consultant input to patient care with improved outcomes.*
- *Radiology and endoscopy are examples of key interventions which are a time critical response to an urgent or emergency need. However, service provision is shown to be highly variable, particularly at weekends.*
- *Consultant-delivered ward rounds are a central pillar for patient care. However, reduced weekend service levels mean many hospitals do not meet national recommendations for twice daily consultant ward rounds.*

Freemantle et al. (2012). Weekend hospitalisation and additional risk of death: an analysis of inpatient data. *J R Soc Med.* (http://www.ncbi.nlm.nih.gov/pubmed/22307037)
Analysis of 2009/10 data found:

- *Patients admitted to hospital on a Sunday had a 16% greater risk of death within 30-days compared to those admitted on a Wednesday.*
- *Patients admitted on a Saturday had an 11% increased risk of death within 30-days compared to those admitted on a Wednesday.*
- *Day of admission was associated with increased risk of death in 7 of the 10 most common CCS groups (clinical conditions). For example:*
- *Patients admitted on a Sunday with acute and unspecified renal failure had a 37% increased risk of death compared with those admitted on a Wednesday*
- *Patients admitted on a Sunday with acute myocardial infarction had an 11% increased risk of death compared to those admitted on a Wednesday*

AoMRC. (2012). 7-day consultant present care.
(http://www.aomrc.org.uk/doc_view/9532-seven- day-consultant-present-care)

In light of evidence demonstrating less favourable patient outcomes at weekends compared to weekdays, the Academy of Medical Royal Colleges presented proposals for achieving parity for inpatient care throughout the week. The report indicated:

- *Most hospitals and specialities already provide a non-resident consultant-led on-call rota which should ensure acutely unwell or deteriorating patients have access to consultants and timely interventions. However, in the absence of daily 'planned' consultant review, the remainder of the patient's care pathway is often put into hibernation particularly over weekends, resulting in delays in diagnosis, investigation, treatment and discharge from hospital.*
- *It is not uncommon for patients whose condition is not deteriorating to wait until the next scheduled weekday review before being seen by a consultant. For example, a patient who is admitted on a Thursday night will usually be seen by a consultant on Friday morning, but may then wait until Monday for their next scheduled consultant review.*
- *The weekend effect is very likely attributable to deficiencies in care processes linked to the absence of skilled and empowered senior staff in a system which is not configured to provide full diagnostic and support services 7-days a week.*
- *Following discharge from acute areas to general wards the frequency of consultant review falls significantly. The result is that departures from the care pathway are not uncommon, and are not detected in a timely manner.*
- *The most effective way to improve outcomes for patients admitted to hospital at weekends is to ensure that care is delivered by adequately supported consultants and monitored during care pathways.*

Aylin et al. (2010). Weekend mortality for emergency admissions: a large multicentre study. *BMJ Quality and Safety.*
(http://qualitysafety.bmj.com/content/19/3/213.short)

- *This study is one of the first, large scale studies of English data to explore weekend mortality rates for emergency admissions. From 2005/6 data, the study found:*
- *Crude mortality rates are higher for patients admitted at weekends compared to weekdays (5.2% for all weekend admissions; 4.9% for all weekday admissions; overall crude mortality rate: 5.0%). There is a 10% higher risk of death for patients admitted as an emergency at the weekend compared with those admitted on a weekday.*
- *There may be a possible 3,369 excess deaths occurring at the weekend compared to weekdays (equivalent to a 7% higher risk of death).*
- *In addition to the evidence of weekend hospital admissions resulting in poorer patient outcomes including higher rates of mortality, there is also some evidence that trainee healthcare staff are also affected by existing weekend practices. A reduction in available senior support at the weekend can lead to an ineffective use of time to support training and improve skills for the benefit of patients and staff. As discussed in the report below.*

Professor Sir John Temple. (2010). Time for training.
(http://hee.nhs.uk/healtheducationengland/files /2012/08/Time-for-training-report.pdf)

This report reviewed the impact of the European Working Time Directive (EWTD) on quality of training for doctors, dentists, healthcare scientists and pharmacists. The report found:

- *Rigid, poorly designed rotas can result in trainees being unsupported and unsupervised*
- *Splitting services into elective and emergency can enhance training, deliver EWTD-compliant rotas and improve quality of care.*
- *Elective work is relatively time driven and proactive and provides good speciality training. By contrast, emergency work is variable over 24 hours (but with predictable peaks) and can provide valuable training but is often not maximised as many trainees are unsupported and poorly supervised.*

There is little support for extending hours or lengthening training programmes. This can perpetuate the situation of staff on specialty training programmes not using the hours effectively for training, which can lead to trainees providing the frontline services outside of hours, unsupported and without direct supervision.

Whilst the evidence for health outcomes for admissions out of hours is **mainly observational** not all research studies have reported inequality of health at these times. Factors that have been proposed to explain the difference in health outcomes for admissions out of hours are staffing issues, effective hand-over communication and the delay in diagnostic and therapeutic procedures.

To date **very little research has been undertaken examining the effectiveness of interventions to improve outcomes out of hours** with expert option stressing the need for well-planned trials to obtain good quality evidence of the effectiveness of interventions to improve patient outcomes at the weekend (P. Alyin, personal communication September 11, 2015).

The QCS 2015 March meeting explored the issues and opportunities associated with out of hours and weekend service delivery system in Queensland. QCS recommended that essential services that are available on weekdays should also be available out of hours and at the weekend along with improving to access to care and communication between healthcare professionals.

The QCS endorsed for an evidenced based review to explore how diagnostic groups and causal pathways impact of admissions out of hours in Queensland to inform diagnosis and service specific solutions and investment priorities for HHS in Queensland.

Aim

Identify the underlying causes of differential health outcomes of patients admitted outside of hours, which includes weekends, and explore intervention/s that have been show to improve outcomes for patients admitted at these times.

Objectives

- This study is a **descriptive literature review** that addresses the issue of inequitable health outcomes that occur from admissions out of hours. The specific objectives include:
- To identify and analyse the factors that influence inequality of health outcomes to patients admitted/presenting to hospital out of hours and at the weekend.
- To identify the range and scope of services specifically targeting patients admitted /presenting to hospital out of hours and at the weekend.
- To identify models of care that has been demonstrated to reduce the inequality of health outcomes for patients admitted/ presenting to hospital out of hours and at the weekend and evaluate their effectiveness.
- To identify the policy implications and identify areas requiring further research.

Condition or domain being studied

- ***Participants/ Population:*** The population is patients admitted out of hours.
- ***Exposure(s):*** The exposure is defined as an intervention that addresses the inequality of healthcare outcomes for patients admitted out of hours.
- ***Comparator(s)/control:*** Patients admitted on-hours (within regular working hours).
- ***Outcome(s):*** The outcomes of interest are short-time mortality, patient outcomes other than mortality (such as functional recovery or readmission) and models of care/ interventions type to encourage equitable health outcomes for patients admitted after hours and at the weekend.

Methods of the review

Because of the broad nature of the review topic, a comprehensive search strategy has been developed and will be cycled through a number of iterations in order to maximise comprehensiveness and precision.

Stage		CI:	PPO:	CE:
Define Study Question		Approve	Lead	Advice
Prepare Protocol		Review	Lead	Review
Undertake Search	Stage 1: Title Search -Relevance		Lead	
Data Extraction	Stage 2: Abstract Review- Significance	Review	Lead	Lead
Quality Assessment	Stage 3: Full Text Review -Impact	Review	Lead	Lead
Data Synthesis		Review	Lead	Lead
Interpretation		Review	Lead	Lead
Write Report		Review	Lead	Review

Search strategy for identification of studies

Initially, scoping search was performed to identify major papers on published evidence and refine the final key terms used to undertake the search strategy detailed below.

The following **concepts** and all possible synonyms (**search terms**) are considered:

Concept: out of hours and at the weekend: 24/7 model; 7-day care; 7-day health; 7-day services; after hours; day of week; late in week; night care; night time; night time; off-hours; off shift ;out of hours; round the clock; utilisation; weekend; weekend service.

Concept: hospital & departments: acute; allied health; care; chemotherapy; elective; emergency department; endoscopy; health care; hospital; intensive care; inter cranial haemorrhage; medical; microbiology; myocardial infarction; nursing; operating theatre; pathology; PCI; radiology; rehabilitation; service/s; STI; stroke; surgery/surgical; trauma; unit; unscheduled; unscheduled; ward.

Concept: study design: Cohort study/studies; Longitudinal study/studies; Follow up study/studies; Prospective study/studies; Retrospective study/studies; Prevalence study/studies; Incidence study/studies; transversal.

Concept: outcomes: Assessment; clinical governance; co morbidity; criteria led discharge; discharge; equity; governance; intervention; medical error; models of care; morbidity; mortality; patient harm; patient safety.

Types of study to be included/ excluded

In this type of research the gold-standard of an RCT is often impossible and sometimes an inappropriate technique. As such all designs of this study with appropriate outcomes measures will be considered including: **RCTs, quasi-experimental studies, cohort studies, cross-sectional studies observational studies /descriptive papers** (where higher quality of evidence is not available). Also written material or information that is unpublished or not published commercially: that which is produced on all levels of government, academics, business and industry, in print and electronic formats, but which is not controlled by commercial publishers" **(grey literature)** including: **(conference papers, blogs, fact-sheets, dissertations, newsletters, course materials, book chapters, memoranda, annual reports, interviews, policy statements, posters, government documents, newspaper clippings, personal communication, pamphlets, essays, emails, questionnaires, speeches, press releases, speeches)**. This information provides a broad range of information and contains new ideas.

Articles will automatically be **excluded** if it is published in a **language other than English**; and/or includes **data from a hospital system in an under-developed country**.

Articles will be **peer reviewed from a reputable source** or have been **contributed by experts** in the field of medicine, nursing, patient safety, health policy, health system economics and /or finance. Additionally, the articles will be those which investigators **feel that make a significant, timely or unique contribution to the development of our understanding in this research area**.

Data Extraction (selection and coding)

The data extraction process will be performed by two reviewers independently. In case of disagreement, consensus will be sought by discussion and in case of disagreement a third party will be consulted.

A number of **approaches** will be utilised and involve 3 stages as follows:

- **Title (eye-balling) Search.** Titles will be screened for **relevance** (including check for duplicates) to the **aims** of the study.
- **Abstract Review** - Abstracts will be screened for **significance (& utility)** to the **aims** of the study.
- **Full Text Review** - Full text format will be analysed for their contribution **(impact)** that may meet the **objectives** of the study.

Stage 1: Title search

Screen title for **relevance** to the project. Articles to be included if they appear to relate to the management of patients admitted/ presenting to hospital out of hours and in particular to models of care and the factors that appear to be driving changes in those models. Studies that are clearly not relevant to the aims of the study will be excluded without any further attention.

Reference titles are to be scanned to identify contributions to the definition, criteria, components and conceptual framework of models of care targeting the identified causes of inequitable outcomes for patients admitted out of hours.

At this stage no limitations are to be placed on publication date in order to retrieve the history and scope of the project topic.

Search of key **bibliographic** databases using a set of key search combinations including:

- CINAHL (incl. PsycINFO).
- Cochrane Library.
- EMBASE.
- Google scholar.
- Joanna Briggs Institute Evidence Based Practice database.
- PubMed (and MedLine).
- Scopus.

Focused review of the contents of national and international medicine, quality safety, health and economic journals, **grey literature** (including guidelines and unpublished research) and thesis with the assistance of:

- ‘Advanced’ Google search.
- ProQuest Dissertations and Theses Global.
- Open Grey.
- Grey Matters.

Additional references will be identified through examination of references **manually** from the most recent publications from specific journals, trial registers, specific websites (including professional organisation pages) (**snowballing**) and through scrutiny of contents pages of highly relevant journals for the last three years including:

British Medical Journal (BMJ); *Journal of America Medical Association* (JAMA); *New England Journal of Medicine; BMJ Quality & Safety; Critical Care Medical Journal; Medical Journal of Australia* (MJA); *The Lancet and the Canadian Medical Association Journal.*

Stage 2: Abstract review

Second screen for relevance to the project: screening for **impact**.

Articles to included are those that appear to make a significant contribution of information that is the article provide evidence to support the **background (content and scope)** as well as the factors contributing to inequality of health for people admitted out of hours, the **analysis of the strategies/ interventions and models of care to affect the inequality of health for patients admitted/presenting to the hospital out of hours**.

Studies that are excluded at this stage will be recorded with a short explanation for the exclusion. Reviewers will assess the abstracts based on the following:

CATEGORY 1	Publications that contain context and background.
CATEGORY 2	Publications that detail existing interventions/models of care, their content and scope.
CATEGORY 3	Publications that provide recommendations for interventions/models of care that are not evidence based.
CATEGORY 4	Publications that provide recommendations for interventions/models of care that are evidence based.
CATEGORY 5	Publications that provide recommendations for interventions/ models of care that are evidence-based and derived from appropriately structured research methods
CATEGORY 6	Other relevant publications that do not align with categories 1-4

Stage 3: Full text review

Final screen for **significance** to the project.

Articles to be included are those that appear to be strong in the articles underlying logic and the investigators are confident that conclusions can be drawn. Articles to be included are those that make a significant contribution.

The assessment of the evidence will be performed by two reviewers independently. In case of disagreement consensus will be sought by discussion, and in case of further disagreement a third party will be consulted

Reviewers will assess the full text format for their contribution towards objectives of the project. Reviewers will assess the full text based on the following:

Level 1	Systematic Review/ Meta-analysis RCTs Experimental
Level 2	Cohort control studies Case control studies 'Outcomes' research Observational research
Level 3	Case studies Other types of studies (e.g., interview based, local audit)
Level 4	Expert opinion without explicit critical appraisal

Risk of bias (quality) assessment: The included studies will be thoroughly read and data will be extracted following a pre-defined data extraction template which will consider the appropriateness of study design to the research objective, risk of bias, and other issues including (choice of outcome measure, statistical issues, quality of reporting, quality of the intervention, generalisability).

Strategy for data synthesis – Interpretation (final report)

A textual narrative synthesis of these studies exploring the relationships between the studies and (if appropriate) will combine results from studies included in the review. The review will include an analysis of the individual selected studies their characteristics, findings and level of quality (including heterogeneity) will be collated, combined and summarised be presented in a diagram (table) reviewing and reporting key information including study setting, year of study, study design, quality of the design (strength/weakness), major findings and implications.

Contact details for further information

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Appendix 2: Search Strategies

Database	Date Range	Search Date	Search Strategy	Results
Scopus	1995-01-01 to 2015-12-22	2015-12-22	(hospital* OR “emergency health service*” OR “emergency health service” OR “emergency department*” OR “emergency department”) AND (“7-day” OR “seven day” OR “night care” OR “after-hours care” OR “week end” OR weekend* OR “after hours” OR “out of hours”)	**3,876**
PUBMED	1995-01-01 to 2015-12-11	2015-12-11	(hospital:de,ab,ti OR hospitals:ab,ti OR ‘emergency health service’/exp OR ‘emergency health service’ OR ‘emergency departments’:ab,ti OR ‘emergency department’:ab,ti) AND (‘7-day’:ab,ti OR ‘seven day’:ab,ti OR ‘night care’:ab,ti OR ‘after-hours care’:ab,ti OR ‘week end’:ab,ti OR weekend:ab,ti OR ‘after hours’:ab,ti OR ‘out of hours’:ab,ti) AND (‘cohort analysis’/exp OR ‘longitudinal study’/exp OR ‘follow up’/exp OR ‘prospective study’/exp OR ‘retrospective study’/exp OR cohort:ab,ti OR longitudinal:ab,ti OR prospective:ab,ti OR retrospective:ab,ti OR audit:ab,ti OR epidemiology:ab,ti OR ‘cross-sectional study’/exp OR ‘cross-sectional’:ab,ti OR ‘prevalence study’:ab,ti OR ‘prevalence studies’:ab,ti OR ‘incidence study’:ab,ti OR ‘incidence studies’:ab,ti OR ‘transversal study’:ab,ti OR ‘transversal studies’:ab,ti)	**2,347**
EMBASE	1995-01-01 to 2015-12-22	2015-12-22	(hospital OR hospitals OR “emergency health service” OR “emergency health services” OR “emergency departments” OR “emergency department”) AND (“7-day” OR “seven day” OR “night care” OR “after-hours care” OR “week end” OR weekend* OR “after hours” OR “out of hours”)	**4,122**
Emerald - Insight	1995-01-01 to 2015-12-21	2015-12-21	(hospital* OR “emergency health service*” OR “emergency health service” OR “emergency department*” OR “emergency department”) AND (“7-day” OR “seven day” OR “night care” OR “after-hours care” OR “week end” OR weekend* OR “after hours” OR “out of hours”)	**341**
CINAHL	1995-01-01 to 2015-12-21	2015-12-21	(hospital* OR “emergency health service*” OR “emergency health service” OR “emergency department*” OR “emergency department”) AND (“7-day” OR “seven day” OR “night care” OR “after-hours care” OR “week end” OR weekend* OR “after hours” OR “out of hours”)	**1,816**

Appendix 3: Data extraction summary of studies reporting the outcomes for patients admitted out of hours and at the weekend - Mortality

Disease specific / non-disease specific type	In-hospital	2-days	3-days	5-days	7-days	14-days	15-days	28-days	30-days	60-days	90-days	120-days	365-days
Medical	**10** [4 6 12 22 98 124 147 1 16 37 107]	**4** [24 98 124 141]							**6** [10 24 11 117 127 139]				
Surgical	**6** [14 15 32 87 93 155]								**4** [7 17 31 32]		**1** [31]		**1** [31]
Intensive Care	**15** [21 67 111 26 28 29 33 78 79 84 100 101 103 105 108 120 137]	**1** [130]			**1** [111]								
Cardio Respiratory	**18** [34 44 52 59 63 65 66 69 80 82 83 92 110 112 115 116 131 145 153]	**1** [115]							**9** [50 62 65 66 73 113 128 136 152]	**1** [145]	**1** [145]		**1** [128]
Nephrology	**1** [13]		**1** [13]										
Neuroscience	**23** [19 20 75 76 151 46 48 58 90 114 36 60 64 72 86 119 125 126 143 156 159]		**1** [68]		**9** [46 53 68 75 76 122 125 135 144]	**3** [75 76 125]		**1** [121]	**9** [55 68 75 76 81 125 134 143 144]		**2** [71 129]		
Gastroenterology	**12** [35 38 39 41-43 45 49 54 74 88 109]								**4** [27 41 74 89]				
Haematology - Oncology and other medical specialties	**4** [40 47 138 142]						**1** [40]		**2** [40 47]				
Paediatrics and Obstetrics	**5** [18 99 140 146 149]												
Trauma	**10** [21 56 70 94 132 133 123]												
Orthopaedics	**4** [57 61 150 154]			**1** [77]					**4** [51 61 77 154]			**1** [61]	

Appendix 4: Data extraction summary of studies reporting the outcomes for patients admitted out of hours and at the weekend - Treatment Delay

Disease specific / non disease specific type	Treatment delay out of hours	No treatment delay out of hours
Cardio Respiratory	**3** [44 50 52]	**5** [59 62 63 65 66]
Neuroscience	**3** [46 48 53]	
Gastroenterology	**9** [35 38 39 41-43 45 49 54]	**6** [19 20 55 58 60 64]
Haematology-Oncology and other medical specialties	**2** [40 47]	
Orthopaedics	**1** [51]	**2** [57 61]

Appendix 5: Data extraction summary of studies reporting the outcomes for patients admitted out of hours and at the weekend - Length of Stay

Disease specific / non disease specific type	Difference in Length of Stay	No difference in Length of Stay
Medical		**1** [37]
Surgical	**1** [87]	**1** [93]
Intensive Care	**1** [85]	**2** [33 78 120]
Cardio Respiratory	**2** [50 73]	1 [92]
Neuroscience	**1** [86]	**3** [19 20 90]
Gastroenterology	**2** [54 88]	**5** [27 35 38 89 91]
Haematology-Oncology and other medical specialties	**2** [40 47]	
Trauma		**3** [56 94 148]
Orthopaedics		**1** [150]

Appendix 6: Data extraction summary of studies reporting the outcomes for patients admitted out of hours and at the weekends - Timeframe

Disease specific / non disease specific type	Analysed weekends and nights seperately						Analysed weekends and nights together							Dirunal	Each day studied					Other							Weekends: all other times considered weekdays				Total
	Yes		No		Mixed		Yes		No		Mixed			No	Yes		No		Mixed	Yes			No		Mixed		Yes			Mixed	
	A	C	A	C	A	C	A	C	A	C	A	C	Systematic review	C	A	C	Case series	C	A	A	C	Meta analysis	A	C	A	Systematic review	A	A	C	A	
Cardio Respiratory	**1** [69]	**2** [52 52]		**5** [59 63 65 128 136]		**2** [34 131]	**3** [44 50 116]		**2** [66 92]	**3** [62 83 110]	**1** [113]	**2** [112 115]						**1** [145]		**2** [152 153]							**2** [73 80]				**26**
Gastroenterology		**1** [42]					**2** [43 74]		**1** [49]	**1** [109]												**1** [45]	**1** [38]	**1** [41]			**2** [139]	**1** [89]	**3** [27 88 91]	**1** [39]	**15**
Neuroscience		**2** [48 134]		**2** [36 129]	**1** [135]		**7** [46 53 76 93 122 125 126]	**2** [68 119]	**3** [19 20 75]	**1** [114]	**5** [58 60 71 81 90]	**2** [55 121]								**1** [151]	**1** [72]			**1** [156]			**1** [143]			**1** [144]	**30**
Oncology			**1** [138]							**1** [47]																		**1** [142]	**1** [40]		**4**
Orthopaedics			**1** [57]		**1** [51]			**1** [77]		**1** [61]											**1** [154]				**1** [150]						**6**
Paediatrics							**1** [18]								**1** [146]		**1** [99]			**1** [149]							**1** [140]				**5**
Nephrology and Renal																															
Trauma				**4** [56 94 132 133]			**1** [86]	**1** [118]	**1** [64]	**1** [70]		**1** [123]												1 [148]							**10**
Medical	**1** [84]	**1** [98]					**5** [10-12 16 107]		**2** [117 124]	**1** [37]	**3** [4 22 127]								**1** [147]	**1** [8]					**1** [24]	**3** [6 9 141]			**1** [24]	**20**
Surgical				**1** [31]			**3** [7 15 17]				**1** [32]			**1** [87]						**1** [155]							**2** [14 93]				**9**
Intensive Care		**1** [137]		**9** [21 28 29 35 67 78 101 103 105]		**4** [33 84 100 130]	**1** [111]			**1** [120]		**1** [26]	**1** [23]			**1** [79]				**1** [85]											**20**
Total	**2**	**7**	**2**	**21**	**2**	**6**	**23**	**4**	**9**	**10**	**10**	**6**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**7**	**2**	**1**	**1**	**3**	**1**	**1**	**11**	**2**	**4**	**3**	**145**

**A= administrative data-set *C= clinical data-set*

Appendix 7: Data extraction summary of studies reporting the outcomes for patients admitted out of hours and at the weekend - Region and dataset (administrative & clinical)

Country	Study Type	Disease specific / non-disease specific type											
		Cardio Respiratory	Gastroenterology	Haematology-Oncology	Intensive Care	Medical	Neuroscience	Orthopaedics	Paediatrics	Nephrology and Renal	Surgical	Trauma	Total
Asia	Administrative	2 [113 152]					3 [117 143 144]						5
	Clinical	2 [62 136]	2 [41 109]		2 [29 33]		3 [48 114 156]					1 [123]	10
Australia	Administrative				1 [111]	2 [8 24]							3
	Clinical				1 [120]		1 [36]					1 [118]	3
Canada	Administrative	2 [44 153]	1 [54]	1 [138]		1 [4]	2 [46 126]						7
	Clinical		1 [91]		2 [101 100]		1 [129]					1 [70]	5
Middle-East	Administrative												
	Clinical	1 [128]			1 [21]								2
Middle-East	Administrative												
	Clinical		1 [45]		1 [23]						1 [32]		3
Other Europe	Administrative	1 [69]				2 [141 139 141]	3 [122 81 135]	2 [51 57]					8
	Clinical	3 [52 110 112]	1 [42]		6 [67 79 84 103 105 137]	1 [98]	1 [119]	1 [77]					13
UK	Administrative	1 [66]	3 [49 89 74]			6 [6 10–12 117 147]	1 [53]		1 [18]		3 [7 14 17]		15
	Clinical	4 [63 65 115 131]			1 [108]	1 [37]	2 [55 68]	2 [61 154]					10
USA	Administrative	5 [50 73 80 92 116]	4 [38 88 43 39]	1 [142]	1 [85]	7 [9 16 22 25 107 127]	10 [19–20 60 71 75 76 90 93 125 151]	1 [150]	4 [99 140 146 149]	1 [13]	3 [15 93 155]	2 [64 86]	39
	Clinical	5 [34 59 82 83]	2 [35 27]	2 [47 40]	4 [78 28 26 130]		3 [72 121 134]				2 [87 31]	5 [56 94 132 133 148]	23
Total		26	15	4	20	20	30	6	5	1	9	10	146

Appendix 8: Data extraction summary of studies reporting the outcomes for patients admitted out of hours and at the weekend – DRG and data set (administrative and clinical)

	Yes										TOTAL (Yes)	No									TOTAL (No)	Mixed								TOTAL (Mixed)	Grand Total
Disease specific / non-disease specific type	**Cardio Respiratory**	**Gastroenterology**	**Neuroscience**	**Orthopaedics**	**Paediatrics**	**Nephrology**	**Trauma**	**Medical**	**Surgical**	**Intensive Care**		**Cardio Respiratory**	**Gastroenterology**	**Neuroscience**	**Haematology-Oncology**	**Orthopaedics**	**Paediatrics**	**Trauma**	**Medical**	**Surgical**	**Intensive Care**		**Cardio Respiratory**	**Gastroenterology**	**Neuroscience**	**Orthopaedics**	**Trauma**	**Medical**	**Surgical**	**Intensive Care**		
Administrative	**8** [44 50 69 80 116 152 153]	**4** [43 54 74 139]	**9** [46 53 76 93 122 125 126 143 151]		**4** [18 146 140 149]	**1** [13]	**1** [86]	**10** [6 8-12 16 84 107 141]	**6** [7 14 15 17 93 155]	**2** [85 111]	45	**2** [66 92]	**3** [38 49 89]	**3** [19 20 75]	**2** [138 142]	**1** [57]		**1** [64]	**2** [117 124]			14	**1** [113]	**1** [39]	**7** [58 60 71 81 90 135 144]	**2** [51 150]		**5** [127 147 24 4 22]	**1** [32]		17	76
Clinical	**2** [52 82]	**1** [42]	**5** [48 68 72 119 134]	**2** [77 154]			**1** [118]	**1** [98]		**2** [79 137]	14	**9** [62 63 65 83 110 128 136 145]	**5** [27 41 88 91 108]	**4** [36 114 129 156]	**2** [40 47]	**1** [61]		**6** [56 70 94 132 133 148]	**1** [37]	**2** [31 87]	**10** [21 28 29 35 67 78 101 103 105 120]	40	**4** [34 112 115 131]		**2** [55 121]		**1** [123]			**5** [26 33 84 100 130]	12	66
Case Series																	**1** [99]					1										1
Meta Analysis		**1** [45]									1																					1
Systematic Review																												**1** [25]		**1** [23]	2	2
Grand Total	10	6	14	2	4	1	2	11	6	4	60	11	8	7	4	2	1	7	3	2	10	55	5	1	9	2	1	6	1	6	31	146